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INTEGRATION OF AN MCA-GIS APPROACH FOR THE MODELLING AND ASSESSMENT OF MASS MOVEMENT RISK. CASE OF AÏN EL HAMMAM, BASIN OF TIZI-OUZOU (ALGERIA)

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Abstract: This paper presents a three-step approach to evaluate and map mass movement risk. First, hazard and vulnerability, the two components of mass movement risk, are evaluated through the use of a Weighted Product Method (WPM) borrowed to the Multi-Attribute Utility Theory (MAUT). The model evaluates each potential action a ∈ A (set of potential actions) according to a set of attributes, points of view and criteria i, i = 1, ..., n, from gi measurement scales. The criteria retained are environmental factors of susceptibility to landslides and surrounding elements at risk (stakes). In a second phase, the risk is estimated by the product of its two components. Finally, the spatial mass movement risk is determined by crossing the susceptibility (hazard) and consequences (vulnerability) maps. The method has been tested in the area of Aïn el Hammam in the basin of Tizi-Ouzou (Algerian Tell).

Key words: landslide, rock fall, multi-criteria analysis, modelling, GIS

* * * * * *

INTRODUCTION

Mass movement risk is related on the one hand to the presence of an event or hazard that is the manifestation of a geomorphological phenomenon and on the other hand to the existence of issues; that is, all the consequences that can hit a specific environment: the loss of life, damage to economic activity, natural environment and national heritage. These consequences depend on the exposed elements and their vulnerability, often expressed in terms of damage level. As it is often difficult to quantify a level of hazard, it is only the susceptibility of land to a geomorphogenic process that has been picked for analysis. These different concepts of risk have been defined by several authors (Aleotti and Chowdhury, 1999; Fell et al., 2005; Glade, 2003; Gokceoglu and Aksoy, 1996; Herman, 2009, 2010).

Mass movement risk assessment methods use have soared, these methods consider hazard as the probability of occurrence of a spatial phenomenon for several environmental predisposing

* Corresponding Author

factors, and vulnerability is evaluated by taking into account the number and the magnitude of potentially affected exposed elements (Bui et al., 2011; Guettouche, 2012; Kouli et al., 2013; Tazik et al., 2014; Xu et al., 2015; Bourenane et al, 2016).

This work presents a methodological mapping process of mass movement risk in a sloping area (Aïn El Hammam) using spatial analysis model, based on the MCA-GIS coupling (Multiple Criteria Analysis and Geographical Information System). The selected area is marked by several rock fall and landslide locations, the largest of which is ranked among the most potentially destructive in Northern Algeria.

METHODOLOGY

The applied methodology in this work includes three large parts; it is essentially based on the integration of the Utility Theory MAUT and GIS (figure 1):

- modelling of mass movement risk through the use of Utility Theory (MAUT) theory simulating the relationship between the two most crucial criteria, namely, hazard and vulnerability;
- appraisal and mapping of hazard and environment vulnerability through the identification of the key elements and the analysis of their potential effects using the GIS tool;
- appraisal and risk mapping through the overlay of hazard and vulnerability maps.

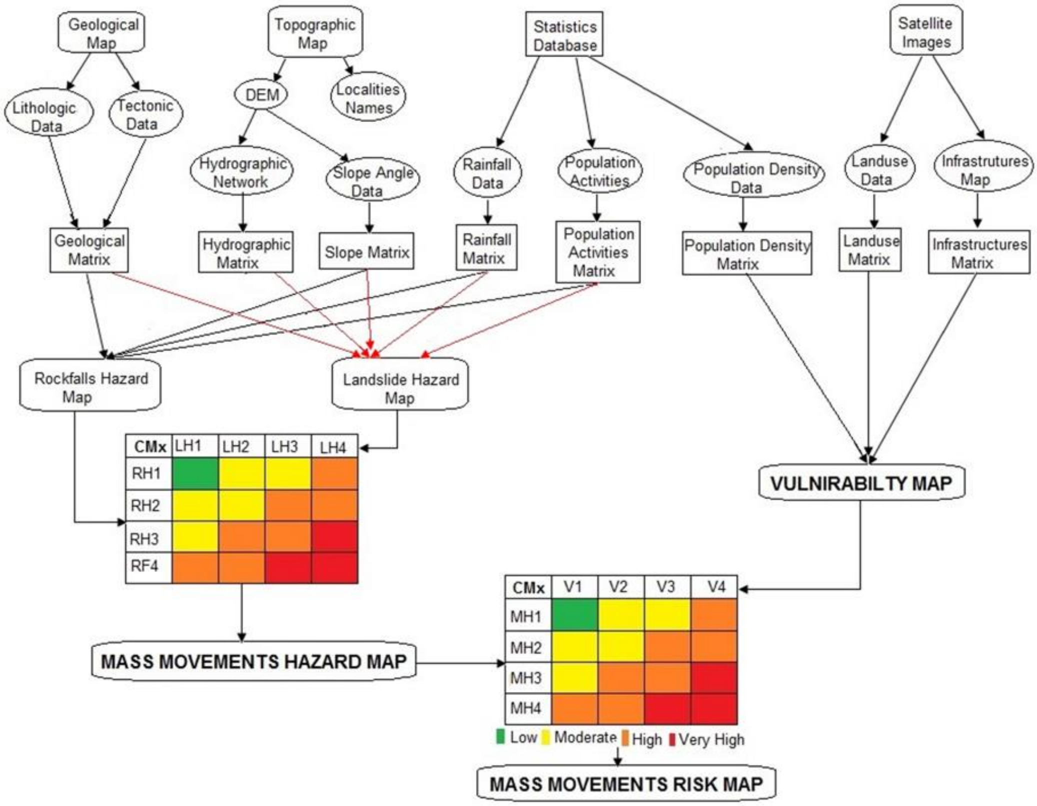

Figure 1. Methodology of mass movement risk mapping
(Source: Berchiche Razika)

To test our methodological approach, the "commune" (town hall district) of Aïn El Hammam in the Wilaya of Tizi-Ouzou was chosen as the study area (figure 3). This choice is all indicated due to the external geodynamic features and existing issues in the area.

Mass movement inventory map

The mass movements inventory maps are important for the study of the relationship between the distribution of these movements and conditioning factors. To produce detailed and reliable maps, thorough investigations and field observations were conducted in the study area. A total of 9 landslide and 5 rock fall locations have been identified and mapped in the study area (figure 2). The rupture types identified in the study area were determined according to the mass movement classification system proposed at the International Conference of Geomorphology (International Association of Geomorphologists).

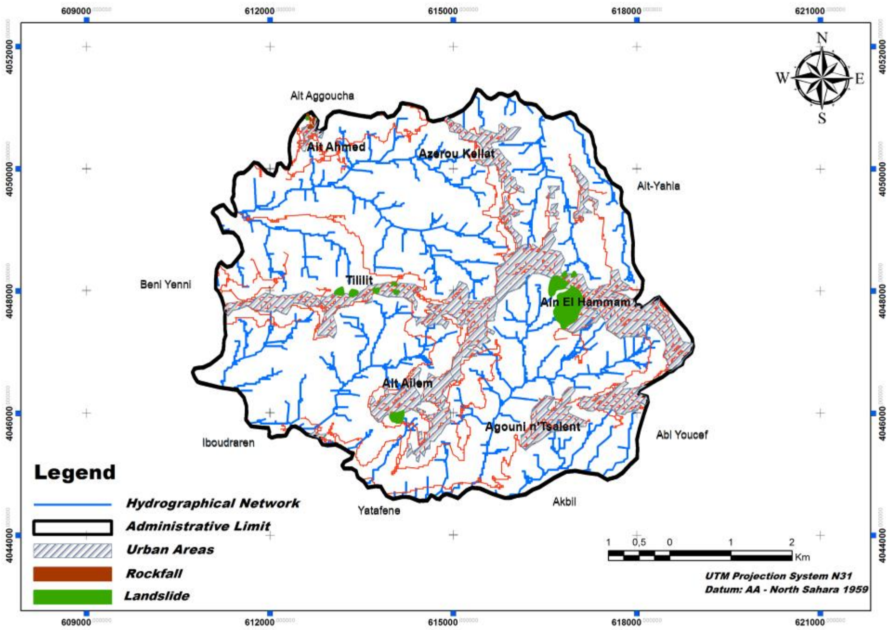

Figure 2. mass movement inventory map of study area
(Source: Berchiche Razika)

Mass movement risk modelling

Stemming from the definition of D. Bernoulli (in Guettouche, 2012) risk is considered to be the product of hazard and vulnerability (eq. 01):

$$R_{mt} = A_{mt} * V \qquad (01)$$

In our instance, mass movement hazard is the cumulative effect of two geomorphological processes, rock fall and landslides. This cumulative effect can be represented by equation (02):

$$A_{mt} = A_{eb} + A_{gl} \qquad (02)$$

Where:
R_{mt}: Mass movement risk. Amt: Mass movement hazard. V: Vulnerability.
A_{eb}: Rock fall hazard. A_{gl}: Landslide hazard.
A_n alternative approach based on the WPM method (Weight Product Model) is used to define either mass movement hazard or vulnerability, (eq. 3)

$$P(A_k) = \prod_{j=1}^{n} (a_{kj})^{\omega_j} \qquad (03)$$

Where:

$P_{(Ak)}$: Action defining the hazard or vulnerability. ωj: relative weight of importance of criterion C_i. a_{kj}: Value of the performance of the variant Ai when evaluated according to criterion C_i.

Identification of hazard and vulnerability criteria

Several authors reckon that a certain number of triggering factors may be responsible for the occurrence of mass movement in a region (Erener and Düzgün, 2008; Kanungo et al., 2009; Tazik et al., 2014; Yalcin et al., 2011) such as lithology, geomorphology, hydrology and entropic conditions; thus, the criteria adopted for the evaluation of landslide hazard and vulnerability are: lithology, slope, rainfall, river systems, vegetation, human activities, infrastructure and population density.

Indeed, the weight given to the chosen criteria are:

For landslide hazard (eq. 04)

$$A_{gl} = Pe^{0.3} * \mathrm{L}^{0.25} * \mathrm{Pl}^{0.2} * \mathrm{Rh}^{0.1} * \mathrm{Ah}^{0.15} \quad (4)$$

For rockslide hazard (eq. 05)

$$A_{eb} = Pe^{0.25} * \mathrm{L}^{0.35} * \mathrm{Pl}^{0.15} * \mathrm{Ah}^{0.25} \quad (5)$$

For environmental vulnerability (eq. 06)

$$V = D^{0.7} * \mathrm{Aa}^{0.2} * \mathrm{I}^{0.1} \quad (6)$$

Where

A_{gl}: Landslide Hazard. A_{eb}: Rock Fall Hazard. V: Vulnerability. L: Lithology. Pe: Slope.

Pl: Rainfall. Rh: Hydrographic network. Ah: human activity. D: Population density (Np /m²). I: Amenities density represented by the line plots in a unit area (m/m).

Aa: agricultural stake evaluated through the ratio of farmland to the total area (ha/ha).

Construction of the spatial database

Through their capabilities of storage, management, analysis, modelling and display of spatial data, GIS are presented as the most suitable tool for the classification of the criteria used to model hazard and vulnerability in terms of their impact on unstable ground in our study area (Mashari et al., 2012; Bourenane et al., 2014; Magliulo et al., 2008; Pradhan and Youssef, 2009).

Based on a choice of criteria, a spatial database relying on categories of elements determining the hazard or vulnerability was built then weights were assigned to each element based on the objectives of the study and/or the socio-economic importance of the elements exposed in the study site. A linear combination allowed the evaluation of the susceptibility degree of the land or the potential damage for each stake. For details on the method please see Guettouche et al., (2011).

Hazard and vulnerability are translated into total risk classes in a double-entry matrix (Sorriso Valvo, 2005) implemented in a GIS tool (ArcGIS) for risk mapping.

Slope (Pe)

Considered the most relevant parameter in unstable hillslopes, the slope is an essential factor as well for the assessment to map mass movement. Therefore, the weight it has been assigned was high (Conforti et al., 2001; Erener et al., 2008; Yalcin et al., 2011; Hantz 2008). There for, the study area is a very rugged ground with slopes ranging from strong to very strong (from 45 to over 65%); this is epitomised by the location of the area, belonging to the Tizi Ouzou Neogene Basin.

Lithology (L)

Lithology plays often a fundamental role in the instability, evolution and the occurrence of mass movement. Undeniably, rock permeability, structure and hardness are parameters that affect the geological formations 'rheological character' (Kanungo et al., 2009; Xu et al., 2013; Tazik et al., 2014; Yalcin et al., 2011). Therefore, the geological nature of our study area appears to be very complex, showing a Paleozoic sedimentary cover that is hardly or not metamorphosed at all, part of the mainly carbonated Kabyle dorsal, dating from the Permo-Trias to the Oligocene with soft soils (Southern area) and hard ones (Northern area).

Rainfall (Pl)

As a general rule, rainfall is regarded as the main land slide triggering factor (Bui et al., 2011), thus, the Algerian Tell - in which the area studied is located- is a wet and rainy region (1000 to 1500 mm/y) making it very susceptible to landslides especially during the winter season.

Hydrographic Network (Rh)

The density of the hydrographic system plays an important role in the instability of hillslopes depending on its nature and its distribution (Bui et al., 2011; Mathew et al., 2007; Kouli et al., 2013; Kanungo et al., 2009). In our case, the study area chosen is a mountainous zone with broad, embedded and/or deep valleys and the classification was made according to the position of the talweg relative to the slope.

Human Activity (Ah)

Several authors (Maquaire et al., 2006; Mathew et al., 2007; Nathanail and Hudson, 1992; Ocakoglu et al., 2002) postulate that vegetation cover and human activity are important for the stability of slopes. For this study, the human activity map has been built relying on Landsat satellite imagery by supervised classification. In our case, human activity is mainly found in the Southern part of the region around the chief town of the district, due to the tender lithological characteristics, thus, facilitating crop growing.

Population Density (D)

The population density present in the study area is high (20,401 inhabitants/h), and is located in the Southern part. Even, the weight given to human life is the highest and the criterion has been segmented into three density classes.

Agricultural activity (Aa)

Economic and agricultural assets are all stakes that may be highly affected. This parameter is divided into four major classes.

Infrastructure (I)

The road network has been considered as the weakest factor for the vulnerability evaluation and has been segmented into classes depending on the importance and role of roads.

APPLICATION

Location of the study areas

Aïn El Hammam is a mountainous area with very steep slopes, located about 50 km southeast of the Wilaya capital of Tizi-Ouzou. It lies between longitude 4° 18' and 4°40' E and 36° 49' and latitude 36° 66' N. It is the county seat and is accessible through roads RN 15 and/or RN 71. It counts more than 20 401 inhabitants. Aïn El Hammam is one of the largest cities in the Wilaya of Tizi-Ouzou to have suffered significant economic and agricultural losses caused by landslides.

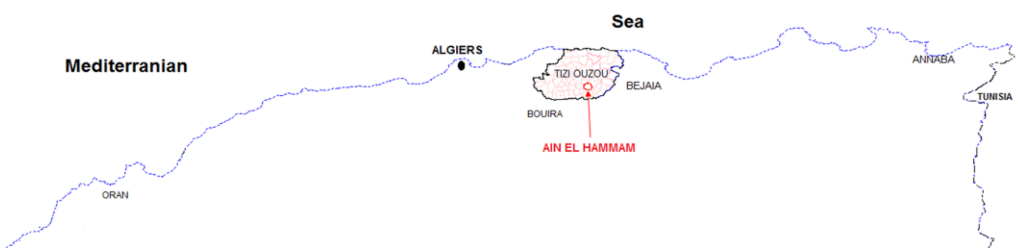

Figure 3. Location map of study area
(Source: Berchiche Razika)

Results

The main results obtained under the exposed WPM method are synthesized on the figures 4-8. The processing and analysis performed have led to a split of the communal space into four mass movement risk classes.

The analysis of different physical and human geography standards leading to mass movement (C_i) helped to determine the number of surface calculation units in the area and their optimal locations. Processing and combinatorial analysis of different matrices led to the spatial mass movement risk. This simulated spatialisation has been empirically validated by comparing the simulation map with the field observation results.

Landslide, Rockfall and mass movement hazard maps

Two hazard maps (landslide and rock fall) were completed (figures 4 - 5).

For the landslide hazard map (figure 4), locations (1, 2, 3) where the hazard is very strong, the lithology proved to be tender (micaceous shales), human activity very intense (urban area coupled to agriculture activities), dense hydrographic network, perpendicular to the slope, high rainfall (over 1000 mm/year) and slopes between 30 and 65%.

Furthermore, as for the rocks fall hazard map (figure 5), locations (1 and 2) are very susceptible (very high hazard) in contradiction with the physical and surface parameters (insignificant human activity, less than 50 inhabitantper km^2, forests and olive plantations), hard lithology (granuliticmica shales (gneis) and granuliticshales slopes between 30 and 65%, rainfall over 1000 mm/year^{-1}.

Overlapping the two maps (figures 4 - 5) produces the mass movement hazard map (figure 6), this latter shows four classes of land susceptibility to movement, of which the strong hazard is located in Aïn El Hammam, Tillilt, Agouni n'tsalent and Ait Ahmed.

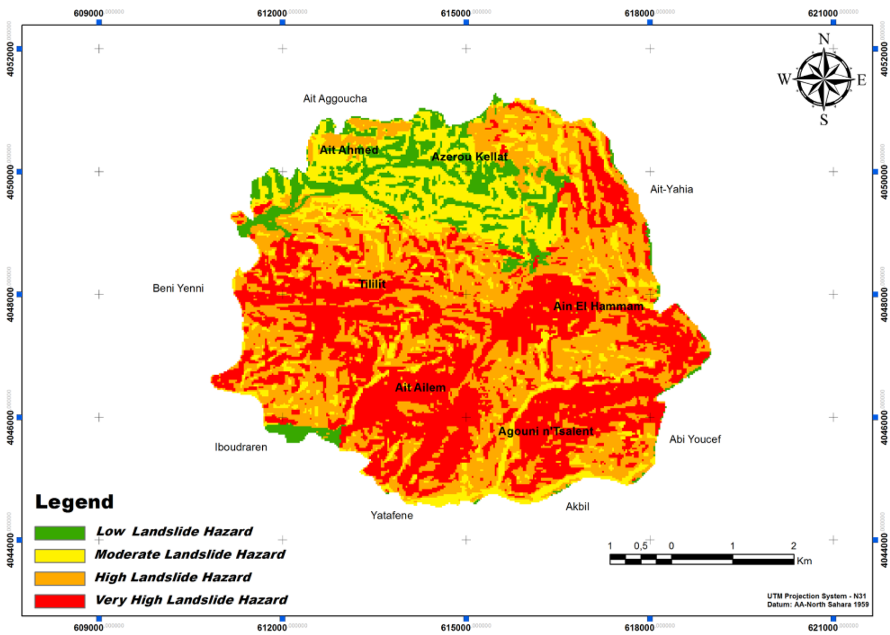

Figure 4. Landslide Hazard map of Aïn El Hammam area
(Source: Berchiche Razika)

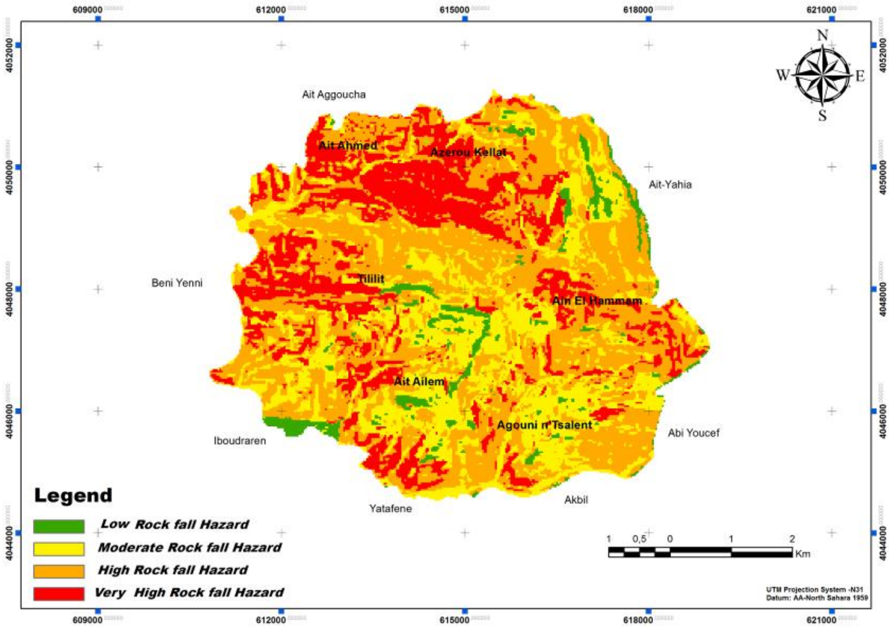

Figure 5. Rock fall Hazard map of Aïn El Hammam area
(Source: Berchiche Razika)

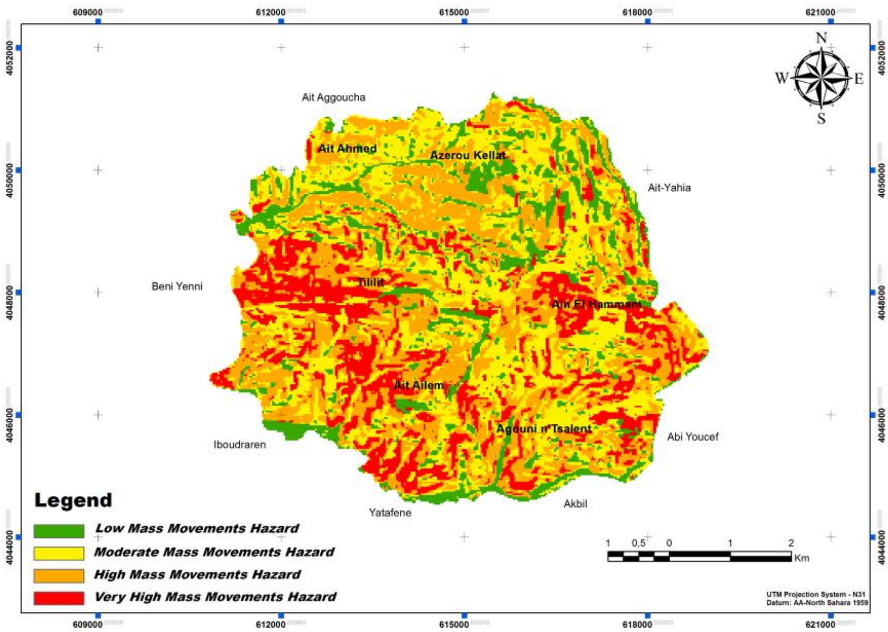

Figure 6. Mass Movements hazard map of Aïn El Hammam area
(Source: Berchiche Razika)

Vulnerability map

The figure 7 shows the total damage potential map (structural, functional and physical). Indeed, the town of Aïn El Hammam shows a significant vulnerability especially in locations 01, 02, 03 and 04 where the density of the population is high (1000 over 5000 inhabitants /ha) and human as well as agriculture activities are strong.

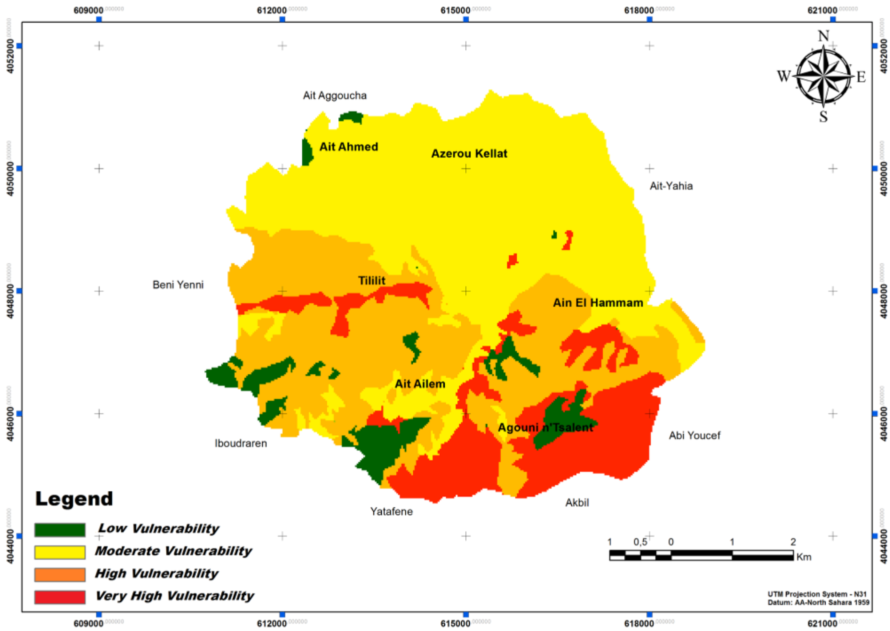

Figure 7. Vulnerability map of Aïn El Hammam area
(Source: Berchiche Razika)

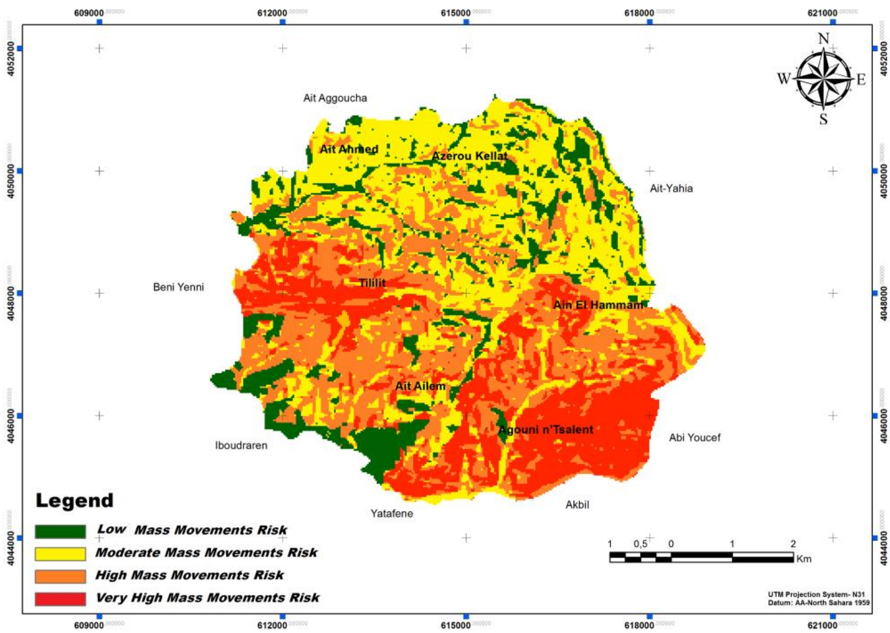

Figure 8. Mass Movements Risk map of Aïn El Hammam area
(Source: Berchiche Razika)

Mass movement Risk map

The combination of the mass movement hazard map (figure 6) and potential consequences map (figure 7) shows the mass movement risk levels in the region of Aïn El Hammam (figure 8).

The risk of mass movement map (figure 7) shows two distinct risk areas: the north area, which represents a low and medium risk, and the south area where the risk is graded strong to very strong.

Firstly, the very high risk - which represents 13.5% of the total land area- and the high risk are developed in areas consistent with sectors with high consequences (urbanized areas and/or agricultural) located on high susceptibility slopes (for example, soft or uneven fields) as in Aïn El Hammam, Tililit, Ait Ailem, and Agouni n'Tsalent.

Secondly, the north area which is graded as a low to medium risk, located in Azerou Kellat and Ait Ahmed, owing its low vulnerability to limited people mobility and agriculture due to the very rugged terrain (steep slopes> 65%) and its geological nature (hard ground: schist granulite, and micaschist granulite).

The comparison of the two maps (figure 8) with the one obtained through in situ mapping (figure 2) shows that the results provided by the model put to test are reliable and coincided with the information collected in the field, for example the infamous great landslide of Aïn el Hammam and is correctly shown and located in figure 8 provided by applying the model, as well as the communities of Ait Ahmed, Tililit and Ait Ailem.

Discussion

The results from the application of the MAUT theory can be dealt with in four points:

The analysis of the two maps elaborated shows that the allocation of the landslide hazard in the study area is mainly located in the Southern part, where the conditions are favourable. In contrast, the rockslide hazard is situated in the Northern part where the conditions are favourable to the occurrence of this latter. The breakdown of these two phenomena can be explained by the geographical situation of the study area which is part of the internal zone of the Kabyle territory; more precisely located between the flysch area to the South and the Kabyle spine to the North, which plainly crops out at Fort National. As a consequence, the maps of landslide and rockslide hazards seem to be very localizing.

The vulnerability map of the study area is represented by two very distinct areas, the northern part with medium vulnerability, and the southern with strong to very strong vulnerability. This can be explained by the strong distribution of the population in the southern part of the area as a result of the location of the county site of Aïn El Hammam and the nature of the soft ground (Schist and Micaschist) which makes for easy lands to exploit, favouring agriculture development.

On the other hand, it can be seen that the mass movement hazard map, shows four an homogeneous distribution of land susceptibility to movement.

Finally, the mass movement risk map, which does not show a homogeneous distribution of the risk, seems to be well localizing, this allocation is strongly influenced by the vulnerability of the environment; therefore, the risk assessment approach can be considered as a satisfactory result.

CONCLUSION

The results as stated illustrate four important topics:

- from a methodology angle, the choice to set up a risk modelling has helped to overcome the tedious and costly standards of accuracy of a conventional field investigation. So this will reduce the field investigations and the cost of studies;

- the inventory carried out, specifically oriented towards basic research through the study of the relationship between physical and human parameters, led to new inputs for risk management in the study area;

- natural hazard mapping set up in this work allowed to clearly distinguish two areas: one where the mass movement risk is high and requires short-term involvement and one where the mass movement is low. These movements are mainly related to lithological conditions, slope, human activity, hydrographic network and rainfall;

- in terms of spatial distribution, and on reading different maps issued from the application of utility theory (MAUT) models, we generally observed the same spatial distributions. In addition, through a fine map reading we noted that the WPM method is reliable and provides more details, and best prediction of the slope movement risk in the study area.

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GEOMATICS APPROACH FOR URBAN EXTENSION MANAGEMENT CAUGHT BETWEEN PLANNING TOOLS AND REALITY ON THE GROUND, CASE OF THE DISTRICT OF BISKRA (ALGERIA)

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Abstract: Biskra city, the administrative center of the Biskra region (wilaya), has poor potential in terms of urban space development; and this is strongly linked to the unfavorable characteristics of the soil with specific geographical features (soil collapse) which prohibits the vertical extension and imposes an urban development horizontal. The incoherence between the urban planning of Saharan cities with a proactive urbanism and the spatial dynamics that obeys other socio-economic factors and financial stakes, due in part to the absence of a prospective vision that It is based on the real needs of an urbanizable space over time, and on the other hand with a reliable spatial analysis allowing an objective diagnosis of the urban space. In view of the large number of variables and their spatiotemporal combination, it is necessary to use geomatics techniques for accurate spatial analysis and sustainable planning. This research work integrates with the results obtained by the geomatic approach compared to conventional land use planning and development master plans (P.D.A.U) which are always outdated even before their approval.

Key words: Biskra, spatio-temporal plan, Geomatics approach, P.D.A.U, soil collapse,

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INTRODUCTION

The growth of Saharan cities is a recent and rapid phenomenon, both from a demographic and a spatial point of view; this does not go without creating enormous difficulties and planning constraints for managers of urban agglomerations as part of a strong social demand in terms of housing, public facilities, infrastructure and diversified jobs. The objective of this study is based on a proposal for geomatics planning by the P.D.A.U to illustrate the deficiencies of traditional development plans to better detect non-compliance with strategic orientations, particularly in studies of management tools.

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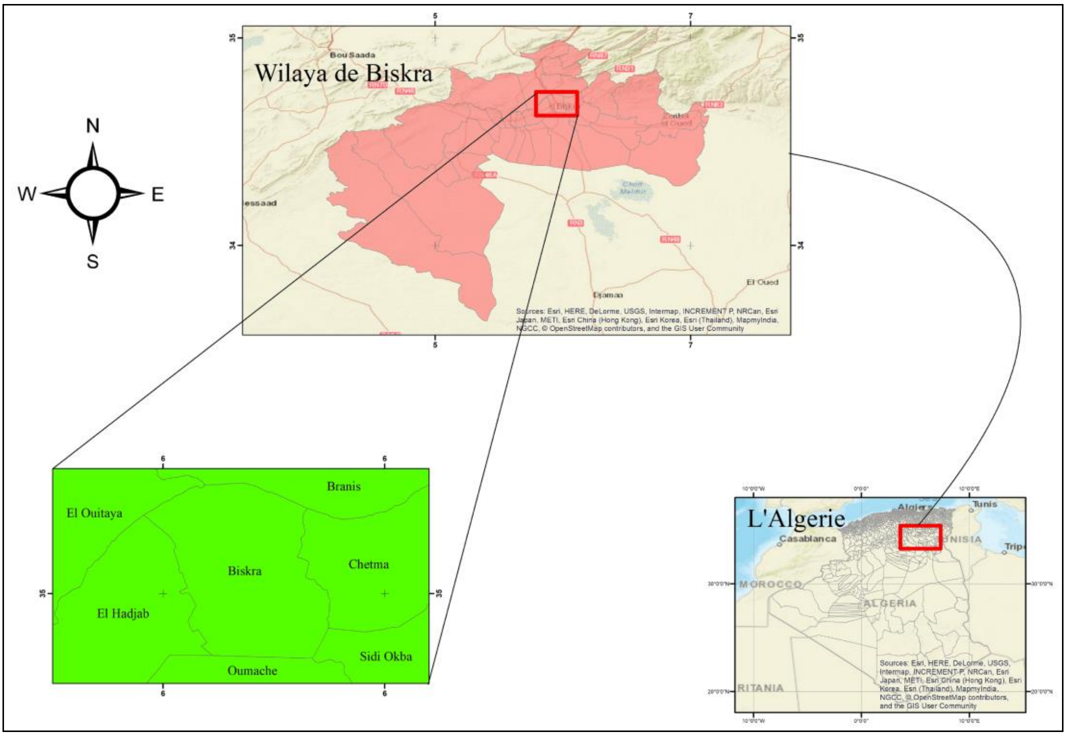

Figure 1. Study area
(Source: Saker Adel)

The study area corresponds to the territorial space of the municipality of Biskra which constitutes a boundary between the Tell zone to the north and the Sahara to the south. It is also a real obligatory passage towards the big Saharan spaces with specified geographical ones such as the geotehnic constraints (soil collapse). The commune of Biskra extends over an area of 127.70 km², 400 km south-east of the capital, Algiers, is administratively limited by the commune of Branis and Djemorah to the north, to the East by the commune of Chetma and Sidi-okba, to the West by the municipality of Elhadjeb, to the south by the commune of Oumache (figure 1).

STRATEGIC PLANNING TOOL

The P.D.A.U. is an instrument of spatial planning and urban management setting the basic orientations of the spatial planning of the municipality (s) concerned.

This essential instrument for the development of the local community plays an important role in the rationalization of the land use (urbanized and non-urbanized) and their prediction for the satisfaction of present and future needs in terms of sustainable development (Loi nº, 1990).

"The imprecisions in the representation of territorial boundaries affected by urban planning are not acceptable under any circumstances, and can only lead to unwanted conflicts that slow down the implementation of plans" (Gomis and Turon, 2017, p. 75).

The strategic directions of the Biskra PDAU are based on the following premises:

- transferring the railway line from the city center to outside the city;
- creation of modern public transport means (tramway);
- extension of the green city on the west side;
- protection of oases on the South side;
- tracking of public facilities and housing in all its forms;
- rehabilitating the old urban fabric.

The complexity of the data and its distribution across different sectors makes coordination difficult between them and constitutes an obstacle to urban development operations because of the bureaucratic burden of information exchange. This situation of lack of fluidity of spatial information amplifies the problems of territorial control, knowing that the revision of the (PDAU) which is carried out every decade (1998-2008) is not sufficient for the follow-up and the evaluation of the proposed strategy (Akakba et al., 2014) (figure 2).

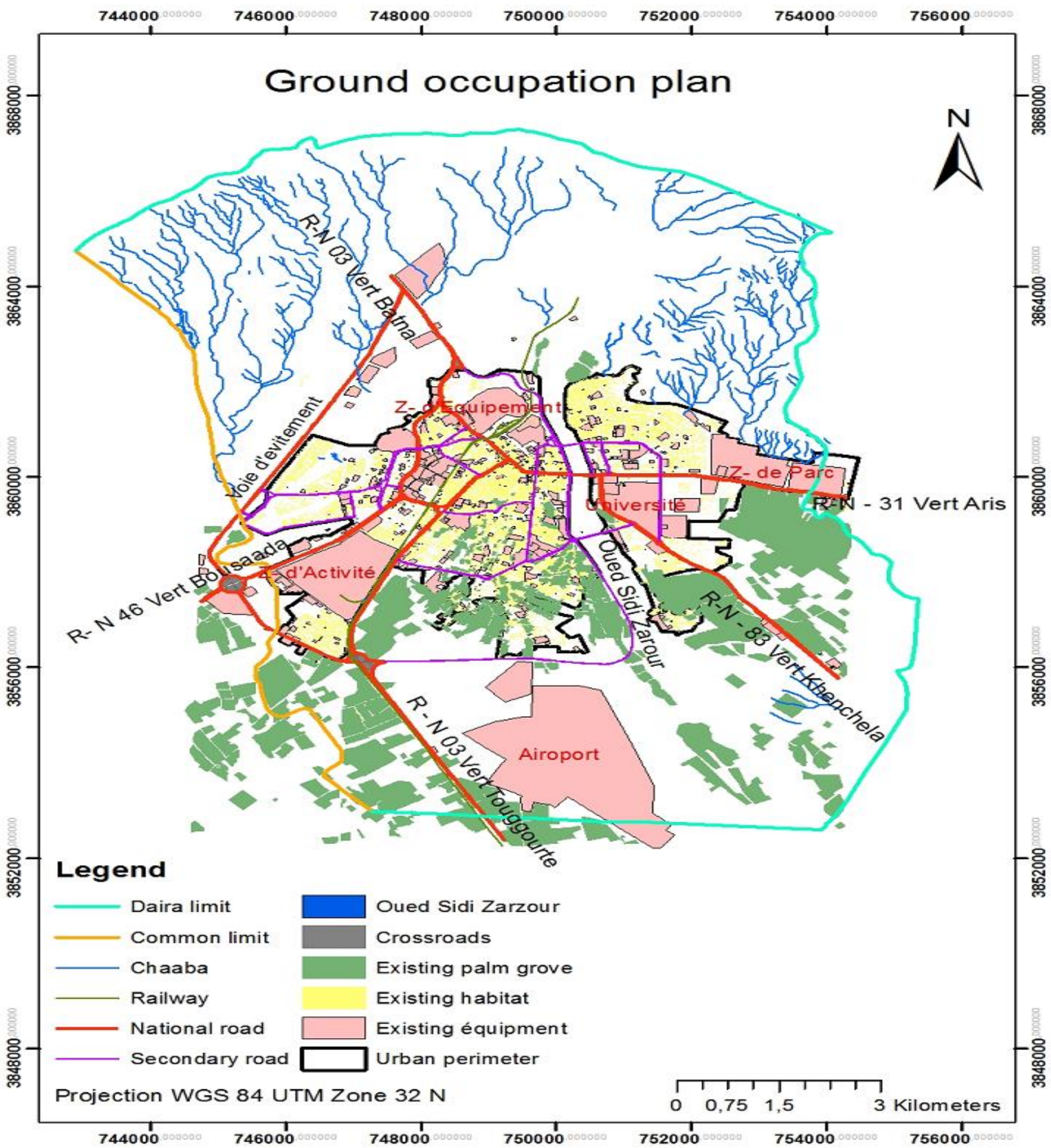

Figure 2. Land cover Municipality of Biskra
(Source: Master Plan of Planning and Urban Planning 2008)

The alteration of the terrain, the population needs and the evolution of the industry will inevitably lead to the formation of an urban conurbation because all these changes mean an unavoidable extension (Chetma, Elhadjeb). ”Suburban areas are exposed to a particularly strong investment pressure due to the growth of cities and their expansion beyond urban limits. Such municipalities face the challenge of imposing spatial order on areas experiencing intensive development. On the other hand, lying in the proximity of a city is an important growth stimulant for suburban communes" (Wolny et al., 2017, p. 113; Wolny et al., 2014; Herman, 2009).

MATERIALS AND METHODS

We used for "this study three Landsat satellite images of 30 x 30 m resolution; the first dating 6 May 1987; the second dated 15 April 2001 and the third dated 24 May 2016. We opted for a color composite channel 432 for images TM 1987 and 2001, instead of 543 for the image LDCM", 2016, "which allows us to cleanly identify the different units of Land Use compared to other colored compositions. Based on the visual interpretations and especially the knowledge of the reality of the field, we defined three classes of land cover (Buildings, Palmary and bare soils). This choice is made in a way to allow better identification of the city, and its extension in reference space-time" (Bouhata et al., 2016, p. 161). The overlaying of the results of the SVM with the P.D.A.U plans allows us to determine in real time the difference between the proposed strategy and the reality on the ground (figure 3).

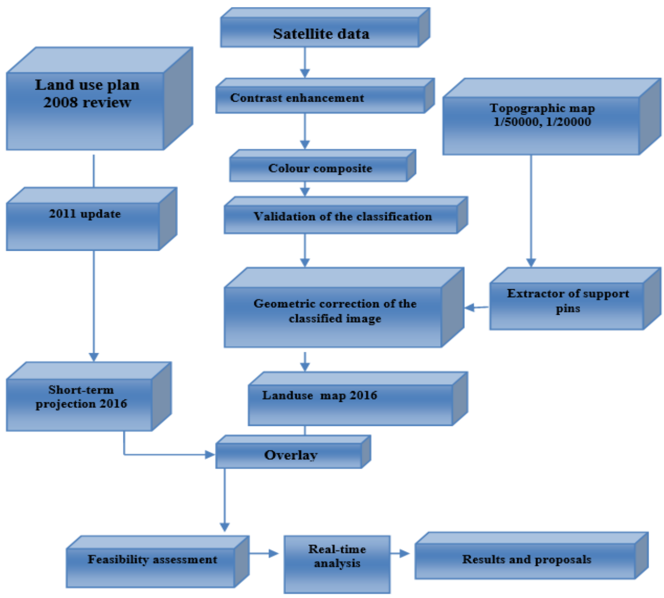

Figure 3. Organization chart of the different stages of management plans evaluation (Source: Saker Adel)

Pan-Sharpening

"Pansharpening is a process of merging high-resolution panchromatic and lower resolution multispectral imagery to create a single high-resolution color image. Google Maps and nearly every map creating company use this technique to increase image quality. Pansharpening produces a high-resolution color image from three, four or more low-resolution multispectral satellite bands plus a corresponding high-resolution panchromatic band" [1]: Low-res color bands + High-res grayscale band = Hi-res color image, for example Landsat 7, which includes six 30 m resolution multispectral bands, a 60 m thermal infrared band plus a 15 m resolution panchromatic band. [2]

[1] *http://www.geocarto.com.hk/edu/PJ-PANSHARP/main_PNSP.html*
[2] *https://en.wikipedia.org/wiki/Pansharpened_image*

”Generally, the Pan-sharpening is defined as a combination of two or more different images to form using an algorithm a new image” (Bouhata et al., 2016, p. 161; Ehlers et al., 2010).

”The aim of image fusionis to integrate complementary data in order to obtain more and better information about an object or a study area than can be derived from single sensor data alone (Sarup and Singhai, 2011). In our work the pan- sharpening is to merge a panchromatic image (band 8) at high spatial resolution (15 m) obtained by the LDCM sensor with a multispectral image of medium spatial resolution (30 m) also obtained by the same sensor and the result produced a multi- spectral image with the same resolution as the panchromatic image. A supervised classification based on the method of maximum likelihood, was used on the previous two colored composition images using the image processing software (ENVI 4.5). This method is considered as a powerful technique for classification. The rule of the decision of this method is based on the probability of a pixel belonging to a given category” (Bouhata et al., 2016, p. 161; Fojstng, 1999; Murtaza and Romshoo, 2014). The average performance of classifications is 98.23% for the classification of TM 1987, 98.69% for the classification of TM 2001 and 98.79% for the classification of 2016 LDCM.

According to (Rupali and Karbhari, 2015), when 0, 81 < Kc < 0,99, it means that our results are statistically perfect (table 1).

Table 1. Validation the results of classification by good values of GP and KC

Matrix of Confusion	Global Precision (GP)	Kappa Coefficient (KC)
Confusion Matrix 1987	98.23	0.9713
Confusion Matrix 2001	98.69	0.9609
Confusion Matrix 2016	98.79	0.9753

RESULTS AND DISCUSSIONS

Comparing the classification of the images makes it possible to locate and identify changes in land use. The visual examination of the satellite images acquired in 1987, 2001 and 2016 shows that the changes in land use have been largely identified in the city of Biskra, the images help to understand at a glance the landscape changes of different parts of the study area. This landscape represents the increase of the urbanization perimeter and the reduction of the bare grounds and the surfaces of the palm groves.

The visual comparison of the changes limits their real appreciation and encourages errors of judgment. This is why, in addition to the visual method, we checked the relevance of the changes using another statistical approach in 1987, 2001 and 2016. This approach was carried out under ENVI 4.5 using the instrument (statistical classes) which makes it possible to measure and calculate the surface area of the different classes (figures 4, 5 and 6).

The following table summarizes the distribution of the area of the units of land occupation.

Table 2. Areas of unit of land occupation

Land use unit	Area in 1987 (km^2)	Area in 1987 (%)	Area in 2001 (km^2)	Area in 2001 (%)	Area in 2016 (km^2)	Area in 2016 (%)
Palm grove	17.97	12.51	12.20	8.46	7.47	5.18
Bare ground and rocky terrain	101.207	53.658	91.857	48.701	84.572	44.839
Urban fabric	14.751	7.821	17.311	9.178	24.066	12.760

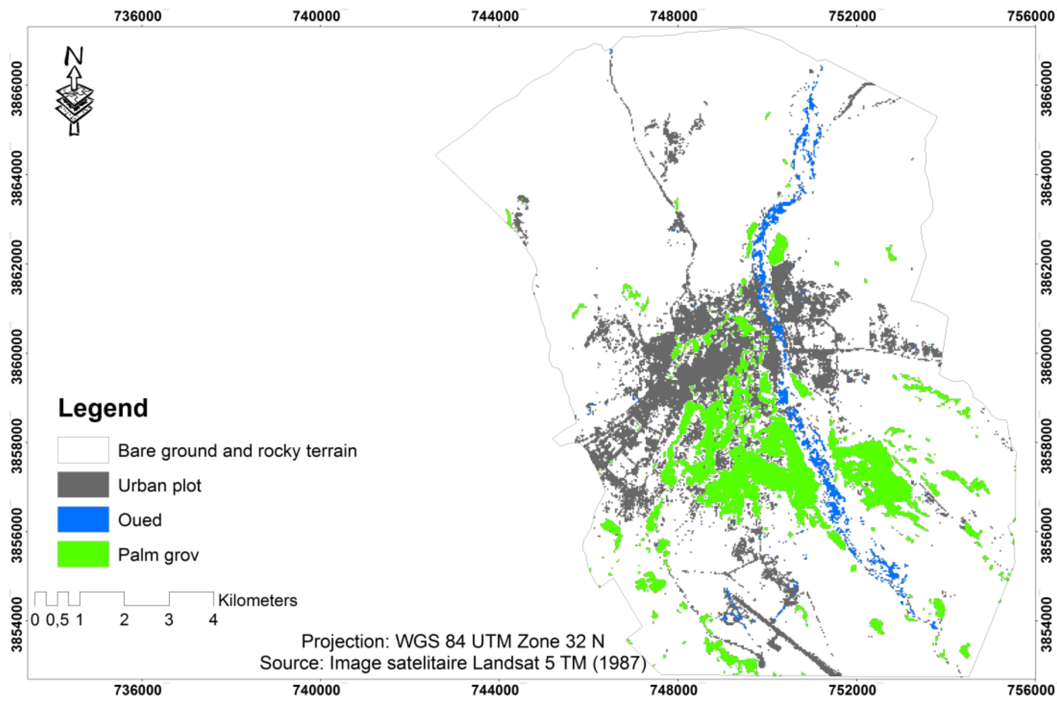

Figure 4. Thematic map of land occupancy in Biskra city in 1987
(Source: Saker Adel)

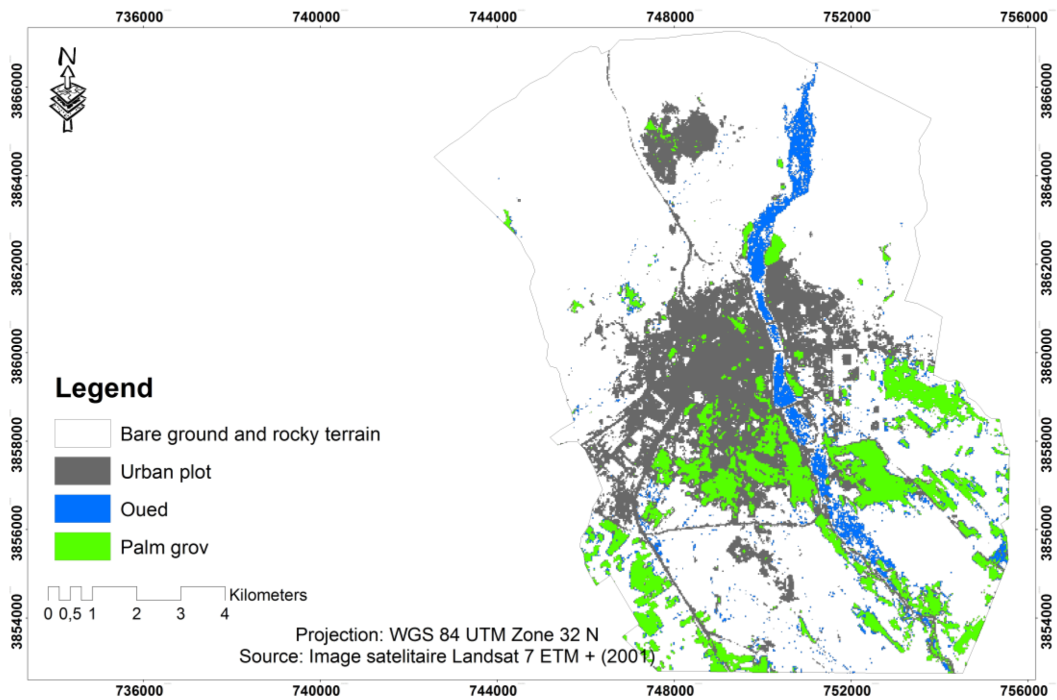

Figure 5. Thematic map of land occupancy in Biskra city in 2001
(Source: Saker Adel)

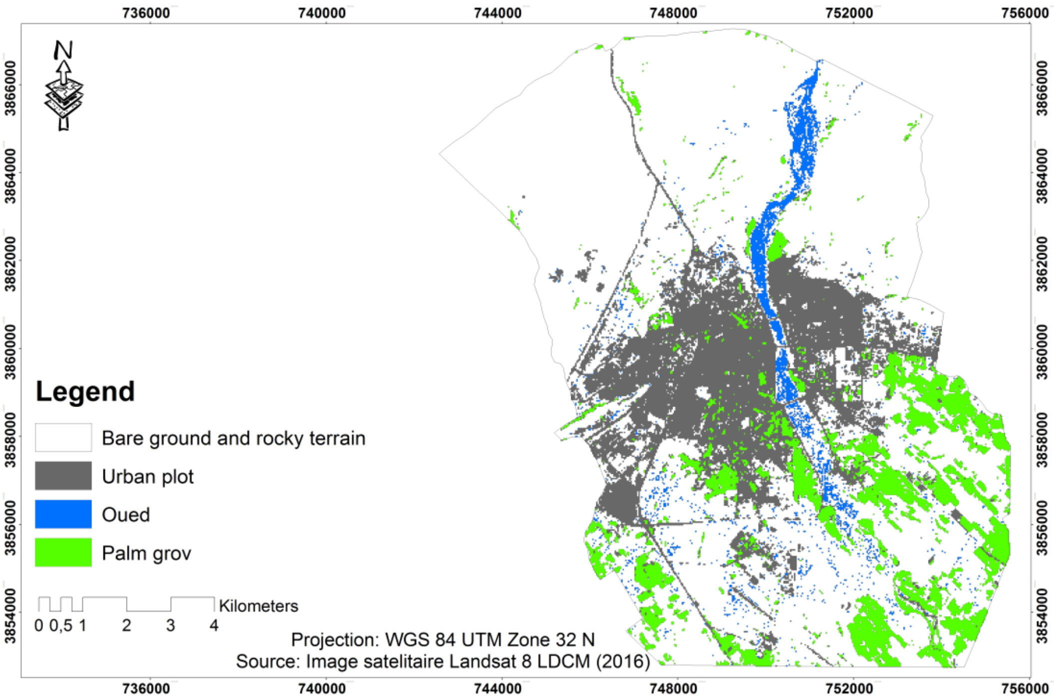

Figure 6. Thematic map of land occupancy in Biskra city in 2016
(Source: Saker Adel)

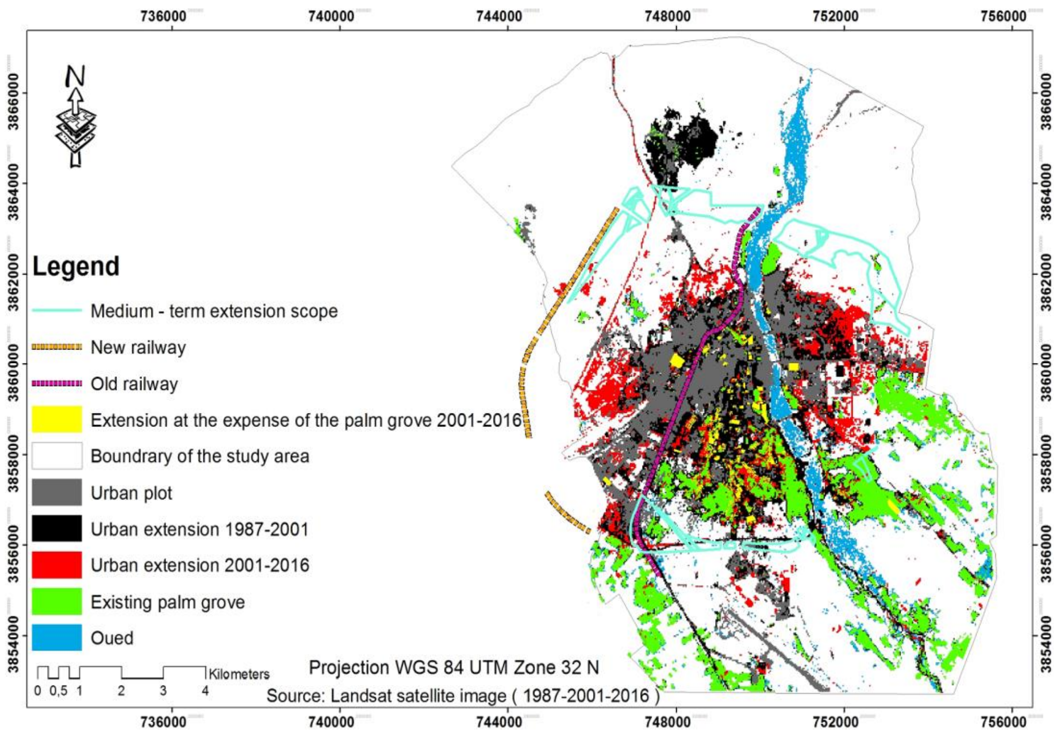

Figure 7. Diachronic evolution of the municipality of Biskra (1987-2001-2016)
(Source: Saker Adel)

Based on a comparison between 2016 and mid-term 2021 short-term extension areas of the P.D.A.U with the 2016 SVM results, it was found that:

- in view of the deficits recorded on the P.D.A.U, it is more than necessary to adopt a geomatics approach as a complementary mechanism for digitizing the urban plan;
- the actual five-year extension areas (2011-2016) exceeded the medium term. Therefore the extension areas proposed by the P.D.A.U are insufficient by contribution to high investment rates;
- projected railway (in progress). The problem has not been solved between the period of study and realization;
- extension at the expense of the palm groves (figure 7).

CONCLUSION

The use of remote sensing techniques has allowed us to evaluate many abuses that prove the futility of the rehabilitation approach in the region, which can be summarized as follows:

- to manage the territory, the P.D.A.U must be updated each year through geomatics approaches;
- it is necessary to direct the expansion towards the inside of the city through renovation actions in order to reduce the expansion outside the city;
- shifting housing projects towards neighboring municipalities.

In order to implement an urban planning strategy, new digital tools are necessary for evaluation and monitoring.

Urban planning is mainly determined by the division of land into zones which, with different degrees of concretion, are assigned to a certain purpose. As a result of this planning, each point of the territory belongs to a particular category, to a particular use of the land.

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DEMOGRAPHIC CHANGES IN THE URBAN SPACE OF APUSENI MOUNTAINS

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Abstract: The study aims to analyze demographic changes in the urban space of the Apuseni Mountains in the post-communist period (1992-2011). In order to observe the demographic changes, demographic evolution, natural dynamics and migratory dynamics were analyzed. Statistical data has been obtained from the website of the National Institute of Statistics. Numeric data has been processed resulting in a series of tables and graphs have been generated in parallel. It was found that during the studied period there were changes in the values of all the analyzed indicators. The most significant changes were mortality and immigration, whose values were increase. Higher mortality and immigration rates set negative demographic changes. The urban area of the Apuseni Mountains is confronted with demographic risk phenomena such as depopulation.

Key words: Apuseni Mountains, demographic changes, urban space, demographic risk phenomena, post-communist period

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INTRODUCTION

This study aimed at analyzing demographic changes at the level of urban space in the Apuseni Mountains. The urban area in Apuseni has undergone ascending and descending changes in terms of demographic evolution, the natural and migratory dynamics of the population. Urban Apuseni Mountains consists of 13 cities, all of them small (less than 25,000 inhabitants). Four cities are from Alba County (Zlatna, Abrud, Baia de Arieş, Câmpeni), five from Bihor County (Vașcău, Nucet, Ştei, Beiuş, Aleşd), two from Hunedoara County (Brad, Geoagiu), one from Arad County (Sebiș) and one from Cluj County (Huedin) (figure 1).

The geographic specificity of the analyzed territory is that it belongs to a mountainous area of old human habitation, which has a large spatial dispersion of the habitats, which is associated with the poor connectivity of the localities and with a low degree of development of the infrastructure.

On this background of conditional manifestation of regional development processes there was a oscillating demographic dynamics, marked by population growth phenomena in urban centers (at certain time intervals) or a long-term regress, with major implications on maintaining the balance of the entire regional system of the Apuseni Mountains.

In any system, the territorial population is the structural-functional component that best reflects the state of equilibrium they are in. Several geographic studies that have been carried out so far integrate the Apuseni Mountains either partially or totally in the category of systems affected by ”functional ruptures” (Ianoş, 2004, p. 67) or as a ”disadvantaged area” (Cândea et al., 2006, p. 93), or regions with demographic risk phenomena (Surd et al., 2007), or ”peripheral regions” (Dragan, 2011, p. 5) or ”critical regions” (Mureşan, 2016, p. 171).

The geographic area analyzed, although it is the most accessible mountainous unit on the territory of Romania, is currently characterized by a weakly popular, the settlements are small and have a low degree of urban coverage (Surd et al., 2017). The analysis aimed at highlighting geographic changes with negative impact on current living, transposed into a diachronically correlative context based on the demographic data and economic, social-political and historical information processing.

Beginning with the 21st century, numerous studies have been carried out on settlements in the Apuseni Mountains, studies covering both rural and urban areas, analyzed under different geographic or geographic related branches. Subjects that formed doctoral theses were made (Buţiu, 2004; Constantin, 2011; Drăgan, 2011). Also, a study completed by a doctoral thesis was conducted on the research of the only country-type mental space entirely located in the Apuseni Mountains (Boţan, 2010). Specialized literature has also been enriched with other reference books on the Apuseni Mountains (Petrea, 2004; Surd et al., 2007; Surd et al., 2017).

Population, demographic dynamics was the target of study for researchers around the world (Josipovic and Repolusk, 2003; Malmberg and Tegenu, 2007; Finney and Simpson, 2009; Prioux and Mazuy, 2009; Sturtevant, 2013; Stupariu et al., 2018).

METHODOLOGY

The analytical approach pursued as the first stage the administrative delimitation of the investigated mountain area. The literature highlights the existence of several opinions regarding the fixing of the Apuseni Mountains limit based on the regional decoupling resulting from the association of the administrative-territorial units integrated into this morphostructural subunit. In direct correlation with the specificity of the research in this paper, we adopted the spatial delimitation developed by Dragan (2011) in a comprehensive study on the resilience of the Apuseni Mountains regional system. A first stage was the administrative delimitation of the Apuseni Mountains (Drăgan, 2011). For delimitation, the Arc GIS 10.1 program was finally used and the map was made. In the continuation of the delimitation, the 13 cities that make up the urban space of the Apuseni Mountains were identified. The second stage consisted in obtaining statistical data on the website of the National Institute of Statistics. After obtaining the data, they were processed resulting in a series of tables and graphs on demographic change in urban space. Subsequently, based on the analysis of the data set on urban demographic demographics in this regional system, several chrono-spatial interpretations of the socio-economic and structural-functional correlation phenomena based on the identification of the main directions of propagation of the demographic flows in territory.

DEMOGRAPHIC EVOLUTION OF THE POPULATION

Most of the localities have been declared cities since the 20th century, especially the second half of the century. In order to highlight the demographic evolution, previous data were used to declare the status of the city. The urban population in the Apuseni Mountains has been on the rise. In 1880, in the 13 cities today, 51,423 people lived. In 1880 the largest settlement was Zlatna with 7,864 inhabitants, Geoagiu with 7,480 inhabitants, respectively Abrud with 7,462. The smallest settlements were Nucet with 807 inhabitants and Ştei with 377. These two were the only ones who registered in 1880, a population under 1000 inhabitants. After World War II, in 1966 the population was 91 289 inhabitants. Demographics grew much in the post-war period. In 1966, Brad was the largest settlement with a population of 15,532 (figure 1).

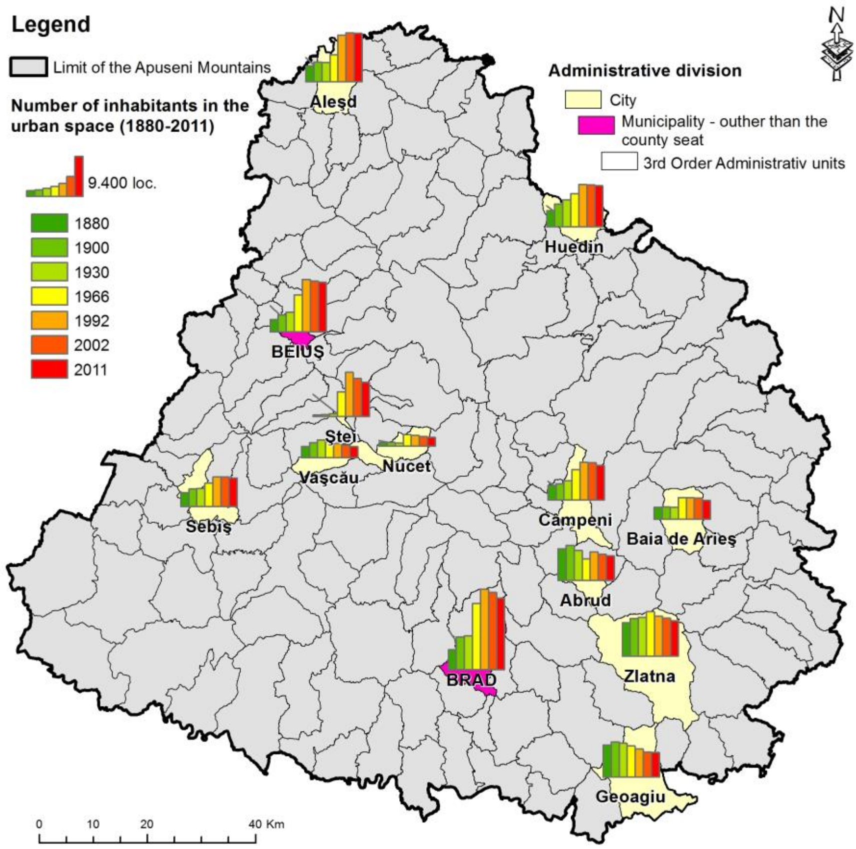

Figure 1. The numerical evolution of the population in the urban space of the Apuseni Mountains

Since 1880 the population has grown 3.3 times and would remain the largest urban settlement of the Apuseni Mountains. From 1992 all cities have had population losses, except in some cases where from 1992 to 2002 the population grew and then dropped. This is the case of Aleșd and Sebiș (table 1, figure 2).

Aleșd's industry has persisted and adapted to the new economic conditions. Among the main industrial branches in Aleșd are those of construction materials, especially cement production. The city has a high potential for development because of its geographical location. It is located less than 50 km away from Oradea and is crossed by important communication routes. Another strong point of Aleșd is the short distance to the exit point of the country. The European road E60 helps to transport road products. The railway transport is ensured by the railway network Cluj-Napoca - Oradea. Also, at the beginning of the 21st century, thermal water resources were discovered in the city's perimeter. Their exploitation was not delayed, as a whole base was built with outdoor pools covered and the possibility of carrying out curative programs through qualified staff.

The city of Sebiş has developed economically due to the diversification of the industry with a focus on the light industry and the wood processing industry. Due to the wood processing, Sebiş has become an important furniture exporter. The case of this city is similar to that of Aleșd, both of which benefit from the favorable geographic position. Communication routes are an important factor in the development of a settlement. As the city approaches the national road (DN 79A), and through its center two major county roads (DJ 793 and DJ 792B). The network of transport routes is complemented by the railway routes, passing through the city through one of the oldest railways in Romania built at the end of the 19th century.

Table 1. Number of inhabitans in the urban space of Apuseni Mountains
(Data source: data processed after the NIS and http://www.varga.adatbank.transindex.ro/?pg=3&action=etnik&id=1364)

No.	City	Year						
		1880	**1900**	**1930**	**1966**	**1992**	**2002**	**2011**
1.	Zlatna	7864	8892	9104	10453	9391	8976	8347
2.	Abrud	7462	8318	7122	5150	6729	6199	5860
3.	Baia de Arieș	2777	2892	2750	5055	5061	4956	4426
4.	Câmpeni	3469	3826	4535	7170	8878	8776	8095
5.	Vașcău	2570	3504	4147	3621	3337	2948	2649
6.	Nucet	807	902	779	2768	2531	2243	2135
7.	Ștei	377	417	586	5754	10415	8925	8048
8.	Beiuș	2947	4016	4683	8744	12353	11976	11677
9.	Huedin	3802	5313	6338	7834	9961	9859	9737
10.	Aleșd	3683	4608	4544	6371	10920	11463	11401
11.	Sebiș	3310	4218	4253	5537	6993	7016	6729
12.	Brad	4695	7643	7938	15532	18861	18141	16811
13.	Geoagiu	7480	8238	7953	7300	6527	5813	5775
	TOTAL	**51243**	**62787**	**64732**	**91289**	**111957**	**107291**	**101690**

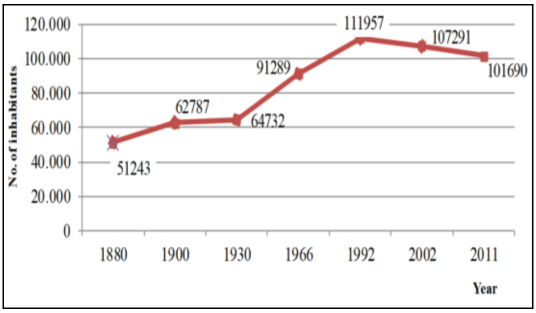

Figure 2. The numerical evolution of the population in the urban space of the Apuseni Mountains
(Source: data processed after the NIS)

The socialist period led to an increase in the population in most of the Apuseni Mountains. In smaller towns where the mining industry was the main one, the population grew heavily (Nucet, Ştei, Brad, Baia de Arieş). The communist industry favored the prosperity of the urban space of the Apuseni Mountains.

CHANGES IN THE NATURAL DYNAMICS OF THE URBAN POPULATION OF THE APUSENI MOUNTAINS

Birth rates have been constantly changing between 1992 and 2011. The highest birth rate in 1992 was in Câmpeni town of 14.1 ‰, followed by Aleşd with 13.8 ‰, respectively two rates of 12.2 ‰ registered in the towns of Abrud and Nucet. In 1992, seven cities out of the 13 had a birth rate of more than 10 ‰. At the 2002 census, there were significant changes in birth rates. There have been large decreases in values, only two of the 13 having a rate of more than 10 ‰. The two administrative units were Huedin with 10.9 ‰ and Aleşd with 12.6 ‰. Câmpeni would have the largest decrease in the birth rate between 1992 and 2002. The significant decline was due to the restructuring that followed the 1989 Revolution, the lack of jobs that led to the migration of the young population. The changes continued after 2002, with the lowest birth rate in 1992-2011 being recorded in the 2011 census. The lowest value was 4.5 ‰ in Baia de Arieş, compared to 1992, the rate declining 2.6 times. Of the natural demographic malfunctions facing most of the Apuseni Mountains we can recall the demographic phenomenon of risk, demographic aging and the migration of the young population. These phenomena have rapidly expanded into the countryside of the Apuseni, but they also gradually include urban space. If at the end of the 20th century the population migrated from the rural area to the urban environment, starting with the 21st century, the population migrated abroad (table 2).

Table 2. Birth rates for each city in the Apuseni Mountains
(Data source: data processed after the NIS)

No.	City	Year		
		1992	2002	2011
1.	Zlatna	11.7	6.1	7.3
2.	Abrud	12.2	7.4	5.3
3.	Baia de Arieș	12.1	7.1	4.5
4.	Câmpeni	14.1	6.8	6.4
5.	Vașcău	7.2	6.4	6.4
6.	Nucet	12.2	7.6	7.5
7.	Ștei	8.6	7.4	8.0
8.	Beiuș	8.1	7.4	8.9
9.	Huedin	11.4	10.9	12.4
10.	Aleșd	13.8	12.6	11.0
11.	Sebiș	9.3	6.6	6.5
12.	Brad	9.4	5.5	4.9
13.	Geoagiu	7.8	9.1	7.3

The number of born children in the 13 cities has been steadily decreasing since 1989. The maximum was registered in 1992, and then gradually dropped. At the 2002 census, the number of births has barely exceeded 800, and in the 2011 census, their number has fallen below the threshold of 800. In the urban area of the Apuseni Mountains, the number of your births is decreasing (figure 3).

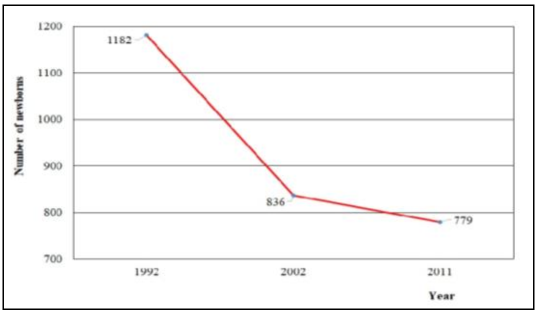

Figure 3. The numerical evolution of newborns in the urban space of the Apuseni Mountains
(Source: data processed after the NIS)

Mortality rates have been in a more rapid change since 1992. Evolution of mortality rates between 1992-2011 was considerably higher than birth rates. In 1992, ten of the 13 cities recorded values higher than 10 ‰. The highest rate of 16.5 ‰ was in Geoagiu, Zlatna with 14.6 ‰ and Vaşcău with 13.5 ‰. In 2011, the highest mortality rate recorded for the whole period of 1992-2011 was in the town of Vaşcău 18.9 ‰. In 2011, only three cities had a rate below 10 ‰, these being Beiuș with 8.3 ‰, Ştei with 8.0 ‰ and Nucet with 7.5 ‰. Geoagiu has been the city with the most worrying mortality rates throughout the entire period. The aging population is more exposed to various diseases, leading to high mortality rates in the urban area of the Apuseni Mountains (table 3).

Table 3. Mortality rates for each city in the Apuseni Mountains
(Data source: data processed after the NIS)

No.	City	Year		
		1992	2002	2011
1.	Zlatna	14.6	13.8	13.3
2.	Abrud	10.1	6.9	11.3
3.	Baia de Arieș	9.5	8.9	11.3
4.	Câmpeni	10.1	9.2	10.3
5.	Vașcău	13.5	15.9	18.9
6.	Nucet	10.7	12.5	7.5
7.	Ștei	6.5	7.7	8.0
8.	Beiuș	10.1	8.7	8.3
9.	Huedin	9.0	9.1	11.3
10.	Aleșd	10.3	11.1	10.4
11.	Sebiș	13.4	12.8	12.2
12.	Brad	10.3	11.5	13.7
13.	Geoagiu	16.5	16.2	14.9

The death rates are noticeably higher than the number of births. The maximum number of deaths was in 1992, the number being down until 2002. The numerical decrease in deaths between 1992 and 2002 did not positively affects the natural dynamics. Since 2002, the number of deaths has started to increase, reaching 1,165 in 2011. By comparing the numerical value of the number of births in 2011 with the numerical value of the deaths, there is a clear natural deficit (figure 4).

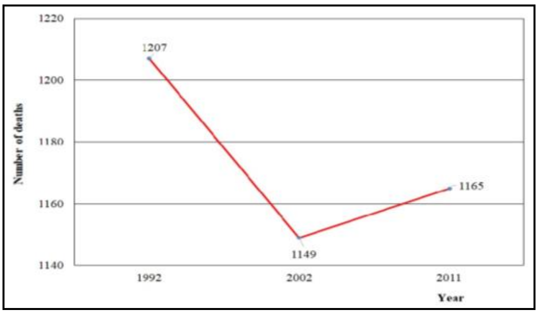

Figure 4. The numerical evolution of deaths in the urban space of the Apuseni Mountains
(Source: data processed after the NIS)

CHANGES IN MIGRATORY DYNAMICS OF THE URBAN POPULATION OF THE APUSENI MOUNTAINS

Among the dysfunctions faced by most cities in the Apuseni Mountains we can mention: the closure of mining activities, especially because there were strictly mono-industrial cities that developed on the basis of the extraction and processing of the underground deposits (Nucet, Vașcău, Ştei). After the closure of the industrial branch, the population faced a lack of jobs, the labor force being forced to move to other places to look for a job. The highest three immigration rates in 1992 were registered in Ştei with 18.1 ‰, Câmpeni with 17.7 ‰ and Nucet with 17.4 ‰. Changes in population migration have continued since the 21st century. In 2002, the highest rate was 20 ‰, being totally of Ştei, and in 2011 it reached 22.2 ‰. Three cities from 2002 to 2011 saw the decrease in the immigration rate, Zlatna, Vașcău and Huedin (table 4).

Table 4. Immigration rates for each city in the Apuseni Mountains
(Data source: data processed after the NIS)

No.	City	Year		
		1992	2002	2011
1.	Zlatna	10.5	10.5	9.5
2.	Abrud	12.0	16.0	19.8
3	Baia de Arieș	14.0	12.1	16.3
4.	Câmpeni	17.7	15.0	19.0
5.	Vașcău	15.9	16.3	13.2
6.	Nucet	17.4	10.3	11.7
7.	Ștei	18.1	20.2	22.2
8.	Beiuș	13.2	13.5	14.1
9.	Huedin	14.8	15.9	13.7
10.	Aleșd	12.5	12.6	13.7
11.	Sebiș	13.4	13.4	19.6
12.	Brad	15.2	13.2	15.8
13.	Geoagiu	15.3	11.5	13.9

Immigration of urban population had a period of decline in the late 20th century, and then increased at the beginning of the 21st century. Worsening economic conditions, redundancies and a small number of jobs forced the population to move. Due to the improvement of the transit conditions in Europe and after Romania's accession to the European Union, the population could travel more easily outside the country. Mortality and immigration are two indicators that lead to negative demographic changes in the urban space of the Apuseni Mountains (figure 5 and 6).

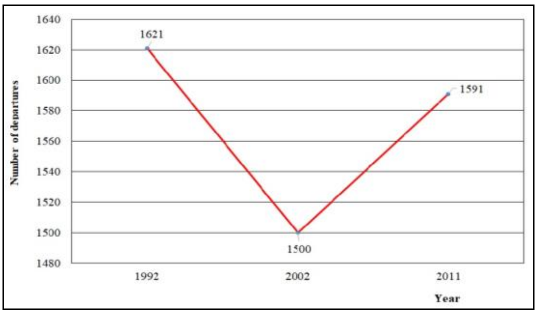

Figure 5. The numerical evolution of the departures from the urban space of the Apuseni Mountains
(Source: data processed after the NIS)

The emigration was much smaller than that of the departure, especially after 2000. In 2002, the highest rate of settlements was in Geoagiu by 21.8 ‰.

If we look at the evolution from 1992 to 2002, we can see that Geoagiu's population is very much identified with their native place. The territorial identity of the Geoagiu population is a unique phenomenon for the urban space of the Apuseni Mountains. Vertical development is poorly represented, with the city having more of a village look.

The development potential is particularly high, as there are important thermal water resources in the vicinity of the settlement. The high therapeutic value of these waters could be an engine for the city's economic development. Also, the long tradition of using thermal water should be exploited to the benefit of local development. In 2011, only three cities had a rate below 10 ‰, such as Zlatna 9.0 ‰, Ştei 8.9 ‰ and the lowest rate of 6.1 ‰ in Baia de Arieş (table 5).

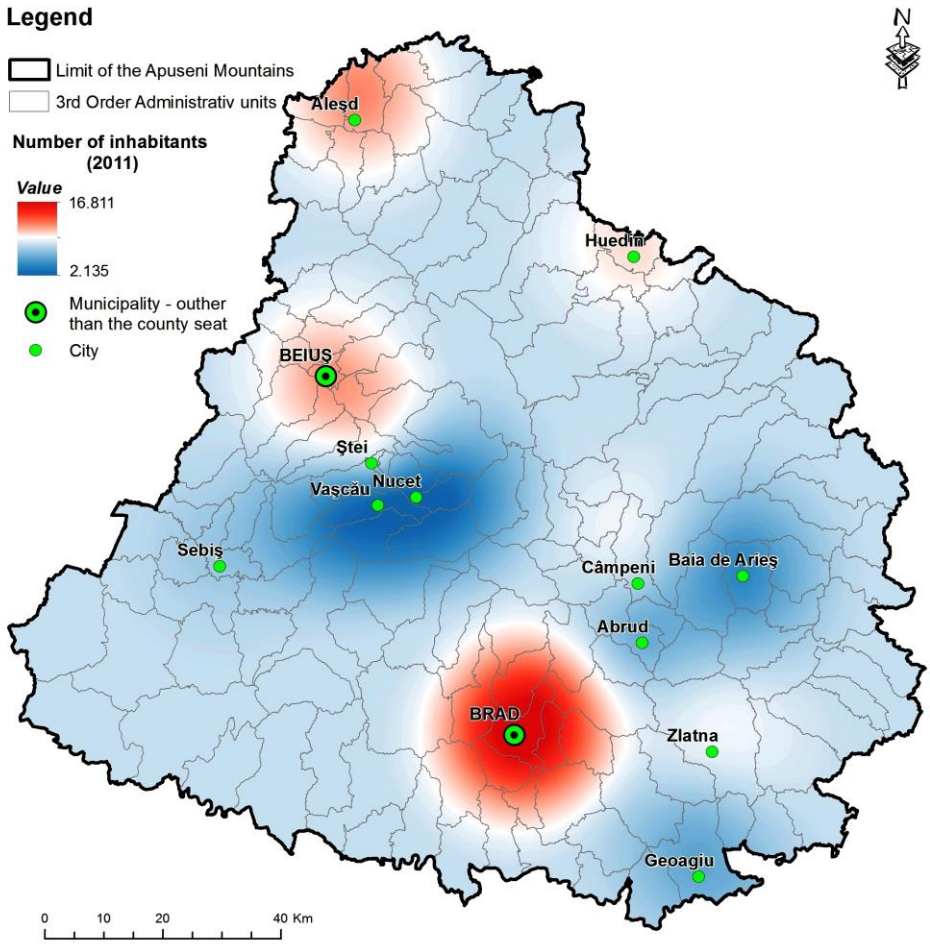

Figure 6. Areas of concentration-dispersion of the urban population in the Apuseni Mountains

Table 5. Emigration rates for each city in the Apuseni Mountains
(Data source: data processed after the NIS)

No.	City	Year		
		1992	**2002**	**2011**
1.	Zlatna	12.8	6.8	9.0
2.	Abrud	22.7	13.4	10.6
3.	Baia de Arieș	27.5	9.5	6.1
4.	Câmpeni	16.0	10.6	12.4
5.	Vașcău	11.7	12.6	11.3
6.	Nucet	15.4	7.6	10.8
7.	Ștei	14.5	9.5	8.9
8.	Beiuș	13.4	15.1	16.2
9.	Huedin	14.5	16.1	14.7
10.	Aleșd	16.8	12.4	11.3
11.	Sebiș	13.3	10.8	14.6
12.	Brad	13.8	12.6	12.2
13.	Geoagiu	26.0	21.8	11.1

The number of establishments in the 13 cities in the post-communist era has been steadily decreasing. The maximum number was 1 800 in 1992, and in 2011 the number of establishments was 1 200. There is a decrease of about 600 establishments. The best evolution of fixations was between 1992 and 2002, with the number being reduced from 2002 to 2011. The poorer living standard was not an attraction for the population (figure 7).

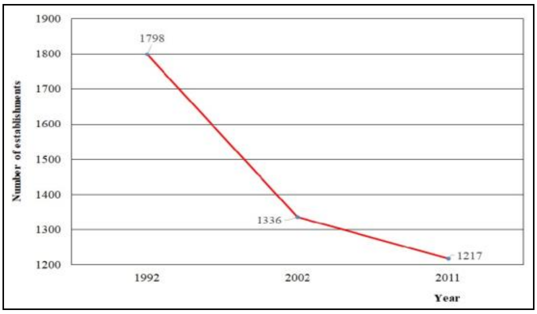

Figure 7. The numerical evolution of establishments in the urban space of the Apuseni Mountains
(Source: data processed after the NIS)

CONCLUSIONS

Demographic changes in the urban space of the Apuseni Mountains began with the communist period, when demographic input was made by moving the rural population to the urban environment. Most of the cities were mining centers where labor was needed. After 1989, industrial activities in most cities began to fall back. After the Revolution of 1989, the demographic changes in the urban space of the Apuseni Mountains began to be significant. The young population had to migrate in search of a job. After them remained the aging population, which with great difficulty could be supported. Demographic changes have led to the emergence of demographic risk phenomena, also present in rural areas. Mortality rates have risen above birth rates and departure values are higher than setting values. Under these conditions, we can talk about the depopulation of the urban space of the Apuseni Mountains.

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HOUSING CONDITION AND HEALTH OF THE AGED IN THE CORE AREA OF IWO, NIGERIA

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Abstract: In the recent period there has been renewed interest by scholars in discerning the seeming relationship between housing quality, environment and the health of the elderly. It is on this premise that this paper attempts an examination of this link in a developing country and secondary city of Iwo in Nigeria. In order to collect relevant data, household questionnaire and observation checklist were used. The household questionnaire contained questions on the socio-economic status of the respondents as well as their housing conditions. Multi-stage sampling strategy was adopted for the purpose of administering questionnaire to randomly selected 275 aged people which was analyzed using descriptive statistics. Findings revealed poor housing condition and an appalling situation where many aged residents were crowded in very limited spaces with many houses lacking adequate ventilation. Some respondents (22.2%) stated that tuberculosis posed a serious health hazard in houses characterized by overcrowding. Similarly, 28.4% respondents believed that houses that were dark, ill-ventilated, damp and dilapidated were dangerous to health of the aged living therein. Poor lighting coupled with steep slope of stairs and slippery floor finish had caused falls and collision with objects among 18.2 respondents. It is, therefore, important for equity purpose and as a vulnerable group that the health of the aged which has been less considered should be given utmost attention in the national housing policy and provision.

Key words: housing condition, elderly, environment health, neighbourhoods, Iwo town

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INTRODUCTION

The growth and complexity of human settlements, particularly the process of urbanization have been phenomenal in Nigeria. The percentage of the population living in urban centres of more than 20,000 inhabitants has been increasing in the country even before the nation's independence. According to the analytical report of the 1991 population census, the total number of Nigerian population living in urban centres in 1921 was 7.18 per cent, by 1952, it had risen to 10.65 per cent by 1962, it was 19.30 per cent and increased to 36.30 per cent in 1991. The national population census of 2006 indicated that the population of Nigerians living in urban centres was 39 per cent. The

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growth of towns and cities in Nigeria is always accompanied with a lot of problems, such as poor quality housing and disintegrating or inadequate infrastructural facilities. The challenges are more pronounced in the core areas of the cities.

The core areas, the longest settled sections of a city, have grown old and shabby with age and as result of poor physical planning structure, deficient maintenance and organic development (Agbola, 2005). These areas are planless, spontaneous in origin and do not conform easily to spatial re-arrangements. The core areas developed from a long, complex process where families and individuals adjust to adverse conditions (often contradictory to planning norms) to co-exist in a precarious equilibrium in an environment generally recognized by everyone as slum (UN-Habitat, 2006). Thus, the core areas of most Nigeria's urban centres have grown haphazardly. This notwithstanding, the population of the core area is increasing because it is the preferred accommodation choice for the urban poor and migrants from the rural areas. With the increasing population, the manifesting challenges in the area include increasing poverty, inadequate utilities and services, poor housing and environmental degradation. At the micro level, socio-economic and cultural causation of disease shows clearly that health is closely related with household income, nutrition, education, personal hygiene as well as housing and its ancillary facilities such as portable water, waste disposal and recreational facilities.

Accessible and well-designed homes and neighbourhoods enhance health and wellbeing (Department for Communities and Local Government, 2011). Good housing conditions create foundation for healthy social economic and political relationship, while substandard housing can have serious repercussions on individual and communal health (NEST, 1991). Inadequate housing causes or contributes to many preventable diseases and injuries, including respiratory, nervous system and cardiovascular diseases and cancer (World Health Organisation, 2012). A significant number of analysts (UNCHS, 1996; WHO 2001; Arimah 1993; Achor, 1998, 2001; Oladepo, 1993; Zhau-Yi et al., 1989; Egunjobi, 1997) have attempted to establish positive correlation between housing condition and human health but most of them have either lumped all groups together or have singled out children and women as the focus of their analyses.

Housing and health link becomes increasingly important with age. This is particularly true for groups who tend to spend more time in the home, especially older people (Centre for Ageing Research and Development in Ireland, 2013); they are at risk of falls and more susceptible to cold or damp related health problems (The Housing and Ageing Alliance, 2013). Housing and health, especially relating to poor housing and the elderly in the developing countries has been under-investigated. There is dearth of information on socio-economic and environmental factors affecting the health and wellbeing of the elderly in sub-Sahara Africa (Arimah, 1993). Against this backdrop, this paper attempts to examine the relationships between housing condition and the health of the elderly in Iwo, a secondary city in Nigeria. Definition of the elderly relates to those above 60 years because 60 years is the age of retirement in most societies. This can be further broken down into the young old (60-74) and the old-old (75years +) (Arimah, l993).

The paper is presented in six sections. Following the introduction is the conceptual anchor and related literature. The third section gives an overview of the study area, the fourth sections discusses the methodology employed in the study. Section five examines housing conditions of the aged and its implications on health. The last section concludes with policy recommendations.

CONCEPTUAL ANCHOR AND RELATED LITERATURE

A series of urban land-use theories and other related theories could be used to describe and explain the characteristics of urban housing and how they influence human health. However, for the purpose of this study, emphasis is laid on the concentric zone theory and concept of environmental health.

Concentric Zone Theory

The theory provides neutral statements about residential pattern, however, it was derived from a set of highly controversial postulates about the nature of human society., The theory was originally formulated by Park (1926). Based on Park's analysis, Burgess (1926) using Park's analysis used the theory to explain residential structure with a reference to biotic processes. According to him, humanity is part of the natural world and, as such, subject to instinctive drives, including the drive to acquire living space. The instinctive drives of human could be liken to what is obtainable in the natural world where plants compete with one another for soil and light, animals for territory, so in the city human species (different social classes, races, ethnic groups and other interest groups) compete for residential space. Saunders (1984), consistent with Darwinian principles, observes that the best locations are commandeered by the 'fittest' species. Within the human settlement, the most accessible central locations are owned by big business, while the spacious new residential land on the perimeter are owned by the owners and top functionaries of big business. 'Lesser' species such as the poor and the aged must adapt to the less favourable environments. The Chicago School saw spatial distribution of housing of various qualities as an outcome of 'ecological' competition for niches between social classes who behaved like different species in terms of their endowments and wants, and who would compete for different locations, with the strongest groups taking the most desirable positions and the weaker groups occupying residual spaces (UN-HABITAT, 2003). In essence, if ecology (a physical science term) is accepted as the study of the adaptation of plant and animal organisms to their environment, then 'cities becomes ordered into "residential areas", through processes of competition, invasion and succession - all of which occur in biological ecology (Giddens, 1989).

According to Burgess (1926), using Chicago as a case study, the city is arranged as a series of concentric housing zones around a central node, itself dominated by commercial and industrial activities, with residential land use occupying the outer zones. The core, otherwise known as the "loop" district is made up of different activities which include shopping areas, hotels, office buildings, banking houses and theatre district (Cater and Jones, 1989). Apart from the "loop" containing the central business district (CBD), Burgess identifies four other concentric housing zones: zone in transition, zone of workingmen's home, middle and high income residential zones and commuters' zone. Residential space is internally differentiated, with social status rising with distance from the city centre (Carter and Jones, 1989).

The zone in transition contains poor and old residential property and run-down areas that have been invaded by business and light manufacturing as the CBD expands (Romanos, 1976). It is referred to as a zone of deterioration or twilight (Fouberg et al., 2010) . In the opinion of Harvey (1976), this twilight zone is, in a sense, the residual zone, the dumping ground of the city, wherein live a high proportion of those who have not the qualifications for acceptance in any purified community (such as..., the urban poor, the aged,...). They are, in effect, the impure and lack political muscles required order to achieve anything in the city politics and power relations. The concentric zone theory of Ernest Burgess implies a high degree of locational freedom on the part of the non-poor, they can move anywhere, while the urban poor, including the aged are limited in respect of residential choices. If there is a decline of population, the outer housing zones tend to remain stationary while the transitional zone recedes into the loop thereby creating residential slums (Romano, 1976) in which most of the aged in Nigeria live.

Following the zone in transition is the zone of workingmen's home, which Fouberg et al (2010) prefers to generalize as a zone of housing of an older type. Earlier generations of working men's housing were slowly being taken over by warehouses, immigrants and the urban poor, as better off households move to the suburbs (UN-Habitat, 2003). Homes in this zone are partly occupied by residents who have lived in the same dwelling units all their lives, majority were born there. These homes have the double advantages of low rents and ease of commuting to work (Romanos, 1976).

Middle class housing, with spacious, usually single family dwelling, intermingled with some exclusive residences and high-class apartment buildings in which the middle as well as high social groups live, characterizes the next concentric housing zone. It encompasses the areas beyond the continuous built-up area of towns and cities and sometimes open countryside which contains large detached houses and villages performingdormitory function. Finally, the commuters' zone is one of residential suburbs and satellite development within commuting distance to the central city. While the theory provides some descriptive basis for residential location, it neglects the fact that zonality is distorted by topography (Splanski, 1966; Mann, 1965), by state interference in the housing market (Robson, 1969), by non-monetary motives (Firey, 1945), and so on.

The core area of Iwo, like most cities in Nigeria, encompasses the CBD, transition zone and zone of workingmen's home. These areas are made up of traditional areas with little or no consideration for urban planning (Splanski, 1966). Majority of the houses in the core areas can be described as submerged residential buildings rather than adequate housing units, Housing entails not only shelter but a bundle of systems and sub-systems that comprises sites, structure and sets of facilities such as water, electricity, drainages, and waste disposal and failure to provide these facilities could result to obsolescence and has environmental health implication (WHO, 1961; Agbola, 2005).

Concept of Environmental Health

Environment is the sum total of all conditions and objects that surround human. It is the most precious asset that humans own, share and use together for mutual benefits and enhanced welfare of the society at large. What this implies is that the characteristics of the environment where people live or work have a number of potential effects on their health. Some of the prerequisites of minimum standard of living include: provision of ventilation, hygienic environment, low rate of occupancy and habitable living (Kasim and Agbola, 2014). The conditions of housing determine the health status of residents. Aregbeyen (1993) asserted that a properly planned house is characterized by good network of road, drainage and refuse disposal system, regular water and electricity supply, recreational grounds among many others.

Housing encompasses services that make it functional; and the residential environment plays important role in determining individual well-being (Okafor, 2013). It is from this premise that the World Health Organisation (WHO) reckons that it is the home, not the clinic that is the key to a better health delivery system. However, as noted by Nwaka (2005), only about 25 to 30 per cent inhabitants mainly top government officials and other rich and privileged people in the developing countries cities enjoy a decent housing. The vast majority of households especially those in informal settlements live in overcrowded conditions within defective physical dwellings. Most often than not, the dwelling units are located in areas which did not provide defences against diseases, natural and human-induced disasters. Over the years, there have been renewed interest and increasing concern by national and international bodies over the environmental health of major cities of the developing nations. The term, "environmental health'' is not easy to define. According to World Health Organization (2001), environmental health encompasses those elements of human health that is influenced by physical, chemical, biological, social and psychological factors in the environment. It is also define as those aspects of the human body, human health and diseases that are determined by factors in the environment. Housing quality is an indicator of healthy environmental conditions. This implies that poor housing conditions can have a lot of effects on environment. Poor neighbourhood conditions can be defined as having abandoned buildings, vacant lots, no access to quality schools, and high levels of poverty. According to WHO (1961) definition, health is a state of complete physical, mental and social well-being and not a merely absence of disease or infirmity. This definition of health implies that health is guaranteed only when certain basic needs are met: these include housing, water and a pollution free environment (Egunjobi, 1993).

Environmental health is a branch of public health that is concerned with all aspects of the natural and built environment that may affect human health. The problem of health in housing can be attributed to environmental factor such as unhygienic area, high rate of urbanization in a particular area with lesser facilities to support the increasing population, and damp and mould due to overcrowded dwelling (Okafor, 2013; Kasim and Agbola, 2014). According to Agbola et al., (2007), housing and health problems in the developing countries are diverse and multi-dimensional and are particularly acute in the urban centres due to pressure of urbanization. For example, Xu et al., (1989) indicates that after controlling for smoking, the prevalence of lung cancer was associated with smoky outdoor environment and increased in proportion to the years of sleeping on beds heated with coal stoves and associated poor indoor air quality. The leading causes of death among the elderly as investigated by Yu (1986) are heart disease, cancer, cardiovascular disease, accidents, chronic obstructive pulmonary disease, pneumonia and influenza, diabetes mellitus as well as chronic liver and cirrbrosis disease.

There is a causal link between housing and the main long term conditions, for example, heart disease, stroke, respiratory, arthritis while risk of falls, a major cause of injury and hospital admission amongst older people, is significantly affected by housing characteristics and the wider built environment (The Housing and Ageing Alliance, 2013). The risk is further increased where household wastes are burnt in the open and dwellings constructed close together (Goldstein, 1990). The amount of ventilation in the house is actually indicated by the building materials and levels of crowdiness and personal hygiene in the home (Iyun, 1993).

Some of the disease vectors that are present in submerged houses can also influence the health of the elderly. The diseases associated with poor housing quality that are major causes of ill-health and their vectors among the aged include:malaria (Anopheles mosquitoes) and diarrhoea diseases (cockroaches, blowflies and houseflies). There are many other diseases caused or carried by insects, spiders or mites, including bancroftianfilariasis (culexmosquitoes), changas disease (triatomine bug), dengue fever (Aedes mosquitoes), hepatitis A (houseflies, cockroaches), leishmaniasis (sandfly), plague (certain fleas), releasing fever (body lice and soft ticks), scabies (scabies mites), trachoma (face flies) typhus (body lice and fleas) yaws (face flies), and yellow fever (Aedes mosquitoes) (Schofield et al., 1990). Many of the chronic health conditions experienced by older people have a causal link to, or are exacerbated by poor housing (The Housing and Ageing Alliance, 2013). General improvement in housing condition by preventing cracks in walls, ceilings and floors and ensuring adequate ventilation and lighting as well as construction of screens and nets will restrict hiding places of and disease vectors access to human beings (Egunjobi, 1997).

THE STUDY AREA

The people of Iwo migrated from Ile-Ife, (specifically from Obaloran compound) in the 14th century. The earliest settlement was initiated by Adekola Telu, a prince from Ile-Ife and the son of the 16th Ooni of Ife, a female called Luwo Gbagida. Before the end of the 19th century, the town had grown to become one of the major towns in Yoruba land. The 1921 census recorded a population of 53,588 for the town, in 1931, its population rose to 57,291, 1952 (100,006), 1963 (101,482), 1991 (105,401) and 2006 (191,348).

The centre of the town lies on Latitude 07.63413^0 N and Longitude 004.18069^{0}E. The core of the town is approximately one kilometre radius from the city centre. As a result of the abundant agrarian land, a large percentage of the residents engage in subsistence farming. The town can be said to have a weak industrial base but there is a fair network of roads linking the various neighbourhoods within the city. The total length of roads identified in the city is 22.3 kilometres. Out of this, 13.4 kilometres (60.1%) are tarred, 6.9 kilometres untared (30.9%) while the remaining 2 kilometres (9.0%) are partially tarred or are at various stages of completion. Majority of the roads (71%) have drainage channels. The total length of the drainage channels is 20.8 kilometres. The town is directly linked to the national grid through 33KV transmission line from Osogbo. The supply of electricity is relatively regular.

Residential land use is the predominant land use and it accounted for 70.7 per cent of the total land area. Most of the residential buildings are overcrowded and characterized with brown roofs (rusting roofing sheet) and ageing mud walls. There is no physical development plan for the core areas of Iwo Township. Hence, these areas have grown organically without consciousness of neighbourhood orderliness. Ancient mud walled dwelling units predominate the core area of the town. However, while some of the buildings have been plastered (and painted), some are giving way to modern buildings. The states of most dwellings are unimaginably appalling. The Brazilian type of “face-me-I-face-you” is still the predominant house type in the area. The houses are characterized by absence or poor maintenance of basic public utilities and infrastructure such as water, sewage systems and waste disposal. For example, access to piped borne water is highly limited as virtually all the public taps remain dry for most parts of the year. Also, the rate of borehole failure, most especially those constructed by the government is very high. Out of the 27 boreholes that are sited in the area, 16 are not functioning when the study was carried out. All these have negative effects on human health.

METHODOLOGY

The data for this study were obtained from primary and secondary sources and they are both quantitative and qualitative. The secondary sources of data for this study include extensive review of the literature and relevant previous censuses documented by the National Population Commission (NPC). The satellite imagery of the town obtained from the State Ministry of Lands, Physical Planning and Urban Development was used to delineate the study area. This study is restricted to 1 km radius from the Oluwo’s palace which is taken as the centre of the town.

In order to collect relevant primary data, household questionnaire and observation checklist were used. The household questionnaire contains questions on the socio-economic status of the respondents as well as housing condition. The observational checklist which was administered along with the household questionnaire contains information on structural, neighbourhood and locational characteristics of housing. For validating the field survey instruments, face validity method was used.

A multi-stage sampling strategy was adopted for the purpose of administering the household questionnaire to randomly selected 275 aged people. Data analysis involves iterative process of preparing descriptive statistics.

FINDINGS AND DISCUSSION

Socio-Economic Characteristics of Respondents

A cursory look at the age distribution of the respondents indicates that the modal class of the respondents was the age group 65 and above years with 66.5 per cent. Not less than 22.5 per cent of the respondents fell below the modal class while 11.0 per cent respondent was under the age of 65. Findings revealed that 45.8 per cent of the respondents were male while the remaining 54.2 per cent were female.

Islam is the most predominant religion in the study area, 83.6% respondents were adherent of Islam. About 14.0 per cent were Christians, only 2.6 per cent respondents are practicing traditional religion. Information on the marital status of the respondents shows that 72.0 per cent were married, while 28.0 per cent were widows/widowers. Extended family is the most important type of family structure within the core areas of Iwo. Investigation revealed that household size ranges between 6 and 18. The educational status of the sampled respondents was low. Only 10.2 respondents attended secondary and tertiary educational institutions. Majority of the respondents (49.8%) were without any formal education. Another 18.2 per cent attained primary, 21.8 per cent had Arabic education. The dominant occupations of residents were trading accounting for 42.3 per cent of the occupation of the respondents. Farming, security, and traditional medicine (28.4%), craftsmanship and private sector employment such as mechanics, panel beating, vulcanizing, bread baking and bricklaying, accounting for 23.3 per cent of the occupations of respondents. The remaining 6.0 per cent were retirees.

The annual income distribution of the respondents shows that about 56.4 per cent of the respondents earned less than N18, 000.00 per month. This category of people relied on their children and extended family members in order to meet basic needs, including housing needs. Relative higher incomes were recorded with 20.0 per cent earning between N18, 001 and N36, 000, 00. The remaining 23.6 per cent earned above N36, 000.00. If converted to the US dollar at the official exchange rate of about N305 to US $1.0, it implies that 76.4 per cent respondents earned about US $2 or less per day.

Housing Condition and Health of Aged

In the context of this study housing is described as residential environment which includes: the physical structure that human uses for shelter, all necessary services, facilities, equipment and devices needed or designed for the physical and mental health and social wellbeing of the household. In other words, adequate or suitable housing encompasses all the ancillary and community facilities which are necessary for human health and well-being. In this section, the various housing characteristics which contribute to poor environmental health include inadequate provision for water and sanitation; high level of indoor pollution, and overcrowding which increases the transmission of air borne infections and increase the risk of accidents.

Types of accommodations available in the studied neighbourhoods are face-to-face, flat, storey building and traditional compound. A significant proportion of dwelling units surveyed were Brazillian face-me-i-face-you (88.0%), traditional compound (1.8%) and storey residential buildings (10.2%). The number of floors in the storey buildings range from one to three. The modal class of the number of rooms per residential building is 6 - 8 representing 90.9% of the buildings sampled.

The study further examined the ownership of the accommodation from the respondents and the result showed that 78.2 per cent occupiers were owners of the dwelling, 14.5% rented the dwelling while 7.3 per cent were free occupants, with no rental payment. Rents paid by tenants range between N500 and N3,000 per month. Most of the houses (73.1%) were constructed more than 50 years ago.

About 80.0 per cent of the buildings consists of 1-6 occupants, followed by 11.6 per cent buildings that contained 6-12 occupants, 5.1 per cent and 3.3 per cent buildings housed 13-18 and more than 18 occupants, respectively. The modal class of the number of rooms per building was 5-8 with 185 (67.3%) residential buildings. This was followed by 9-12 rooms' class with 14.5 per cent buildings. Another 10.2 per cent building contains between 13 and 16 rooms, 17-20 room (6.5%) and only 1.5 per cent buildings had more than 20 rooms. This frequency of varied habitable rooms/house might be due to the different types of houses constructed.

Findings revealed that 62.2 per cent respondents of the sampled households shared dwelling units with 1-6 other households, 19.6 per cent shared dwelling with 7-8 other households while 8.4 per cent households shared dwellings with 9-10 other households. The remaining 9.8 per cent households shared dwelling with more than 10 households.

The epidemiology of certain diseases such as tuberculosis and chicken pox often are significantly influenced by housing conditions and rates of room occupancy in the transmission cycle of these diseases. Respondents (22.2%) stated that tuberculosis poses a serious health hazard in houses characterized by overcrowding. Similarly, the prevalence of mental illness was found to the substantially higher among the elderly residing in poor neighbourhoods within the core areas.

The windows of most houses (75.3%) were made of wood and this has many implications on ventilation and air circulation, especially when the windows are shut at night. This indicates that buildings have little or no resistance to inflow of cold air in the night, during the rain, and of heat during the hot seasons. Building materials such as asbestos, mostly used for ceiling construction in the core area and other inorganic compounds (e.g. formaldehyde and chloroform) found in building materials, wood preservatives and other solvents have greater effect on the health of the elderly, especially where ventilation in rooms is poor. Seventy-eight respondents (28.4%) believed that houses that were dark or ill-ventilated or damp or dilapidated were dangerous or prejudicial to health of the aged living therein. Another 25.1 per cent respondents argued that home accidents are peculiar features of houses that were characterized by overcrowding and poor lighting. Poor lighting coupled with steep slope of stairs, uneven floor and slippery floor finish had caused falls and collision with objects among 18.2 respondents. The falls and collision were fatal for about 12.0 per cent of respondents owing to poor eyesight, one of the major characteristics of old age.

Findings showed that 53.8 per cent residential buildings used mud/mud bricks for their external walls. Structural conditions of the buildings also showed that only 25.5 per cent houses were physically sound. While 51.6 per cent needed minor repairs, 22.9 per cent required major repairs. Condition of wall shows that 58.2 per cent were cracked and another 13.1% was dilapidated.

About 10 per cent of the respondents observed that near collapsed structures or dilapidated buildings put residents under perpetually threat of building collapse and homelessness. Displaced individuals from collapsed buildings suffered untold hardships as they were often homeless. Potential homeless aged are likely to experience psychiatric symptoms such as anxiety, depressions and change in character and lifestyles. They were vulnerable to high blood pressure, stroke and other stress related ill health, as noted by 7.2 per cent of the respondents. Psychological ills such as mental irritations, depression and anxiety are conditions that flourish in among the occupants of dilapidated houses. The social factors associated with poor housing condition of the aged, such as low socio-economic status and relative inequality play important roles in the causation of‛ non-communicable diseases like hypertension and peptic ulcer.

The houses in which most of the aged live are substandard (74.5%) and aesthetically displeasing (68.0%). They are characterized by open cracks/holes on walls (58.2%), ceilings and floors (52.4%); poor lighting and ventilation (56.0%); dusty floor (62.2%); and broken plaster and peeling paints (22.2%). Most houses (55.3%) lack screens or wire netting at the windows and doors to keep out insects, especially mosquitoes. In addition to the use of poor and non-durable building materials, 58.2 per cent dwelling units show signs of poor workmanship and poor standard of construction.

The survey unveiled that 85.5% of the sampled households used corrugated iron sheets to roof their houses, 3.6% of them used asbestos, while 10.9% used aluminum. The percentage of the residential lots that majority of the houses (68.3%) occupy was more than 80.0 per cent against the maximum of 50.0 per cent stipulated by town planning regulation in Nigeria. In terms of air space, the distance between 79.3 per cent of the houses selected is less than the required three metres. The rules pertaining to setback requirements were also violated by 72.0 per cent of the respondents. Majority of the respondents (68.4%) accessed their houses through footpath alone. The major reason responsible for this is haphazard development (88.1%).

Most of the residential buildings (64.0%) used outdoor toilets. Only 36.0 per cent of the buildings sampled had indoor toilets. With reference to bathrooms, only 34.2 per cent houses have indoor bathrooms while the remaining 65.8 per cent depend on outdoor bathrooms. Furthermore, 45.1 per cent of the sampled houses had indoor kitchens, while 54.9 per cent used detached and or outdoor kitchens. Modern cooking technologies use clean energy sources such as gas and electricity. However, most of the buildings sampled (78.6%) were using fuel wood and charcoal for household cooking. This has implications on indoor and outdoor air pollution.

According to 55.3 per cent of the respondents, respiratory infections among the aged could be linked to poor indoor air pollution emanating from the usage of environmental unfriendly fossil fuels (fuel wood, charcoal and kerosene in and inefficient stoves) for cooking in poorly ventilated rooms, corridors, verandas and kitchens. High levels of air pollution in such houses had been linked to a high incidence of bronchitis and asthma by 48.0 per cent of the respondents. Increase in respiratory disease symptoms was linked to indoor air pollution from open coal fires by 32.0 per cent respondents.

The main source of water was well which accounted for 78.9 per cent of the sampled households. Other sources of water were borehole, bottled/sachet water and pipe borne water together representing 21.1 per cent of water sources. Household members responsible for fetching water were mostly children as well as adult and aged females. Water treatment was not a widespread practice but some residents (24.4) used alum, chlorine and other water purifiers. Adequate supply of domestic water is not only an insurance against water-borne diseases but it is also essential for the maintenance of healthy hygiene habits in the house.

According to 55.3 per cent respondents, poor access to potable water and adequate sewage connection has resulted in debilitating and easily prevented diseases being endemic among the aged. Such diseases include malaria, diarrhoea, helminthiasis, dysentery, cholera and typhoid. Also, improper food storage and lack of protection of food or food stuff from pathogens has led to food contamination and poisoning according to 55.3 per cent of the respondents.

Majority of the respondents (80%) had access to electricity supply by the Ibadan Electricity Distribution Company (IBEDC). Supply of power is relatively regular compared to other Nigerian towns and cities characterized by inadequate and erratic power supply. Some households compliment electricity supplied by IBEDC with other sources such as electricity generating set, rechargeable lamp\torchlight and hurricane lantern. Some of the houses without electricity (5.1%) were dilapidated buildings inhabited by the poor and aged residents. Available health care facilities in the area were trado-medical health institutions, clinic and maternity centres (5), community/public health centres (3), health post (1) and general hospital (1). The conditions of the health care facilities available were rated fair by 62.2 per cent respondents.

The major components of wastes generated were household food waste, polythene, leaves, bottles and metal scrap (87.3%). Type of waste storage facilities commonly used by residents were plastic containers (53.1%), sack and basket (25.5%) and bucket (21.4%). Communal refuse storage, collection and disposal facilities were lacking. Hence, refuse collection system was inadequate.As observed, uncollected refuse caused unsanitary conditions and clogging of storm drains and streams. Most of the residential neighbourhoods were very dirty and generate offensive odour. Most of the houses sampled (73.1%) did not have drainage channels.

Some respondents (48.0%) believed that a steady but less noticeable toll of disease disability among the aged often result from inadequate facilities for the disposal of liquid waste which favours the presence of stagnant pool of water. Such stagnant water, according to them often served as an important habitat for a range of disease vectors such as mosquitoes, which cause malaria fever. Owing to prevalence of diseases cuasing vector, especially mosquitoes in the tropical zone, it is usually expedient to have a first wall of defence against them using mosquito's nets in windows and doors. However, only few dwellings of the aged (10.2%) installed nets in doors and windows. Malaria has been documented as one of leading diseases responsible for high mortality in Africa (Shapshak et al., 2015) The transmission of non-communicable diseases like malaria, typhoid, dysentery, worm infestation, upper respiratory infection and pneumonia is fostered by poor sanitation, overcrowding, inadequate water supply (Archor, 2001).

Without adequate provision for the collection of garbage and drainage, a great range of disease vectors will live, breed or feed within and around houses and settlements. Therefore, heaps of unmanaged garbage had been reported by 87.6 per cent of the respondents to create opportunities for the breeding of mosquitoes, flies, rats and several vermin's with high potential to compromise the health of the aged. The disease they cause or carry according to 58.2 per cent respondents include malaria (Anopheles mosquitoes) and diarrhoeas diseases (cockroaches, blowflies and houseflies).

Many houses where the aged live present multiple disadvantages that include not only missing and inadequate infrastructure and services, but also unfavourable geography, vulnerability to environmental shocks and seasonal exposure. In the rainy season, cold homes have a serious impact on older people's health. Twenty-four per cent of the respondents revealed a strong positive relationship between cold temperatures and cardio-vascular and respiratory diseases. According to them, cold housing increased the level of certain illnesses such as colds, flu, arthritis and rheumatism. About 15.0 per cent respondents (15.3%) erected their dwellings along flood plains, on hill slopes and in marshlands. In houses situated on steep slopes and other perilous locations, 13.1 per cent of the respondents claimed that injuries from falls were common. Furthermore, flood plains or any environment lacking adequate drainage systems for surface water leads to damp and mold growth, frequent flooding and increased transmission of diseases. These factors increase health risks of the aged, with corresponding economic costs for seeking health care.

According to 22.5 per cent respondents, frequent use of pepper grinders, wood machines and con millers by the aged in order to augment little income or pension at home generate excessive noise which can make the aged people to develop tinnitus, become stressful, physiological aroused, irritable, aggressive and even develop insomnia (inability to sleep). Mental and psychological disorder like depression, anxiety and alcohol abuse attain high level of prevalence in poor quality houses. Structural defects in housing and unsafe working environment expose the aged to unprecedented kinds of home accidents.

CONCLUSION AND POLICY RESPONSE

Findings revealed that majority of the houses in the study area can be described as shelters rather than houses. In most places, residents were usually crowded in very limited space and the houses usually lack adequate ventilation. Several residents live in life and health-threatening homes because of the poor housing conditions characterised by inadequate provision for safe and sufficient water supplies, provision for sanitation, drainage and the removal of garbage.

There is inseparable link between the quality of housing and the health status of the aged. Whereas decent housing promotes good health, a submerge housing predisposes the aged to a range of communicable and non-communicable diseases and disorders. Owning to this close nexus, conscious provision of favourable factors in housing will no doubt improve the health status of the aged. Consequently, health of the aged should form important inputs in the national housing policy. Decent, suitable housing units for older people will reduce the costs of health care and this will in turn contribute to more savings as well as achieving the policy aspirations of integration of the aged and prevention of certain diseases. The provision of warm, safe and well designed housing units will have quantifiable effects on the health and well-being of older people with chronic health problems such as heart disease, stroke, respiratory conditions, mental health, arthritis and rheumatism.

One of the primary functions of housing is improvement and sustenance of quality of life and the present concept of health show that the notion of health is an important element of wellbeing. Since housing plays a major role in modulating the health status of the aged, it follows logically that the provision of health policy will certainly include the right of the aged to adequate housing. Against this background, it is important to ensure that the various levels of association between housing condition and health of the elderly constitute an important input in Nigeria’s health policy. Both housing and health policies should have an interface where adequate housing should be given adequate attention.

Risk of income loss has been associated with the elderly of above 65 years old. The two main areas of policy intervention should include reducing the impact of poor housing condition on ill-health in the old age and secondly preventing and helping old people out of housing poverty. Majority of the aged in Nigeria face housing problems because they have failed to invest in adequate housing when they were active or because of low income or unfavourable economic policies or non-payment of gratuities and pensions on time. In addition, majority of them during their economic active period engaged themselves in informal activities which have no gratuity or pension. There is, therefore, the need for compulsory pension insurance in addition to social assistance to the old. This arrangement will enable the aged to have access to decent house after retirements. There is also the need to review the minimum pension benefit, as this will enable the aged to maintain their houses and, thus, prevent such houses from deterioration.

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HOUSEHOLDS' TRIP-CHAINING BEHAVIOUR: EVENING INTERVENING STOPS ACROSS RESIDENTIAL AREAS IN IBADAN, NIGERIA

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Abstract: The study examined the stop-making behaviour of households during evening commute across residential zones in Ibadan, Nigeria. 1,794 commuting household heads were selected from 15 wards in the city. Significant relationships were established between evening intervening stops and most socioeconomic characteristics. Moreover, a significant relationship was found between residential zone and time added to evening commute, while distance added to evening commute varied across the three residential zones. Unlike most previous studies, the study came up with some important findings that are capable of enhancing our understanding of the trip-chaining behaviour of households with no access to private vehicles.

Key words: commuting, trip chaining, intervening stop, residential density, Ibadan

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INTRODUCTION

Work trips account for over 20 per cent of all person trips (Jou et al., 1992). This is why transportation planners accord top priority to the study of commuting as an integral aspect of travel behaviour. In other words, what goes on in the course of morning and evening peak periods, intervening stops inclusive, as well as their implications for urban transportation planning are of interest to transport planners, especially now that it is gradually dawning on them that trip chaining has come to stay as an indispensable aspect that must be reckoned with in traffic forecasting modelling. This is because on a daily basis commuters have diverse reasons for making intervening stops on their way to work in the morning, on their way back from work in the evening, or on both occasions. Intervening stops are stops associated with chained trips (Liu, 2013). They form an integral part of trip chaining as they necessarily constitute trip legs or trip segments. By combining such discretionary trips for which stops are made with the nondiscretionary work trips, commuters engage in trip chaining. Reasons for intervening stops range from such chores shared among household members as shopping and dropping and/or picking up schoolchildren to such other trip purposes that constitute trip legs as social visits, recreational trips, and trips to places of worship, among others.

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Studies have shown that working household members share chores and engage in several non-work activities, and perform them before returning home (Ajay and Levinson, 1995; McGuckin and Nakamoto, 2004; O'Fallon and Sullivan, 2005, 2009). Besides, consolidating work and non-work trips can be viewed broadly within the paradigm of the concept of bounded rationality: people respond to changing urban form, demographic and life-cycle stages and rising congestion by pursuing several activities along a single trip chain to achieve travel economies (Ajay and Levinson, 1995). In addition, the growth in female employment and the increase in per capita income on the one hand, and the need to accommodate different daily chores within the 24-hour day on the other hand, have resulted in an emergence of complex travel patterns on a scale not known decades ago (Baldwin and Fagan, 2007; Ajay and Levinson, 1995; McGuckin and Murakami, 1999; Pekol and Brown, 2005).

While discretionary trips form part of the daily itinerary of many commuters, evening intervening stops have been reported to be more common, and take more time, than morning intervening stops (Jou et al., 1992; Ajay and Levinson, 1995; Jou and Mahmassani, 1997; American Association of State Highway and Transportation Officials (AASTHO), 2013). Reasons for this are not farfetched. Ordinarily, commuters would want to get to work without much delay in the morning. As such, they may not be able to afford to stop by. However, in the evening, on their way back home, there would be ample opportunities to accommodate a number of discretionary trips in the homeward journey. According to Ajay and Levinson (1995), this is especially applicable to commuters who live on the urban fringe, as they find it easier and more convenient to perform non-work activities before returning home in the evening.

Previous studies tend to support the argument that trip chaining is capable of explaining the rise in non-work (maintenance/discretionary) trips, which take place during the peak periods and posited as one of the reasons for increased congestion problems at rush hours. Therefore, better understanding of how commuters make trip-chaining decisions that are associated with their commuting constitutes a fundamental prerequisite for improving the validity of travel demand modelling as well as the development of congestion relief policies and strategies (Chu, 2003).

The literature of commuting is replete with studies that analysed series of trip-chaining behaviour in which intervening stops for non-work activities are introduced into the home-work-home travel pattern, and a few of these studies have isolated intervening stops with a view to advancing our understanding of the phenomenon. However, generally, there is a dearth of studies that focus the trip-chaining behaviour of commuters in the developing world. Thus, what obtains as far as intervening stops are concerned in this region of the world is yet to be extensively explored. More specifically, no known published research has looked into intervening stops among commuters in Nigeria. Meanwhile, it is apparent that not unlike the experience in other countries of the world, Nigerians, too, naturally combine several trips in one chain to achieve travel economies. This study is an attempt to examine evening intervening stops among commuters in Ibadan, one of Nigerian major cities. The examination of morning intervening stops has been carried out elsewhere (Fadare and Olojede, 2017).

Several methods and models have been developed to advance the cause of trip chaining in travel behaviour analyses. These include the Markov Process (Collins, 1975; Horton and Shuldiner, 1967; Howard, 1971a, 1971b; Kitamura, 1983; Nystuen, 1967; Wheeler, 1972), Entropy-Maximizing Model (Tomlinson et al., 1973), Random Utility Choice Model (Ben-Akiva et al., 1978; Horowitz, 1980; Lerman, 1979), Bernoulli Process (Mazurkiewicz, 1985), Gravity-Type Formulation (Borgers and Timmermans, 1986), Recursive Model (Konstadinos and Kitamura, 1989), Stochastic Model (Damberg et al., 1996; Drezner and Wesolowski, 1982; Hanson, 1979; Miller and O'Kelly, 1983; Southworth, 1983), and very recently Shannon Entropy (Scheiner and Holz-Rau, 2017), among other models.

In this study, a rather simplistic approach has been used owing to certain peculiarities of the study area. For instance, in Nigeria, there are neither nationwide households travel surveys nor specially designed metropolitan personal travel survey on which such a study as this can be based. As such, the retrospective (stylised) questionnaire approach was employed whereby respondents were asked questions on their activity/travel patterns for the previous day. However, conscientious efforts were made to obtain as accurate data as possible from the respondents. As such, even though the method employed was simplistic, important findings were made that are capable of enhancing our understanding of the phenomenon of commuters' intervening stops en route home in the evening.

LITERATURE REVIEW

A careful look at the existing literature affords us the understanding that commuting and trip chaining are related, and that trip chaining constitutes an integral part of commuting. The characteristics of the purposes for which intervening stops are made, otherwise known as trip legs or trip segments, have also been examined by other studies (McGuckin and Nakamoto, 2004; O'Fallon and Sullivan, 2005, 2009; Olojede, 2017). According to the literature, commuters chain their discretionary trips with their work trips in three major ways: by making intervening stops during the morning commute, by making intervening stops during the evening commute, and by embarking on discretionary trips that start and end in the workplace (Chu, 2003). The trips that start and end in the workplace are also referred to as loops (Valiquette and Morency, 2010). Meanwhile, morning and evening intervening stops have more direct link with commuting as they form part of the trip to work and the homeward trip.

By and large, studies have found that evening intervening stops are more common than morning intervening stops. For instance, in their study of chained trips in Montgomery County of Maryland, United States, Ajay and Levinson (1995) found, among other things, that commuters chain multiple discretionary trips made for non-work activities with the homeward trip in the afternoon more than in the morning. They also found that women chain their trips more than men, and that commuters who reside in areas closer to the central city are less likely to combine work and non-work trips relative to those living in the outer suburbs. These can be explained given the traditional roles of women which increase their propensity to make intervening stops, and the higher need of suburban dwellers that contribute to their tendency to make more intervening stops.

By a sharp contrast, in an empirical analysis of intervening stops among commuters in New York City, Chu (2003) found that commuters [in New York City] make more morning stops than evening stops. The study found that the primary determinants of intervening stop propensity in the city are arrival time and commuting in personal car for morning commute, while departure time and income influence intervening stops during evening commute. It was also found that an enhanced personal mobility, made possible by convenient public transit in the city, makes younger commuters to have a lower evening stop-making propensity since they can afford to undertake their non-work activities after a temporary home sojourn. In addition, the study revealed that during both morning and evening commutes, non-work activities pursued on intervening stops tend to be closer to home than work. Meanwhile, a longer commute travel time reduces the number of evening intervening stops because severe congestion on roadways in New York may outweigh activity opportunities to affect commuters' decision to make decisions on intervening stops. However, it is clear that this study features a number of obvious peculiarities that possibly account for the unusual results. Not every city has it as good as New York does, especially in terms of 'convenient public transit'. However, the study came up with an interesting finding that, all things being equal, the state of public transit influences commuters' decision as far as making intervening stops is concerned.

Jou and Mahmassani (1997) studied day-to-day trip-chaining behaviour of urban commuters in two cities. They investigated day-to-day variation in auto commuter trip-chaining behaviour. They developed models to relate trip-chaining patterns to three kinds of factors: socio-economic characteristics, workplace conditions and traffic system characteristics. They found that trip chaining was an essential feature of work trip commuting, and was more extensive in connection with the evening commute than with the morning commute. Activities completed at stops in the morning differed from those completed in the evening. The latter were longer and less likely to be routine. The results were similar in both Dallas and Austin, Texas. However, results pertaining to the relative locations of the stops in terms of their proximity to home or workplace are different between the two cities reflecting the underlying differences in spatial and size characteristics between the two cities.

Using multi-day observations, Bhat (1999) examined the number of stops made by individuals during their evening commute. One important contribution of the study is that it applied a methodological framework that related stop-making to relevant individual, land-use, and work-related characteristics. The framework also accommodated unobserved variation in stop-making propensity across individuals in intrinsic preferences and in responsiveness to work-related attributes. The study also succeeded in providing a 'superior data fit' relative to a model that ignores unobserved variations in stop-making propensity across individuals. As such, it provided important behavioural insights which are often masked by the model that disregards unobserved variations. However, the study did not provide any empirical evidence as to whether or not evening stops are more common than morning stops. It is important to note that a good number of studies on commuting and trip chaining employed either specially designed surveys or national surveys that do not make for the availability of tangible travel characteristics and patterns for a large sample in any specific city. This made it impossible for them to analyze activity patterns as far as intervening stops are concerned in detail. McGuckin and Murakami (1999), for example, used the 1995 Nationwide Personal Transportation Survey to examine trip-chaining behaviour of adult men and women travelling Monday through Friday in the United States; Greenwald and McNally (2006) also examined how land use based substitution effects on travel behaviours manifest by examining the direct impact of land uses inducing trip-making behaviour in Portland, Oregon; while Noland and Thomas (2007) examined whether lower-density environments are related to more frequent reliance upon trip chaining and more complex tours.

Furthermore, Van Acker and Witlox (2011) used data from the 2000 to 2001 Travel Behaviour Survey in Ghent, Belgium; Zhao et al. (2012) traced the evolution of trip chaining patterns in London from 1991 to 2010; Ho and Mulley (2013) used a home-based tour dataset created from the Sydney Household Travel Survey; and Harding et al. (2015) used the 2010 Swiss Microcensus on mobility and transportation. In any case, these studies are very crucial to our understanding of how, why and when commuters make intervening stops.

From the foregoing, many researchers have examined a myriad of relationships between commuting, as it relates to trip chaining, and a number of influencing factors; conflicting findings abound, and it is quite difficult to reach a consensus on a number of issues that relate to the phenomenon of trip chaining. The aspect of intervening stops is another on which opinions differ but as made for by empirical findings. More importantly, the majority of studies available, as reviewed, on the trip-chaining aspect of commuting were carried out in developed countries. What obtains in the developing countries, especially in Africa, in this regard is scarcely available in the literature. Specifically, putting it very conservatively, there is surely or almost certainly not any known major published work on trip chaining in Nigeria. Meanwhile, trip chaining is no doubt a global phenomenon; and intervening stops are certainly inevitably made in less developed countries even as obtained in developed countries. Consequently, this study focuses homeward tours (evening commute), providing empirical evidence on evening intervening stops in a prominent Nigerian city. This is with a view to meeting part of the information need in the extant literature of trip chaining in the developing world.

STUDY AREA

Ibadan had been a capital city since 1939 when the Colony and Protectorate of Nigeria was trifurcated into three administrative units. Currently, the city is the capital of Oyo State. It is located approximately between latitude 7.37º and 7.67º North of the Equator, and between 3.88º and 4.17º East of the Greenwich Meridian. Ibadan is about 145 kilometres from Lagos (the former Federal Capital of Nigeria) by road, and about 345 kilometres northeast of Abuja (the current Federal Capital City) as the crow flies. Ibadan is directly connected to many towns in Nigeria and its rural hinterland by a system of roads, railways [moribund at present, though] and air routes.

Ibadan metropolis comprises the main city (municipality), made up of five local government areas, and its suburbs (also sometimes referred to as less city) with six local government areas.

The Ibadan metropolitan area can be divided into three distinct residential zones. This division can be linked to three historical periods, with their nature and characteristics determined by social, economic and physical patterns (Fadare, 1987, 1993, 1997; Onibokun, 1985; Sanni & Akinyemi, 2009). They are the pre-colonial residential development (high-density/traditional), the colonial/pre-Independence residential development (intermediate/ medium-density) and the post-Independence residential development (low-density). Even the more recent classification by Onibokun and Kumuyi (2004) of Ibadan metropolis into seven morphological regions can still be regrouped into these three residential zones. The zones are also as obtained in such other traditional Yoruba cities as Ilorin (Akorede, 1975) and Ogbomoso (Afon, 2005; Okewole, 1977).

Ibadan is an important socioeconomic, administrative, educational and industrial centre (Fadare & Wojuade, 2007a). The land use pattern compares with what obtains in other large cities in Nigeria. The general land use pattern of the Ibadan metropolitan area shows a clear distinction: purely non-agricultural use for Urban Ibadan, and agricultural use for Rural Ibadan. Residential land use is the most predominant among all land uses in the built-up part of Ibadan. The metropolitan area of the city has one of the highest population densities in the country, and the mostly densely settled areas remain the central and indigenous High of the city (Ayeni, 1994).

The first motorable road in Nigeria was constructed from Ibadan to Oyo in 1906, while the railway system which began in 1896 from Lagos to Kano in 1911 passed through the city. However, there is no internal rail system in the city. At present, there is no operational mass transit system in Ibadan. The implication of this is that there is high prevalence of automobile use among residents who can afford automobiles. Less financially buoyant residents, especially commuters, take taxicabs, minibuses (danfos), and commercial motorcycles (okadas).

According to Fadare and Wojuade (2007a) 5.3% of the roads in Ibadan are federal roads, 20.8% are state roads, while the remaining 73.9% are local government roads. Generally these roads are inadequate and in poor condition, especially the local government roads which are barely paved, and are in most cases not motorable during the rainy season. The federal and state government roads that are paved are in most cases not maintained. More often than not, these contribute to traffic congestion and delay in the city (Fadare, 1998; Fadare & Wojuade, 2007a, 2007b; Fadare et al., 2007; Olojede, 2015).

The choice of Ibadan for this study is strategic for a number of reasons. Among other things, Ibadan has a metropolitan status which makes commuting indispensable. Meanwhile, as big as the city is its transport system is best described as being mono-modal, the only operating mode being the road. Besides, there is no sustainable public transit; as such, paratransit modes are predominant. In fact, in spite of its safety and security implications, the commercial motorcycle (popularly called okada, named after Okada, a small town in Edo State of Nigeria where motorcycles were first used as a means of commercial transport in Nigeria in the 1980s) is quite pervasive, even along major roads and expressways. In fact, there are commuters who travel a distance of over 10 kilometres to work daily on commercial motorcycles! However we look at it, commuting in Ibadan is an interesting phenomenon with its unique peculiarities. As such, conscientious caution should be the watchword when what obtains in the city in terms of commuting is being compared with what obtains elsewhere.

SAMPLING PROCEDURE

The sample population for the study was made up of households in all the five local government areas of the Municipal Ibadan: Ibadan North, Ibadan Northeast, Ibadan Northwest, Ibadan Southeast and Ibadan Southwest. The Independent National Electoral Commission of Nigeria categorised these local government areas into political wards for the purpose of the 2011 general elections. These were further categorised by stratification into the High, Medium and low-density residential areas. For the purpose of questionnaire administration for this study, inasmuch as the study area had been grouped into homogenous political wards, one ward was randomly picked without replacement from each residential zone. In all, 15 wards were selected across all the three residential zones of the study area. Using systematic sampling technique, 5% of the buildings in the selected wards were sampled. The first building was randomly picked; subsequently, every 20th residential building in each ward was selected for the survey. From each of the sampled buildings, a household was randomly selected, and the household head was the respondent. Where the household head was not available, any available adult who was a commuter was surveyed. Eventually, 1,794 commuters were successfully surveyed: 728, 592 and 474 in the high-, medium- and low-density residential areas respectively.

RESULTS AND DISCUSSION

Some socioeconomic attributes deemed relevant to the evening commuting behaviour of household heads in Ibadan were examined. The summary is as shown in Table 1. According to the table, irrespective of the residential zone, there were more male than female household heads. This was most pronounced in the high-density residential area of the city where only about 23.1% of the household heads were women. In the medium-density residential area, there was only a marginal percentage difference of 2.8 between the proportion of male household heads and female household heads. Also, about 78.0%, 68.9% and 70.3% of household heads in the High, Medium and low-density residential areas of Ibadan respectively were married. It is thus clear that the highest proportion of married household heads was found in the high-density residential area of the city.

A large percentage (67.8) of the household heads fell in the 21-40 age group, followed by 27.0% household heads in the 41-60 age group. Table 1 also shows that 73.0% of household heads were married. Barely 2.7% and 3.0% were separated/divorced and widowed respectively, while 21.4% were single. The distribution of household incomes reveals that 46.7% of the households earned between 50,000 and 100,000 naira per month, 25.1% earned less than 50,000 while 28.2% of the households earned over a hundred thousand naira monthly. The highest percentage of households that earned over 100,000 naira (48.5%) lived in the low-density residential area.

From Table 1 it is further shown that in the low-density residential area 74.9% household heads had private vehicles. This is followed by 19.6% and 42.1% in the high- and medium-density residential areas respectively. As may be expected, a significant relationship was found between income and private vehicle ownership in the study area ($\chi 2 = 463.8$, $p < 0.001$). It is also found in this study that 50.4% of household heads in Ibadan travelled daily to their workplaces on commercial cabs and buses. This study found that no household head in any of the residential zones travelled by foot to work.

Table 2 shows the breakdown of the stops made by household heads in Ibadan in the course of their evening commute. Only 13.4 per cent of the household heads in the study area did not make any evening stop, while 33.7% and 52.9% of the household heads made one and at least two evening stops respectively. In the high-density residential area, 18.7% of the household heads did not make any stop, while 23.1% and 58.3% made one and at least two evening stops respectively. In the medium-density residential area, 13.5% of the household heads made no stop in the evening, while 33.8% and 52.7% made one and at least two evening stops respectively. In the low-density residential area, 5.1% of the household heads did not make any stop, while 50.0% and 44.9% made one and at least two evening stops respectively. Thus, the highest percentage (18.7) of household heads who did not make evening stops was found in the high-density residential area of the city, while household heads in the low-density residential zone made more evening stops than household heads in other residential zones. This finding supports those of Ajay and Levinson (1995), and Noland and Thomas (2007) who found that residential location of suburban dwellers influences intervening stops. A significant relationship was found between residential zone and the frequency of evening intervening stops ($\chi 2 = 126.4$, $p < 0.001$). The ANOVA test also showed that significant variation existed across the three major residential zones in the number of stops made during the evening commute ($F = 5.896$, $p = 0.003$).

Table 1. Socio economic Characteristics of Household Heads in Ibadan
(Data source: Author's Field Work, 2015)

Factor	Residential Zone			Total
	High	Medium	Low	
Gender				
Male	560 (76.9%)	304 (51.4%)	283 (59.7%)	1147 (63.9%)
Female	168 (23.1%)	288 (48.6%)	191 (40.3%)	647 (36.1%)
Age				
≤20	32 (4.4%)	8 (1.14%)	15 (3.2%)	55 (3.1%)
21-40	448 (61.5%)	416 (70.3%)	352 (74.3%)	1216 (67.8%)
41-60	224 (30.8%)	160 (27.0%)	100 (21.1%)	484 (27.0%)
>60	24 (3.3%)	8 (1.4%)	7 (1.5%)	39 (2.2%)
Marital Status				
Single	160 (22.0%)	136 (23.05)	88 (18.6%)	384 (21.4%)
Married	568 (78.0%)	408 (68.9%)	333 (70.3%)	1309 (73.0%)
Separated/Divorced	0 (0.0%)	24 (4.1%)	24 (5.1%)	48 (2.7%)
Widowed	0 (0.0%)	24 (4.1%)	29 (6.1%)	53 (3.0%)
Average Household Income (₦[1])				
<50,000	235 (32.3%)	165 (27.9%)	50 (10.5%)	450 (25.1%)
50,000-100,000	352 (48.4%)	292 (49.3%)	194 (40.9%)	838 (46.7%)
>100,000	141 (19.4%)	135 (22.8%)	230 (48.5%)	506 (28.2%)
Private Vehicle Ownership				
Owned	143 (19.6%)	249 (42.1%)	355 (74.9%)	747 (41.6%)
Not Owned	585 (80.4%)	343 (57.9%)	119 (25.1%)	1047 (58.4%)
Household Size				
1-2	160 (22.0%)	168 (28.4%)	142 (30.0%)	470 (26.2%)
3-4	160 (22.0%)	128 (21.6%)	54 (11.4%)	342 (19.1%)
5-6	304 (41.8%)	240 (40.5%)	222 (46.8%)	766 (42.7%)
>6	104 (14.3%)	56 (9.5%)	56 (9.5%)	216 (12.0%)
School-Age Household Members				
0	176 (24.2%)	168 (28.4%)	141 (29.7%)	485 (27.0%)
1	144 (19.8%)	96 (16.2%)	159 (33.5%)	399 (22.2%)
2	224 (30.8%)	192 (32.4%)	150 (31.6%)	566 (31.5%)
3	152 (20.9%)	96 (16.2%)	24 (5.1%)	272 (15.2%)
4	32 (4.4%)	40 (6.8%)	0 (0.0%)	72 (4.0%)
Working Household Members				
0	0 (0.0%)	0 (0.0%)	8 (1.7%)	8 (0.4%)
1	184 (25.3%)	224 (37.8%)	116 (24.5%)	524 (29.2%)
2	448 (61.5%)	296 (50.0%)	294 (62.0%)	1038 (57.9%)
>2	96 (13.2%)	72 (12.2%)	56 (11.8%)	224 (12.5%)
Usual Daily Mode				
Personal Car	36 (4.9%)	160 (27.0%)	311 (65.6%)	507 (28.3%)
Personal Motorcycle	73 (10.0%)	40 (6.8%)	11 (2.3%)	124 (6.9%)
Commercial Cab/Bus	463 (63.6%)	305 (51.5%)	137 (28.9%)	905 (50.4%)
Commercial Motorcycle	156 (21.4%)	87 (14.7%)	15 (3.2%)	258 (14.4%)

As shown in Table 3, 68.9% of the household heads in the study area did not make any stop for others in the course of their evening commute, while 15.6% and 15.5% of the household heads made one and at least two evening stops for others respectively. In the high-density residential area, 64.8% of the household heads did not make any stop for others, while 15.4% and 19.8% made one and at least two evening stops respectively. In the medium-density residential area, 68.9% of the household heads made no stop for others in the evening, while 17.6% and 13.6% made one and at least two evening stops for others respectively. In the low-density residential area,

[1] As of 21st April, 2018, a US dollar (USSD1) exchanged for Nigerian 360.00 naira (₦360.00) officially.

75.1% of the household heads did not make any stop for others, while 13.5% and 11.4% made one and at least two evening stops for others respectively. It then follows that, generally, household heads in Ibadan do not usually make stops for others in the course of their evening commute.

Table 2. Stops during Evening Commute
(Data source: Author's Field Work, 2015)

Residential Density		**Number of Stops**				**Total**
		0	**1**	**2**	**>2**	
High	Count	136	168	288	136	728
	%	18.7%	23.1%	39.6%	18.7%	100.0%
Medium	Count	80	200	248	64	592
	%	13.5%	33.8%	41.9%	10.8%	100.0%
Low	Count	24	237	166	47	474
	%	5.1%	50.0%	35.0%	9.9%	100.0%
Total	Count	240	605	702	247	1794
	%	13.4%	33.7%	39.1%	13.8%	100.0%

Table 3. Stops Made for Others during Evening Commute
(Data source: Author's Field Work, 2015)

Residential Density		**Number of Stops for Others**				**Total**
		0	**1**	**2**	**>2**	
High	Count	472	112	112	32	728
	%	64.8%	15.4%	15.4%	4.4%	100.0%
Medium	Count	408	104	72	8	592
	%	68.9%	17.6%	12.2%	1.4%	100.0%
Low	Count	356	64	31	23	474
	%	75.1%	13.5%	6.5%	4.9%	100.0%
Total	Count	1236	280	215	63	1794
	%	68.9%	15.6%	12.0%	3.5%	100.0%

Further, a higher proportion (35.2%) of household heads in the high-density residential area made stops for other household members during their evening commutes than in either the medium- (31.1%) or low-density residential area (24.9%). The one-way ANOVA test established significant variation between residential density and number of stops made by household heads for others in Ibadan during the evening commute ($F = 26.042$, $p < 0.001$). Similarly, the Chi-square tests carried out showed a significant relationship between residential zone and number of stops made for others during the evening commutes of household heads in Ibadan municipality ($\chi 2 = 37.897$, $p < 0.001$).

According to Table 4, 40.5% of the household heads in the study area did not have any time added to their usual commuting time consequent on intervening stops made in the course of their evening commute, 23.6% and 16.9% had 1-15 minutes and 16-30 minutes added to their commute time consequent on stops made respectively, 10.9% and 5.2% had 31-45 minutes and 46-60 minutes added respectively, while 3.0% had over an hour added to their commute time as a result of intervening stops made. In the high-density residential area, 41.2% of the household heads had no time added to their evening commuting time, 28.6%, 17.3%, 6.2% and 4.8% had 1-15 minutes, 16-30 minutes, 31-45 minutes and 46-60 minutes added to their evening commuting time respectively, while 1.9% had more than one hour added to their evening commuting time consequent on the intervening stops made.

Table 4. Time Added to Evening Commute Consequent on Stops
(Data source: Author's Field Work, 2015)

Residential Density		Time Added (minutes)						Total
		0	1-15	16-30	31-45	46-60	>60	
High	Count	300	208	126	45	35	14	728
	%	41.2%	28.6%	17.3%	6.2%	4.8%	1.9%	100.0%
Medium	Count	187	128	106	88	51	32	592
	%	31.6%	21.6%	17.9%	14.9%	8.6%	5.4%	100.0%
Low	Count	239	88	71	62	7	7	474
	%	50.4%	18.6%	15.0%	13.1%	1.5%	1.5%	100.0%
Total	Count	726	424	303	195	93	53	1794
	%	40.5%	23.6%	16.9%	10.9%	5.2%	3.0%	100.0%

In the medium-density residential area, 31.6% of the household heads did not have any time added to their evening commuting time, 21.6%, 17.9%, 14.9% and 8.6% of the household heads had 1-15 minutes, 16-30 minutes, 31-45 minutes and 46-60 minutes added to their evening commuting time respectively, while 5.4% had more than one hour added to their evening commuting time consequent on the intervening stops made. In the low-density residential zone, 50.4% of the household heads did not have any time added to their evening commuting time, 18.6%, 15.0%, 13.1% and 1.5% of the household heads had 1-15 minutes, 16-30 minutes, 31-45 minutes and 46-60 minutes added to their evening commuting time respectively, while 1.5% had more than one hour added to their evening commuting time consequent on the intervening stops made.

It is thus clear that consequent upon the stops made during their evening commute, household heads in Ibadan had time added to their evening commute. However, household heads in the high-density residential area spent more time in aggregate than those in either the medium- or low-density residential area in addition to their normal trip time as a result of stops made for others in their evening commute. The Chi-square tests established a significant relationship between residential zone and time added to evening commute consequent on stops made ($\chi 2 = 108.3$, $p < 0.001$). The ANOVA test also established significant variation in the distance added to evening commute across the three residential zones as a result of stops made ($F = 9.458$, $p < 0.001$).

As shown in Table 5, 34.7% of the household heads in the study area did not have any distance added to their usual commuting distance consequent on intervening stops made in the course of their evening commute; 17.4%, 16.4%, 12.2%, 10.4% and 5.9% had less than 1 km, 1.0-1.9 km, 2.0-2.9 km, 3.0-3.9 km and 4.0-4.9 km added to their usual commuting distance respectively; while 3.0% had over 5 km added to their usual commuting distance consequent on stops made. In the high-density residential area, 18.7% of the household heads had no distance added to their evening commuting time; 26.9%, 17.0%, 13.7%, 14.6% and 6.6% had less than 1.0 km, 1.0-1.9 km, 2.0-2.9 km, 3.0-3.9 km and 4.0-4.9 km added to their usual commuting distance respectively; while 2.5% of the household heads had over 5 km added to their evening commuting distance consequent on the intervening stops made.

In the medium-density residential area, 22.0% of the household heads did not have any distance added to their usual evening commuting distance; 18.2%, 22.3%, 17.6%, 9.5% and 6.4% of the household heads had less than 1 km, 1.0-1.9 km, 2.0-2.9 km, 3.0-3.9 km and 4.0-4.9 km added to their usual commuting distance respectively; while 4.1% of the household heads had over 5 km added to their evening commuting distance. In the low-density residential zone, 75.3% of the household heads did not have any distance added to their usual evening commuting distance; 1.7%, 8.2%, 3.2%, 5.1% and 4.2% of the household heads had less than 1 km, 1.0-1.9 km, 2.0-2.9 km, 3.0-3.9 km and 4.0-4.9 km added to their usual commuting distance respectively; while 2.3%

of the household heads had over 5 km added to their usual evening commuting distance consequent on the intervening stops made.

Table 5. Distance Added to Evening Commute Consequent on Stops
(Data source: Author's Field Work, 2015)

Residential Density		Distance Added (kilometres)							Total
		0	**<1.0**	**1.0-1.9**	**2.0-2.9**	**3.0-3.9**	**4.0-4.9**	**≥5**	
High	Count	136	196	124	100	106	48	18	728
	%	18.7%	26.9%	17.0%	13.7%	14.6%	6.6%	2.5%	100.0%
Medium	Count	130	108	132	104	56	38	24	592
	%	22.0%	18.2%	22.3%	17.6%	9.5%	6.4%	4.1%	100.0%
Low	Count	357	8	39	15	24	20	11	474
	%	75.3%	1.7%	8.2%	3.2%	5.1%	4.2%	2.3%	100.0%
Total	Count	623	312	295	219	186	106	53	1794
	%	34.7%	17.4%	16.4%	12.2%	10.4%	5.9%	3.0%	100.0%

As obtained in Table 5, more household heads in the high-density residential area had considerable distance added to their evening commute than those in either the medium- or low-density residential area. ANOVA tests established this variation ($F = 18.222$, $p < 0.001$). Furthermore, the Chi-square tests established a significant relationship between zone of residence and time added to evening commuting ($\chi2 = 523.6$, $p < 0.001$). In aggregate, more distance was added to the evening commute of household heads in the high-density residential area.

CONCLUSIONS, IMPLICATIONS AND RECOMMENDATIONS

The underpinning for this study was the realisation that given the array of the socioeconomic and demographic attributes of households in Ibadan, coupled with spatial indices in terms of land use and accessibility factors, households in the city would have a high propensity to combine discretionary trips with nondiscretionary trips with a view to achieving travel economies. Thus, intervening stops, especially in the course of evening commute, would be expected. The examination of socioeconomic characteristics of the households revealed that they varied across the residential zones. For example, households in the high-density residential area were characterised by both a low level of average monthly income and private vehicle ownership. By contrast, households in the low-density residential area had a higher level of income and enjoyed a high level of vehicle ownership, while households in the medium-density residential area stood midway in terms of both household income and private vehicle ownership. Evening stops made by household heads varied significantly across the residential zones, with the highest proportion of household heads that made stops during the evening commute found in the low-density residential area.

The findings of this study have several implications. First, most of the previous studies available in the extant literature of trip chaining were conducted in the West and other developed economies, with just a few conducted in developing countries, and scarcely any in Nigeria. Therefore, the results from this study are expected to find better relevance in the context of developing economies, especially in Nigeria, than those of previous studies. For instance, variations in terms of personal and household socioeconomic characteristics, national economic profiles, and national transportation systems are known to vary between developed and developing economies. Meanwhile, they are important factors that come to bear on travel behaviour. Besides, most of the previous studies made use of secondary data that were extracted from national surveys. These are unavailable in most developing countries, and definitely inexistent in Nigeria.

Moreover, almost all of the reviewed previous studies in the literature of trip chaining limited themselves to automobile-driving commuters. Meanwhile, as found by this study, not only car-driving commuters consolidate their discretionary trips with non-discretionary ones. Therefore, this study has come up with some important findings that are capable of enhancing our understanding of the trip-chaining behaviour of households with no access to private vehicles. However, this study considered mainly tours between the two anchor points of home and workplace. Therefore, other studies are needed especially on such other tour types as work-to-work (trips made during the workday or official/work-related looping) and home-to-home, which are non-work trips.

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INDUSTRIAL RESTRUCTURING IN SMALL AND MEDIUM SIZED TOWNS FROM ROMANIA – EVOLUTION BACKGROUND AND POSITIVE PERSPECTIVES WITH CHALLENGES

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Abstract: Small and medium sized industrial towns of Romania faced numerous challenges and difficulties together with the postsocialist transformation processes under the transition to the market economy. The paper analyses small and medium sized industrial towns from Romania through their socioeconomic evolution under the impact of the industrial restructuring process that started in the 1990s. Employing several sets of statistic data, the analysis evidences also several directions for the development of these towns through urban regeneration actions and different economic alternatives.

Key words: industrial restructuring, urban regeneration, cultural heritage, small and medium sized industrial towns

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INTRODUCTION

Industrial restructuring in Romania - development conditions under the market economy transition and the globalization process. Urban restructuring was detailed as a concept starting with

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the 20th century, but it represents a part of cities' history. Urban landscapes constitute the product of a long urban evolution marked by different development stages. Urban mutations are influenced by the political, administrative, economic, social and cultural changes. Under this framwork, urban planning involves more than imagining, drawing and building, but it also means to correct the urban environment for increasing its sustainability. The concepts of restructuring, revitalization, remodelling or renewal include the "re" prefix reffering (as the latin meaning) to a return or repetition. The ambiguity of restructuring includes both the maintanance of certain urban features and radical changes. Generally, some of the transformations generated by urban restructuring processes may be socially – through the ruptures within the vecinity relations in the cases of population relocations in other urban areas, economically – given the benefits that some investors get when compared to other investors losses, or morphologically criticized – due to the new differentiation introduced within the urban fabric.

Industrial restructuring marked both the dynamics of large cities, of small and medium sized towns and the evolution of the surrounding areas. The structural factors of industrial restructuring are multiple: the transition from a centralized economic system to one based on eficiency and competitivitty, finally leading to the resizing or even the elimination of urban industrial production; the national and international complex and dynamic economic framework which tends to accentuate the selective development of industries; the urban tendency of cities to partially or totally exclude traditional industrial activities from the urban economy, especially given the recent environment policies (Cepoiu, 2009, p. 69).

The negative effects of industrial restructuring were felt stronger in the case of Central and Eastern Europe due to the difficult process of transition from the centralized to the market economy (Jucu, 2011; Popescu, 2014; Milošević and Đorđević, 2015; Šerý et al., 2018). The transition period generated a difficult adaptation process to the new economic context due to demand changes and the temporary or permanent destruction of former commercial relations. The decrease of investments also adds to the context, together with the reduction of specialized production, in correlation with the decrease of the labour force and the financial capital depreciation in the absence of replacing investments (Popescu, 2014).

In Eastern Europe, the evolution of industrial restructuring needs to be analyzed in relation to the deindustrialization policy, as a consequence of the economic restructuring that started after 1990. Industrial restructuring produces through a process of deindustrialization which does not involve the total dissolution of industry or its elimination from the urban economic structure. In Romania, the decrease of the industrial production represented the consequence of, among others, loosing the markets, of the imposiblity to ensure raw materials and of the realization of internationally noncompetitive products (Ianoș, 2004, pp. 48-49). Mountain monoindustrial towns faced strong deindustrialization effects as these urban areas could not employ suplimentary resources in comparison to the small agricultural towns where the population returned to the traditional economic activities (Ianoș and Heller, 2006, p. 320).

At national level, industrial restructuring started in the '90s and it registered several stages, among which the privatization of industrial enterprises and the implementation of reducing the mining sector policy (Braghină, 2004; Cândea and Bogan, 2009; Popescu, 2014). Although the national economy opened to the tertiary sector, the following economic increase was gradually realized and it did not absorb the entire workforce formely employed in the industrial sector as the low industrialized economy lacked the endogenous potential to replace the industrial loss (Popescu, 2014).

Tertiarization developed in most of small and medium sized towns, mostly through simple services, predominantly oriented to covering the deficit of commercial services in addition to financial and bank services. For some of the small and medium sized towns, tourism represents an alternative economic activity to the industrial activity, especially in the situation of national or local tourist resorts towns (Merciu, 2011; Bănică and Istrate, 2012; Matei et al., 2013).

Small towns in Romania have difficulties in adapting to the new social and economic context under the impact of multiple socioeconomic factors: the change of the urban functional profile, predominantly agricultural after the closure of industrial units; the high rates of unemployment; the lack of utilities and of urban infrastructure, some towns having a previous poorly developed infrastructure while others faced the deterioration of the urban infrastructure due to the lack of investments (Ianoş, 2000; Bănică et al., 2013; Sîrodoev et al., 2015).

During the industrial restructuring process of small and medium sized towns of Romania, industry was confrunted with the reduction of industrial activities to keeping only what that industrial domain had specific and performant or with the delocalization of certain industrial activities, especially of those which negatively impact the living conditions and deteriorate the quality of urban life. These cases are rare, as most of towns faced the gradual closure of production units due to the market economy competition.

In parallel with the process of industry destructuring, another process of a new industry development took place. But, it can be observed that this new process is not always based on the current and future necessities of towns. Unfortunately, the developing of industry through replacing the traditional industrial activities with new ones characterizes mostly the larger cities or the towns located close to some important economic urban centres. The strategies to continue the development of new industries or to reintroduce industrial activities in the case of urban areas which had recognition for their former production activities but stopped their industrial activity after 1990, have as general objectives: the recovery of the local economy; the employment of the former industrial workforce; the attraction of new labour force from the surrounding areas; and the increase of the local standard of living. The specific objectives of the urban restructuring process include: the increase of the cultural and social offer; the improvement of public spaces; the support of developing the local entrepreneurship; the renewal of architectural landscape; and the consolidation of the local identitiy feeling within the local communities in connection to the town. In the same time, urban restructuring strategies need to exclude the risk of negative consequences such as the development of unviable bussiness which fail in bringing socioeconomic development within those urban areas. In order to avoid the potential negative impacts, the restructuring process needs to be conducted together with employing reindustrialization policies aiming at building a viable industrial environment, based on competitivity and a stable, simple and coherent legislative environment to ensure the conditions of sustainable economic growth.

New production activities within industrial towns mean their functional and economic reconversion produced through the reorganization of functional areas. The restructuring process involves changes, simultaneously or successively, at financial, organizational, technological and spatial level (Cercleux, 2016, p. 74).

Urban restructuring stimulated by the competitivity between cities includes the optimal use of the spaces with limited and unprofitable functionality, being often unfunctional or abandoned, targetting especially industrial brownfields. Industrial restructuring may also involve, as secondary negative effect, the creation of brownfields due to the closure of former industrial units, situation raising both ecologization and functional conversion issues (Haller, 2005; Cepoiu, 2009; Paraschiv and Nazarie, 2010; Gavrilidis et al., 2011; Paraschiv, 2012; Pavolova et al., 2012; Cercleux et al., 2012; Fernández Águeda, 2014; Filip and Cocean, 2012; Herman et al., 2016; Jigoria-Oprea and Popa, 2017), which bring management difficulties especially for the local public administration of small and medium sized towns.

Generally, the urban spaces that remained after the closing of former production units were facing two situations of functional restructuring. On the one hand, it is the case of factories becoming functional only through eliminating the equipments specific to the former industrial profile and through the readaptation of former spaces to the new coming activities. These restructurings include mostly new tertiary functionings: IT, bank, insurance, food services, meddia, commerce activities, etc., oftenly developed inside former industrial platforms of which some were transformed into industrial parks. The closure of factories was many times followed by their demolition, while especially the industrial buildings were considered to be unfunctional for the new activities (Cercleux, 2016, pp. 80-81).

But, there are also cities that develop new industrial activities, even following an industrial profile close to the former activity, which are considered to be neccessary to the area or which facilitate economic profit as they may not be present within other surrounding areas, they are profitable industries on the market economy or they present the advantage of being located in a border area. The occurence of new industries in urban areas is very different, based on complex location principles. They include both green and grey developments, using the former industrial infrastructure (buildings and public utilities).

Urban regeneration constitutes a fundamental process for urban development and it builds the economic restructuring with the industrial restructuring of urban areas as essential pillar. Urban regeneration transforms an urban area or parts of a city through the demolition or reorganization of some constructions and older facilities of residential spaces or of different urban economic activities (Cercleux, 2016, p. 113). Technical innovations represent one of the main factors of urban regeneration actions, accompanying the dezindustrialization process, the delocalization of economic activities and the demolition of industrial buildings (Cercleux, 2016, p. 115). In the situation of areas with former production activities, urban regeneration actions depend on the property conditions, on the fiscal context or on the protection actions specific to heritage buildings (Cercleux, 2016, p. 116).

The issue of revitalizing industrial cities, especially referring to small and medium sized towns, became stringent in the context of the industrial production reduction or even of closing certain unprofitable industrial activities. Small and medium sized towns face a slowly implementation process of urban restructuring (Jucu, 2016), being characterized by a poor innovation capacity and a lower attraction and retention of creative workers (Selada et al., 2012).

The anticipation of restructuring actions represents more than an economic necessity and it needs to consider a complex of factors related to the socioeconomic context at macro level. The current challenge is represented by the implementation of alternative development policies that are compatible with the economic, social and cultural particularities of small and mediul sized towns as their preconditions and resources are considerably particular when compared to large cities (Selada et al., 2012). Moreover, small and medium size towns face diverse opportunities and challenges: the creation of value added products and services – creative experiences, creative spaces and innovative products, especially for the niche markets (van Heur, 2010 quoted by Selada et al., 2012), and the possibility of planning the city's future in terms of urban quality, with the aim to "revitalize the abandoned and deteriorated areas and reconnect the social, productive and spatial ties" (Fernández Águeda, 2014, p. 5), or for strengthening their urban identity.

As small and medium sized towns have particular development characteristics, they require specific solutions of urban regeneration with macroscale implementation (Selada et al., 2012; Chizzoniti et al., 2014; Jucu, 2016) and adapted to the local socioeconomic context and to the endogenous factors of urban development. Some authors consider that each small and medium sized industrial town has its personal role and character and they also feature rich historical townscapes which can play an active part in the urban regeneration process (Chizzoniti et al., 2014).

Morfologically, industrial towns include certain specific elements: the industrial-logistic area, the transportation area, and the historic (residential) fabric – a particular feature especially for the industrial towns of the 19th century (Matlovič et al., 2014). Industrially specific urban physical structures are complemented with different socio-cultural infrastructures: the workers' casino, the technical museum, for example.

At the same time, industrial towns own indicative relicts (sites), buildings (historic industrial plants, the workers' boroughs, office buildings) and other infrastructure elements initially created for the industrial activity that are currently valorized as tourist attractions, as it is the case of the narrow railway lines mainly used in the mining industry. Some of these resources that are specific to industrial towns represent heritage elements included in several conservation and recovery processes through their cultural valorization as local identity elements in the post-industrial period: "Industrial heritage is a specific type of human societies heritage that has emerged as a product of industrialization, i.e. as a side effect of deindustrialization, when certain facilities were abandoned" (Beaudet and Lungren, 1996 quoted by Ćopić and Tumarić, 2015, p. 44).

The inclusion of industrial elements into the local heritage constitutes a frequently used instrument for the current competitive development strategies of traditional industrial areas as it actively promotes the local development and the redefining of urban economic and social identity (Dansero and Scarpocchi, 2008 quoted by Merciu et al., 2014).

The choice of the type of conservation for former industrial sites and buildings is demanding as some of these spaces occuppy large surfaces within the urban areas while they also involve technical management difficulties. Reuses of industrial heritage usually include tourism, cultural and recreational regeneration projects with the aim of recuperating the industrial heritage for the urban population by creating new community services (Cercleux et al., 2012; Pavolova et al., 2012; Fernández Águeda, 2014; Chizzoniti et al., 2014; Ćopić and Tumarić, 2015; Merciu et al., 2014; Milošević and Đorđević, 2015; Merciu et al., 2017; Van Der Merwe and Rogerson, 2018).

In many cases, former industrial complexes are chosen as location of different cultural activities organized by specific clusters (Mommaas, 2004). Culture received significant attention in the recent decades, as more and more urban centers have turned to the arts economy as a substitute for the declining industrial activities (Stern and Seifert, 2010 quoted by Merciu et al., 2014). Cultural-led urban regeneration is associated with multiple positive effects at different territorial dimensions: intensified economic activities, enhanced value on cultural heritage and improved quality of the urban environment.

Dynamics of small and medium sized industrial towns in Romania after 1990

Economic restructuring has severely impacted the socioeconomic dynamics of small and medium sized towns leading to their decline especially in the case of industrial towns. Small and medium sized industrial towns registered both an economic and demographic decline due to the reduction or closure of industrial or agroindustrial activities and the decrease of the industrial workforce in correlation with the increase of unemployment leading to the general decrease of the local and regional population as consequence of external and internal migration. Generally, following the process of deindustrialization, on the one hand, large cities and their metropolitan areas started to receive massive fluxes of migration from former industrial areas, and, on the other hand, the urban-rural migration intensified especially in the middle of the '90s transition period.

Small and medium sized towns are important for their role to equilibrate the national and regional urban systems. Small and medium sized towns maintain the connection between the urban and the rural space, strongly influencing the development of the adjacent rural space. In this sense, many rural settlements were being declared as urban spaces during the communist period as part of an urban policy destined to ensure uniform urbanization at national level through the process of forced industrialization (Ianoș, 2004; Popescu, 2014). So that, rural areas with significant natural resources became towns with a preponderently monofunctional industrial development – mainly mining, textile, food or chemical industry (Stasac et al., 2016).

The socioeconomic decline of small industrial towns during the postsocialist period influenced the maintenance of their rural features while they were being recognized as rural towns after the deindustrialization process (Ianoș, 2000; Bănică and Istrate, 2012; Sîrodoev et al., 2015).

METHODOLOGY

The analysis includes the assessment of small and medium sized industrial towns at national level, considering in this category only those urban areas with a share of the active population of over 50% and a population of up to 100 000 inhabitants in 1992. The data of the census year 1992 represents the reference as, until then, industry constituted the key economic activity for the local urban development in Romania, providing the respective towns with a significantly higher prosperity than the towns concentrating on other types of economic activities.

In order to analyze the impact of the industrial restructuring process on the selected small and medium sized industrial towns, several indicators were employed, using statistical data provided by the National Institute of Statistics: the share of employees in industry, the population growth rate and the migration rate. The analysis of the statistical data considered several factors for the discussion of the results: the successive phases of urbanization in Romania, the regional context of development, the location and size of towns, and the structural and local socio-economic and cultural factors.

The selected case studies used in the analysis represent towns with different industrial profiles in order to assess the complex network of small and medium sized industrial towns in Romania. So that, the first category of included towns refers to the mining urban centres. They constitute the category of small and medium sized industrial towns that registered the strongest negative impact of the industrial restructuring process, both economically and socially. Zlatna of Alba county is the selected town which developed based on metals exploitation, while Aninoasa and Petrila, both of Hunedoara county, were analysed under their coal mining development. The third case study of the analysis is represented by Azuga (Prahova county), specialized in the light industry, which was assesed in comparison with the socioeconomic dynamics of heavy industry towns.

RESULTS AND DISCUSSIONS

The impact of industrial restructuring on local development

This study focuses on the analysis of case studies from the category of small and medium-sized industrial towns in Romania, which first explored industrialization and further on different urbanization concerns. The urbanists and architects of the 1960-1970s in the small and medium-sized industrial towns in Romania had as inputs free land that offered multiple advantages but which, unfortunately, many times had not been capitalized and valued accordingly. The consequences of industrial restructuring are visible both economically, as well as socially, in local cultural life, in many small and medium-sized industrial towns in Romania.

The deep crisis in the small and medium industrial towns registered since the mid-1990s, as a consequence of deindustrialisation and the post-socialist transition: "The post-communist transition brought with it an increase in urban unemployment, an increase in general poverty, a land restitution process and the need for new adaptive strategies from the part of the transition losers" (Sandu et al., 2004, p. 1).

Generally, since 1990, these towns have concentrated their activities on small perimeters and the development of specialized services, which has led to the liberation of large land plots, which have sometimes been capitalized, but sometimes have not.

Zlatna

Zlatna is located in the depression with the same name located between the Metaliferi Mountains and the Trascau Mountains, being a small industrial mountain town. The presence of significant underground and soil resources has led to the development and socio-economic development of Zlatna, whose main focus related to mine extraction, non-ferrous metallurgy, wood exploitation and agriculture. The new economic requirements after 1990 assumed a reorientation of economic activities in terms of increasing economic efficiency, preserving the stability and viability of the town.

The industrial restructuring in the late 1990s and the closure of the two largest mining companies (Zlatmin SA) and the processing of non-ferrous metals (SC Ampelum SA, figure 1) in 2004 generated an economic and social decline, with disastrous consequences: massive layoffs, a real unemployment rate of about 80% of the active population at the beginning of 2005, a drastic drop in living standards and a steady decrease in the population from nearly 10 000 in the early 1990s to around 8 000 in 2017. In 2004, there was a maximum unemployment rate of 25.8%, due to the acceleration of the restructuring in the mining and metallurgical sectors, as well as the legislation on the compensatory payments in case of dismissal. Between 2004 and 2013, the unemployment rate oscillated, being years in which it has reached worrying levels proving the economic instability in the area. Since 2014, the unemployment rate has registered a downward trend, currently below 5.3%. The number of employees in the town of Zlatna had a strong downward trend between 1991 and 2016, down by around 65% during this period.

As far as the industrial activity is concerned, only a few workshops and production units were saved, which, following privatization, continued to operate. These units produce atomised aluminum products and pastes for autoclaved cellular concrete and aluminum powder and paints for paints and varnishes, with 40% of this production destined for foreign markets.

Figure 1. Decommissioning of the former S.C. Ampelum S.A. (2009)
Source: Elena Bogan

Figure 2. The Robydav footwear factory, located on the site of the former S.C. Ampelum S.A. (2017)
Source: Elena Bogan

Forest exploitation has also experienced a regression. Until the last decades of the 20th century, beech, oak, spruce, poplar and other species of forests for the production of sleepers, staves, rural constructions, pillars, fibreboards, cellulose, saw logs and rolling were exploited in the area to obtain other categories of products, as charcoal. Today, wood in the Zlatna forests and generally in the Apuseni Mountains is used in the few furniture factories opened in the locality.

At present, the main productive activities, the mining and the processing of non-ferrous ores have almost disappeared, which has caused radical changes in the potential of the locality. Industrial production is supported by several private companies in the field of chemistry, methane gas bottling, wood processing, food industry and textile production.

Many small and medium-sized companies (SMEs) with domestic and mixed or foreign capital were set up in Zlatna, including a lucrative Italian investment in footwear (figure 2), with various business objects. An important objective of the local authorities was in 2005 the setting up of an industrial park on the site of the former S.C. Ampelum S.A., but the project could not be materialized because it could not benefit from a Phare project worth 5.3 million euros, which they have won for the establishment of this industrial park. The cause was determined by insufficient financial resources for feasibility studies (Zlatna City Hall, 2005).

Out of a total of 145 active companies, 51% are micro-entrants, with a maximum of 9 employees and an annual turnover and / or annual total assets of up to EUR 2 million (the Trade Register Office in Alba, 2017).

Intervention of foreign capital, which is in its infancy, is almost insignificant. The economic activity is quite low, one of the reasons being the proximity to the city of Alba Iulia, which absorbs part of the available labor force, while the local entrepreneurs are more oriented towards commerce. The most important areas in which the registered companies operate are: the logging; processing and marketing of wood; furniture, carpentry, construction joinery; building construction; building materials; livestock farms; bakery; clothing; freight transport; hotels, motels and other means of accommodation; retail of various products (food and non-food); restaurants, bars. Of the total number of the existing companies in Zlatna, only a small part is related to industrial units, most of them operating in the sphere of trade and services. Moreover, almost all companies in this area, according to the registration office, carry out multiple activities of production, trade and services, often also with construction activities.

The declining population (Table 1), but with a working and technical potential, is available to start other activities, with young people being most affected by this situation. The decline in population incomes has led to a gradual decline in service activities. The gradually emerging private industrial activities could introduce new changes in the structure of active population and employees in the period ahead. The real chance for socio-economic revitalization in the depression is the organization of small private enterprises, craft centers based on the use of local resources, repair workshops and the development of tourism considering the tourist resources offered by the natural environment of the area.

Aninoasa

Aninoasa is one of the first settlements in the Petrosani mining basin in which mining perimeters were opened in 1885 (Munteanu and Ioniță, 1971 quoted by Merciu, 2011). Although with a long evolution of the coal mining activity, Aninoasa registered a strong industrial decline as a result of the restructuring economic process, being the first urban center in the Petrosani basin in which the mining activity was closed, namely in 2006. Being a small town (4 665 inhabitants in 2017) and with mono-industrial specialization, the negative effects on the demographic level were reflected in the decrease of the population, more pronounced in the 1990s, when the massive layoffs of the miners became more attenuated, especially in the last years (population growth rate between 2004-2014: -9.48). The decrease of the population in the last years is determined, on one hand, by the low birth rate and, on the other hand, by the migration (-16.71 ‰).

Table 1. Socioeconomic characteristics of small and medium sized industrial towns selected as case studies
Source: National Institute of Statistics, 2018

SMITs	Population growth rate (%) (2004-2014)	Migration rate (‰) (2014)	Share of employees in industry (%) (2014)
Aninoasa	-9.48	-16.71	34.65
Azuga	-7.27	-11.26	21.59
Petrila	-7.33	-9.43	36.25
Zlatna	-7.93	-1.27	34.08

It can be noticed that the town of Aninoasa retains a relatively large proportion of the employed population in industry (34.65%). This is due to the development in recent years of new industrial branches: the manufacture of road transport vehicles, trailers and semi-trailers.

From the point of view of alternative development prospects, Aninoasa does not present various opportunities. However, the mining site is a valuable cultural resource whose importance is conferred by technological, architectural, historical and cultural valences, for which it was proposed to transform it into a mining museum. The plan to transform the mining site into a museum resulted from the collaboration of representatives of the local public administration and a team of American mine engineers with experience in setting up an industrial site for museum purposes. The museum will consist of the following buildings: the extraction tower, the extraction machine house (figure 3), the electromechanical workshop (it will be used for receiving the visitors and as an exhibition space, figure 4), the rescue station, the explosive storage to be used as underground exhibition space), the mine access tunnel and the visit of a subterranean gallery on a length of 800 m.

Some mine buildings in an advanced state of decay due to age will be strengthened and refurbished. For the mining site to be redeveloped from the tourist point of view, work will be required for the internal redeployment of some of the buildings. For example, the electromechanical workshop will undergo an internal partitioning of the space, to create more of the different endings (visitor reception area, exhibition spaces). The extraction tower has already been reinforced (figure 5).

Figure 3. Extraction machine house (2014)
Source: Cristina Merciu

Figure 4. Electromechanical workshop (2014)
Source: Cristina Merciu

Figure 5. Aninoasa mine extraction tower (2018)
Source: Cristina Merciu

Although the project to convert the mining site as a museum space has been initiated, in recent years the lack of funds has not allowed the continuation of this action. However, there is a prospect of resuming this project by attracting non-reimbursable funds. Because the mining site has an extensive surface, it can be used to host various cultural and tourist activities: concerts, outdoor theater performances (these artistic performances can be supported by theater actors in the neighboring city or by independent theater groups). Urban regeneration actions that can be implemented through cultural activities have the role of transforming the abandoned Aninoasa mining site into a dynamic cultural space.

Petrila

The Petrila town with a population of 24 795 inhabitants is among the traditional mining urban centers in Hunedoara County, the first mining operations being opened in 1859 (Jujan and Svoboda, 2009, quoted by Merciu, 2011). The mining activity was closed in October 2015.

Unlike the town of Aninoasa, the mining activity has also taken place in recent years as a result of the fact that the Petrila mine was one of the large-scale exploitation areas due to the coal-rich resources. From a technological point of view, this was also exploited by building a coal sorting and preparation station (figure 6). In recent years, the coal sorting and preparation station has not worked.

Figure 6. Petrila coal mining and preparation station (2012)
Source: Cristina Merciu

Although the effects of industrial restructuring have, among other aspects, led to significant staff reductions in industrial activity, the town of Petrila has easily adapted to the current conditions rather than Aninoasa. This is due to the greater diversity of the local economy, since after 1990 the town of Petrila opened up to the tertiary sector. It is noteworthy that Petrila retains a relatively large share of the employed population in industry (36.25%) thanks to the extractive industry that operated until 2015. It is noticeable that although the town of Petrila records negative values of the population growth rate (-7.33%), or the migration rate (-9.43 ‰), these values are moderate. Referring to Petrila's development opportunities, it is important to highlight the prospect of granting value to the industrial heritage due to the complexity of the Petrila mining site (figure 7), on one hand because of the technological value conferred by the exploitation and processing methods (the sorting and preparation station of coal), but also from the point of view of the additional components they engage: eg. transport: The mine was also equipped with railway infrastructure elements to ensure the transport of coal to the production units (e.g. coke ovens, thermal power stations).

Figure 7. Petrila Mining Site (2014)
Source: Cristina Merciu

After the closure of the Petrila mine, the local public administration had the intention of demolishing the buildings forming the mining site. At the initiative of young architects, this future action was stopped and, moreover, they have developed the emergency file of the Petrila mine as a valuable industrial site.

Azuga

Azuga, a small town (4 794 inhabitants in 2017), is one of the urban centers located in the Prahova Valley mountain sector that did not have an early development of tourism. Azuga has been an industrial town, registered in the area of light industry since the nineteenth century (textile factory, glass production, food: the beer factory – figure 8, the Rhein-Azuga wine cellar), plus the factory of chamotte. Since the 1990s, the industrial restructuring process has affected Azuga's economy: the baize factory has been demolished, with the construction of a tourist, commercial and recreational base on that land; the glass factory, "SC STIAZ SA", was also demolished, and a residential complex will be built on that location.

The beer factory is no longer operational, the Azuga beer brand being purchased and licensed by a German company.

Figure 8. The beer factory Azuga (2004)
Source: Cristina Merciu

Azuga Wine Cellar (founded by the German Rhein in 1892) remains the only current industrial unit functioning in Azuga (Rădoi and Crângu, 1959). Before it became a champagne factory in 1903, the cellar functioned as a deposit for the bottling and the storage of wine at maturing. The Azuga champagne factory was the sparkling wine provider of the Royal Court, while also the Royal House domains were one of the shareholders. In 1998, the factory was bought by the British company Halewood International, owning the Romanian subsidiary Halewood România Vinuri SRL.

Azuga Wine Cellar is currently famous for the red wines it produces, as part of Dealul Mare-Valea Călugărească vineyard with a surface of over 140 hectares of vine. The sparkling wine produces here was also internationally rewarded (receiving a golden medal at Bruxelles, in 1999).

The massive reduction of the industrial activity contribution for the local economy gradually resulted in demographic negative consequences, especially related to the population decrease and the increase of outmigration. So that, the current demographic situation of Azuga is marked by the moderate negative values of the population growth rate (-7.27%) and of the migration rate (-11.26‰).

The recent economic dynamics of Azuga indicates tourism as a viable alternative for its development. The first tourist facilities of the ‘90s in Azuga were related to the creation of the ski domain on Sorica and Cazacu slopes. Together with the following tourist developments included in the “Superski in the Carpathians” program significantly contributed to declaring Azuga as a mountain resort of national interest in 2003.

Azuga Wine Cellar, which also benefits of a historical building, was included within the tourist attractios of the town as a space of promoting the traditional method („champenoise”) of producing the sparkling wine. The tourist program of the wine cellar includes: the visit of the cellars, the presentation of the wine technologies and the wine tasting of 5-6 sortiments, with lunch or dinner being included.

CONCLUSIONS

Industry is currently developed through the flexibility of localization, supply and sale points, partners and competition. Social and economic difficulties of small and medium sized industrial towns require the need to rethink their future industrial and tertiary development.

The findings of the study emphasize that, regardless their industrial profile that brought them national or even international recognition, small and medium sized towns of Romania require the improvement of their economic performance and new investments in order to consolidate a new economic identity resulting in increasing the local quality of urban life. The available development alternatives for small and medium sized towns are very different, depending on the regional context, but the exploitation of new local resources and the active involvement of all territorial actors, with a focus on the local community, represent the general action directions.

Industrial restructuring plays a key role within the dynamics of urban areas in Romania and the achievement of the process' objectives asks for solid institutional, juridical and financial instruments for the implementation of development strategies that are capable to create optimal economic and social structures for maintaining small and medium sized towns on the national economic map.

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LAND SURFACE TEMPERATURE IN PART OF SOUTH-WEST NIGERIA (1991 - 2015)

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Abstract: The study examined the spatial and temporal variation of land surface temperatures over a typical medium-size traditional settlement in southwestern Nigeria. Data were the multi-date satellite Landsat imageries (1991, 2002 and 2015) covering the area, as well as values of ambient air temperatures that were measured at different landuse areas (industrial, commercial, residential and outskirts) and along the major road that traverse the study area using a portable handheld air weather station thermometer. Ambient temperature values were obtained between 0600 and 1900 hours of the Nigerian local standard time. Analysis of the Landsat imageries indicate that thermal reflectance (in terms of normalized difference build-up index, NDBI) has generally increased between 1991 and 2015 by about 92 %. The NDBI shows that temperature has increased over the built up regions by 49 - 52 % between 1991 and 2015. Average land surface temperature (LST) in the area also increased by about 2.2 ºC (22.8 ºC - 25 ºC) in the study period, but with higher than average increase around road junctions, industrial and commercial centres. Analysis of diurnal variation showed that daytime temperature was about 0.5 - 1.4 ºC higher in the afternoon than either the morning or evening. The study concluded that increased in anthropogenic activities, including urbanization and commercialization are main causes of temperature increase in the traditional area, and that remote sensing imageries and in situ measurements of temperature are complementary for monitoring of changes in urban climate.

Key words: landsat imageries, land surface temperature (LST), traditional urban settlement, Normalized Difference Building Index

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INTRODUCTION

Rapid urban growth is an attribute of settlements in many developing countries (UNEP, 2002; Ichimura, 2003; Yuan and Bauer, 2007; United Nation, 2010). Many cases of urban growth are often defined in terms of population increase, land expansion, unmonitored constructions and depletion of vegetation as a result of increased extent of impervious surfaces (Herman, 2008, 2009, 2010). In general, many urban areas are characterized by modified microclimates and creation of urban heat islands, such that certain areas in the urban centres contribute to elevated air temperature increase of energy demands, and elevated pollution concentrations compared to rural surrounding areas (Oke, 1982; Voogt, 2002). Atmospheric and surface temperatures within urban environments are generally warmer than their peripheries, especially in areas with poor greening. This is due to the replacement of natural green surfaces with non-evaporative and non-porous urban materials with high heat capacity and low solar reflectivity, such as concrete masses, asphalt roads and metal surfaces (Rose and Devadas, 2009; Arrau and Pena, 2010). Studies have indicated that people residing in areas with intense temperature can be subjected to adverse health issues, including heat stroke, physiologic disturbances, among others (Besancenot, 2002; Luber and McGeehan, 2008).

Urban heat island is considered as one of the major problems in the 21st century posed to human beings as a result of human civilization (Lu et al., 2009). Accurate observation of surface temperature provides much information about surface climate thereby inputting to the general database of urban heat island studies. Apart from the temperature influences, the welfare and health of inhabitants could also be affected by local heat waves. More than 800 people died during the heat wave in Chicago in 1995 (Changnon et al., 1996). The hot summer in 2003 in Europe also caused 15,000 deaths due to heat related illness in Paris (Wright et al., 2005). Urban heat island will also cause increase in air pollutants. Urban heat island also increases the energy demand used for cooling. This in turn causes extra heat to be dumped into the urban area further exacerbating the urban heat island effect (Voogt, 2004).

Studies have indicated that traditional and growing urban areas have become increasingly vulnerable to increase in temperature and urban heat island, probably due to population increase and built up areas. While, most cities today exhibit heat island effects relative to predevelopment conditions, their individual intensities depend on a number of factors: geography, topography, land use, population density, and physical layout. Available studies have shown that in situ temperature data which are generally discontinuous and remotely sensed data that are typically continuous and ensure greater land coverage can be used complementarily. The aim of this study is to assess changes in temperature along the traverse of Ile Ife, a traditional urban settlement in southwest Nigeria. Specific objectives of the research are to examine the spatio-temporal variation of land surface temperature; and evaluate the difference in the in situ values of the temperatures and the values extracted from satellite imageries over the area.

STUDY AREA

GEOGRAPHICAL LOCATION, POPULATION AND LANDUSE

The study area is Ile-Ife, a university town in Osun State in the Southwest Nigeria (figure 1). Ile Ife is located within Latitude 7° 24' to 7° 33' North of the equator and Longitude 4° 27' to 4° 36' East of the Greenwich meridian. The total land area is about 218 kilometres square (NPC, 2006). Ile Ife is semi urban city (Obioh et al., 2005). Its population is estimated at about 600, 000 in 2016 (Popoola, 2017), an increase from the National Population Commission figure of 355,813 in 2006 (NPC, 2006). Ile-Ife is an ancient city which has witnessed immense growth in size of built-up areas, number of immigrants, transportation, and commercial activities with the pattern of land distribution shows that about 25.81% is used for residential Built-up purposes, while the remaining portions are shared for industrial 1.20%, commercial 0.79%, vegetation 61.16%, water body 0.15% and educational purposes 5.63%. Bare soil or unused or vacant land is 6.47% (Arodudu, 2008).

The centrally located Ife-Ibadan road, Ife-Ilesha and Ife - Ondo roads remains the most important centre of commercial activities in the town. The road also forms a node for a number of roads linking other nearby settlement. Tall buildings and tarred surfaces are found within the environment. The residential zone extends into the commercial zones and is densely populated around these main roads. The study area is undergoing rapid urbanization which is affecting the drainage system through unplanned development.

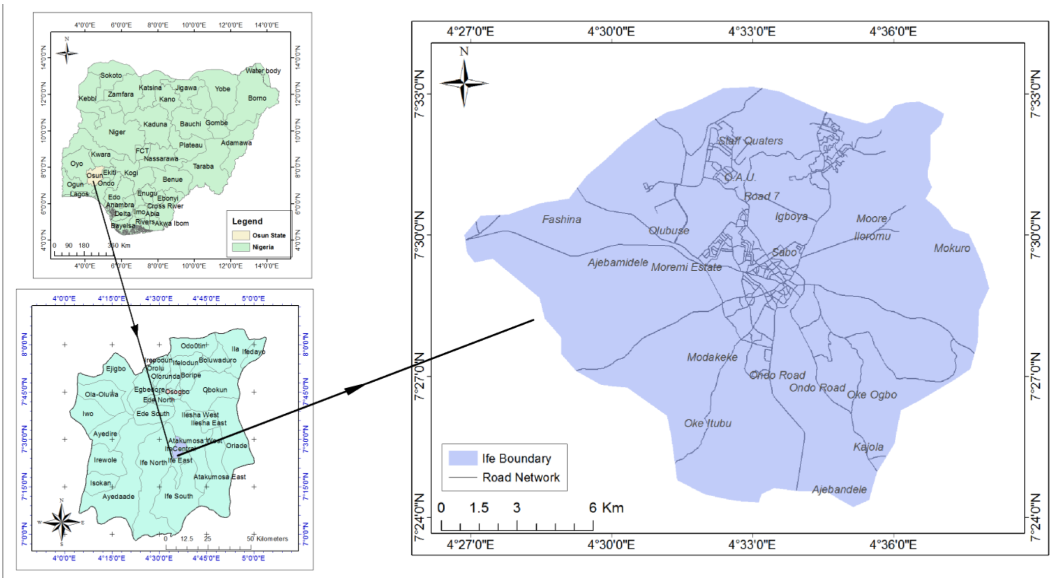

Figure 1. The study area, Ile-Ife in Osun State, southwest Nigeria

CLIMATE AND LANDUSE/COVER

Ile Ife is located within the rainforest ecological belt or tropical wet and dry climate (Eludoyin et al, 2014). The climate is is influenced by the monsoons originating from the South Atlantic Ocean, which is brought into the area by the maritime air mass. It is characterized by small (1-2 ºC) temperature range of 26 °C - 28 °C, average rainfall of 1250 mm per annum, and 75% mean relative humidity range. The pattern of rainfall is characterized by the double maxima regime, the two period of maxima rainfall being June/July and September/October. The vegetation is primarily of lowland rainforest and derived savanna. In most areas the natural vegetation has been replaced by secondary forest, perennial or annual crops (Mengistu and Salami, 2007), and many of the farm areas have become built up areas (Iyanda, 2017).

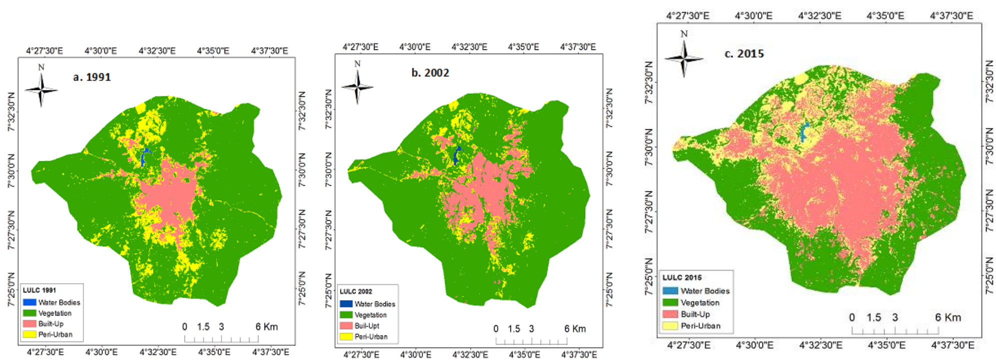

Figure 2. Land cover changes over Ile-Ife, Nigeria in 1991, 2002 and 2015

Land cover classes (water body, vegetation, built-up and peri-urban) around the study area have changed between 1991 and 2015. While areas covered by vegetation have decreased by about 32.7 %, the built-up area has increased by about 28.9 %; area classified as peri-urban and water body have slightly increased by 0.01 % and 4.1 %, respectively (figure 2, a, b, c). The spatial distribution of the built-up areas showed that the areas expand from the core (centre of the study area) towards the surrounding regions between 1991 and 2015. About 38 % of the vegetation has been converted to either the built-up area or peri-urban area within the period of study.

METHODS

DATA

Data used were values of ambient air temperatures of some selected geo-referenced points within the study area, measured with a portable handheld air weather station thermometer through traverse surveys method. Ambient air temperature values were recorded 100 m interval at road junctions and near major industrial, residential and commercial activities, along the main roads (Ibadan road-Mayfair, Mayfair-OAUTHC, Lagere-Ondo road) that traverse Ile-Ife, and air temperature values were measured before noon (0600-0800 Nigeria local standard time, LST), at noon (1100-1300 LST) and after noon (1700-1900 LST) hours. The time range of three hours for each period was to allow the period of moving from one sampling point to the other. The measurements were carried out, concurrently, with the help of field assistants at the different observation points. With the assistants, measurements were obtained between 20th and 22nd of December, 2015. Coordinates are obtained with Global Positioning System (GPS, ±10 m accuracy).

In addition, freely available multi-date satellite Landsat imageries (Landsat TM of 1991, Landsat ETM+ of 2002 and Landsat OLI of 2015) of the area were downloaded from the archive of the United States Geological Survey (USGS). Landsat-5 Thematic Mapper (TM) image (acquired by the USGS on 5th January 1991), Landsat-7 Enhance Thematic Mapper (ETM+) (acquired on December 12th 2002) and Landsat-8 Operational Land Imager/Thermal Infrared Sensor (OLI/TIRS) (acquired on January 5th 2015) are part of the few sensors whose imageries are free for users, especially in developing countries where students and researchers rarely find sponsorship. Table 1 shows the attributes of the Landsat imageries used for this study.

Table 1. Some characteristics of the Landsat imageries used in this study

Satellite/Space craft ID	Sensor ID	Path/row	Date of Acquisition	Spatial Resolution/ Grid Cell Size (m)	Sun Elevation (Degree)
Landsat-5	Thematic Mapper	190/055	1991-01-05	30	43.74
Landsat-7	Enhance Thematic Mapper Plus	190/055	2002-12-12	30	48.66
Landsat-8	Thermal Infrared Sensor	190/055	2015-01-15	30	56.45

ANALYSIS

The imageries were geo-processed, separately and re-georeferenced for local referencing of the features using ArcGIS 6.3 software to correct for radiometric and geometric errors. Subsequently, the Normalized Difference Built-up Index (NDBI, one of the widely used indices to extract the built-up land from the urban area; (Lu et al., 2009) and Land Surface Temperature (LST) over the study area were determined. The NDBI index was developed by Zha et al., (2003), to analyze increments of reflectance on TM 5 and ETM+ 7 bands 4 and 5 while band 6 and band 5 of reflectance on OLI/TIRS 8 for images of urbanized and barren land areas. NDBI in this study was were derived using equation (1)

NDBI**Error! Reference source not found.** (1)

This index was created on the assumption that the reflectivity of urban buildings in the shortwave is higher than in the near infrared (Lu et al., 2009). The processes were performed for the years of 1991, 2002 and 2015. Land Surface Temperature was thereafter determined using the mono-window algorithm (Zhang et al., 2009), following equations 2 a-e.

$$LST = \frac{BT}{1+w} \times \frac{BT}{p} \times In(e) \qquad (2a)$$

$$p = h \times \frac{c}{s}\left(1.438 \times 10^{-2} mK\right) \qquad (2b)$$

$$e = 0.004Pv + 0.986 \qquad (2c)$$

$$Pv = \left(\frac{NDBI - NDBI_{min}}{NDBI_{max} - NDBI_{min}}\right)^2 \qquad (2d)$$

$$NDBI = \left(\frac{MIR - NIR}{MIR + NIR}\right) \qquad (2e)$$

Where
BT = At-sensor brightness temperature
w = wavelength of emitted radiance
h = Plank's constant $(6.626 \times 10^{-34} Js)$
s = Boltzmann constant $(1.38 \times 10^{-23} J/K)$
c = velocity of light $(2.998 \times 10^{8} m/s)$
e = LSE
In = Natural Logarithm
L_λ = Spectral Radiance at the Sensor's Aperture [W/(m^2sr μm)]
Pv = Proportion of Vegetation
MIR = Mid Infra-Red Band
NIR = Near Infra-Red Band
$NDBI_{min}$ = Minimum value of NDBI
$NDBI_{max}$ = Maximum value of NDBI

RESULTS

DIURNAL VARIATIONS LST VALUES

The temporal variation of temperature values at different road junction of the land use/cover, along the major road indicate that LST values at 0600 and 1900 hours varied over time and space (table 2).

Table 2. Mean, variation and range of ambient surface temperatures along major roads in Ile-Ife, Southwest Nigeria (in December 2015)

Road	Morning 0600-0800 hr	Afternoon 1100-1300 hr	Evening 1700-1900 hr
	Mean ± SD (ºC) (Min- Max)	Mean ± SD (ºC) (Min-Max)	Mean ± SD (ºC) (Min-Max)
Ibadan - Mayfair	29.1 ± 0.4 (28.5 - 29.8)	44.9 ± 0.9 (43.1 - 45.8)	34.4 ± 0.3 (34.0-35.1)
Mayfair - OAUTHC	29.6 ± 0.5 (28.7 - 30.6)	46.6 ± 0.8 (45.6 - 47.3)	36.0 ± 0.9 (34.2-36.8)
Lagere - Ita Osa	28.7 ± 0.9 (26.9 - 29.9)	44.3 ± 1.7 (41.4 - 46.5)	35.3 ± 0.6 (34.2-36.0)
Overall average	*29.1±0.6 (26.9-30.6)*	*45.21±1.1 (43.1-47.3)*	*35.2±0.6 (34.0-36.8)*

At 0600-0800 hr, Mayfair-OAUTHC recorded the 29.6 ºC, and by 1100 - 1300 hr, this increased to an average of up to 46.6 ºC, and later 36 ºC at 1700-1900 hrs. Temperature also varies at different land use/cover in the study area with motor parks exhibiting higher temperature values than the other landuses, especially in the morning (figure 3). Temperatures were also higher at traffic-busy junctions (such as opposite the Teaching Hospital, and commercial areas, Sabo and Lagere, than the residential areas (Ita-Osa) at all the periods investigated. in the three periods.

CHANGE IN LST BETWEEN 1991 AND 2015

Average LST values were 22.8 °C, 23 °C, and 25.8 in 1991, 2002 and 2015, respectively (figure 4). Average temperature was highest at the peri-urban in 1991 (25.9 ºC), and at the built-up area in 2002 (28.7 ºC) and 2015 (27.8 ºC). The vegetal surfaces and water bodies recorded the least values of temperature in the three years. The spatial variations of LST within the study area indicate temperature increase from the nucleus of the town towards the outskirts over the period of the study. Hotspots, indicating the thermal urban heat surface occurred at the core of the settlement, and more hotspots developed with the increase in years (i.e. more hotspots occurred in 2015 and 2002 than in 1991).

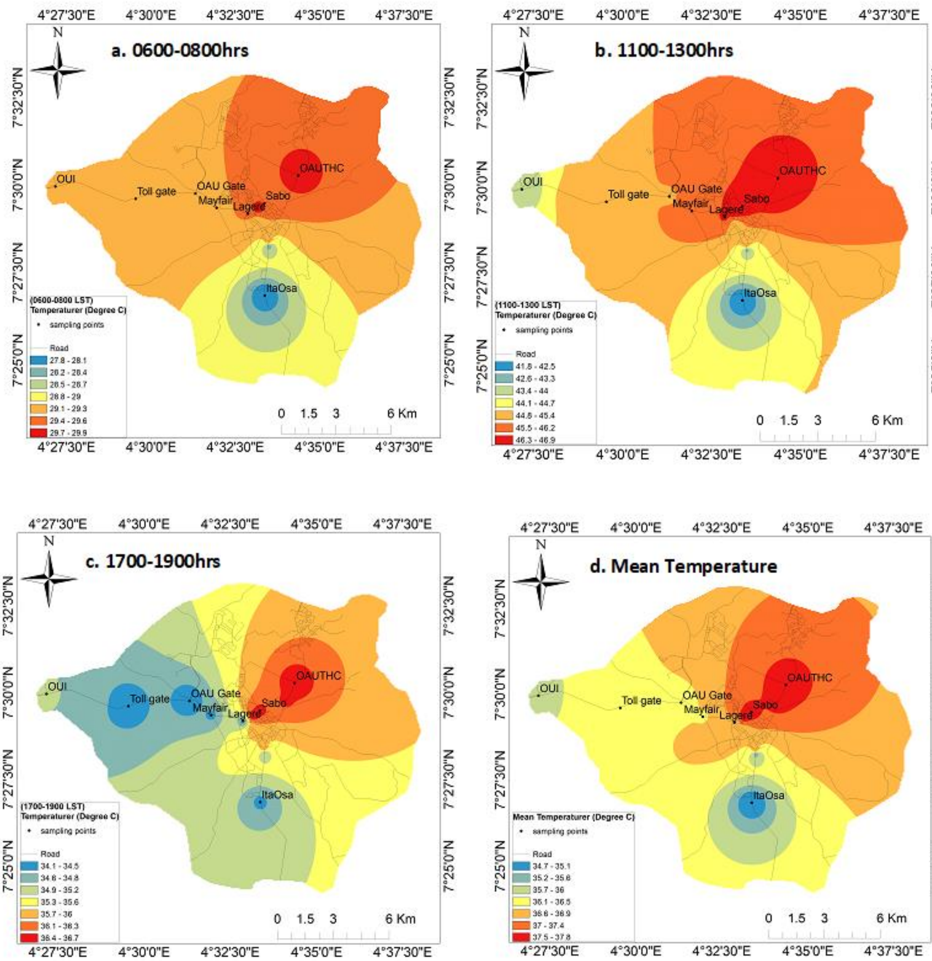

Figure 3. Temporal variations of ambient temperature on a typical day in December 2015

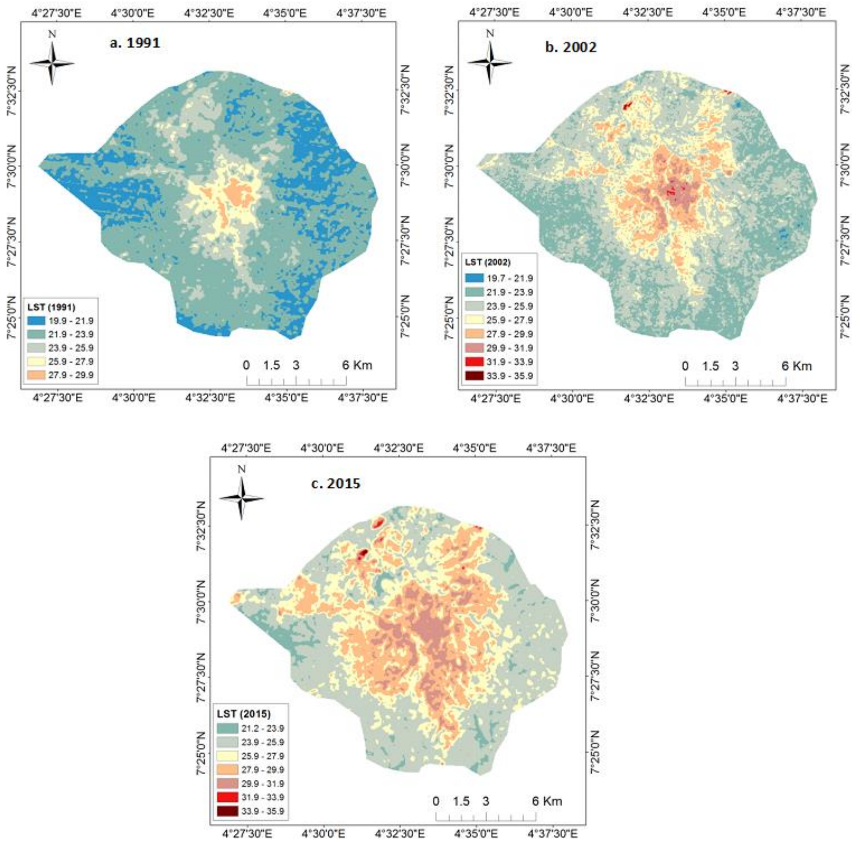

Figure 4. Temporal and spatial variations in land surface temperature (°C) over the study area in 1991, 2002 and 2015

Land surface temperature also increased temporally in the study area from 1991 to 2015 with a maximum LST value of 29.0 °C at 1991, 31.7 °C and 30.7 °C for 2002 and 2015. It is projected that by 2026 and 2038 the maximum LST will have a maximum temperature of 32.5 °C and 34.9 °C (table 3). The spatial distribution of LST indicate that by 2026 the LST is expected to be concentrated at the commercial area around the north east of the study area while by 2038 it is expected to have increase and concentrated at the north west an industrial area where smelting industry is located.

Table 3. Mean, standard deviation and range of ambient air temperature values at different land use/cover in the study cover

Land use/cover	Morning 0600-0800 Nigerian local standard time (NLST)	Afternoon 1100-1300 Nigerian local standard time (NLST)	Evening 1700-1900 Nigerian local standard time (NLST)
	Mean ± SD (°C) (Min- Max)	Mean ± SD (°C) (Min- Max)	Mean ± SD (°C) (Min- Max)
Residential	28.7 ± 0.4 (28.5 - 29.8)	44.0 ± 0.9 (43.1 - 45.8)	35.4 ± 0.3 (34.0-35.1)
Motor Park	29.6 ± 0.5 (28.7 - 30.6)	46.8 ± 0.8 (45.6 - 47.3)	36.5 ± 0.9 (34.2-36.8)
Industrial	28.7 ± 0.9 (26.9 - 29.9)	43.9 ± 1.7 (41.4 - 46.5)	34.7 ± 0.6 (34.2-36.0)
Road Junction	29.3±0.6 (28.0-30.1)	45.2±1.1 (43.4-46.5)	35.0±0.6 (34.1-36.0)
Commercial	29.5±0.5 (29.0-29.9)	46.4±0.1 (46.3-46.5)	35.8±0.2 (35.6-35.9)

CHANGE IN NDBI VALUES BETWEEN 1991 AND 2015

The Normalised Difference Built-up Index (NDBI) - that was used to examine the land use / cover change that can be attributed to construction or concretisation of surfaces in the study area – indicated that mean NDBI values increased both temporally and spatially within the study period (figure 5). Mean NDBI values varied from 0.04 (0.07) in year 1991, through 0.09 (0.1) in 2002 to ─0.07 (0.07) in year 2015, and the temporal spread exhibit a polynomial relationship over the study period. The polynomial relationship indicates that the average NDBI values increased in 2002 from 1991, but declined from 2002 till 2015.

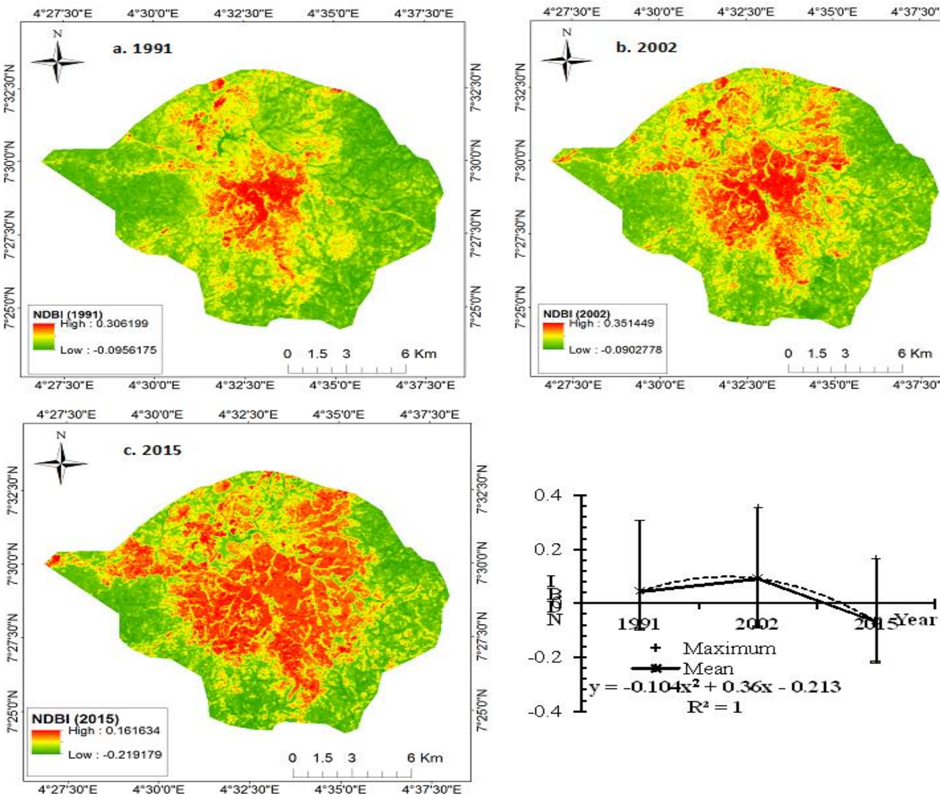

Figure 5. Spatio-temporal variations in the NDBI values around Ile-Ife in 1991, 2002 and 2015

The spatial distribution of the NDBI values showed that they increase from the central part of the study area towards the outskirts. A statistical comparison of the total area coverage (in ha) of built-up areas and corresponding NDBI values in the studied period indicate that about 85% of the change in the built up area was explained by the NDBI values in equation (3)

$$y = -45919x + 5736.9 \quad (R^2 = 0.85) \qquad (3)$$

y = built-up area (ha)
x = NDBI values (no unit)

Comparing the spatial and temporal land surface temperature which is a determinant of surface urban heat island and the in-situ air temperature measured a determinant of canopy urban heat island at various land use/cover of the study area. Table 4 indicates that the average temperature varies at different land use/cover, and that the values derived from the Landsat data were less than that from the in situ recording by about 5 – 8 °C. The graphical representations of both data also reveal variation in the spatial distribution of the heat islands (figure 6). Whereas the imagery indicates higher temperature values at the northwest region of the study, the study area indicates that the northeast exhibited higher temperature than the surrounding.

Table 4. Comparison of the temporal variation of surface-based LST (derived from Landsat 8) and ground based LST (based on ambient temperature values) over Ile-Ife in 2015

Land use/cover	Ground-based LST	Surface-based LST
Residential	36.1	29.9
Motor Park	37.6	29.4
Industrial	35.8	29.6
Road Junction	36.5	28.4
Commercial	37.1	30.1

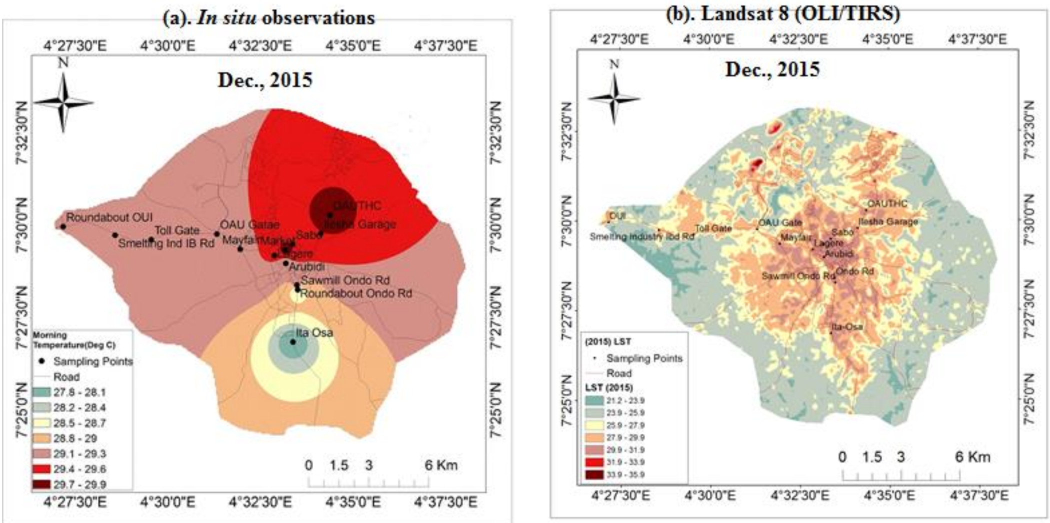

Figure 6. Comparison of the spatio-temporal distribution of land surface temperature from in situ observations and Landsat (OLI/TIRS) imagery in December, 2015

DISCUSSION

Land surface temperatures obtained at the commercial areas and junctions of major roads in this study were higher than those of the outskirts. This result is expected as such has been observed in many region with similar characteristics. For example Aboyeji (2015) noted that road junction in a study of Ilorin, Nigeria often exhibit higher concentration of carbon-oxide gases due to the emission from transport facilities. In addition, Aknbode et al., (2008) attributed temperature increase at commercial centres at a medium size administrative city of Akure, Ondo State, also in the southwest Nigeria to increased human activities in the area. Commercial cities in many African countries are often characterized with higher (than the surrounding areas) population movements, vehicular movements and relatively higher number of buildings (often used for offices, shops and residential purposes). The commercial areas in the study area are also characterized by buildings whose thermal properties are also capable of increasing the temperature of the area. The result of the remote sensing analysis of the Landsat imageries examined in this study indicate that thermal reflectance (in terms of normalized difference building index) has generally increased between 1991 and 2015 by about 92 %.

The NDBI shows that temperature has increased over certain areas (especially Built up, Peri-Urban, Vegetation and Water bodies) at Ile-Ife by about 49-52% in the 34 years range examined. Increase temperature is often attributed to increased population activities, urbanization and climate vulnerability (Voogt and Oke, 2003). Although the specific cause of the increased temperature was not focused in this study, it is known that population and population activities, impervious surfaces and temperature activities have increased in the town within the study period (Oyinloye and Adesina, 2011; Oloukoi et al., 2014). Existing studies of the climate has also reported an increase in the maximum temperature by about 5-10 °C (Voogt, 2002; Voogt and Oke, 2003). Diurnal variation in this study showed that daytime temperature was about 0.5 - 1.4 °C higher in the afternoon than either the morning or evening.

In general, the difference between the lowest temperature and highest temperature, 29.3 °C, 35.9 °C and 35.5 °C, from the remote sensing images for the periods of 1991, 2002 and 2015, and for 2015 (from the ground based results) indicates that 37.8 °C. The variation indicates that the UHI in the study area compares well with those of bigger cities in Nigeria (e.g. Ibadan 3-5 °C, Adebayo, 1990); Benin City 3-4 °C (Omogbai, 1985) and Akure: 3-5 °C (Akinbode et al., 2008). The regression based prediction indicates that hotspots of high temperature will increase towards either parts of the town including a junction of a tertiary hospital in the town (OAUTHC).

The spread of hotspots for temperature increase appears to be explained by the multiple-nuclei model of city arrangement hypothesized by Hoyt (1933). Hoyt (1933) hypothesized an explanation of city development in which a place is characterized by more than one nucleus for development. In Ile-Ife there seem to be a more than one nucleus focus, which may also be linked with or developed from the pre-colonial communal governance method in the region. Ile-Ife, the traditionally acclaimed origins of the Yorubas was sub-grouped into subsections (Akodi) of communities which were under a royal head (Ooni). This arrangement, with the location of the Obafemi Awolowo University at core extreme and the teaching hospital at the other; with the communally valued commercial centres, has translated to multi-nuclei arrangement. The multiple nuclei arrangement is similar to the distribution of temperature hotspots in the area.

Furthermore, the result of the comparison of the ground based temperature with the remote sensing based analysis shows that spatially, the remote sensing based temperature LST thermal urban heat surface is observed to be concentrated at the north east of the study while the ground based temperature hotspot is observed to be concentrated at the north west of the study. Lastly the study, from the results of the comparison of the LSTs showed that the values derived from the imagery do not replace that of the in-situ observations. Whereas the analysis of the imagery reveals the surface urban heat islands (SUHI), which are often most intense during the day when urban materials receive the most solar radiation, and are not heavily influenced by the anthropogenic heat sources such as transportation vehicles or heating and cooling units (Shahmohamadi et al., 2011), the atmospheric urban heat islands (AUHI) reveals the elevation in near-surface air temperature of an urban area over that of nearby rural areas, and are often not more intense at night due to a gradual release of heat from urban surfaces and water bodies (Voogt and Oke, 2003). The difference in their values could also be explained by the effect of difference that can be associated with anthropogenic sources, and vegetation. Vegetation are known to reflect about part of the incoming short-wave radiation (visible light or short- wavelengths) and provides less radiant energy to me detected by image sensors (Xian and Crane, 2006; Hoffmann and Sgrò, 2011).

CONCLUSIONS

The study concluded that Land surface temperature increased by 2.2 °C between 1991 and 2015 in the study area, and that the temperature increases can be attributed to urbanization. It also showed that LST values from satellite imagery and in situ measurements are provide complementary results, and do not duplicate the other. The study recommends urban greening to reduce the impact of future temperature increase in the area. This study is typical of urban cities in Nigeria, and developing countries, where it can be replicated.

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HEALTHY LIVING AND ENVIRONMENTAL SANITATION PRACTICES IN AKUNGBA-AKOKO, NIGERIA: ISSUES AND CHALLENGES

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Abstract: This paper examines sanitation practices in Akungba with a view to determining it implication on healthy living. The basic data set for the paper was collected using a structured questionnaire administered on selected household in Akungba. Simple percentages and correlation analysis were used to summarize data. The study revealed that diverse ill-health abounds in the study area. However, malaria, cough and catarrh have the highest proportion 54.2% and 23.3% respectively as a result of the observed inter-relationship between increased malaria parasites. Majority of the residents of Akungba do not have access to basic infrastructure. Sanitation condition in Akungba is not up to expectation, people have poor attitude towards sanitation which could be reasons for ill health among residents. The study recommended that government should engage in vigorous environmental sanitation education and implement the environmental sanitation bye-laws.

Key words: Sanitation, bye-laws, aliment, healthy living and pollution

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INTRODUCTION

Environmental sanitation is set of actions geared towards improving the quality of the environment and reducing the number of diseases in the area of management of water, solid and industrial waste as well as pollution and noise control Lawal and Basorun, 2015. World Health Organization (2006) describes sanitation as a package of health-related measures and of the view that every human should have a healthy and productive life in harmony with nature because in tragically degraded environment, human health is threatened. Poor sanitation and unhygienic behaviour led to the launching of "War Against Indiscipline" by Major Gen Tunde Idiagbon who said that slums and ghettos were the incubators of epidemic diseases that pose danger to human health. Similarly, problems of mortality, morbidity and poverty have been reported in the literature as consequences of poor sanitation coverage (Madise et al., 2012; WHO, 2010). The relationship between human and the environment is reciprocal in that the environment has the profound influence on human and at the same time human extensively alter the environment to suit their needs. Some of these changes create new hazards; the human attitudes towards the environment are still negative and are often contrary to the concept of sustainable development (Herman, 2008, 2009; Ianoș et al., 2009; Mac, 2003). Sadalla et al., (2001) noted that the environmental problems

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may be caused by inadequate provision of facilities and residents behaviour in communities. He emphasized the importance of education in achieving the goal in environmental sanitation; he stressed strategies such as sensitization, information and motivation.

Several efforts have been made by the state government to ensure that the city is always clean. It has engage the services of private waste management companies to ensure that major streets are always cleaned and also ensure that communal dumpsters are emptied regularly. Coupled with these are the provision of new sanitation facilities and the maintenance of old ones. However the behaviour and attitude of people towards sanitation do not augment this effort. People do not seem to care about good environmental sanitation practices as a result National Environmental Policy spells out the guidelines and gives power to the local government to promulgate bye-laws to address environmental issues in their locality in an effort to reduce environmental pollution. It also gives power to the judiciary to establish and empower community Tribunals to prosecute offenders against this sanitary bye-laws and regulations. It is against this background this study access the knowledge and attitudes of the people toward various sanitation practices such as liquid and solid waste disposal, water supply and drainage system on state of health of people in the study area and a sustainable healthful environment.

CONCEPTUAL CONSIDERATIONS AND RELEVANT LITERATURE

The importance of healthy environment and socio-economic development cannot be overemphasized. Access to adequate sanitation is part of the Millennium Development Goals of reducing poverty. However, abnormally low levels of access to adequate sanitation by a large proportion of humanity have been reported (Smith and Marin, 2005). Environmental sanitation comprises a number of complimentary activities including the provision of and maintenance of sanitary facilities, safe excreta disposal; solid and medical waste management (Afon, 2006). However the pattern of waste management could create environmental problem. Schertenleib et al., 2002 define sanitation as interventions to reduce people’s exposure to diseases by providing a clean environment in which to live and with measure to break the cycle of disease. Wherever human gather their wastes also accumulate. In Nigeria, 52 percent of the populations do not have access to adequate sanitation (UNDP, 2009, UNICEF, 2005). Access to adequate sanitation prevents the spread of sanitation related diseases. In developing countries lack of adequate sanitation often result in about two million infant deaths annually (Cosgrove and Rijsberman 2003, Gomez and Nakat, 2002). Yet many people still have no adequate means of appropriately disposing their waste. Environmental sanitation therefore involves controlling the aspect of waste that may led to the transmission of diseases.

Environmental sanitation management requires the assignment of responsibilities to specialized institutions (Benneh, 2007) argues that the successful management of environmental sanitation in any country depends to a large extent on the effectiveness of the institutional arrangement put in place by government for the management. The two management strategies that could be adopted to improve environmental sanitation are behavioral management sanitation and regulatory management. These strategies involve activities that would ensure that people understand the consequences of poor environmental sanitation practices. The regulatory management involves activities that would ensure that people comply which can be achieved through enforcement of sanitation regulations. There are different ministries involve in environmental sanitation. The Environmental Protection Agency is a leading body responsible for protecting and improving the environment. It job is to ensure that air, land and water are looked after by everyone in today’ society so that tomorrow generation inherit a cleaner and healthier world (Vodounhesis, 2006).

As part of government debate concerning participation, there are by-laws and punishment and fines meted out to defaulters (Amoaning, 2006) since the most valuable resources is the human resources base. Consequently the protection and enhancement of the health and well-being of the people constitute a major responsibility of the government. By their individual and collective behaviour human make significant positive or negative impact on the natural resources. Environmental sustainability will be impossible unless human numbers and resources demand level off within the carrying capacity of the Earth. Since the major objective of the natural environmental policy is to encourage measures which sustain a balance between population and environment, inter-sectorial cooperation involving all tiers of government is envisaged.

THE STUDY AREA

The study area is Akungba-Akoko, Ondo State, Southwest Nigeria (fig. 1, 2). Akungba Akoko lies between latitude $7^0 21^1$N and $7^0 31^1$N and longitude $5^0 22^1$E and $5^0 30^1$E, surrounded by Supare- Akoko (in the West), Iwaro-Oka (East), Ikare-Akoko (North) and Oba-Akoko (South). The inhabitants of the study area are mostly Yoruba's and the population as at 2006 was 21,200 (NPC, 2006). At present the Town is said to have population of over 30,000 people. Since the establishment of the university in 1999, there has been massing of people and activities in the Town. The Town morphology has changed over time to assume its present status as university town with its attendant sanitation condition problems. It is located within the tropical rainforest region where rainfall is high throughout the year. The influence of Akungba as University Town has promoted its rapid growth and increased socio-economic activities.

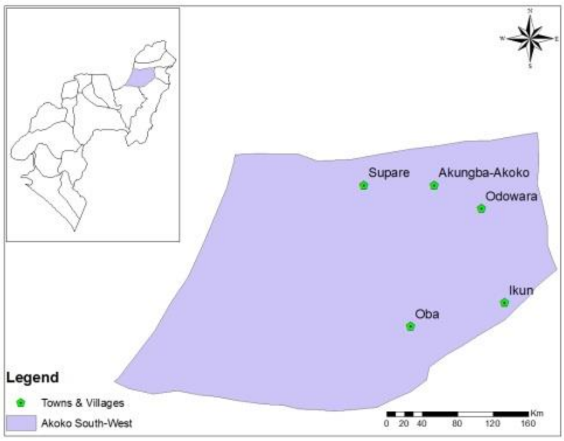

Figure 1. Map showing the situation of Akungba-Akoko in Akoko Southwest. Local Government Area (LGA). Inset is the map of Ondo State, showing the location of the LGA

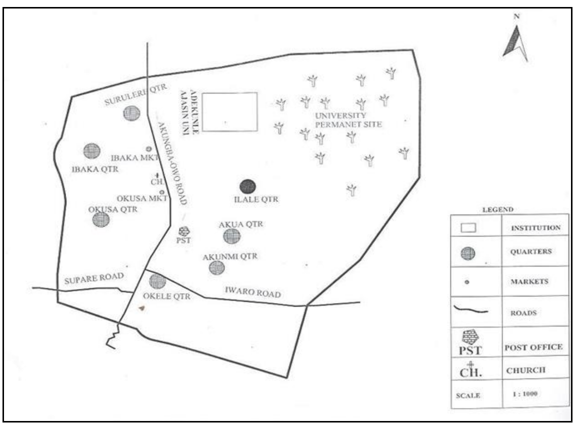

Figure 2. Map of Akungba-Akoko showing major streets and quarters
Source: Ministry of Lands and Housing, Akure, Ondo State

DATA AND METHODS

The scope of this article requires a comprehensive data containing variables on the economic, social and demographic variables of households as well as indicators of sanitation and health condition characteristics including their accessibility to sanitation and health facilities in the study area. The basic data set utilized for this paper was collected using a structure questionnaire administered to selected residents in Akungba. Systematic sampling technique was used to select buildings at interval of every fifth building in street. In all a total of 288 questionnaires were administered in the Town. Appropriate statistical techniques including frequency tables and percentages were used to explain the results of the study. Focused Group Discussions (FGDs) held in six different purposively selected residential areas in the Local Government-Ilale and Akua; Okusa and Ibaka; and Araromi and University area for the Low, Medium and High Class residential areas respectively as seen in table 1.

Table 1. Classification of Residential Area
(Data source: Author field work 2015)

FGD Theme	Residential Districts	Study Areas
Environmental Characteristics of Respondents	Low Class Residential Areas	1. Ilale 2. Akua 3. Akunmi
	Medium Class Residential Areas	1. Okusa 2. Ibaka 3.Surulere
	High Class Residential Areas	1. Okele 2. Araromi 3. University area

The Low Class Residential Areas (LCRA) is highly congested indigenous areas with poor quality housing. These areas are typical of old Akungba. Most of the residents of these districts are either partially literate or total illiterates and they are in the lowest strata of socio-economic status among the three categories of the residential districts. They belong to the lowest income group earners. Environmental quality is also very poor in these districts, with very narrow roads, unacceptable refuse sites and poor drainages.

The Medium Class Residential Areas (MCRA) is moderately congested areas with relatively fair housing quality. Residents here are economically better, with a bit higher literacy level than the residents of the LCRA. Also, the environment is a bit finer with better drainages and organized refuse sites.

The High Class Residential Areas (HCRA) is properly planned residential estates with good quality housing. This district comprises planned quarters. The inhabitants are unarguably the highest income earners and are top businessmen and professionals who belong to the upper class in the society.

RESULTS AND DISCUSSIONS OF FINDINGS

SOCIO - ECONOMIC CHARACTERISTICS OF RESPONDENTS, INFRASTRUCTURE AND SANITATION CONDITION IN AKUNGBA

Table 2 depicts the pattern of the income structure of the respondents as obtained from field investigation. It is evident from Table 2 that a high proportion of the respondents 75.6% earn below #15,000 monthly. It can be inferred that majority of the respondents are low-income earners, while about 20% are middle-income earners. The remaining 4.6% of the sampled population are therefore under the high-income group. This result shows that majority of householders or residents of the study area are low and medium income earners. This pattern of income distribution has a lot implication on residents’ ability to access adequate sanitation.

Table 2. Income Profile of Respondents
(Data source: Field Survey 2013)

Income (Naira)	Freq	%
Below #15,000	211	75.6
#15,001-#50,000	60	19.8
Above #50,000	17	4.6
Total	288	100

Some infrastructure sample in respondents' house was used for this study. Some of those considered were as follows: mode of waste disposal, water supply and availability of toilet. On method of refuse collection and disposal in the study area, the Waste Management Authority is responsible for collection and disposal of waste form 31.2 percent of all buildings in the city (Table 3) 55.1 and 11.8 percent of waste generated in Ondo state are disposed-off by dumping them on dump site and by burning them respectively. These methods are not only unhealthy but destroy and pollute the environment.

Table 3. Mode of Solid Waste Disposal
(Data source: Field Survey 2013)

Method of disposal	No of House	%
Waste management van	90	31.2
Burning/Incineration	34	11.8
Dump site	159	55.1
Others	5	1.8
Total	288	100

Table 4. Type of Toilet Facilities
(Data source: Field Survey 2013)

	Freq	Percent
Water Closet	102	35.38
Pit Latrine	119	41.31
None	67	23.25
Total	288	100

Another parameter taken into consideration in the study area is types of toilets. Table 4 shows that the highest percentage (41.31) of building in the study area is provided with pit latrine. This is closely followed by water closet which accounted for 35.38 percent. It is evident from the Table that 23.25 percent lack any form of toilet facilities. The fact that 35.38percent of buildings in the city and another 23.25 percent of all buildings do not have any form of toilet facilities indicate that majority of buildings in the study area lack toilet facilities and many residents of the city will defecate anywhere, causing environmental problems.

Table 5 shows the major sources of water supply in Akungba. Analysis of the Table shows that majority of the residents of the city depend on wells for their water supply. This constitutes 65.7 percent. This is followed by those categorized as others 19.5 percent which include springs, brooks, rain, and streams and in some cases public tap. Boreholes and pipe-borne water accounted for 6.0 and 8.3 percent respectively. The State government had provided boreholes for many of the towns and villages in the local government but the ground trotting information showed that more than 70% of the boreholes were no longer functioning, as a result of poor maintenance. The implication of this is that majority of the residents in the study area depends on water supply from unsafe sources thereby lowering the quality of urban life.

Table 5. Source of Water Supply
(Data source: Field Survey 2013)

	Freq.	Percent
Pipe Borne Water	23	8.3
Boreholes	17	6.0
Wells	189	65.7
None	56	19.5
Others	3	0.4
Total	288	100

VARIATIONS IN HOUSING/ENVIRONMENTAL CHARACTERISTICS OF RESIDENTIAL DISTRICTS IN AKUNGBA

There are clear variations in terms of type and quality of houses located in Akungba and the number of occupants per room also varies from one residential district to the other. Based on the Focused Group Discussion, The Low Class Residential Areas (LCRA) such as Ilale and Akua are predominantly dominated by face to face traditional buildings which are characterized by tightly packed together buildings with extremely poor ventilation, bad drainage system and poor environmental sanitation. See Table 6. It is obvious during the FGD, that there is an average of three persons per room in the LCRA. The field survey revealed that the Medium Class Residential Areas (MCRA) such as Okusa and Ibaka comprised a mixture of flats and face to face traditional buildings system. Features such as ventilation, drainage and environmental sanitation are averagely fair in these places and an average of two persons per a room is a common practice in this area.

Table 6. Housing/Environmental Characteristics of Residential Districts in Akungba
(Data source: Field Survey, 2015)

Residential Districts	Residential Areas	Defecation Methods	Sources of Water	Solid Waste Disposal Methods	Drainage	Sanitation
Low Class Residential Areas	1. Ilale 2. Akua	Pit toilet Pit toilet	Well Well	Dumping/Burning Dumping/Burning	Very bad Very bad	Not neat Not neat
Medium Class Residential Areas.	1. Okusa 2. Ibaka	Water closet/pit toilet Water Closet/Pit toilet	Well/borehole Well	Dumping/collected Dumping/burning	Fair Fair	Fair Fair
High Class Residential Areas	1. Araromi 2.Varsity area	Water Closet Water Closet	Pipe-borne/bore-hole Pipe-borne/bore-hole	Collected Collected	Very good Very good	Very neat Very neat

Note: 'Dumping' in table 6 above means dropping solid wastes in unapproved places, while 'Collected' means packing them at designated points for onward movement to where they will either be recycled or buried.

The case of the High Class Residential Areas (HCRA), especially University area is totally different as it comprises mixtures of modern blocks of flats, detached bungalows and mansions with extremely aesthetic environment, good ventilation and very good drainage system. Also, an average of one person occupies a room here. Research has revealed that ventilation, drainage, environmental sanitation, type of house and number of occupants per room bring about variation in outbreak of diseases from place to place. It is not amazing therefore while outbreak of diseases is common in the Low Class Residential Areas such as Akua and Ilale and scarce in the High Class Residential Areas based on the discussions held. This means that with regard to these points of discussion, more diseases outbreak recorded from the LCRA due to poor sanitation practices.

HEALTH OF RESPONDENTS AND ENFORCEMENT OF SANITATION LAWS

In addition to the parameter discussed above, other parameters used are ailments commonly treated by respondents were examined in order to ascertain if poor sanitation attitude have impact on health status of the populace in the study area.

Table 7. Aliment recently treated by respondents
(Data source: Field Survey 2015)

	Freq	**%**
Malaria	156	54.2
Cough & Catarrh	67	23.3
Diarrhea	33	11.5
Typhoid	18	6.3
Others	14	4.9
Total	288	100

Malaria ranked the highest percentage of ailment commonly treated by respondents. It is evident that cough and catarrh accounted for 23.3% of the sampled population. While diarrhea and typhoid accounted for 11.5% and 4.9% respectively. Health constitutes an essential aspect of socio-economic development and a major component of the quality of life as well as a pre-requisite of high level productivity. Therefore the need for adequate sanitation is essential. The correlation between residential districts of respondents and reported ill-health is shown in Table 8.

Table 8. Correlation between Residential Districts and reported ill-health
(Data source: Field Survey 2013)

	Malaria	Cough & Catarrh	Diarrhea	Typhoid	Others
Low Class Area	.121*	.110*	.169*	.138*	.075
Medium Class Area	.118*	.078	.033	.058	.130*
High Class Area	.105*	.063	.072	.037	.140

**correlation is significant at 0.05 level. Source: Authors' Survey, 2015*

The above relationships show that the reported ill-health in the study area varied with diverse influence of the residential area in the study area. In additions, low class residential area accounted for the highest numbers of correlated patterns that play significant roles in the state of health conditions of the residents. It is generally clear that stable consideration for ideal residential area is pre-requisite to averting the incidence of reported ill-health in the study area.

On enforcement of sanitation laws, violating of environmental sanitation laws entails some punishment and fine by the state government. Table 9 depicts punishment for violating the law.

Table 9. Punishment for violating sanitation law
(Data source: Field Survey 2015)

	Freq	**%**
Fine	118	44.2
Imprisonment/Fine	52	16.7
Community Service	80	28.3
Others	38	10.0
Total	288	100

It is evident from Table 9, that payment of fine constitutes 44.2% of the sample population followed by community service 16.7%. While imprisonment with option of fine accounted for 16.7% of the sampled population and other act of violation accounted for 10% which may be inform of confiscation of property.

POLICY IMPLICATION

The results of this study indicate inadequate sanitation in the study area resulting to ill health. It also reveals that the majority of the householders in the study area lack basic facilities that make living conductive. It also exposes the fact that government action and policies have not been effective in improving sanitation in the study area. Therefore the government of Ondo State should give a keen attention to enforcing provision of modern toilet facilities in every house, providing good water supply and modern waste disposal facilities as these will help to reduce morbidity which invariably will reduce outbreak of diseases. This is so sure because areas with better provision of the aforementioned have lower epidemic than other areas with poor housing/environmental qualities. The government of Ondo State should try to make modern toilet facilities cheaper and affordable for a common man to have. The predominant use of pit latrine, dunghill and short put, especially in the Low Class Residential Areas of Akungba should be discouraged because of its unhygienic nature. Moreover, people should be discouraged from throwing solid wastes in the drainages as these serve as breeding places for mosquitoes and block the free flow of water and waste products. Serious laws should be enacted in the State against improper refuse disposal. The government should also make the use of modern toilet facilities compulsory for each household while the use of pit latrine and dunghill should be totally prohibited as serious laws should be enacted where offenders against this law will be prosecuted and seriously dealt with if found guilty.

CONCLUSION

From the above exposition and analysis, the paper indicates that sanitation in the study area is inadequate and there is no strong policy for violators. People have a non-chalant attitude towards sanitation. Sanitation condition in Akungba is not up to expectation, people have poor attitude towards sanitation which could be reasons for ill health among residents. The paper recommended that government should engage in vigorous environmental sanitation education and implement the environmental sanitation bye-laws.

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ANALYSIS OF DROUGHT TRENDS IN SENEGALESE COASTAL ZONE ON DIFFERENT CLIMATIC DOMAINS (1951-2010)

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Abstract: In this article, a quantitative evaluation of drought characteristics and their variability in Senegalese coast (and/or western) zone in different domains (south and north Sudanian and Sahelian) was carried out. Monthly precipitation data for ten selected stations. SPI analysis for 1, 3, 6 and 12 months was performed. Results of SPI analysis revealed an alternation of negative values indicating an occurrence of drought and positive values for wet conditions. SPI analysis showed several years of drought during the study period with decades 1971-1980, 1981-1990, 1991-2000 which witnessed a persistent drought on Senegalese coast. This drought is classified as light, moderate, severe and extreme. An in-depth examination shows the predominance of mild droughts with the greatest number of occurrences during study period on Senegalese coast. In the context of reducing the drought impacts, this study provides useful information for proactive intervention and effective planning of rain-fed agriculture on Senegalese coast.

Key words: Drought, Trend, Standardized Precipitation Indices, Coast, Senegal

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INTRODUCTION

Drought is a natural phenomenon that poses many problems around the world, insofar as it requires huge punctures on natural resources and particularly on water resources (Barua et al., 2009). Drought occurs in areas of high and low rainfall and almost all climatic regions, although in the past drought was only associated with arid, semi-arid and desert fringes when the definition was based solely on quantities. absolute precipitation (Omonijo and Okogbue, 2014). Drought is now associated with the dates of onset and cessation of rains, and the duration of the rainy season. Thus, it is better. In another context, drought is one of the extreme climatic conditions that affects more people than any other form of natural disaster (Wilhite, 2000). Indeed, in recent decades, the occurrence of major droughts occupying large territories on all continents highlights the importance of phenomenon (Beaudin, 2007). Both developing and industrialized countries are affected. In developing countries, effects can be very disastrous (Soro et al., 2014). According to Obassi (1994), nearly 1.3 billion people died from direct or indirect causes of the phenomenon. It is thus certain that the timely determination of the level of drought would help to support the decision-making process in its impact reduction objectives.

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Droughts occur in all climatic zones of Senegal. However, its characteristics vary considerably from one region to another (Faye et al., 2017). Drought is a recurring phenomenon in the coastal zone of Senegal and its hazards affect the economies of the predominantly agricultural population. If rainfall is insufficient or rainy season ends abruptly, crops may not ripen and yield will be very low (Oguntoyinbo and Richards, 1977).

The Sahelian drought that began in 1969 and lasted until 1973 affected Senegal and had enormous socio-economic repercussions on the area with pressure on available resources that has increased in the face of a fluctuating rainfall regime (Omonijo and Okogbue, 2014). The term drought is applied at a time when an unusual shortage of rain causes a serious hydrological imbalance like empty water supply tanks. The severity of drought is measured by the degree of moisture deficiency, its duration and the size of the affected area. Many countries have experienced considerable difficulties as a result of drought, famine and food insecurity, particularly in developing world where economies are linked to agriculture. The littoral zone is one of the most endangered areas of Senegal (Faye et al., 2017) and has suffered a prolonged drought of two decades (1970 and 1980).

Droughts tend to be more severe in some areas than in others. Catastrophic droughts usually occur in areas bordering the arid regions of the world, like Senegalese coastline. Drought causes insufficient precipitation to meet the socio-economic requirements of a region in terms of water supply for domestic and industrial uses, agriculture and the ecosystem. The reduction in rainfall resulting from drought in the Sahel was often seen as a result of human activity (clearing, overgrazing, and inappropriate land use practices) (Charney et al., 1977).

To characterize the persistence of drought on Senegalese coast (especially during the 1970s, 1980s and 1990s), a very simple and effective meteorological drought index was used: standardized precipitation index (Nalbantis and Tsakiris, 2009). This index, popular in the characterization of meteorological drought, is widely used throughout Senegal for drought analysis (Sow, 2007; Faye, 2013; Faye et al., 2015; Faye et al., 2017). It has been chosen because it allows to evaluate meteorological drought on different time scales, to measure the recent rainfall anomalies for a zone, to place current conditions in a historical perspective (Loukas et al., 2003) and to make spatial and temporal representations of droughts. Finally, this index has advantages in terms of statistical consistency, and has the capacity to describe, through different time scales (short, medium and long-term), the impacts of the drought in question.

In this climatic context of a possible increase in occurrence and impacts of droughts in coming years (Watson et al., 1997), it is essential to propose mitigation or adaptation measures to populations (Soro et al., 2014). It is in this context that the present study was initiated in Senegal, on the littoral zone. Its purpose is to analyze the trend of drought for period 1951-2011, through standardized precipitation index and on different time scales. This index was used to evaluate drought in Senegal over short periods (applications for agriculture) and over longer periods (applications for water resources management).

STUDY AREA

Senegal's 700-kilometre long coastline connects the Saint-Louis region to the natural region of Casamance from North to South. It is structured around the peninsula of Cape Verde and three mouths that form Senegal River, Sine Saloum and Casamance. Senegalese coastline can be broken down into 6 distinct geomorphological entities: Senegal River Delta, big coast or North Coast, Cape Verde peninsula, small coast, Sine Saloum Delta and Casamance (MEPN, 1997).

Senegalese coastline is limited to North by Senegal River Delta, to West by the Atlantic Ocean and to South by Guinea Bissau. The eastern limit corresponds to axis Thiès -Louga- Fatick-Ziguinchor which is parallel to coast (figure 1). The Senegalese littoral zone has a Sudano-Sahelian climate with an annual rainfall ranging between about 1250 mm in South to just over 200 mm in North. This climate is marked by an alternation between a rainy season and a dry season. The rainy season, which is monsoon period, extends roughly from June to October with a peak in

August-September. Rain varies digressively with latitude (Leroux 1983; Sagna 2005). On the coast, ocean brings freshness and temperatures are of the order of 16° C to 30° C. Given variations in rainfall in space and time, the South-North coastline is characterized by three climatic domains: southern Sudanian, northern Sudan and Sahelian domains.

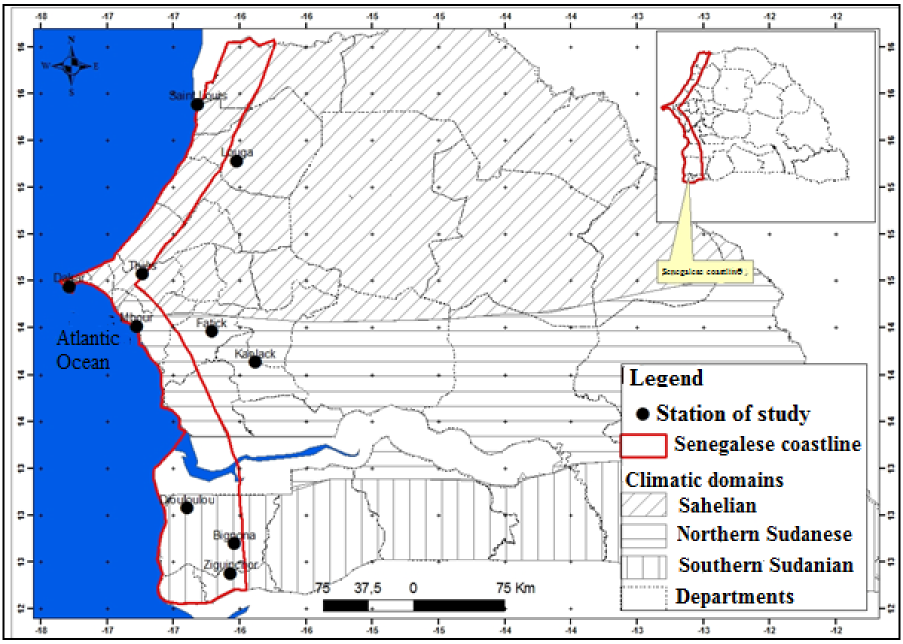

Figure 1. Location of study area and selected stations
(Source: CSE)

DATA AND METHODS

Data

Basic data consist of 60-year rainfall records (1951-2010) from 10 stations (table 1) located in the coastal zone of Senegal (and/or West) on different domains (South and North Sudan and the Sahel). This choice was made so as to allow the most homogeneous coverage possible of the study area. Data were made available to us by the National Agency of Climatology and Civil Aviation (ANACIM) of Senegal. The ten stations follow criteria of continuity, duration of available information and data quality. The 60 years (1950-2010) of the study were subdivided into 6 decades. The dataset has been used to assess and monitor drought over past 60 years through Standardized Precipitation Indices (SPI).

Methods

Standardized Precipitation Index (SPI)

Understanding that a rainfall deficit has a different impact on groundwater, reservoir storage, soil moisture and flow have led to the development of Standardized Precipitation Index (SPI) (McKee et al. 1993). SPI is a simple index adopted in 2009 by World Meteorological Organization (WMO) as a global instrument for measuring meteorological droughts (Jouilil et al., 2013). It is expressed mathematically as follows:

$$SPI = \frac{(R_i - R_m)}{S}$$

With Ri: the rain of month or year i; Rm: the average rainfall of series on time scale considered; S: the standard deviation of series on timescale considered.

Interpretation of SPI time scales

Precipitation data are normalized to a flexible multiple time scale (SPI 1, SPI 3, SPI 6 and SPI 12) respectively. According to the classification of Nigerian Meteorological Agency, 1 month (SPI1) represents meteorological drought, 3 months (SPI 3) agricultural drought, 6 months (SPI 6) hydrological drought and 12 months (SPI 12) socio-economic drought (Omonijo and Okogbue, 2014).

The 1-Month SPI (August) reflects relatively little soil moisture during growing seasons. It is more accurate because the distribution has been standardized. The 1-Month SPI deals with meteorological drought.

The 3-Month SPI (July-September) provides a comparison of precipitation over a specific 3-month period with precipitation totals for the same 3-month period for entire series. This time scale addresses both meteorological and agricultural droughts.

The 6-Month SPI (June-November) can be very effective in showing the rain on distinct seasons. The 6-month SPI may also begin to be associated with abnormal flow rates and reservoir levels; This scale is good for monitoring hydrological drought.

The 12-Month SPI (January-December) reflects long-term precipitation patterns. These delays are usually related to flows, reservoir levels and even groundwater levels at longer timescales.

Table 1. Classification of Dryness Sequences of Moisture
(Data source: Omonijo and Okogbue, 2014)

SPI Values	Drought Sequences	SPI Values	Wet Sequences
0.00< SPI <-0.99	Slightly dry	0.00< SPI <0.99	Slightly wet
-1.00< SPI <-1.49	Moderately dry	1.00< SPI <1.49	Moderately wet
-1.50< SPI <-1.99	Severely dry	1.50< SPI <1.99	Severely wet
SPI < -2.00	Extremely dry	2.00< SPI	Extremely wet

McKee et al. (1993) used classification system according to SPI values (table 1) and defined criteria for a "drought event" for all timescales. A drought event occurs whenever SPI is continuously negative and its value reaches an intensity of -1 or less and ends when the SPI becomes positive. Standardized precipitation index (SPI) was calculated for each time interval.

RESULTS

The illustrations (figures 2, 3, 4, 5, 6 and table 2) show the characteristics of standardized precipitation index calculated on different time scales.

Spatial variation of 1-Month SPI (August)

As in Senegal, generally monthly rainfall peaks are noted in August, this month's precipitation was used to analyze SPI1 over six decades (figure 6). The spatial pattern of drought classification with SPI1 is shown in figure 2. In general, the incidences of drought were most intense during 1971-80 decade (average SPI: -0.27), 1981-90 (average SPI: -0.22) and 1991-00 (average SPI: -0.14) while decades 1951-60 (0.50) and 1961-70 (0.33) are wetter. The decade of 2001-10 saw an alternation of positive SPI (-0.2 in Saint Louis, -0.18 in Louga and Kaolack, -0.29 in Diouloulou) and negative (0.17 in Thiès, 0.18 in Bignona, 0.13 in Fatick), corresponding respectively to a slight drought (on some stations) and a slight humidity (on others).

However, this decade, with an average SPI of -0.05, is very slightly dry. During the three decades of drought (1971-80, 1981-90 and 1991-00), the indices of different stations are negative, indicating a drier August, unlike the first two decades (1951-60 and 1961-70) where the month of August is wetter. In the wettest decade (1951-60), Kaolack station retains highest positive index (0.84) while it is the only station whose index is negative (-0.08) on the wet decade 1961-70. Over the 6 decades of study, the positive values of SPI1 indicate a littoral with slight humidity and those negative a littoral with light drought. Since the 1970s, the rainfall deficit noted in the area has affected rainfall in August, resulting in a slight drought on the almost entire coastline.

Table 2. Frequencies of drought occurrences of selected stations from 1951 to 2010
(Data source: ANACIM)

Saint Louis	**SPI1**	**SPI3**	**SPI6**	**SPI12**	**Louga**	**SPI1**	**SPI3**	**SPI6**	**SPI12**
Slightly wet	6.7	0	0	3.3	Slightly wet	2	0	0	0
Moderately wet	0	0	0	3.3	Moderately wet	10	2	0	0
Severely wet	5	5	3.3	6.7	Severely wet	6	0	2	2
Extremely wet	26.7	50	48.3	38.3	Extremely wet	30	44	46	42
Slightly dry	**50**	**43.3**	**48.3**	**35**	**Slightly dry**	**36**	**50**	**52**	**56**
Moderately dry	**11.7**	**1.7**	**0**	**5**	**Moderately dry**	**16**	**4**	**0**	**0**
Severely dry	**0**	**0**	**0**	**6.7**	**Severely dry**	**0**	**0**	**0**	**0**
Extremely dry	**0**	**0**	**0**	**1.7**	**Extremely dry**	**0**	**0**	**0**	**0**
Dakar	**SPI1**	**SPI3**	**SPI6**	**SPI12**	**Thiès**	**SPI1**	**SPI3**	**SPI6**	**SPI12**
Slightly wet	5	0	0	0	Slightly wet	4	0	0	0
Moderately wet	3.3	0	1.7	0	Moderately wet	2	4	0	0
Severely wet	8.3	8.3	6.7	5	Severely wet	6	2	4	4
Extremely wet	23.3	35	36.6	41.7	Extremely wet	26	42	46	46
Slightly dry	**50**	**53.3**	**53.3**	**53.3**	**Slightly dry**	**48**	**46**	**50**	**50**
Moderately dry	**8.3**	**3.3**	**1.7**	**0**	**Moderately dry**	**10**	**6**	**0**	**0**
Severely dry	**1.7**	**0**	**0**	**0**	**Severely dry**	**4**	**0**	**0**	**0**
Extremely dry	**0**	**0**	**0**	**0**	**Extremely dry**	**0**	**0**	**0**	**0**
Mbour	**SPI1**	**SPI3**	**SPI6**	**SPI12**	**Fatick**	**SPI1**	**SPI3**	**SPI6**	**SPI12**
Slightly wet	3.4	0	0	0	Slightly wet	2	0	0	0
Moderately wet	3.4	1.7	1.7	1.7	Moderately wet	2	4	0	0
Severely wet	3.4	6.8	3.4	3.4	Severely wet	14	6	6	4
Extremely wet	32.2	33.9	40.7	40.7	Extremely wet	30	42	40	40
Slightly dry	**49.2**	**52.5**	**52.5**	**52.5**	**Slightly dry**	**32**	**42**	**54**	**56**
Moderately dry	**6.8**	**3.4**	**1.7**	**1.7**	**Moderately dry**	**16**	**6**	**0**	**0**
Severely dry	**1.7**	**1.7**	**0**	**0**	**Severely dry**	**4**	**0**	**0**	**0**
Extremely dry	**0**	**0**	**0**	**0**	**Extremely dry**	**0**	**0**	**0**	**0**
Kaolack	**SPI1**	**SPI3**	**SPI6**	**SPI12**	**Diouloulou**	**SPI1**	**SPI3**	**SPI6**	**SPI12**
Slightly wet	3.4	0	0	0	Slightly wet	1.8	0	0	0
Moderately wet	6.8	3.4	1.7	0	Moderately wet	3.6	0	0	0
Severely wet	3.4	3.4	1.7	3.4	Severely wet	10.7	3.6	1.8	1.8
Extremely wet	25.4	40.7	35.6	33.9	Extremely wet	37.5	55.4	48.2	48.2
Slightly dry	**52.5**	**50.8**	**59.3**	**62.7**	**Slightly dry**	**26.8**	**32.1**	**46.4**	**46.4**
Moderately dry	**8.5**	**1.7**	**1.7**	**0**	**Moderately dry**	**14.3**	**8.9**	**3.6**	**3.6**
Severely dry	**0**	**0**	**0**	**0**	**Severely dry**	**3.6**	**0**	**0**	**0**
Extremely dry	**0**	**0**	**0**	**0**	**Extremely dry**	**1.8**	**0**	**0**	**0**
Bignona	**SPI1**	**SPI3**	**SPI6**	**SPI12**	**Ziguinchor**	**SPI1**	**SPI3**	**SPI6**	**SPI12**
Slightly wet	2.0	2.0	0	0	Slightly wet	3.3	0	0	0
Moderately wet	2.0	0	0	0	Moderately wet	5	0	0	0
Severely wet	3.9	5.9	2.0	2.0	Severely wet	6.7	6.7	5	5
Extremely wet	37.3	39.2	47.1	52.9	Extremely wet	33.3	41.7	41.7	41.7
Slightly dry	**43.1**	**45.1**	**49.0**	**43.1**	**Slightly dry**	**40**	**43.3**	**51.7**	**51.7**
Moderately dry	**5.9**	**7.8**	**0**	**0**	**Moderately dry**	**5**	**8.3**	**1.7**	**1.7**
Severely dry	**5.9**	**0**	**0**	**0**	**Severely dry**	**5**	**0**	**0**	**0**
Extremely dry	**0**	**0**	**2.0**	**2.0**	**Extremely dry**	**1.7**	**0**	**0**	**0**

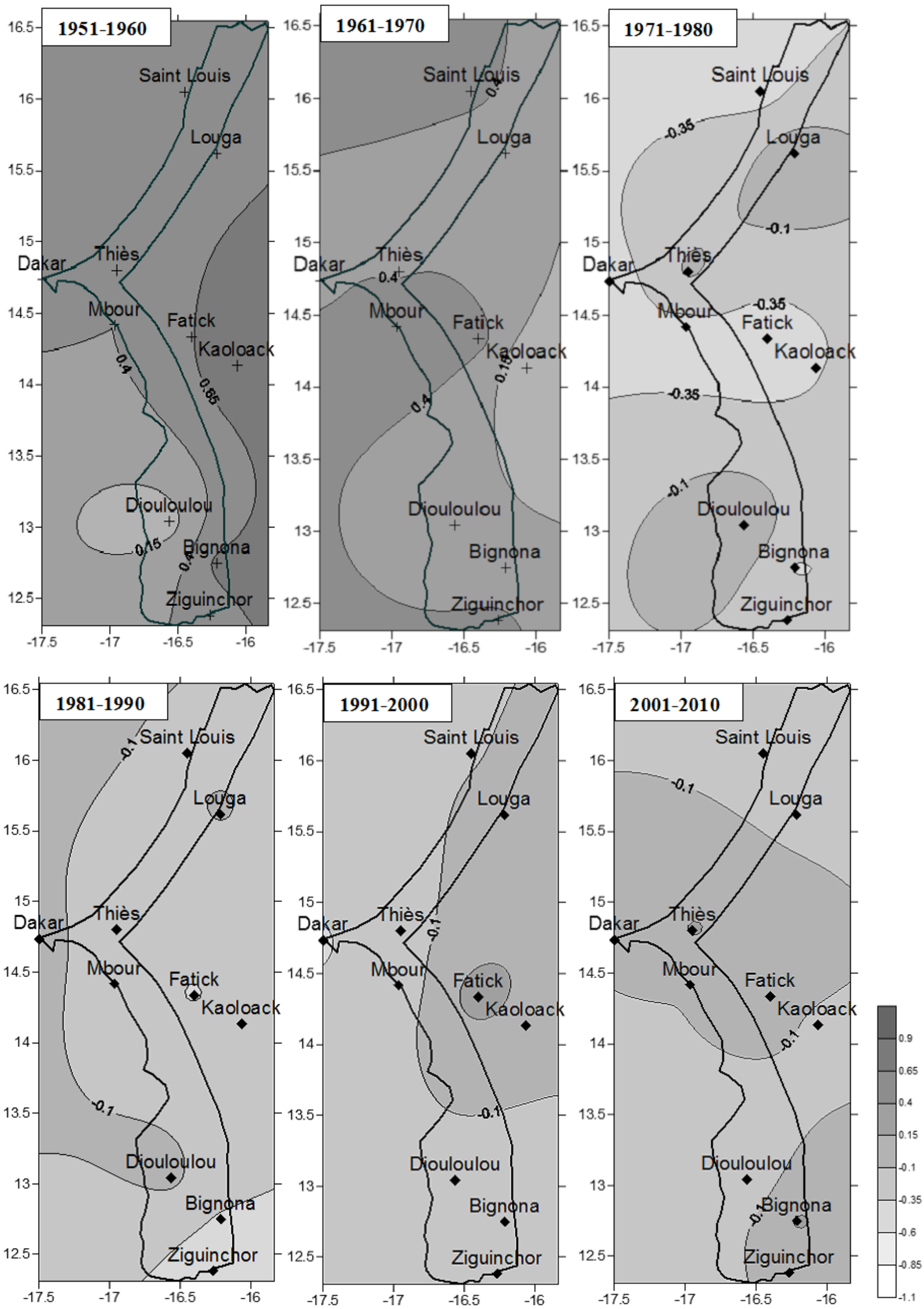

Figure 2. Spatialization of SPI1 (August) by decade on Senegalese coastline
(Source: ANACIM)

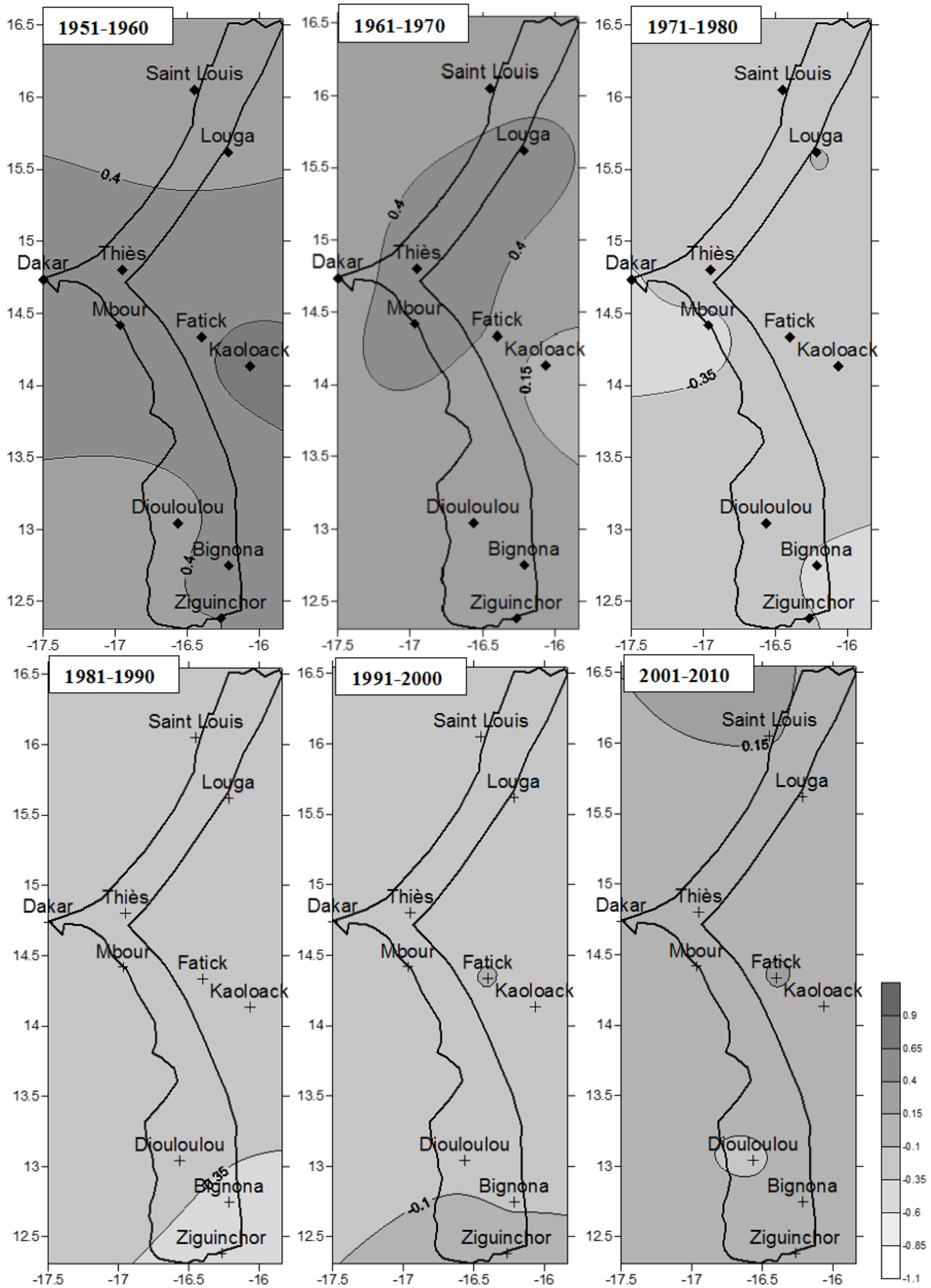

Figure 3. Spatialization of SPI3 (July-September) by decade on Senegalese coastline
(Source: ANACIM)

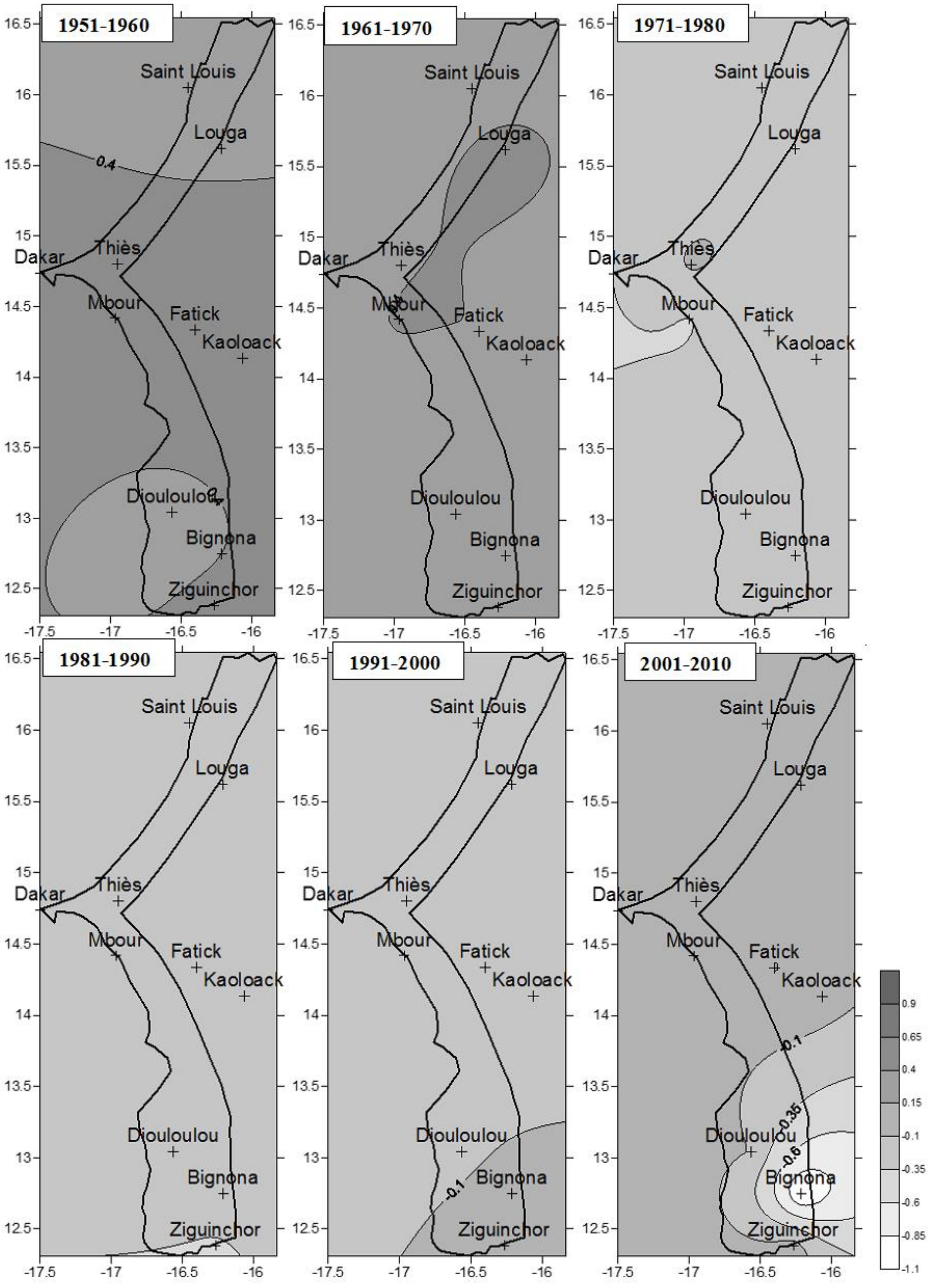

Figure 4. Spatialization of SPI6 (June-November) by decade on Senegalese coastline
(Source: ANACIM)

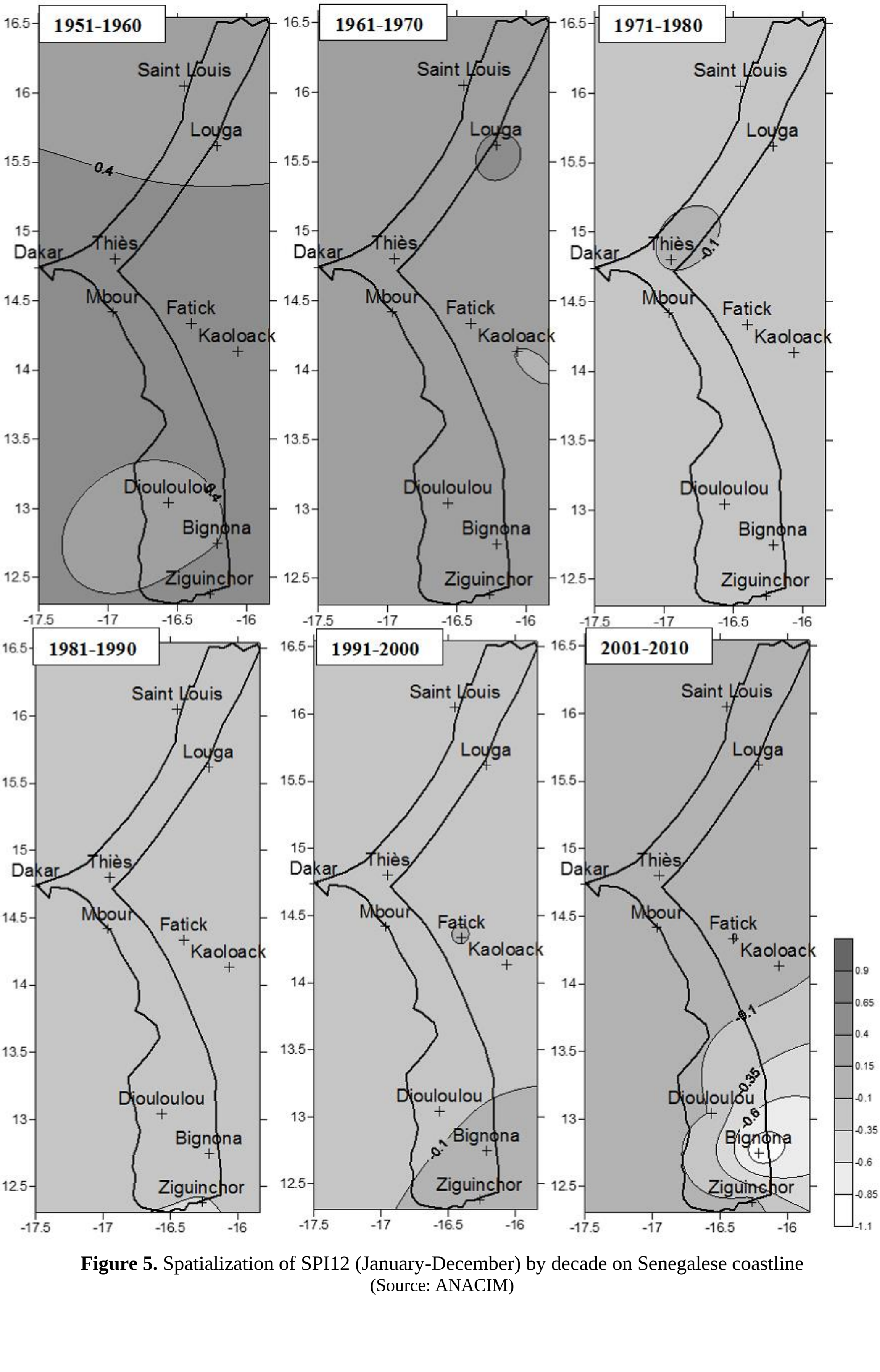

Figure 5. Spatialization of SPI12 (January-December) by decade on Senegalese coastline
(Source: ANACIM)

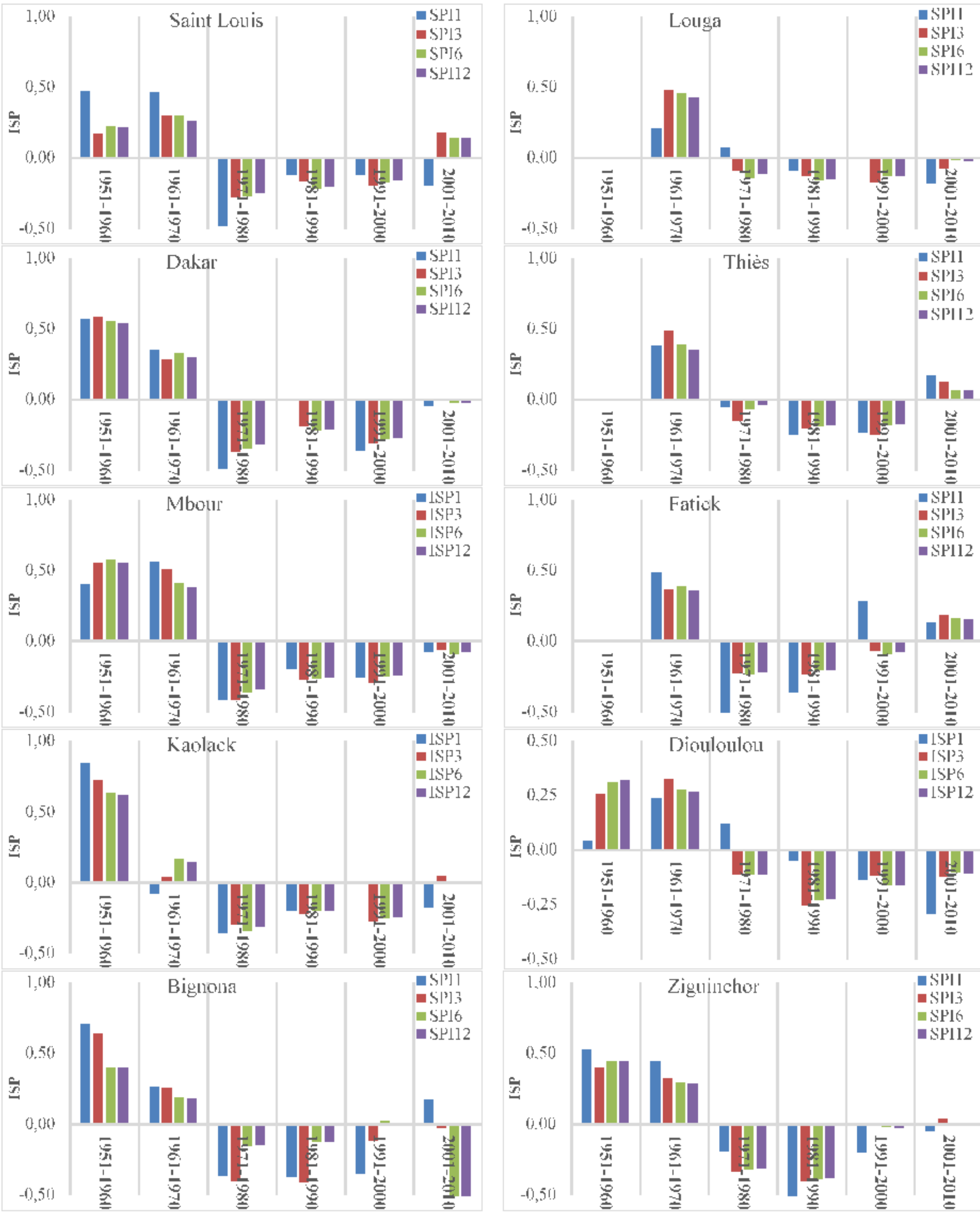

Figure 6. Evolution of SPI at different time scales in the area
(Source: ANACIM)

Over study period (1951-2010), SPI1 values indicate a slight drought on most coastal regions, with occurrence frequencies reaching 50% at station levels (50% in Dakar and Saint Louis; 52.5% in Kaolack). Frequencies of occurrence of moderate drought are also noted and may even exceed 10% in some stations (16% in Louga and Fatick; 14.3% in Diouloulou) (table 2).

The incidence of the most severe drought of the study period was observed during the decade 1971-80 and at Fatick station (-0.53) followed by Diouloulou (-0.52) over the decade

1981-90, two decades which is simply the period of the great drought of the 1970s and 1980s. If, per decade, drought and moderate humidity are absent, they have been observed in some parts of coast in some years.

Spatial variation of 3-Month SPI (July-September)

The 3-month time scale (July-September) of the SPI was calculated using monthly precipitation in July, August and September (figure 6). This period is at the heart of the rainy season on the entire coast of Senegal. The spatial trend of drought classification with SPI3 is given in figure 3. The SPI3 indicates characteristics quite similar to SPI1, unlike first two decades (1951-60 and 1961-70) called wet, drought was noted over the rest of the study period, particularly after years 1971-80, 1981-90 and 1991-00 during which the indices for all stations were negative. Mean SPI3 is positive over the decades 1951-60 (0.47) and 1961-70 (0.34) and negative over the decade 1971-80 (-0.27), 1981-90 (-0.25) and 1991-00 (-0.18). The last decade (2001-10), unlike SPI1, has a mean positive SPI of 0.03 (with 6 out of 10 wet stations). This slight humidity is more pronounced in the central part of the coast. All occurrences of SPI3 drought are slight overall decades, with a minimum value of -0.42 noted over the years 1971-80 (at Mbour station) and 1981-90 (at Bignona station).

The decrease in precipitation from the 1970s is also noted over the months of July, August and September until 2010, leading to a slight drought, although some parts of coastline show a slightly wet state over the last decade (Saint. Louis and Fatick with 0.18; Thies with 0.13...). This is why in the last decade light drought has covered less surface area than in previous three completely dry decades. During the decade 2001-10, it was noted in Senegal an increase of rainfall forecasting the improvement of rainfall regimes in the country compared to the drought period of the preceding decades, although the persistence and the durability of current increase are still to be proven, knowing that climatological scale, ultimately, is the thirties (Faye *et al.*, 2017).

Over the study period (1951-2010), like SPI1, SPI3 values indicate a slight drought on most coastal regions, with occurrence frequencies exceeding 40% at all levels. stations (52.5% in Mbour, 50.8% in Kaolack, 50% in Louga). Moderate drought is also noted with occurrence frequencies of less than 10% (highest being recorded in Diouloulou with 8.9%) (table 2).

Spatial variation of 6-Month SPI (June-November)

The SPI 6-month time scale was calculated using wettest 6 months (June-November) on the Senegalese coastline (figure 6). The spatial trend of SPI6 drought classification is presented in figure 4. Beyond a slight humidity observed at all stations over the first two decades (with an average of 0.45 and 0,32 respectively in 1951-60 and 1961-70), all four other decades recorded a slight drought, but to varying degrees and gradually decreasing (on average -0.24 in 1971-80, -0.22 in 1981-90, -0.15 in 1991-00 and -0.09 in 2001-10).

The SPI6 importance of the decade 1971-80 is explained by its position at the heart of the drought of the 1970s, whereas the weakness of the index of the decade 2001-10 is related to the recent improvement of conditions rainfall in the country. Some stations recorded a positive SPI6 (0.16 at Fatick, 0.14 at Saint Louis, 0.06 at Thiès). For humid decades, the humidity conditions are light, but the character of humidity is more accentuated in the central and southeastern part of the coast. This slight humidity is also more pronounced in the central and northern part of coast over the last

Spatial coverage of light drought has increased sharply to be total along the entire coastline since the 1970s. SPI6 values generally indicate a type of light, drought, over most coastal areas from 1951 to 2010, frequencies of occurrence reaching 59.3% in Kaolack, 54% in Fatick, 53.3% in Dakar, 52.5% in Mbour... It is followed by the moderate drought whose values of frequencies of appearance range from 1.7% (in Dakar, Mbour, Kaolack and Ziguinchor) to 3.96% (in Diouloulou) (table 2). The important frequencies of light, drought is closely followed by those of light moisture.

Spatial variation of 12-Month SPI (January-December)

SPI12 was calculated using average monthly precipitation from January to December (figure 6). The spatial pattern of drought classification with SPI12 is shown in figure 5. SPI12 records, on average, similar values to SPI6: slight moisture at all stations on both first decades (0.44 in 1951-60 and 0.29 in 1961-70) and a slight drought over another four decades (-0.22 in 1971-80, -0.22 in 1981-90, -0.15 in 1991-00 and -0.09 in 2001-10).

The decade 2001-10, while being dry with average, still records this alternation of positive SPI (0.16 to Fatick, 0.14 to Saint Louis, 0.01 to Kaolock) and negative (-1.07 to Bignona, -0.11 to Diouloulou, -0.08 in Mbour). Thus, from the 1970s, a light drought was observed on the whole coastline, from South to North, whereas the decade 2001-10 is the only one which recorded a light humidity in only some parts of the littoral. Of all-time scales used, the SPI6 and SPI12 are only ones that have recorded, per decade, a moderate type of drought (Bignona station over the decade 2001-10).

After being a total of 1970 of, the spatial coverage of light, drought has been declining all along the coast in recent years, with the return of wet years. From 1951 to 2010, only the station of Saint Louis, in the North of littoral, recorded all the categories of drought (light with 35%, moderate with 5%, silver with 6.7% and extreme with 1.7%). Beyond that, the category of light drought is most represented on the entire coastline. Thus, the frequencies of appearance of light, drought reach 62.7% in Kaolack, 56% in Louga and Fatick, 53.3% in Dakar, 52.5% in Mbour... On the other hand, those of

The SPI used for the rainfall deficit assessment from 1951 to 2010 show a significant fluctuation of dry and wet periods with a strong tendency to drought, especially over the period 1971-2000. The longest drought period that affects Senegalese coastline extends from 1970 to 2000. On the various climatic domains and studied stations of littoral, SPI indicate very important frequencies on slightly dry sequences (approximately 50%), modest on moderately dry (less than 10%) and very weak sequences on severely dry sequences. Thus, the number of occurrences per classification decreases with increasing severity. On different time scales, the indices frequencies on different climatic domains and studied stations of littoral are quite close. The values of indices on different time scales show that South-Sudanian coastal climate domain is less affected by droughts than the Sahelian climatic zone of the coast. A closer look at the number of occurrences of drought in the area shows that the extreme northern parts of coastline are more sensitive to extreme and severe drought. On the other hand, this is in tune with the northern parts of the country which are more prone to drought and desertification.

DISCUSSION

The analysis of standardized precipitation index (SPI) calculated for time scales of 1 month, 3 months, 6 months and 12 months for 10 stations of Senegalese littoral with different climatic regimes, revealed that the Senegalese coastline knew a major rainfall deficit since the 1970s, a deficit that lasted for the 1980s and 1990s. These results confirm the research carried out by Goula et al. (2005), Soro et al. (2014), Omonijo and Okogbue (2014) in West Africa. In Senegal, the works of Faye (2013), Faye et al. (2015) and Faye et al. (2017) who showed that the 1970s, 1980s and 1990s were dry periods marked by a high rainfall deficit.

Although the rainfall decline intensified in Senegal during 1980s and 1990s, it did not persist in 2000s as noted by some authors (L'Hôte et al., 2002; Soro et al., 2014). During the 2000s, it was noted in Senegal that an increase in rainfall predicted the improvement of rainfall patterns in the country compared to the drought period of previous decades, although the persistence and sustainability of current increase are still to prove, knowing that climatic scale ultimate is the thirties (Faye et al., 2017). However, this improvement in rainfall conditions is in concert with the work of some authors (Ali and Lebel 2009; Ozer et al., 2009; Bodian, 2014) who suggest the end of Sahelian drought during the 1990s over the period 2001-2010, statistical indices have detected in Senegal important wet sequences even if the optimum of the 1960s is not yet reached.

Results obtained vary by station, scale and domain. By climatic domains, the SPI values of different stations on different time scales show that South-Sudanian climatic domain is least affected by droughts than the Sahelian climatic domain. In terms of the intensity of drought and the frequency of appearance of dry sequences, the results obtained are similar on different time scales. In this study, dry sequences were characterized strictly with rainfall data, an approach highly dependent on the quality of data measured in situ, especially as the mesh of stations on Senegalese territory is very loose. To remedy this, other authors (Bayarjargal et al., 2006; Beaudin, 2007) use satellite imagery in their studies to monitor weather and environmental conditions. Indeed, this technique offers both the possibility of acquiring daily data for the desired territory, increases the accuracy and monitoring of drought conditions and helps explain the contribution of temperatures in drought analysis.

CONCLUSION

In this paper, Standardized Precipitation Index (SPI) was evaluated at different timescales to study the drought intensity and frequency using monthly rainfall data from 10 stations located in different locations. climatic domains of Senegalese littoral for period 1951-2010. Drought occurs in all parts of the globe and negatively affects lives of a large number of people, causing considerable damage to economies, environment and property. Drought also affects countries or regions differently and has a greater impact on poor countries or regions. On many occasions, droughts have been so severe that local people have been forced to migrate. Results revealed that Senegalese coastline is generally facing severe and prolonged drought events.

Analyzes revealed that most remarkable droughts in intensity, duration and frequency were observed during the period 1971-2000, regardless of time scale and domain considered. These dry episodes reached their peak in 1972 and 1983 with extreme and severe droughts. However, light drought is predominant over the 60 years of study because having the greatest number of occurrences on Senegalese coastline. Of ten stations studied, those in the Sahelian field (Dakar, Matam) seem to be the most affected by drought. Of four time scales considered, one at 12 months seems most appropriate for describing drought sequences because, at this time step, the index becomes stable thus making it possible to define with more precision dry episodes.

This study therefore confirmed that there was no consistent timetable for the onset of drought. It also confirmed the high intensity of droughts over the period 1970-90. Analysis showed that some stations are already in wet situations during the last decade of study. This study demonstrates need to put in place measures that can be used to address and improve the impact of drought in their next reappearance.

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CHARACTERISTICS OF MICRO-DRAINAGE SYSTEM AND ITS ENVIRONMENTAL IMPLICATIONS IN URBANIZED TROPICAL CITY OF ILORIN, NIGERIA

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Abstract: The importance of micro drainage infrastructure, especially in rapidly growing cities cannot be over-emphasized. It is needed to evacuate storm runoff and household sewage to the natural drainage in order to prevent flooding and pollution; and promote public health and safety. The efficiency and effectiveness of this drainage infrastructure however depend on their distribution, size, and integration with the natural drainage. In this study, the effect of drainage capacity expressed as a product of length, width and height on efficiency and effectiveness have been explored. Data used were sourced from the field personally by the researcher during the peak period of rainy season in year 2015. Result obtained indicates that the dimension of the drainage channels are just too small for efficient transmission out the city, the increased runoff discharge brought about by increased frequency and intensity of rainfall induced by climate change and catalyzed by rapid rate of urbanization in the study area. People's poor solid waste generation and disposal attitude was also observed as one of the problems confronting the effectiveness of micro drainage in the study area; this is because sediments of various types were found reducing flow efficiency in the drainage channels. Methods that can be used to effectively manage the drainage channels were subsequently recommended.

Key words: Micro-drainage, Infrastructure, Urbanization Sedimentation Carrying capacit

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INTRODUCTION

Urban drainage is managed through two systems of micro and macro drainage infrastructure. The micro drainage relates to conduits constructed for conveyance of water from urban paved surfaces. Such a system according to Miguez and Rezende (2012) is essentially defined by the layout of streets in urban areas. The macro-drainage on the other hand, refers to the main drainage network within a catchment; this can either be natural such as rivers and streams or complimentary engineering works such as canals, storm water galleries or dikes. Such features receive and discharge out the catchment, the surface runoff earlier taken by the micro drainage system. The macro drainage system within a catchment typically has a wider area in which to flow; within such a system tress and small log or debris jam can be easily accommodated by minor diversions of flow without causing problems. As a matter of fact, the presence of vegetation and

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minor obstructions in macro drainage systems that cause riffles and pools are desired because they aids in the improvement of such habitat and water quality. Unlike the macro system however, the micro drainage system is typically designed to use less surface area to carry more water. Such system thus needs more attention as regards their operation because there is no room to carry overflows which can either result from blockages or sedimentation.

The main purpose of urban drainage according to United Nations center for Human Settlement Report (1991) is to convey storm water to the receiving waters with a minimum of nuisance, danger and damage. According to the report, goals of urban drainage management include:

I. ensuring that floodwater inundation of commercial, residential and industrial areas located in flood-prone landscape occurs only on rare occasions and that the velocity/depth of conditions during these events are below prescribed limits;

II. providing convenience and safety for pedestrians and traffic by controlling storm water flows within prescribed limits; and,

III. retaining within each catchment as much incident rainfall and run-off as is possible given the planned use of the catchment terrain and its biotic and engineering characteristics.

However, reports from studies of many urbanized settlements, especially in developing nations are not indicating the achievement of the above enumerated objectives. Studies such as (Aderogba et al., 2012; Aid, 2006; Ajibola et al., 2012; Dodman et al., 2007; Frimpong, 2014; Herman, 2009, 2010; Iroye, 2008; Omole and Isiorho 2011; Tucci, 2001) indicates that urban areas in developing countries, most times present risk of flooding following rainfall event. Reasons given for the extreme hydro meteorological hazards of flood in the region include rapid urbanization leading to land pavement, inappropriate solid waste generation and disposal methods, lack of development planning and climate change. According to Silveira (2002), problems of urban drainage management is more serious in the developing countries than developed nations because urban developments in the region are occurring under more difficult socio-economic, technological and climatic conditions.

Though the above reasons adduced for flooding, especially in urban centres in developing countries are germane, the frequency and intensity of flood disasters in the region differ from one urbanized area to another due to nature and conditions of micro drainage infrastructure (Mathingly, 1995; Jimoh, 2008; Iroye, 2013). Aina et al., (1994) described the condition of micro drainage system in Lagos, Nigeria which exemplifies most urban centres in developing countries thus: “In many areas, roads have been built without complementary gutters for rainwater. Where a drainage system exists, it is often not properly constructed and maintained. The lack of solid-waste collection compounds the problem as wastes block gutters and drains. In addition, many buildings have been erected in ways that block storm water routes. Little attention is given to clearing the drains in advance of periods of the year when rain is expected”.

Availability of an efficient and effective drainage infrastructure is not only vital for flood control, it is a major pre-requisite for achieving a clean and healthy environment.

Though the capacities of some of the micro drainage system may be adequate to effectively control flood when designed; changes in urban areas induced by urbanization and in storm frequency and intensity resulting from climate change are now producing higher flows in most cities that exceed their capacities. Together with water supply facilities and sewage system, urban drainage according to Silveira (2002) forms the third of three basic structures for managing water in cities. This reason thus justify urban drainage study, especially in a tropical city of a developing country where rapid rate of urbanization (figure 1) is not commensurate with investment in infrastructure. This is against a background of climate change, poor land-use planning, weak institutional framework, people’s poor attitude towards solid waste generation and disposal and weak optimization of little resources available as a result of bad management (Yilmaz, 2004; Rahman, 2004; Goldenfum, 2001).

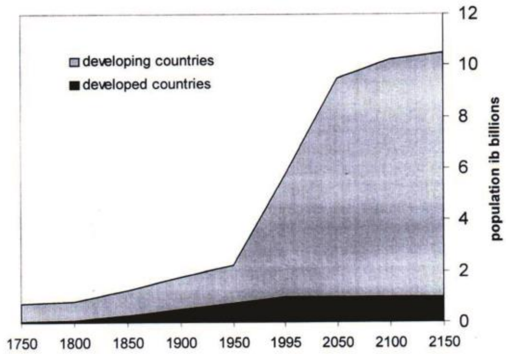

Figure 1. World Population Growth
Source: Tucci (2001)

Poor urban drainage systems apart from causing flooding, also interferes with the functioning of the entire city, affecting sanitation, housing, transport, public health among other systems (Miguez and Rezende, 2012). Though deaths due to floods, landslide and building collapse seems to be the most dramatic signs of the suffering that improved drainage can help to alleviate, noticeable and tangible are the greater impacts of the troll of disease and disability that can emanate from poor drainage (Cairncross and Quano, 1991). Attempt at managing the urban environment thus calls for study of this nature. Specifically, this study seeks to examine the characteristics of micro drainage system in the study area; compute and compare the designed capacities of the drainage channels at construction with the present capacities and analyse the composition of materials found in the channels.

THE STUDY AREA

Ilorin, the capital city of Kwara State, Nigeria is the study area for this investigation (figure 2). The city which lies between longitudes 8^0 24’ and 8^0 36’ north of the equator and between latitudes 4^0 10’ east of the Greenwich meridian has humid tropical climate which is characterized by wet and dry seasons.

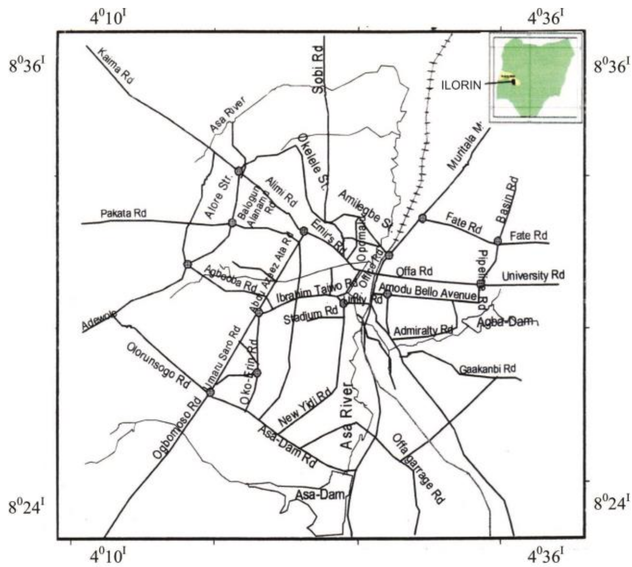

Figure 2. Street Map of Ilorin the Study Area with Nigeria as Inset
Source: Kwara State Town Planning (2000)

Wet season in the town begins towards the end of March when Tropical Maritime Airmass is prevalent and ends in October, often abruptly. Dry season in the town begins with onset of Tropical Continental Airmass which is predominant between the months of November and February. The mean annual total rainfall for Ilorin is 1200 mm (Olaniran, 2002). Analysis of rainfall values for the town shows that rain scarcely fall in the months of January, February, November and December (Oyegun, 1983). Rainfall concentration is usually between the months of March and October, exhibiting double maxima pattern with peak periods in the months of June and September and a period of dry spell in August. Temperature in the town is uniformly high between 25 ^{0}C and 28 ^{0}C. Ilorin is covered mainly by ferruginous tropical soil on crystalline acidic rock (Areola, 1978). The soil type has both sandy and clayey deposits lying on each other while the city is drained mainly by River Asa.

Urbanization process is fast replacing the natural surface in the town with artificial surfaces with its consequent effects on runoff generation. Oyegun (1987) observed the built up area in Ilorin to have grown from 20.40 sqkm in 1963 to about 58.00 sqkm in 1982, while the area occupied by grass, fallowland and tall covers decrease from 35.84 sqkm to 9.70 sq.km within the same period. In this same vain, Aderamo (1990) observed that urban development in the city increased from 1235.8 hectares in 1963 to 4515.8 hectares in 1988 representing almost 400% growth rate within a period of 25 years. This analysis indicates the level at which the hydrological process is being affected by urbanization process in the city.

MATERIALS AND METHODS

The study is based on data collected directly from the field during the rainy season between the months of July and September, 2015. Channel characteristics of micro drainage system along fifty four (54) road networks which total a length of 45.04 km was examined in this study. The micro-drainage characteristics examined include channel depth, width, length and capacity. While a measuring tape was used to take readings on channel depth and width, the length of each channel was computed from readings from a car speedometer. Two readings on depth were taken during the study; these are readings on depth at construction taken after clearing out the debris inside the drainage channel and current depth taken by leaving the debris inside the drainage channel. These two readings aid in the computation of drainage capacity at construction and current capacity after siltation respectively. All readings were taken at 500 meter equidistance position along each road network in the study area. At each site where measurements on channel characteristics were taken, sediments inside the channel were scouped out, separated into types and weighted in percentage. Because the road networks in the study area are mainly flanked by two drainage channels, one on each side; mean value of measurements on sediments taken from each sampling site inside both drainage channels along the road is recorded as value for such road network. However, in few cases where drainage channel only exist on one side of the road, mean value of measurements on sediments taken at each sampling site inside such drainage channel was used in this analysis as value for such a road network. The 90.08 km drainage channel length covered in this study is an ideal representative to critically expose the problems of micro drainage system in Ilorin metropolis and to provide sufficient framework for formulating practical recommendations for ameliorating problems of flooding, sedimentation and pollution which can be induced by poor drainage system.

RESULTS AND DISCUSSION

Table 1 presents the data on characteristics of micro-drainage system in the study area. The table revealed that most street networks examined in this study (90.7%) have drainage system on both sides with the exception of Airport – Garin Alimi and Mini Campus – Queen School Roads which have drainage system only on one side. These two road networks which total 1.72 km length shows that one sided drainage channel only represents 3.82% in the study area. However, Yebumot – Adeta Road had no drainage channel at all while Government House Roundabout - Challenge and Central Bank - Challenge Roundabout have sealed drainage system that could not be assessed.

Table 1. Characteristic of Micro Drainage in the Study Area
DC: Double Channel; ODC: Open Drainage Channel,
Source Author's Fieldwork (2015)

S/N		Nature of Road Network	Nature of Drainage Channel	Length of Road (M)	Length of Drainage Channel (Both Side) (M)	Depth at Construction (M)	Width of Channel (M)	Channel Capacity at Construction (M3)	Current Mean Depth (M)	Current Capacity (M3)	Reduction in Capacity (M3)	% Reduction in capacity
1.	Gaa Akanbi Roundabout – Danialu	DCL	ODC	1380	1380	1.00	1.00	1380.00	0.96	1324.80	55.20	04.00
2.	Garin Alimi – Dangote	DCL	ODC	1050	2100	0.61	0.61	781.41	0.29	371.49	409.92	52.45
3.	Garin Alimi – Sawmill	DCL	ODC	680	1360	0.61	0.61	506.05	0	0	506.05	100.00
4.	Garin Alimi – Yebumot	DCL	ODC	1200	2400	0.61	0.61	893.04	0.28	409.92	429.12	51.14
5.	Sawmill – Osere Junction	SCL	ODC	1140	2280	0.58	0.58	766.99	0.24	317.38	449.61	58.62
6.	Sawmill – Queen School	DCL	ODC	965	1930	0.61	0.61	718.15	0	0	718.15	100.00
7.	Queen School – New Market Junction	DCL	ODC	720	1440	0.58	0.61	509.47	0.37	325.01	184.46	3621
8.	Queen School – Owoniboys	DCL	ODC	875	1750	0.38	0.46	305.90	0.31	249.55	56.35	18.42
9.	Owoniboys – Unity Junction	DCL	ODC	560	1120	0.38	0.48	204.29	0.18	96.77	107.52	52.63
10.	Unity Road	DCL	ODC	580	1160	0.61	0.61	431.63	0.49	346.72	84.91	19.67
11.	Mini Campus – Queen School	SCL	ODC	340	340	0.61	0.61	126.51	0.27	55.99	70.52	55.74
12.	Unity Junction – Emirs Road Junction	DCL	ODC	880	1760	0.60	0.58	612.48	0.22	224.58	387.90	63.33
13.	Emirs Road	DCL	ODC	1,340	2680	0.89	0.89	2122.82	0.81	1758.34	364.48	17.16
14.	Opo Malu Road	DCL	ODC	875	1750	0.58	0.58	588.70	0.28	284.20	304.5	51.72
15.	Yebumot – Adeta Roundabout	SCL	NO DRAINAGE CHANNEL									
16.	Alfa Yahaya Road	SCL	ODC	840	1680	0.55	0.50	462.00	0.22	101.64	360.36	78.00
17.	Pataoloje – Ogidi Junction	SCL	ODC	550	1100	0.60	0.55	363.00	0.34	224.40	138.60	38.18
18.	Agbo-Oba Adeta Roundabout	SCL	ODC	1100	2200	0.75	0.60	990.00	0.62	818.40	171.60	17.33
19.	Oko Erin – Agbo-Oba Junction	SCL	ODC	340	680	0.55	0.58	216.92	0.21	82.82	134.10	61.82
20.	Oro Road	SCL	ODC	480	960	0.38	0.50	182.40	0.17	81.60	100.80	55.26
21.	Obbo Road	SCL	ODC	395	790	0.58	0.60	274.92	0.15	71.10	203.82	74.14
22.	Yoruba road	SCL	ODC	230	460	0.58	0.55	146.47	0.27	68.31	78.16	53.36
23.	Stadium Road	SCL	ODC	470	940	0.61	0.55	315.37	0.33	170.61	144.76	45.90
24.	Flower Garden – Tanke Junction	SCL	ODS	800	1600	0.53	0.70	593.60	0.47	526.40	67.20	11.32
25.	Tanke Junction – Tanke Roundabout	DCL	ODS	1,115	2230	0.61	0.58	788.97	0.49	633.77	155.20	19.67
26.	Tanke Roundabout – University Gate	DCL	ODS	1,220	2,440	0.60	0.66	966.24	0.47	756.89	209.35	21.67
27.	Awolowo Road	SCL	ODS	830	1,660	0.55	0.55	502.15	0.39	356.07	146.08	29.09
28.	Pipeline Road	SCL	ODS	1,425	2,850	0.61	0.62	1,077.87	0.28	187.11	890.75	82.62
29.	Gaa Akanbi Roundabout – Danialu	SLC	ODC	1,210	2,420	0.61	0.58	856.20	0.34	44.88	378.98	44.26
30.	Gaa Akanbi Roundabout – Equity Chambers	SLC	ODC	740	1,480	0.58	0.60	515.04	0.39	346.32	168.72	32.76
31.	Admiralty Villa Road	Double	ODC	1,235	2,470	0.61	0.58	873.89	0.55	787.93	85.96	09.84
32.	Flower Garden – Shoprite Road	SLC	ODC	700	1,400	0.63	0.60	529.20	0.53	445.20	84.00	15.87
33.	Fate Tanke Road	SLC	ODC	1,260	2,520	0.60	0.60	907.20	0.11	166.32	740.88	81.69
34.	Fate Roundabout – Niger Basin	SLC	ODC	750	1,500	0.61	0.60	540.00	0.38	342.00	198.00	36.67
35.	GSS Roundabout – Fate Roundabout	DCL	ODC	1,100	2,200	0.62	0.60	818.40	0.54	712.80	105.60	12.90
36.	Muritala Road	DCL	ODC	1,960	3,920	0.60	0.60	1,411.20	0.38	893.76	517.44	36.67
37.	Maraba Garage – GSS Roundabout	DCL	ODC	680	1,360	0.62	0.60	505.96	0.33	269.28	236.64	46.77
38.	Government House Roundabout – Challenge	SEALED DRAINAGE, INACCESSIBLE										
39.	Government House Roundabout – Fate	DCL	ODC	985	1,970	0.60	0.62	732.84	0.56	683.98	48.86	6.67
40.	Post office – Offa Garage	Double	ODC	2,050	4,100	0.65	0.61	1,625.65	0.48	1,200.48	425.17	26.15
41.	Adabata Road	Slane	ODC	1,250	2,500	0.60	0.60	900.00	0.34	510.00	390.00	43.33
42.	Ogidi	DCL	ODC	1,210	2,420	0.78	0.78	1,472.33	0.54	1,019.30	453.03	30.77
43.	Maraba – Pata Market	DCL	ODC	1,150	2,300	0.61	0.61	855.33	0.32	448.96	406.87	47.54
44.	Eruda Road	SLC	ODC	380	760	0.58	0.58	255.66	0.27	190.02	136.64	53.45
45.	Fossil Petrol Station – Unity Road	DCL	ODC	1,118	2,236	0.61	0.76	1036.60	0.52	883.66	152.94	14.75
46.	Cemetery Road	SLC	ODC	586	1,172	0.61	0.56	400.35	0.38	249.40	150.95	37.70
47.	GSS Roundabout to Sango	DCL	ODC	1,280	2,560	0.61	0.60	936.96	0.45	691.20	245.76	26.23
48.	Henrold – Post Office	SLC	ODC	920	1,840	0.60	0.58	640.32	0.33	352.52	288.14	45.00
49.	Matrite – Flower Garden	SLC	ODC	620	1,240	0.60	0.60	446.40	0.47	349.68	96.80	21.69
50.	Central Bank – Challenge Roundabout	SEALED DRAINAGE, INACCESSIBLE										
51.	Oloje Road	DCL	ODC	1,815	3,630	0.66	0.65	1769.63	0.48	1,306.80	462.20	26.12
52.	Atiku Road	SLC	ODC	925	1,850	0.60	0.60	643.80	0.45	499.50	144.30	22.41
53.	Erin-Ile Road	SLC	ODC	620	1,240	0.68	0.68	463.76	0.36	245.52	218.24	46.06
54.	Agba Dam Road	SLC	ODC	880	1,760	0.68	0.68	682.18	0.38	381.22	300.96	44.12
	TOTAL			45,044	84,922	31.09	31.09	36,646.71	18.99	23,267.40	13,379.31	36.51

The depth of drainage channel at construction in the study area range between 0.38 m observed in both Queen School - Owoniboys Road and Owoniboys - Unity Junction Road and 1.00 m observed in Airport-Garin Alimi Road. However, the current channel depth range between 0.11 m observed in Fate - Tanke Road and 0.96 m observed in Airport - Garin - Alimi Road. Infact, two road networks (Garin Alimi-Sawmill and Sawmill - Queen School) had zero depth as the channel networks along the two roads are completely filled up with sediments. While the mean channel depth at construction in the study area is 0.61 m, the current mean depth is 0.37 m. This value thus represents 39.3% reduction in mean channel depth between the period of construction and time of data collection for this study. Channel width in the study area has a mean value of 0.61 m and range between 0.46 m observed along Owoniboys - Unity Road Junction and 1.00 m observed along Airport - Garin Alimi Road.

The readings observed on both channel depth and width at construction in the study area are considered too low in this era of climate change, especially in a rapidly growing city like Ilorin situated in tropical environment. Studies such as Interagency Climate Change Adaptation Task Force (2011), Trenberth (2011), Intergovernmental Panel on Climate Change (2012), Gersonius et al., (2013) have indicated that increasing precipitation intensity and number of storm events are being experienced in different parts of the world induced by climate change. This fact will no doubt increase the magnitude of runoff discharge, and inundate the drainage channels. According to Denault, et al., (2012), one major assumption of the traditional approach in drainage infrastructure design is that the statistical parameters of the hydrological variables will remain constant over time without major fluctuations or long term trends. However, this assumption no longer holds as increase in radiatively active gases in the atmosphere is intensifying the hydrological cycle in different parts of the world. The implication of this is that, even with functioning drainage systems the capacity of such infrastructure will be unable to cope with the extreme rainfalls that are expected to be induced by climate change. Thus, as can be seen on figure 3, the small dimensions of drainage channels (both depth and width) which are designed for pre-climate change conditions in the study area are no longer able to accommodate the increasing runoff discharge.

Apart from the above described climate change induced problem of drainage infrastructure in the study area, urbanization process is also presenting a challenge. Ilorin, the study area is undergoing rapid urbanization process since it became a state capital in 1967. Oyegun (1987) observed the built-up area in the city to have grown from 20.40 sq. km in 1963 to about 58.00 sq km in 1982. By 1997, the area occupied by artificial paved surface in the city has increased to about 150 sq km with consequent effect on runoff generation. Urbanization process is one of the anthropogenic distortions to the theoretical operation of the hydrological cycle. According to Jones (1997), its greater consequence on catchment runoff pattern is as a result of paved surfaces. Increase in urban development usually results in reduced infiltration, increase in volume and rates of runoff discharge and reduction in lag time due to increase in velocity of overland flow (Hall, 1984; Roel, 1984). And with constricted nature of drainage system as observed in this investigation, the resultant effects are flooding, pollution, erosion, sedimentation amongst others. The total capacity of drainage networks at construction in the study area was 36,646.71 m^3 and a mean value of 718.56 m^3. However, the current total capacity of all the drainages is 23,267.40 m^3 and a mean value of 456.22 m^3. This thus shows that the total capacity of all the drainage networks in the study area has dropped by 13,019.31 m^3 which represent 35.53% reduction in carrying capacity. This reduction in carrying capacity is basically due to reduction in depths of the drainage channels caused mainly by anthropogenic activities. As a matter of fact, the percentage reduction in carrying capacity of two of the drainage networks examined in this study (i.e. Garin Alimi – Sawmill and Sawmill – Queen School) is 100%. This is because the two drainage networks have been completely filled up with sands and other waste materials. Three of the drainage networks (i.e. Airport – Garin Alimi, Government House Roundabout – Fate Roundabout and Admiralty Villa Road) however recorded very low (<10%) percentage reduction in carrying capacity. The tree drainage channels only recorded 0.4, 6.67 and 9.84% reduction in carrying capacity respectively; thus they can be regarded as being fairly clean of wastes and sand. The field result on these three drainages networks is understandable, Airport – Garin Alimi drainage channel is the deepest and widest in the study area. The drainage channel because of its dimensions of width and depth is thus able to transmit any load deposited into it easily as the competence is very high due to the amount of water it carries. The other two drainages are located in Government Reserved Areas where population density is very low. Not only that, much of the land area draining into the two drainages are covered by lawn, especially the Admiralty Villa Road drainage channel which drains runoff mainly from a Golf court.

Figure 3. Flood Situation in Ilorin

Figure 4. Solid Wastes in Drainage

As a result of urban growth accompanied by high population density, waste generation and disposal has become a serious environmental concern in the study area as can be seen on figure 4. It is this particular factor that can be largely held responsible for the high degree of sedimentation in the drainage channels examined. Generally, the nature of sediments found in the drainage channels in the study area can be categorized into eight; such includes plastics, polythene nylon, metals, glass, sand and stones, leaves, wood, and other miscellaneous materials such as cloths, food and animal remains. As can be seen on figure 5, the percentage composition of the sediments however vary significantly with sand and stones accounting for more than 65% while polythene nylon accounted for 11.71%.

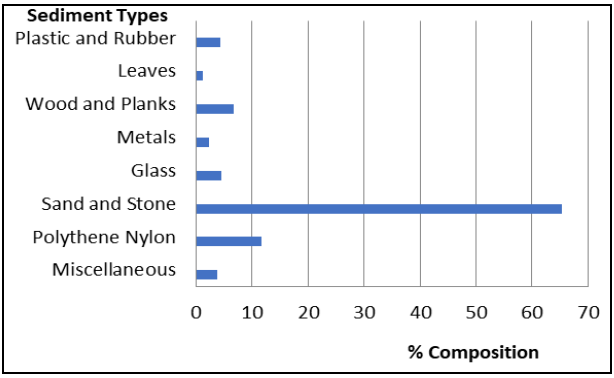

Figure 5. Percentage Composition of Sediments in the Drainage Channels
Source: Author's Fieldwork (2015)

The enumerated waste materials find their way into drainage channels due to peoples' poor attitude towards refuse disposal. It is even not uncommon to find people directly dumping their wastes into flowing water whenever it rains in the study area (Jimoh 1994; Iroye, 2008; Iroye, 2013). While lightweight materials such as plastic and rubber, leaves, polythene nylon, and wood thrown into micro drainages flow into the main rivers when runoff volumes are high, these materials stop moving when rain ceases, thus causing debris pile-ups which obstruct the movement of subsequent storm flow. The dumpling of heavy materials such as stones and metal debris into moving water reduces channels depth, affect drainage competence to carry load; hence the high sedimentation values observed in the studied channels. In some places, utility lines such as water pipes were found obstructing storm flow as they are laid across the drainage channels (figure 6) while in other places, the drainage channels have been overgrown by vegetation (figure 7). Both utility lines laid across drainage channel and vegetation growth within a channel serve as clog, preventing the free movement of solid wastes within drainage channel, thus encouraging sedimentation.

Figure 6. Storm Flow Obstruction by Utility Lines

Figure 7. Drainage Channel Overgrown by Vegetation

Effective and efficient drainage infrastructure is vital, especially in urbanized area such as Ilorin. Apart from the fact that it aids in flood control, it plays an essential role in public health and safety while also helping in the area of environmental protection. Poor drainage management aids the infiltration of polluted water into water supply systems such as broken pipes and shallow wells, it creates faecally contaminated wet soils while also serving as breeding sites for mosquitoes. Functional drainage infrastructure is thus effective and cheaper means of mosquito control; according to Cairncross and Quano (1991) it is cheaper than application of insecticides because it does not have to be repeated regularly. Not only that, drainage infrastructure has no detrimental effect on the environment like chemical insecticides; it rather constitute an environmental improvement. With good working drainage infrastructure, the danger of mosquito developing resistance to insecticide is completely removed.

CONCLUSION AND RECOMMENDATIONS

Effective and efficient drainage infrastructure is vital for flood control, reduction of pollution and promotion of public health and safety. However, in most cities of the world today, especially in developing countries, rapid urbanization process is combining with the incident of climate change to render most drainage infrastructure ineffective. While urbanization process increases the amount of runoff discharge due to reduction in infiltration capacity of the soil brought about by land pavement; climate change is producing an increase in both frequency and intensity of precipitation due to global warming. The event of climate change and the process of urbanization are thus combing to increase amount of runoff discharge which in most cities, inundate the drainage infrastructure.

This bad drainage condition which is mainly obtainable in developing countries is due to the fact that most drainage infrastructure in the region were design using traditional approach which was based on the assumption that the statistical parameters of hydrological variables will remain constant over time, without major fluctuations or long-term trends. However, recent climate change is rendering that assumption of stationarity erroneous as flooding induced by inundated drainages is now a common occurrence in most cities. Drainages designed for pre-climate change condition are neither deep nor wide enough to accommodate and transmit increased runoff discharge induced by climate change and urbanization process.

The poor waste generation and disposal attitude of the people is also exacerbating drainage problem as solid wastes dump into drainage channels clog the system, result in debris pile up and finally silt up the drainage channels. There is therefore the need to urgently revisit the traditional design practices, especially that of urban drainage in order to develop a more strategic approach which will incorporate not only the anticipated climate change impacts but will also factor in, the rapid rate of urbanization and peoples' poor waste generation and disposal attitudes. Specifically however, the study recommends that government and government agencies responsible should:

I. prioritize the implementation of drainage master plan in the study area;

II. involve citizens in drainage management by charging property owners drainage fees as part of property rate for maintenance;

III. develop a robust maintenance culture. This can be through: inspection of the entire drainage system at least once a year, visitation to problem sites during or immediately after heavy rainfall and removal of debris in the channels on a daily basis and;

IV. develop anti-dumping programme which can come inform of environmental education as earlier recommended by Jimoh and Ajibade (1995). This can be carried out through public enlightment programmes using various prints and electronic media. While the print media will help in re-educating the literate society, the use of electronic media such as radio and television programmes which can be carried out in different languages will help in educating the illiterate on the issue of environmental management.

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QUANTIFICATION OF *C FACTOR* FROM *USLE* MODEL USING CERTAIN SETS OF CLASSICAL AND SATELITE DATA IN NW ROMANIA

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Abstract: C Factor is alongside the topographic factor, one of the most influential factors in estimating soil losses by means of the USLE model. Starting from this reality, we have used three methodologies in this study in order to obtain a cover-management factor in a 291 km^2 territory located in North-West of Romania. The main objective of this comparative analysis is to highlight the best suited workflow for the medium-sized areas under the medium and high usage of data sets. The results were partly corroborated with data obtained from ESDAC which resulted from the application of the so-called LANDUM model. The best results have been obtained by using the *Linear Spectral Unmixing* technique on Landsat 8 OLI/TIRS to derive the vegetation and bare soil at the pixel level, and two more variants of built-up areas, namely one for the water, followed by the algorithm of the first four components and the evaluation of the C Factor (C_{LSU}).

Key words: C-factor - cover management factor, Linear Spectral Unmixing - LSU, Abundances, Endmembers, Normalized Difference Vegetation Index - NDVI

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INTRODUCTION

Soil losses caused by the sheet and rill erosion due to water under conditions of antropic intervention represents one of the most important of today's world issues with multiple economic and environmental implications (Vrieling, 2006), since the decreasing of agricultural lands fertility, increase of the suspended solid flow at the rivers and changes in the global circuit of CO_2 (Wang et al., 2010). According to Oldeman et al. (1990), the fields on which soil decaying inducted by the sheet and rill erosion takes place (considering the two process categories) are summing up globally 920,3 mil ha. In Europe alone, this type of erosion affects 104,6 mil ha, that is 16% of the continent's area, except for the European side of Russia (Gobin et al., 2002; Jones et al., 2012).

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Utterly natural, due to numerous social demands, the issue raised a particular interest from geoscientists, many methods of erosion and/or deposition assessment and prediction have been developed over time, applicable on the parcel, slope, basin level (local level), regional or global (Kirkby and Cox, 1995): empirical methods, among which it is remarked USLE (Wischmeier and Smith, 1965, 1978) and its derivative variants (MUSLE, Williams, 1975; RUSLE, Renard et al., 1994, 1997); process-based models – physically based methods, which are based on minimum energy dissipation rate theory (Yang, 1971, 1976, 1996), also known as the unit stream power theory, adapted for inter-rill and rill flow (Moore and Burch, 1986).

Many of them underwent translations and adaptations in electronic format, thus becoming empirical, physical or mixed computerized models of simulation / estimation of erosion and / or sedimentation processes: RUSLE 1, RUSLE 2, [1] USPED (Mitasova et al., 1996, Mitas and Mitasova, 1998), USLE 2D (Desmet and Govers, 1996), Watem/Sedem (Van Oost et al., 2000; Van Rompaey et al., 2001, Verstraeten et al., 2002;), WEPP (Nearing et al., 1989), ANSWEARS (Beasley et al., 1980), AGNPS (Young et al., 1989), CREAMS (Knisel, 1980; Foster et al., 1980), KINEROS (Woolhiser et al., 1990), EUROSEM (Morgan et al., 1998), LISEM (De Roo et al., 1996, Jetten et al., 2003), PESERA (Kirkby et al., 2004), EROSION 3D (Schmidt et al., 1999).

Synthesis studies about the weight and utilization of these methods at European level are revealing the fact that USLE (Universal Soil and Loss Equation), in its various adapted variants, represents the most used evaluation/prediction model of soil erosion on a long term. For instance, Van Camp et al. (2004) performs an inventory of the estimation methods of erosion exercised by water on the E.U. countries, and the presented result can be summarized as follows: in 16 out of the 36 studied countries there could be identified the used patterns, and 12 out of those 16 countries are using USLE. Van Beek, and Tóth (2012), in a synthesis for RAMS (Risk Assessment Methodologies) about erosion, carried out on the basis of thematic questionnaires within the EU RAMSOIL project in which 17 countries were involved, mentions that 7 out of the 11 RAMS for soil erosion inventories are using USLE (or some of the modified versions of it):

$A = R \times K \times L \times S \times C \times P$ (Wischmeier and Smith, 1978), where:

A - the medium rate of erosion ($t\ ha^{-1}yr^{-1}$)

R - the rainfall and runoff factor, plus a factor for runoff from snowmelt, where it is significant ($MJ\ mm\ ha^{-1}\ h^{-1}yr^{-1}$);

K - the soil erodibility factor, understood as an intrinsic measure of soil susceptibility to erosion ($t\ ha\ h\ MJ^{-1}\ ha^{-1}\ mm^{-1}$);

L - the slope-length factor (dimensionless);

S - the slope-steepness factor (dimensionless);

C - the cover and management factor (dimensionless);

P - the support practice factor/ influence factor of anti-erosion works (dimensionless).

The Wischmeier and Smith equation was tested and adapted (calibrated) in Romania as well for several decades on standard leakage plots in experimental stations (Perieni - Vaslui County, Bilceşti - Argeş County, Câmpia Turzii - Cluj County, Valea Călugărească - Prahova County, Aldeni - Buzău County), under the aegis of ICPA (Research Institute for Pedology and Agrochemistry, at present INDCPAPM – National Research and Development Institute for Pedology, Agrochemistry and Environmental Protection), so that today the Romanian derived model of USLE has the widest spatial-temporal applicability spread at national level:

$E = K \times L^n \times I^n \times S \times C \times C_S$ (Moţoc et al., 1975, 1979, 2002), where:

E - the average annual rate of the effective erosion ($t\ ha^{-1}yr^{-1}$);

K - the correction coefficient for pluvial aggressiveness;

[1] *www.ars.usda.gov*

L - the length in meters of the slope;
I - the slope (%);
m and n - coefficients; m = 0.3; $I^n = 1{,}36 + 0{,}97\ i + 0{,}381\ i^2; i$ − mean slope
S - the indicator of soil erodibility;
C - the indicator of the protection offered by crops;
Cs - the indicator for the effect of the erosion control measurements.

Of all the factors taken into account in these equations, the cover-management factor (C factor) is considered to be among the top two as the level of importance for the risk of rill and inter-rill erosion (Renard et al., 2011) is concerned, as at the micro and mesoscalar level, alongside the topographic factor (LS factor), it induces greater variability in terms of input data and as it can act on it in a real way, by management measures, to reduce erosion processes.

The main objectives of this material are:

- to perform a comparative analysis of the C-factor (cover-management factor) estimation methods applied to a selected territory;
- to highlight and interpret the value differences from the results obtained;
- to validate a method that is suitable for the NW of Romania, by reference to the results obtained on European scale (Panagos et al., 2015).

STUDY AREA

The territory to which this study applies belongs to the territorial administrative units of Oradea, Biharia, Paleu and Cetariu, which are integrated from the territorial and economic management point of view to Oradea Metropolitan Area in Bihor County, located in the north-west of Romania (figure 1).

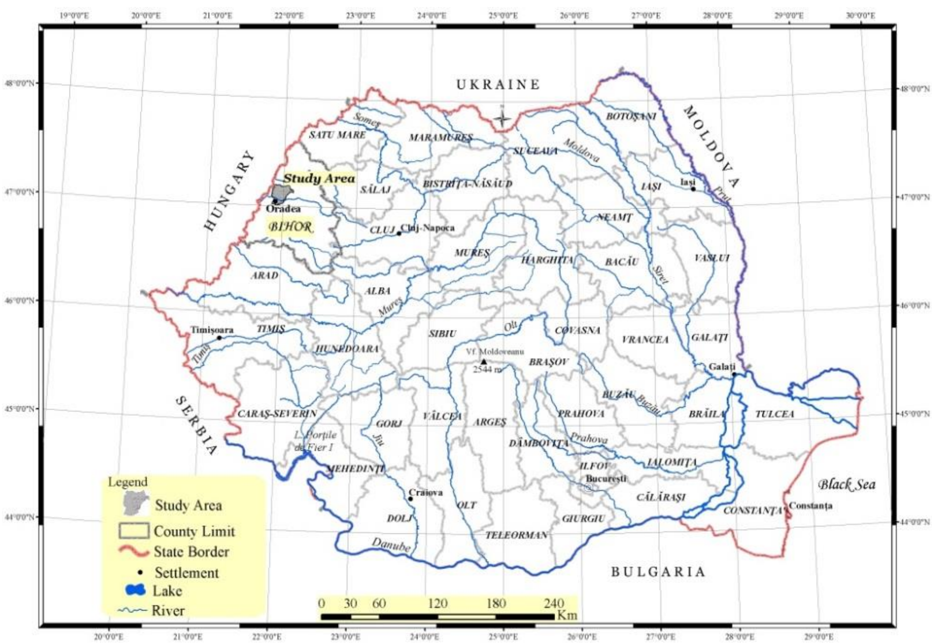

Figure 1. Location of the Study Area

The motivation for choosing this workspace resides in the accentuated dynamics of functional and especially residential areas, which have gradually expanded into fragile geomorphosystems in terms of stability.

On a macro-morphological scale, the four administrative units are developing on relief units belonging to the Hills and the West Plain: Oradei Hills (Crişene Hills Subunit), Crișurilor Low Plain, Miersigului Plain, and Bihariei Plain (figure 2). From a genetic point of view, we are in the situation of a fluvial morphology, imposed mainly by Crişul Repede, which interacts with the hillslope geomorphostructures conditioned by the torrential, gully and gravitational processes, their functional and geomorphic interconnection being ensured by glacises.

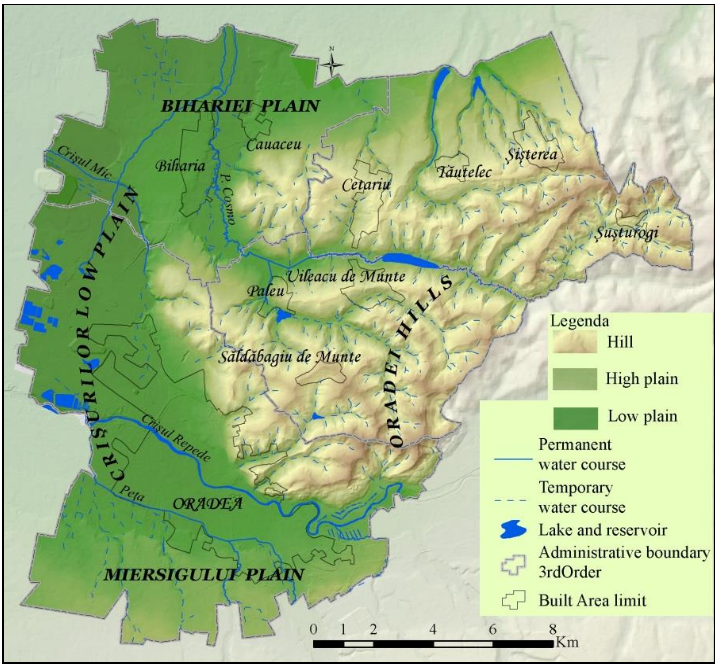

Figure 2. Relief Units Map
(Background data source: EU-DEM v1.1)

MATERIALS AND METHODS

Starting from the stated objectives, some clarifications have to be made regarding the cover-management factor connotation. From a quantitative point of view, in USLE, it expresses the ratio of long time soil loss in a field with a particular type of agricultural crop and the soil losses that took place in the uncultivated standard Unit Plot (22.1 m long, 9% slope), over the same time period (Kinnel, 2010), and is quantified dimensionless. Conceptually, it expresses the combined effect of all the interrelated cover and management variables (Wischmeier and Smith. 1978).

Initially, both USLE and the variant adapted for Romania were designed to predict soil erosion on agricultural land, respectively for arable land with reduced territorial extension. During over 50 years this equation has been used, in the context of the diversification of the techniques for processing and extraction of the coefficients taken into account, the work areas have become increasingly varied from geomorphological and bio-pedogeographical point of view, but also more extended, from the hydrographic basins (Van Rompaey et al., 2005) to continental territories (Van der Knijff et al., 2000; Panagos et al., 2014).

Therefore, cover-management factor underwent a series of modifications, in the sense that it needed to be adapted to the lands which are not arable and which have another type of land cover as well.

If we were to summarize its estimation methods, irrespective if it is about USLE or RUSLE, with their different variants, there could be outlined three main group of methods:

- the standard methodology, which we shall call the classical methodology;
- methods based on the processing of multispectral satellite images;
- mixed methods.

Classical methodology requires the use of correction coefficients established according to the USLE Standard Technique as set out above, i.e., on the basis of the reporting of soil losses in parcels of different agricultural uses or natural vegetation coverings, to soil losses in homogeneous parcels without vegetation or with poor vegetation, obtained by measurements made in the experimental research stations. In Romania, the values of these correction indices can be found in tables or cartographic format in a series of specialized materials (Moţoc et al., 1975; Moţoc and Sevastel, 2002; Moțoc et al., 2010).

This is the technique used in most studies published since 2000s in Romania, which aimed at the multiannual estimation of soil losses in different areas of the national territory (Anghel and Todică, 2008; Anghel and Bilașco, 2008; Bilașco et al., 2009; Arghiuş and Arghiuş, 2011; Ștefănescu et al., 2011; Alexandru et al., 2012; Zisu and Năsui, 2015), and with respect to the data sources, CORINE Land Cover is the dominant one for the identification of the land use types, which means a resolution of 100 m, and in a relatively small proportion, orthophotos, with a resolution appropriate to this type of research (0.5 m).

We used orthophotos with a 0.5 m resolution from 2012 for parcel vectoring corrected on Pleiades 1A high resolution multispectral images (1.6 m for multispectral and 0.4 m for panchromatic) of June 2014 (figure 3), as 2014 is the reference year for all data categories used in the study. The latter were reprojected in Stereo 70 from GCS_WGS_1984 (Geographic WGS84) and subjected to a geometric correction process (warp from GCPs, with 32 ground control points).

Figure 3. Detail from ortophoto 2012 (ANCPI) and Pleiades 2014, panchromatic (Source: ANCPI) [2]

The result of this processing consists of a set of vector data, with alphanumeric data where can be found the types of land cover and the values of the C factor, according to Moţoc et al. (2010), with small changes that we will specify when referring to the results obtained. For viewing, they have been transformed into a map showing the heterogeneity and mosaic of the analyzed territory in terms of land use patterns (figure 4).

[2] *https://spacedata.copernicus.eu*

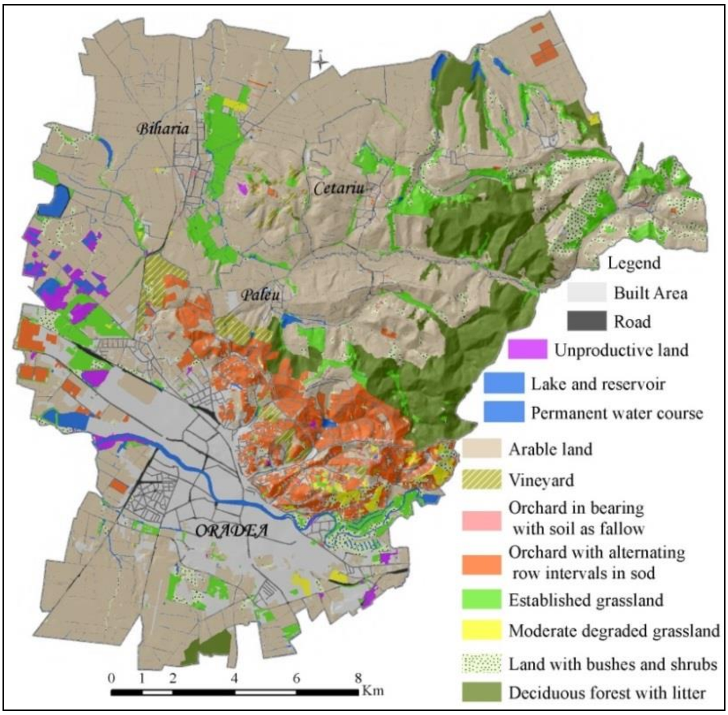

Figure 4. Land Cover Map
(Source: Ortophoto and Pleiades 1A)

Methods based on the processing of multispectral satellite images

Generally, starting from specialized works dealing with this issue, there can be identified two main working directions which use satellite data to extract the C factor: the first one is based on finding certain correlations, by means of regression equations, between itself and the slope-based vegetation indices, the best known and used being *Normalized Difference Vegetation Index – NDVI* (Rouse et al., 1973), and the second one uses processing techniques from *Spectral Mixture Analysis* group.

The extraction of factor C by *rescaling NDVI* is probably the most used, but also the most criticized way of working in this direction due to the speed and ease of obtaining the normalized index of vegetation differentiation on the one hand and due to the poor correlation that can appear between it and the cover-management factor, under certain environmental conditions, which are related to the particularities of climate, soil and vegetative vitality in the work area, on the other hand. Thus, it is well known that the value of this index is strongly influenced by the presence of dark soils and atmospheric pollution (Jiang and Huete, 2010), and its nonlinear or linear relationship with fractional vegetation cover, and implicitly with C factor, is still discussed in the specialty literature with pros and cons (Jiang et al., 2006; Ding et al., 2016).

Essentially, the most used procedure starting from this spectral index (De Jong, 1994; Van der Knijff et al., 2000; Lin et al. 2002; Durigon et al., 2014) involves obtaining it using NIR and RED spectral bands: $(NIR - RED)/(NIR + RED)$, as green vegetation absorbs radiation from red domain and reflects radiation from infrared domain, then the values obtained are related to vegetation coverage in the field, resulting an empirical expression that may be linear or exponential, but which does not have physical basis anyway. The validity of these regression equations is strictly related to the study territory, and the application of such regression models from one region to another can generate great confusion in the results. They were mostly critically analyzed by those who promoted them.

With all the criticisms we have known, we have selected a model of this kind that we will apply in the field, which should have been adapted by the authors (Van der Knijff et al., 2000) to the European continent or at least of the European Union:

$$C = e^{\left(-\alpha * \frac{NDVI}{\beta - NDVI}\right)}, \text{ unde } \alpha = 2;\ \beta = 1$$

It is worth mentioning that at the level of the Romanian territory, except for the material mentioned above, which is anyway on a European scale, there are some attempts to estimate the C factor on the NDVI, which use different regression equations, such as those of De Jong (Patriche et al., 2006), Van der Knijff et al. (Roşca et al., 2012) or Karaburun (Copăcean and Oncia, 2015), the former being derived for a Mediterranean territory in southern France, and the latter for an area in Turkey, west of Istanbul.

Linear Spectral Unmixing (LSU) is a standard technique for processing multispectral and hyperspectral satellite scenes developed by Adams et al. (1986), by means of which the fractions and the percentage weights, referred to as abundances, can be obtained at the pixel level, of the material components considered, called endmembers, based on their spectral responses.

The model assumes that the spectral signatures at each pixel level can be expressed as a linear combination of so-called endemembers, weighted by their abundance (Iordache and Dias, 2012):

$$y_i = \sum_{j=1}^{q} m_{ij} \propto_j + n_i$$

where y_i is the measured value of reflectance at the spectral band i, m_{ij} is the reflectance of the *j*th endmember at spectral band *i*, α_j is the fractional abundance of the *j*th endmember, and n_i represents the error term for the band *i*.

The LSU has been applied with good results in a series of studies that aimed at the effective obtaining of factor C in USLE (Meursberger et al., 2010a) or assessing soil losses through the USLE / RUSLE model (Lu et al., 2004; Alejandro and Omasa, 2007; Meursberger et al., 2010b).

The essential aspects in this procedural approach are the selection of those endmember value elements so as to best cover the component pixel structure of the used satellite scenes as well as the quality of the spectral signatures of these components that can be extracted directly from multispectral data, field data, or online databases.

The number of selected components, that will eventually identify with those land cover categories that we consider to be the main in work area should not exceed the number of spectral bands in the used satellite images (ENVI EX User`s Guide; Bangira et al., 2017), and from our point of view it is advisable to be even smaller.

In this regard, we used a Landsat 8 OLI / TIRS satellite scene acquired in June 2014 with 30 m resolution (15m for panchromatic), from https: //glovis.usgs. Before the actual processing in the LSU operational stream of ENVI 5.3, the data stored in the Multispectra (Level 1 Product) were converted from the DN (digital number) format into radiation values (a process called Radiometric Calibration), after which into reflectance values (ToA - Top of Atmosphere Reflectance) through the Dark Subtraction method.

Five categories of endmember-value components were selected for this study: vegetation, bare soil, water, and two variants for the built-up surfaces due to their chromatic heterogeneity. For each of them, the spectral signature was extracted directly from the pure pixel of the satellite image (figure 5). They were identified by the Pixel Purity Index (PPI) application from ENVI.

Based on these spectral responses the relative abundance at the pixel level of the components (figure 6) was obtained, which is actually identified with their percentage per pixel. The values are between the 0 to 1 scale (by LSU constraint mode), i.e. 0 is translated to the absence of the component in question, and the value 1 represents the 100% weight of the component in the elementary unit of work.

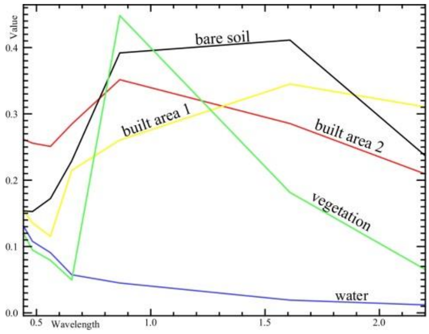

Figure 5. Spectra for endmembers

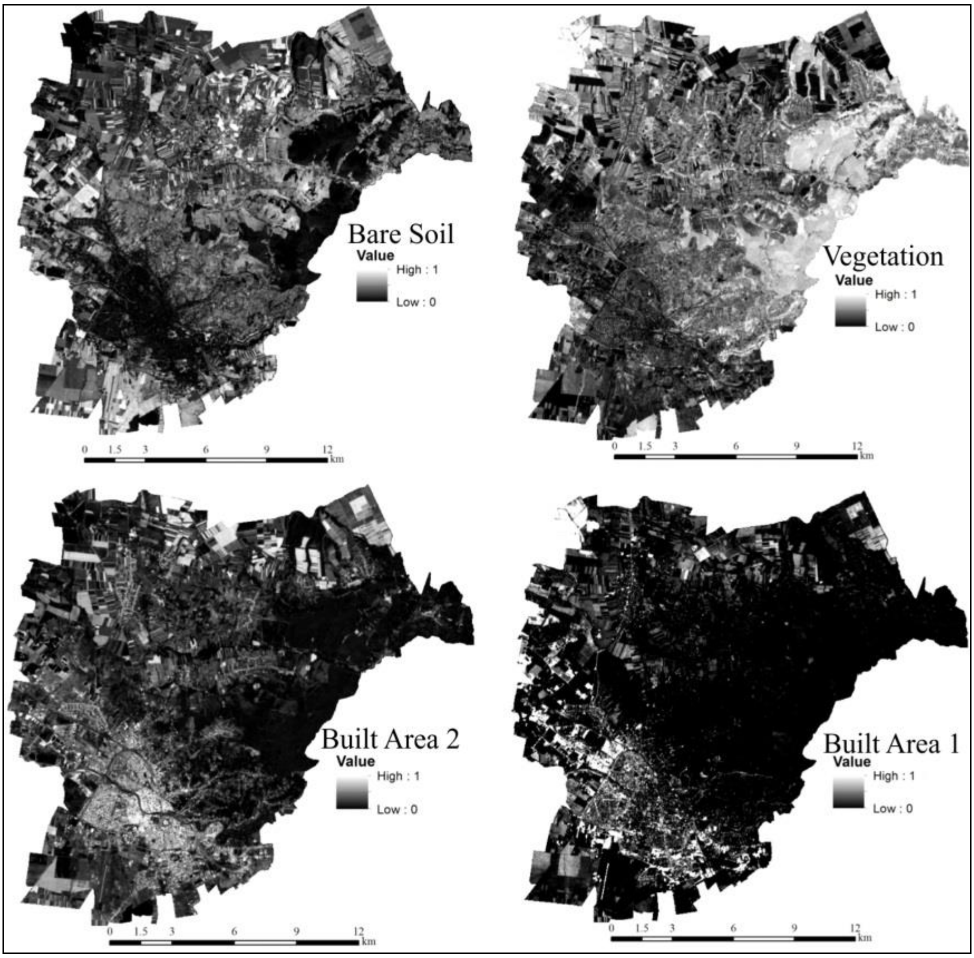

Figure 6. Abundances for endmembers

The water component, which is identified with shadow, had to be considered for the Linear Spectral Unmixing process, since it is part of the core component of the study area, but the factor C algorithm is insignificant, which is why we did not consider it necessary to illustrate it in figure 6.

Further, obtaining the values for the C factor was made by adapting the Alejandro and Omasa equation (2007) to the territorial reality of our work area:

$$C = \frac{F_{bs}}{1 + F_v + F_{ba1} + F_{ba2}}$$

were, F_{bs}, F_v, F_{ba1} and F_{ba2} are the fractions of bare soil, vegetation and built areas.

For *mixed / hybrid methods*, they involve a combination of standard data and remote sensing data. In this category we can frame the work of Panagos et al. (2015), where one type of data is used for factor C at the arable land level, while for other land, satellite data is used (see the so-called LANDUM model).

RESULTS AND DISCUSSIONS

Three sets of data stored in the rasters for *cover-management factor* of were obtained for the area, following the methodological approaches presented, plus a fourth, obtained from ESDAC (European Soil Data Center), developed by Panagos et al. (2015).

As we have pointed out, in order to obtain the C factor through the standard methodology, based on C_{LC} - C land cover, we have used the correction indexes reviewed by Moţoc et al. in 2010. The small changes we took the liberty of making, are related to the need of introducing a new class, in this case land with bushes and shrubs, and a bar field limitation to 1 (not 1.6). More than half of the surface of the 4 territorial administrative units (50.56%), the factor C is 0.8 (figure 7) due to the extension of the arable land, the structure of which dominates maize in monoculture. In contrast to the homogeneity of parcels of C factor obtained traditionally, we notice the heterogeneity of the spatial distribution of C derived values by LSU (figure 8) where we notice a higher weight of the class 0.04 - 0.25, which is 151.6 km^2 (table 1) and 52.012%, respectively.

In other words, from a quantitative – numerical point of view, in a comparative analysis between C_{LC} and C_{LSU}, there is clearly a change of place in the dominance between classes 0.7 - 0.8 (in fact 0.8) and 0.04 - 0.25.

Table 1. Surface distribution of value classes for C factor

Serial No.	Class values	C_{LC} (km^2)	C_{LSU} (km^2)	C_{NDVI} (km^2)	C_{LANDUM} (km^2)
1.	1 - 1.47	0	0	1.4	0
2.	0.8 - 1	3.09	0.95	4.56	0
3.	0.7 - 0.8	*147.391*	1.3	12.38	0
4.	0.6 - 0.7	3.93	3.45	18.2	0
5.	0.4 - 0.6	0.37	25.71	54.7	1.22
6.	0.25 - 0.4	2.13	51.5	*63.39*	*132.22*
7.	0.04 - 0.25	19.68	*151.616*	*99.05*	68.16
8.	0.01 - 0.04	13.48	28.27	33.85	4.49
9.	0.001 - 0.01	19.88	6.58	3.88	25.52
10.	0.0001 - 0.001	26.63	0.59	0	0.009968
11.	0 - 0.0001	54.87	21.5	0	0

For the NDVI factor C, there can be noticed approximately the same spatial heterogeneity in the distribution of the values (figure 9), and from the quantitative point of view the classes 0.04 - 0.25 and 0.25 - 0.4 hold 55.72% of the total area. Data from ESDAC (European Soil Data Center) indicates a predominance of classes 0.25 - 0.4 (45%) and 0.04 - 0.25 (23.38%) with a spatial continuity in the distribution of C_{LC} - like values (figure 10).

The differences in territorial extension for class 0.8-1 are related to the interpretation of the land categories included here, meaning that in C_{LC} we considered non-productive land with correction index 1, equivalent to bare soil / fallow land, but in this category fall in particular as land types: those without vegetation, land on the banks of rivers and lakes occupied by hydrophilic vegetation, swamps, salty soils, landfills, dumps, areas occupied by torrents and ravines, while for

C_{LANDUM}, the authors considered, according to Eurostat, that the fallow land category is: bare land bearing no crops at all, land with spontaneous natural growth which may be used as feed or ploughed in, and land sown exclusively for the production of green manure (this is also the explanation for using a correction coefficient of only 0.5 for this type of lands). In addition, for C_{LSU}, we considered bare land to be the only non-vegetation areas that really occupy relatively small areas in continuous form, but the soil bar fractions identified in agricultural crops or in forestry at the pixel level, are very important in the correct estimation of factor C.

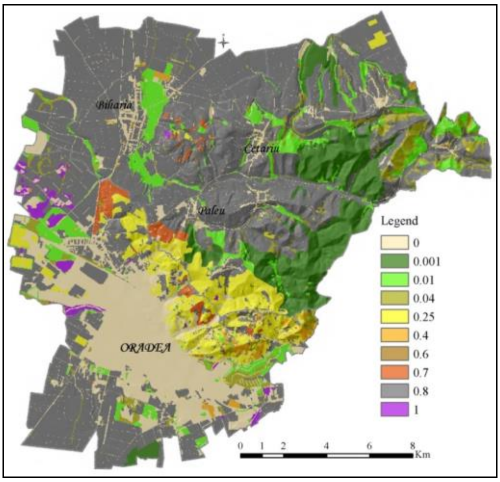

Figure 7. C_{LC} Map

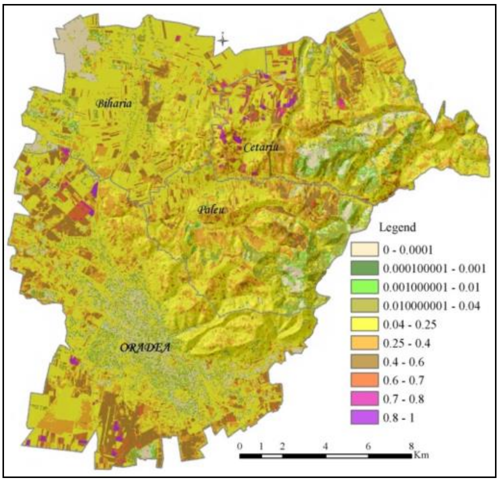

Figure 8. C_{LSU} Map

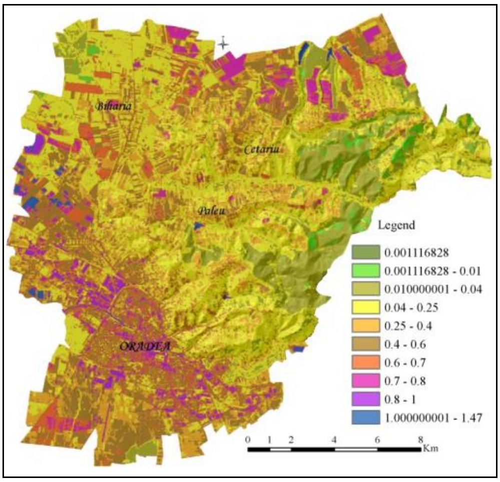

Figure 9. C_{NDVI} Map

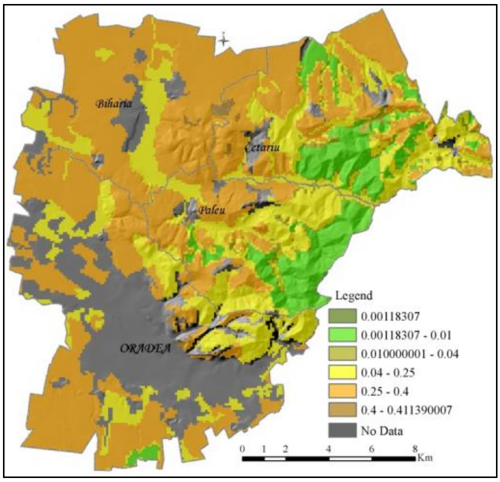

Figure 9. C_{LANDUM} Map
(Source: European Soil Data Center)

As for the areas occupied by the forest, equivalent to the classical methodology with the value of 0.001, it is observed that C_{LC}, C_{LANDUM} and C_{NDVI} appear as compact areas, classified in classes 0.0001 - 0.001, 0.001 - 0.01 and 0.01 - 0.04, respectively while at C_{LSU} there is a redistribution of values on three classes, which leads to a spatial mosaic in their distribution.

In order to obtain a complete image of spatial relationships between C_{LCU} and C_{LSU} value classes, which we consider to be most relevant in this study, we performed a Tabulated Area process between the two datasets, where the areas are defined by classes derived from land cover (table 2).

Table 2. Tabulate Area between C factor from classical method (C_{LC}) and C factor from LSU (C_{LSU})

C_{LC} Classes	C_{LSU} Classes (km^2)									
	0 - 0.0001	0.0001 - 0.001	0.001 - 0.01	0.01 - 0.04	0.04 - 0.25	0.25 - 0.4	0.4 - 0.6	0.6 - 0.7	0.7 - 0.8	0.8 - 1
0	8.12	0.21	2.27	8.64	30.51	3.99	1.01	0.069	0.02	0.004
0.001	5.36	0.21	2.61	11.41	6.85	0.15	0.02	0	0	0
0.01	0.44	0.01	0.14	0.71	8.32	5.82	4.19	0.16	0.035	0.0009
0.04	2.03	0.058	0.53	2.01	6.95	1.26	0.59	0.018	0.004	0
0.25	0.16	0.0081	0.079	0.54	14.39	4.22	0.30	0.003	0	0
0.4	0.03	0.0027	0.01	0.05	1.28	0.54	0.21	0	0	0
0.6	0.0018	0.0000	0.002	0.01	0.31	0.036	0.0009	0	0	0
0.7	0.0189	0.0009	0.008	0.03	2.41	1.4	0.054	0	0	0
0.8	5.19	0.083	0.886	4.76	*78.90*	*33.24*	*18.92*	3.18	1.24	0.95
1	0.128	0.0018	0.018	0.08	1.65	0.81	0.37	0.018	0	0

From the analysis of the results it is clear that almost 79 km^2 in the class 0.04 - 0.25, 33 km^2 in the class 0.25 - 0.4 and approx. 19 km^2 in the class 0.4 - 0.6 overlapped over class 0.8 from C_{LC}.

The 30 km^2 of class 0.04 - 0.25, which overlap with the C_{LC}-rated class 0, are perfectly justifiable (as well as the entire distribution of this value class), as not even Oradea city we cannot talk about an urban continuum, that is, everywhere, but especially at the outskirts, the built surfaces alternate with the green spaces, the agricultural cultivated parcels and even small forest areas. The 5 km^2 of class 0 - 0.0001 (C_{LSU}), appearing in C_{LC} class 0.8 space, which seem at first sight in total contradiction with the conceptual logic of C factor, actually come to complete a reality so far by numbers and percentages: by its conception the C_{LSU} also expresses the phenological reality in the field, meaning that the vegetative stages of the different cultures or the phenophases from the natural vegetation greatly influence the value of C, through the density of the strains, the size of the foil covering or the height of the canopy (more details from this point of view can be found in the handbooks and other works cited so far). In other words, on the same cultivated surface or land with natural vegetation, the value of factor C varies over a year, a fact known and illustrated in literature, even from the studies of Wischmeier and Smith, only that those methodologies are applicable at the microscale level.

CONCLUSIONS

Starting from the stated objectives and the results materialized in spatial distributions or the value strings of the factor studied, we can make some statements supported by the presented data.

When working on areas with medium expansion (our work area was 291 km^2), where it is physically impossible to apply the classical methodology due to the high consumption of time and the high material costs, regardless of the USLE or RUSLE models, obtaining the C factor with LSU is the method that has results closer to the requirements of the model considered (USLE), because even if soil losses are considered as multiannual average estimates, the values of the factors taken into account are punctual, adapted to the reality of the land or the work plot. It should not be forgotten that, at the plot, factor C of this model takes into account the type of crop rotation (crop rotation), the type of agricultural works, the residual elements of the plant crops, and the stages of development of plants as well. We have used the classical methodology in the sense it is used in most studies in Romania or elsewhere, but the values of those indices have been calibrated for morpho-erosion conditions that are not present in western Romania and there are no experimental data for this region either. On the other hand, we must point out that given the absolutely conventional management practices, here we refer to tillage practices (not to be confused with support practices), they can be considered as 1, so anyway they would not affect the results in the classic workmanship.

It is obvious that C_{LSU} does not directly store all the C factor subcategories taken into account at parcel level, but among all the methods we have applied, the one that provides good quality results in average resolution data of the insertion data is *LSU* based.

As expected, the use of NDVI in the manner presented above overestimates the values of C factor, as noted by other researchers mentioned throughout the paper. Moreover, by rescaling, aquatic surfaces usually fall into the class with the highest values. This would not be the major impediment (pixels containing lakes or other hydrological entities may be masked), but overestimation at the level of value classes, which can be reflected in the final estimates derived from the equation. It is, however, a quick method, and correspondence between values and land use patterns can be established.

The C_{LANDUM}, derived from ESDAC data, can be used for partial verification of other data sets of the same profile, but in no case for validation, as we thought in the pre-stage of detail analyzes. The reasons are multiple, but all of us note the resolution of the input data which, in our opinion, is insufficient to provide adequate content to the final result (CORINE Land Cover and MERIS data with 100 m and 300 m resolution respectively). A question mark is also related to the harmonization of sets of hierarchical data in different value scales that have been incorporated into the same factor. Even if we believe that such analyzes should be limited to narrower territories, so that the results do not become too general, it is to be appreciated the considerable effort made by the authors to get an EU-wide C-factor as a starting point in the local scale analyzes.

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NATURE-BASED SUBURBAN LEISURE OPPORTUNITIES WITHIN THE ORADEA METROPOLITAN AREA

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Abstract: Over the past 15 years, the periurban area in the proximity of Oradea has been accredited as a place of great attraction for the urbanites eager to move to the countryside, taking advantage of the natural resources, numerically generous and possessing an ecological quality. On such a background, these urbanites or tourists have come into contact and continue to discover these natural resources from the point of view of their new qualities, namely people motivated to do thematic tourism. This study seeks to know in detail the potential of the 11 communes and their related villages in the Oradea Metropolitan Area (OMA) and what they provide for weekend-type activities or forms of tourism based on discovery and leisure. The researched area has various natural resources, but diversity is configured according to the environment and morpho-hydrography specific for the hilly, plain and hilly-plain contact area relief. The inventory of local resources (8 categories) prone to nature-based tourism is dominated by protected areas, rivers and lakes for fishing, deciduous forests and associated hay fields as well as the hilly relief in the eastern part of the area. The

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expression of the attractiveness of local nature for leisure tourism is given by the attractiveness index, which at the OMA level is 87.47 points, with an encouraging maximum of 11.67 points (out of a maximum of 25 points). The detail of the distribution and the natural resources attraction weight can be found in the four thematic maps.

Key words: nature, natural resources, attractiveness, leisure activities, rural, Oradea Metropolitan Area

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INTRODUCTION

Green spaces can play a vital role for providing leisure opportunities of urban population and trigger environmental, social and economic benefits (Papageorgiou and Gemenetzi, 2018). Tourism can capitalize these benefits in favor of the local communities form the neighboring localities surrounding big cities as well as in the favor of urban tourists who need to escape the agitation and pollution of big cities. Metropolitan areas turned out to be drivers for the development of rural tourism, agritourism, food tourism and nature tourism (Sznajder, 2017).

This research paper aim is to settle a current inventory of the natural resources of the Oradea metropolitan belt and make an assessment of these resources so as to highlight which of the communes of the Oradea Metropolitan Area (OMA) has a higher potential for nature-based tourism. Along with an over agglomeration in the city people need the urge to search for leisure in nature and the suburbs provide such a comfort. Their related green spaces encourage social interaction, stimulate people to practice sports and thus enhance the population public health and fitness (Zaręba et al., 2016). Metropolitan areas are veritable repositories of biodiversity and meanwhile a place for leisure and relaxation with a high socioecological function (Junior and Santos, 2017). Along with urbanisation the quality of life has decreased therefore many urban residents move to nearby rural areas to enhance their quality of life (Hołderna-Mielcarek, 2017), nonetheless the more mobile residents become the higher the traffic congestion (Ewing et al., 2018).

The main motivations of a tourist who chooses nature-tourism should be: the return to nature, active rest, air and fruit cure, the consumption of fresh food from hosts' homes, sports, fishing and hiking. However, sometimes there are impediments that trigger potential tourists not to choose a particular tourist destination.

Many western countries witnessed in the ‘60s a widespread outward expansion with new settlements emerging in the suburbs (Cheng et al., 2017) which were later on integrated as metropolitan areas. A regional economic development is targeted through the merging of nearby neighboring rural areas to the cities, which are no longer treated distinctively, but in the light of a territorial cohesion (Tarta et al., 2007), some of these surrounding communes converting later on from a monocentric to polycentric functions (Huang et al., 2017).

Oradea City from the western part of Romania was set up as the Oradea Metropolitan Association on the 9th of May 2005 whose main objective was the economic development of the metropolitan area and its specific aim the alignment of the Oradea Metropolitan Area to the Euro-Atlantic economic and social standards in accordance with the national ones. [1] The Oradea Metropolitan area currently includes 11 communes, but initially it only included eight communes, i.e. Biharia, Borş, Cetariu, Nojorid, Oşorhei, Paleu, Sîntandrei and Sînmartin to which Girişu de Criş added up in 2007; Toboliu added up in 2008 and in 2010 Ineu commune was intergrated too (Ilieș et al., 2013; Staşac and Bucur, 2010). All the communes feature good premises for a nature-based and villegiatura tourism (Dincă, 2009).

From June 2nd 2010 the Oradea Metropolitan Area counts 12 members, of which 11 rural localities along with the municipality of Oradea city too. Its stated aim is to stimulate and support

[1] *www.zmo.ro*

the growth and prosperity of the area, enhance the wellbeing of its citizens and the quality of life in general (Strategia de Dezvoltare a Zonei Metropolitane Oradea, 2015). The current paper is exclusively related to the rural area of OMA and its natural tourist resources supply.

The Oradea Metropolitan Area has been inhabited for a long time, namely the 11th century, the thermal waters of Sanmartin being mentioned in documents since 1214-1215 and Ineu commune even earlier in the year 1014.

MATERIALS AND METHODS

The research consisted of a natural resources territorial survey within the radius of the 11 communes of the rural Oradea Metropolitan Area, the research team approaching more than 34 tourist sites, de visu and in situ from which photos were taken as well as an assessment of their status was conceived. The raw data were processed through the ArcGIS program which allowed the natural resources mapping, thus generating more theme maps such as the attractiveness index of the natural potential of the OMA map, the time-distance map, a physical-geographical map, an original material meant to stimulate potential urbanites (overburdened by air pollution and agglomeration in the city) to undertake quality nature-based leisure time in the proximity of their residential area, as well as to stimulate short-distance leisure travel which implies lower travel costs. The nature-based resources included in the study are avens, forests, monuments of nature, natural reserves, leisure lakes as well as rivers and streams that cross the area. The authors included also in the natural resources' category the man-made lakes which got a leisure function across time given that their primary natural source which led to the development of leisure activities is water. The attractiveness index of the natural tourist attractions was calculated according to the national methodology of the tourist potential assessement in the basic administrative-territorial units in Romania. The scores for each category were given as a result of consultations with specialists from the field of economy of tourism, territorial planning, geography, sociology, architecture, geology, operators in tourism in the public and private field, local or central public authorities, etc so that a final 100 points' score was granted after assessing the 4 items referring to the natural tourist resources for which 25 points were granted; the man-made tourist resources - 25 points; the tourist specific infrastructure - 20 points and the technical infrastructure - 30 points. For the current paper only the first part of the assessment was taken into consideration with a maximum score of the attractiveness index of up to 25 points referring to the rural OMA natural resources.

RESULTS

The natural touristic assets of the rural OMA

The paper starts from the consideration that one of the basic pillars of rural development in the OMA is its natural capital. Meantime, we have to admit that there is a certain delay in the touristic capitalization of this potential, even though urbanites have shown a real interest to move to OMA villages for over a decade, due to the quality of natural resources, especially the landscapes (Dincă and Teodorescu, 2015). Starting from these considerations our analysis focuses on natural tourist resources, possibly becoming tourist micro-destinations, resources that include: relief, climate, hydrographic and bio-geographical resources and landscapes as a synthetic expression of all local natural elements. Here, the tourist can come in direct contact with nature, can resort to an active rest in an unpolluted natural environment that typologically, structurally and functionally fits the subnatural and low-average anthropomorphic landscapes (Dincă, 2008).

The OMA lays over a lowland plain and low hills area. The relief is set in light steps and consists of the low plain of Crişuri, the Depresionary Corridor of Crişul Repede river (Oradea - Bratca Depression), Oradea Hills in the north-east and Tăşad Hills in the south-east area.

The Oradea Hills are part of the western border of Crişana Hills, which delineates the Carpathian mountain range. The southern part of these hills form the right slope of the Crişul Repede Valley (in the Oradea - Bratca Depression). In terms of altitude, in the OMA area, these hills range from 150 to 350 m (figure 1). The administrative-territorial units located in Oradea Hills are Ineu commune (i.e. the villages of Botean and partly Husasau de Criş), a part of Oradea city, the villages of Paleu and Cetariu (figure 1). The interfluves in these hills are rounded and above the general level, in some places, a peak that sets itself apart into a belvedere spot stands up. The contact with the plain is made directly or by means of some more or less tilting glacises. The Tăşad Hills are more discrete in the rural metropolitan area, being present in the south-east area. But, from the tourist point of view, the Şomleu Hill (346 m altitude) from Sînmartin commune sets itself apart, due to the unique existence of a form of endocarstic relief: Betfia / Hud (r) of Bradi. Genetically, this hill is a prominent limestone spur prolongated from the Padurea Craiului Mountains. The administrative-territorial units of the Tăşad Hills are the communes of Nojorid (i.e. the villages of Apateu and Sauaieu), Sînmartin (i.e. the villages of Cordău and Befia) and Oşorhei (i.e. Felcheriu village).

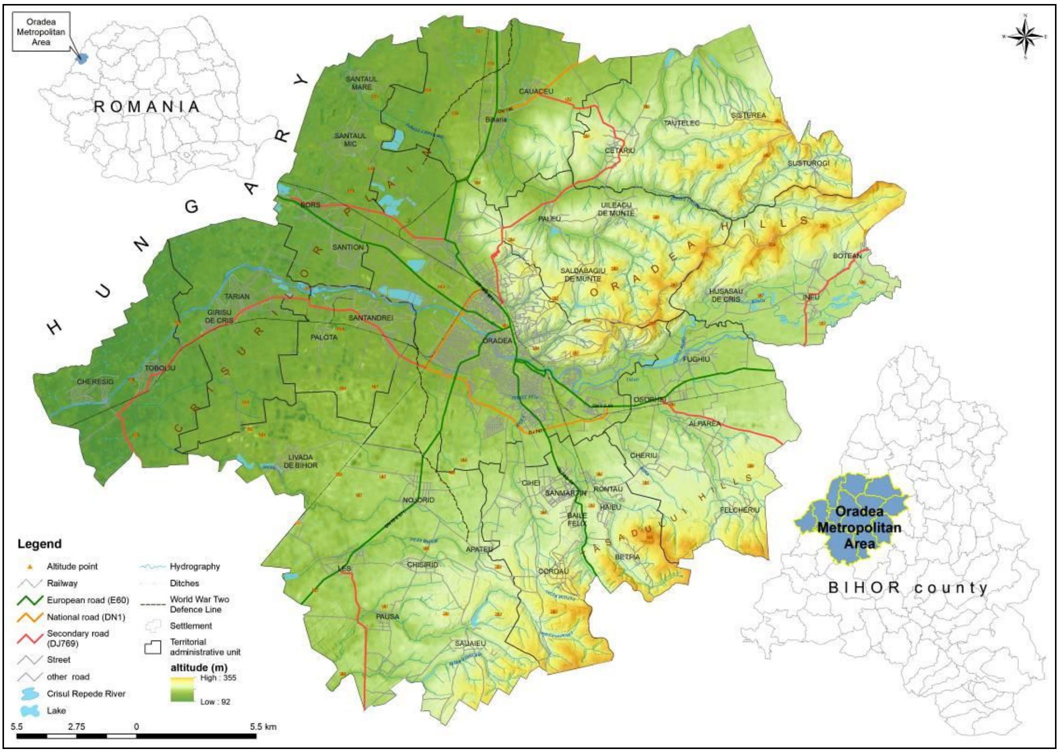

Figure 1. Physical-geographical map of the Oradea Metropolitan Area

The Depressionary Corridor of Crişul Repede River, a golf-type depression specific to western Romania, is represented by the Oradea - Bratca Depression, widely considered to be the main morphological axis in the specialized literature, as well as a road and railway link of Bihor County. The administrative-territorial units in this corridor are the Ineu commune (i.e its homonimous village and partly Husasau de Criş), partly Oradea, Bors commune (i.e. the villages of Bors, Santău Mare, Santău Mic and Sântion). The relations between the rural OMA are enhanced by the "blue blood connection" represented by the Crişul Repede valley (Filimon, 2014). In this corridor, the lower terraces of Crişul Repede are revealed, capitalized by agriculture, and the vineyards and orchards appear at the contact with the hills.

The third step of the OMA is given by the Crişuri Plain, which is the central part of the Western Plain of the country. There is an upper plain section (over 100 m altitude: Biharia Plain, Miersig Plain) and a lower alluvial section below 100 m altitude (Borş Plain). In the upper plain we find the communes of Biharia, Sînmartin (partially), Nojorid (partly), part of Girişu de Criş commune (i.e. the homonymous), part of Paleu commune (i.e. the homonymous village), and in the lower plain there are the communes of Toboliu, Sîntandrei, Borş, partly Oşorhei and partly Ineu.

Climate, from a tourist point of view, is an intangible resource, but it strongly influences the development of tourist activities in nature. In the OMA, the temperate continental climate with oceanic influences is defined on the basis of the continuous flow measurements carried out at the Oradea weather station since 1961. These climatic data have been processed and interpreted in several scientific articles, as well as two published doctoral theses (Dumiter, 2007, Şerban, 2010). The climate elements with reverberation in tourism are: air temperature, duration of sunshine/nebulosity, rainfall, wind and some climatic risk phenomena (hail and storms). Overall, their values do not present restrictive thresholds for tourism activities. The average annual temperature is 10.3 °C (20.8 °C in July and -1.7 °C in January), the amount of rainfall reaches 615 mm per year, the relative humidity is below 80%, the wind speed is low (below 3 m/s), with a maximum frequency from the south or south-east direction. We draw attention to the fact that the highest rainfall amounts fall in the warm semester of the year (April to September, with a peak in June), but without diminishing the quality of the tourist activity, apart from exceptional cases. We mention the emergence of climatic risk phenomena. It seems that June hosts the maximum number of hail cases in the Crişuri Plain, but also that of storm occurrence. Storms are fast-paced phenomena that cannot be predicted early, and the Crişuri Plain is included in the high vulnerability class (1-4 days). Regarding the spa resorts of Băile Felix and 1 Mai, correlating the climate elements with the sanogenesis effect, the authors Teodoreanu and Gaceu (2013) indicate a sedative bioclimate with excitation nuances.

The OMA hydrography (figure 1) is represented by surface waters in the form of man-made lacustrine water storage and anthropogenic channels, but also by groundwater (ground and deep). The central part of the OMA is crossed by the Crişul Repede River (its lower sector) over 42.5 km, representing its main hydrographic artery. Its main tributary is the Peţa brook, with under thermal waters (Ilieș et al., 2015). In the north of the study area, the streams are tributary to the Barcău River, and in the south to the Crişul Negru river. The average hydrographic density is 1.27 km/sqkm, the highest values being in the Sîntandrei commune (i.e. 1.91 km/sqkm), and lower in the commune of Biharia (i.e. 0.9 km/sqkm).

A major component of hydrography is given by lake accumulations. From the category of the natural ones, we mention Lake Peţa, the thermal lake (on the territory of Sînmartin commune) (Şoldea, 2003). In the last five years, it seems to be losing its thermal character due to the drying out of the sub-lacustrine spring that should fuel it. To it are added several eutrophic lakes from the Crişul Repede meadow, formed in the abandoned river meanders after massive hydro improvement work interventions. There are also several man-made lakes in the OMA, as well as many ponds for fishing. Although their cuvette/basin is anthropogenic, by its very natural water body attribute, and because they have turned into genuine natural ecosystems (some of them included in Natura 2000 sites), we will assimilate them into the natural capital. Thus, on the Crişul Repede River, on the territory of Oşorhei (at Fughiu), there is a man-made water storage lake (reservoir) with a flow control role, as well as meant to fuel with water the municipality of Oradea, and in its meadow, as a result of the gravel and sand diggings numerous man-made lakes were formed. Besides these, we can also find some reservoirs with a defensive role against floods and with a leisure purpose, such as the reservoirs of: Alceu, Leş, Sauaieu, Popii, Viţeilor, Steluţa, Paleu (ABA Crişuri, 2016) or just with a leisure function, such as the lakes of: Camelot, King's Land, Saldabagiu, Biharia, Merita.

Until the middle of the 20th century, the low Crişuri plain was known for its marshy features, because the rivers that drain it (the three Criş rivers, Barcău) had barely sketched river beds and at any water level rise they yielded floods. After 1950, large-scale hydro-technical (through the construction of dams and reservoirs) and hydro-improvement works (dams, drains, channeling, etc.) started in the Crişului basin. For OMA, the construction of the Collector Channel (Criş Channel) with a total length of 61 km in north-south direction between Tămaşda and Tărian should be mentioned. It is a belt channel with the role of regulating the flows between Crişul Repede and Crişul Negru rivers, but also for water supply and irrigation.

Ground waters play an important role, especially in the meadow sectors, because it supplies the gravel-quarry dug generated lakes (which have become real poles of attraction for local or migratory ornithofauna but also for fishing enthusiasts). Of particular importance are the deep waters due to their thermal feature, known as geothermal or thermomineral waters. The OMA sits on a thermal aquifer of Triassic age, lower Cretaceous, at different depths (2000-3000 m in Oradea - Borș and 50-350 m at Băile Felix) and higher Pannonian with depths exceeding 1000 m (Biharia - Săcuieni - Marghita aquifer) (Ţenu, 1981; Cohut, 1986; Paál, 2013). [2] These waters are known and used for a long time in Băile Felix and 1 Mai for balneology and leisure, and more recently in Oradea (home heating), Livada (Nojorid commune) for leisure. There are also thermal drillings on the territories of the communes of Toboliu, Sîntandrei and Borş but they are not currently used, the water flowing freely but it can be collected and used for heating and balneary purposes.

The Oradea Metropolitan Area vegetation belongs to the forest steppe and oak forest floor, with a strongly modified structure by the anthropogenic intervention (Herman, 2012). In the OMA, in the rural area, especially in the hills of Oradea and Tashad, forest bodies are preserved forming some massive forest bodies, made of oak (*Quercus robur*), the Turkey oak (*Quercus cerris*), sessile oak (*Quercus petraea*), common hornbeam (*Carpinus betulus*). There are also to a lesser extent the wild cherry (*Prunus avium*), the silver linden (*Tilia tomentosa*), the tatarian maple (*Acer tataricum*), etc (Burescu and Herman, 2010; Herman, 2010a, b; 2012; Herman and Herman, 2011).

Within the land fund structure, forests cover 16.1% of the metropolitan area (figure 2). Large areas of forests belong to Sînmartin (2,021 ha, 32.7% of the commune's surface), Nojorid (2,369 ha, 18.9%), Ineu (1,660 ha, 33.5%), Cetariu (1,345 ha, 20.6%), Paleu (1,281 ha, 26.8%), Oşorhei (1,242 ha, 19.1%). The presence of these forests at the outskirts of the metropolitan belt contributes to the air cleaning of dust particles and the improvement of topoclimate, but also gives some degree of physical and mental comfort. Within these forests there are some interesting cenoethtical and tourist elements from the forest. Thus, in the commune of Cetariu (in the eastern village of Cetariu), the presence of a linden tree near the Peştea hamlet and the edible plated chestnut forests (*Castanea sativa*) must be mentioned in order to keep small boars and cervids away from cereal crops (Dincă et al., 2012). In the Peţa Brook Nature Reserve there is a secular oak (over 300 years old), and in some forests (1 Mai spa, Cordău, Sişterea, Paleu, Botean) grow the butcher's-broom (*Ruscus aculeatus*), a species protected as a monument of nature (Herman, 2012). In the vegetation that develops on the ground floor of the forest, it is necessary to mention the edible mushrooms (*Boletus mushrooms, chanterelle mushroom, Blancaccio, Russula mushroom*), and at the edge of forests, the shrub layer consists of rose bushes (*Rosa canina*), hawthorn (*Crataegus monogyna*), common hawthorn (*Crataegus monogyna*), blackthorn (*Prunus spinosa*), blackberry (*Rubus fructicosus*). These products are sometimes found in the local cuisine or medicinal supply.

Along the watercourses there is an azonal vegetation, represented by willow (*Salix alba*), alder (*Alnus glutinosa*), poplar (*Populus tremula*), and on some lacustrine surfaces such as King's Land and Ineu the white lily (*Nymphaea alba*) and yellow lily (*Nuphar lutea*). In 1 Mai spa, in a subtropical ecosystem (Peţa thermal lake), until recently we could find an endemic plant, unique in the world, surviving the glacial periods: the thermal water lily (*Nymphaea lotus var. Thermalis*), along with two other endemic fauna species: the thermal snail (*Melanopsis parreyssi*) and thermal ray-finned fish (*Scardinius racovitzai*). As a consequence of the chaotic real estate development, possibly due to the decrease in the amount of precipitation in the last years with consequences in the supply of the thermal reservoir, the sub-lacustrine thermal spring that fuelled the lake has dried out and the species are extinct in situ.

[2] *http://biwaterm.hu/wp-content/uploads/2013/05/Stud-for-geoterm-an-geochim-an-partea-romana-cluster.pdf*

The primary herbaceous vegetation was degraded by intensive pasture and replaced by secondary meadows where a xerophilous and xeromezophilous vegetation develops, represented by hays (*Festuca sulcata*, *F. pseudovina*, *F. valesiaca*), Kentucky bluegrass (*Poa pratensis*, *P. bulbosa*), feather grass (*Stipa joannis*), crested wheat grass (*Agropyron cristatum*), smooth brome (*Bromus inermis*) with a varied color, adapted to conditions of dryness and intense sunshine, accompanied by bush formations. However, they cover smaller areas because most of the land is covered by agricultural crops or forests. Carrying out of the hydro-improvement works from the Criş low plain along with the drying out of extensive marshy areas, led to a considerable water decrease of the areas with hydrophilic vegetation, which is only found along valleys and reduced spaces where the elimination of the water surplus is difficult. This vegetation is represented by the common cattail (*Typha latifolia*), Scirpus radicans, Greater Pond Sedge superplugs (*Carex riparia*), reed (*Phragmites commnunis*) (Pop, 2005).


Forests and secondary pastures in Cetariu and Ineu communes

Shrubs at the edge of the forest

Vineyards and orchards in Cetariu commune

Figure 2. Vegetal formations specific for the OMA

We also mention the presence of vineyards and orchards, but on small surfaces. We integrate them into the category of natural tourist resources, even if they are due to typical anthropogenic lucrative processes. The vineyards and orchards can be attractive and stand out as a natural distinct tourist resource and the experience of discovery, through fruit varieties and its associated products as a result of their processing, by the possibility of maintaining a beneficial trade for the farmer and the tourist. Paleu and Cetariu communes (figure 2) hold about 40% of the metropolitan vineyards and some 29% of the orchards [3] can be found in Nojorid commune.

[3] *https://zmo.ro/strategie*

The present fauna of the metropolitan area is characterized by species that have adapted to the physico-geographic conditions of the lowland plain and hills. Among these are rodents such as *Citellus citellus, Cricetus cricetus, Spalax hungaricum, Lepus europaeus, Sciurus vulgaris*, different bird species such as *Coturnix coturnix, Perdix perdix, Sturnus vulgaris, Falco tinnunculus, Alauda arvensis* - the only singing bird in flight, etc. There are also various insects and reptiles. The amphibian class has enjoyed increased attention from researchers, some species being protected or threatened with extinction. It is the *Bombina bombina* (the fire-belly toad), *Bombina variegata* (yellow belly toad), *Triturus cristatus* (great crested newt), *Lissotriton vulgaris* (smooth newt), *Rana ridibunda* (marsh frog), *Rana dalmatina* (agile frog), all protected species. Among mammals, the European roe deer (*Capreolus capreolus*) can be found frequently in large metropolitan areas fields, and the wild boar (*Sus scrofa*) abounds in metropolitan forests. Other faunistic elements with a more discrete presence are the wild cat (*Felis silvestris*), fox (*Vulpes vulpes*) and even wolf (*Canis lupus*) (Dincă et al., 2012). Of the birds, the common pheasant (Phasianus colchicus) found particularly favorable reproduction conditions in areas cultivated with cereals. In the streams of the metropolitan area, species of fishing interest (the *Prussian carp*, the *European chub*, ray finned fish) can be found, and the reservoirs and gravel quarry dug lakes are familiar to Cypriots (*Prussian carp, carp*), perch, catfish, etc.

Forest or field wildlife is of particular interest for hunting and fishing, and there are several hunting stocks in the metropolitan area: Giriş hunting stock, Bors hunting stock, Biharia hunting stock, Paleu hunting stock, Salard hunting stock, Ineu hunting stock, Livada hunting stock, Păuşa hunting stock, Alparea hunting stock, Boboștea hunting stock. [4]

The natural leisure attractions analysis from the OMA

The tourist natural resources of Oradea Metropolitan Area relate to avens, forests, monuments of nature, reserves, leisure lakes as well as many rivers and streams that cross the area. From the natural resources analysis it comes out that most of natural attractions are found within the Sînmartin and Cetariu communes with a share of 23% each, followed by Borş commune (18%), Ineu, Paleu and Nojorid with 10% each, Biharia (4%), Oşorhei and Toboliu with 3% each (figure 3).

Borş, Biharea, Nojorid and Toboliu communes stand out exclusively with the leisure lakes-related potential. Their in-built leisure lakes are the lakes of Borş and Sîntion (Bors commune), the swamp of Biharea (Biharea commune), the lakes of Leş and Şauaieu (Nojorid commune) and the Merita pond of Cheresig (Toboliu commune). Osorhei commune is naturally attractive by its daffodil forest of Alparea and the leisure lake of Fughiu, as well as the Crişul Repede stream. Instead the bulk of the remaining communes feature mixed natural attractions such as butcher's-broom (*Ruscus Aculeatus*) - monument of nature of Cetariu Forest; the forest of Cetariu; the linden forest of Peştea; butcher's-broom (*Ruscus Aculeatus*) - monument of nature of Şişterea Forest; the leisure lakes of Viţeilor, Popilor and Steluţa (Cetariu commune), butcher's-broom (*Ruscus Aculeatus*) - monument of nature of Cordau Forest; the aven of Betfia; the Natural Reserve Dealul Şomleu; the secular oak tree of the Natural Reserve Peţa Brook the water lily - monument of nature from the Peţa stream (*Nymphaea Lotus var. Thermalis*) (Sînmartin commune), butcher's-broom *Ruscus Aculeatus* - monument of nature of Botean; Cordău, Şişterea, Băile 1 Mai forests; the leisure lake King's Land of Ineu; the leisure lake Balta Ursului of Husasău de Criş; the leisure lake Camelot of Husasău de Criş (Ineu commune) and the Natural Reserve Fâneața Valea Roșie; the leisure lake of Paleu (Paleu commune).

In order for the tourist to reach and estimate the time allocated to the movement to these attractions a distance-time (driving) map was created as the short-distance leisure travel to the suburbs implies lower costs and less time allocated to traveling. The time-distance map shows how near the potential tourists are to a certain attraction.

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[4] *http://oradea.gardaforestiera.ro/files/552_Harta%20fonduri%20Bihor.jpg*

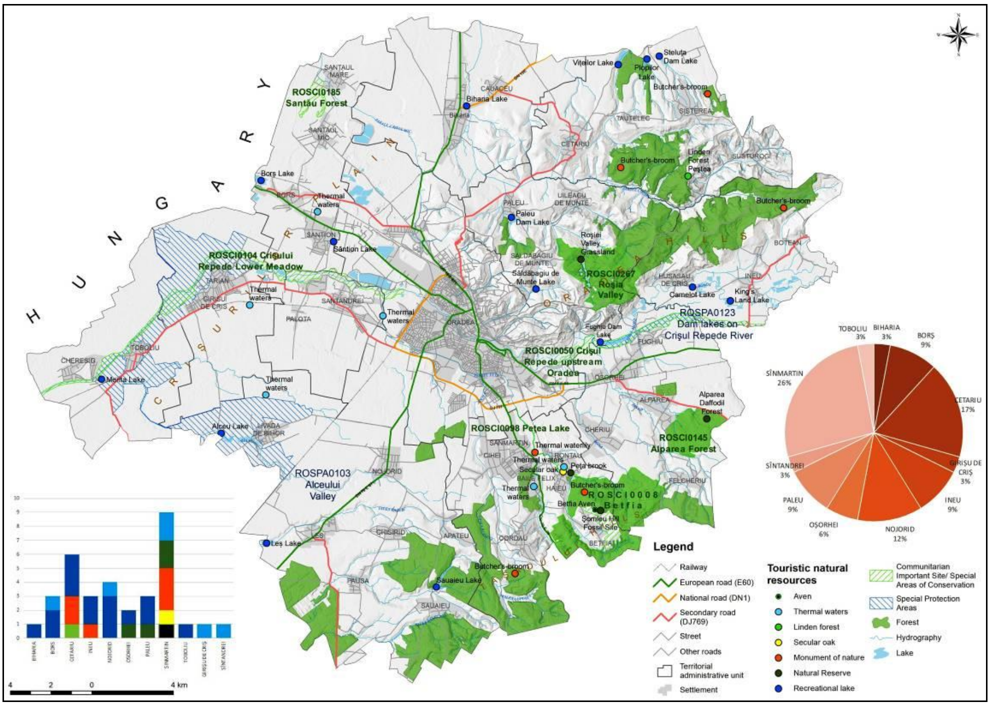

Figure 3. Natural tourist resources within the rural Oradea Metropolitan Area and their percentage (right side) and numerical (left side) distribution per commune

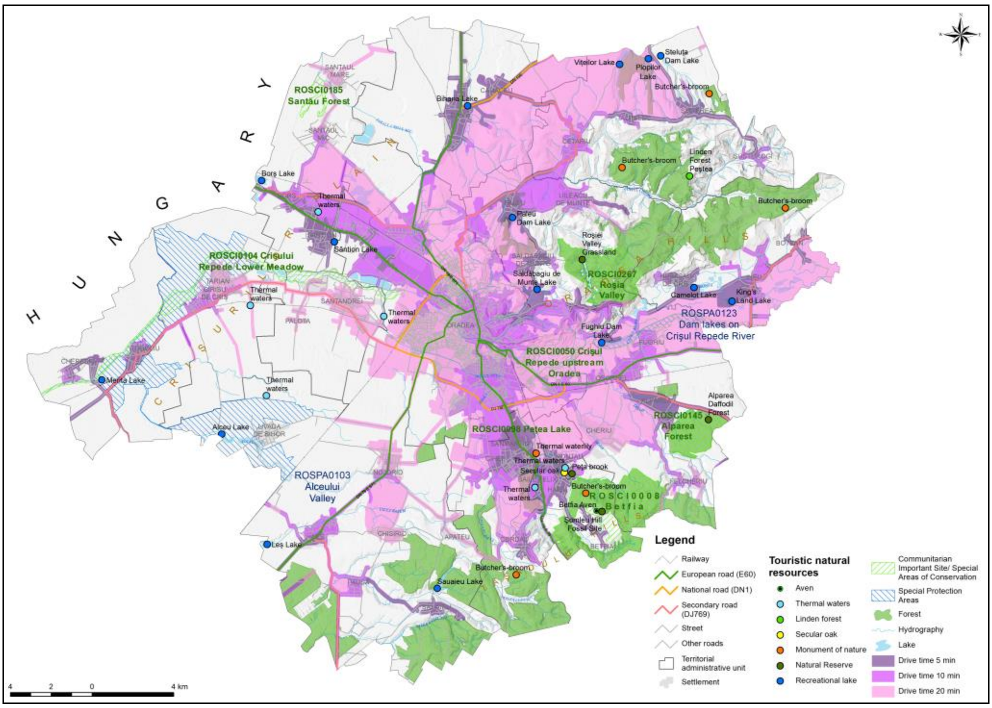

Figure 4. Necessary allocated driving time to reach the natural tourist attractions within the rural Oradea Metropolitan Area

For instance taking into consideration the attraction A the dark purple ring around it indicates that tourists are within a five minutes driving time to the attraction A and the light purple ring indicates that tourists are within a twenty minutes driving time to the attraction A (figure 4).

The arterial transportation easy access to the suburbs enables the urbanites to reach faster and more conveniently these favorite leisure nature attractions. The demand for weekend and holidays to the periphery encouraged the development of many scenic locations and recreational spots as well as its adjacent transportation facilities (Wu and Cai, 2006). By the generated map it is highlighted that most of these scenic natural attractions can be reached easily from the central part of the Oradea city. Within the specialized literature there is the concept of distance-decay which applies to tourism too in which the gravity model of distance-decay suggests that tourist flows decrease with distance from the origin (Hinch and Higham, 2004). Therefore the attractions which are further away from the residential place of tourists are less prone for visitation as they imply higher costs and time for travel.

The attractiveness index of the tourist natural resources

For this research paper only the scores related to the natural tourist resources were taken into account for the analysis so that only a maximum of 25 points could be given. Nonetheless as the natural tourist resources analysis will later on show in the analyzed area of the OMA the scores did not go above 12 points which indicates an average tourist potential when compared to the national territory. The class values for the analysis were divided between 2.1 - 4; 4.1 - 6; 6.1 - 8; 8.1 - 10; 10.1 - 12 (figure 5).

In order to carry out the natural tourist attractions' analysis for the current study of the rural OMA more items were calculated such as the position on relief steps for which a maximum of 14 points were given, geomorphology for which maximum 1 point was given, vegetation for which a maximum of 1.5 points were given, fauna (maxium 1.5 points), hydrography (maximum 3 points), bioclimates (maximum 0.66 points), protected areas (maximum 5 points), landscape (maximum 3 points).

At the subcategory referring to the position on relief steps more items were taken into consideration such as field, hills, mountains; the geomorphology subcategory includes gorges, karst relief; vegetation includes a coverage of over 30% or below 30% (coverage with bushes, vineyards and orchards, pastures); at the fauna subcategory of high or average hunting interest (herbivores – little cervids, wild boar; carnivorous mammals – fox, wolf; wild birds – pheasants and birds of the wet environment; reptile and batraciens; fishes) were taken into consideration; the hydrography subcategory includes the presence of lakes, ponds, mineral springs, waterfalls; the landscape category was assessed according to the high or average interest for the identity of the places (villages or communes). The natural protected areas subcategory was assessed according to their representativeness degree, their conservation status and the possibility to practice a form of tourism (Herman et al., 2016; Ilieș et al., 2017a, b).

The influence of the OMA nature on people interested in leisure tourism in one of its belonging communes results from the analysis of the attractiveness of natural resources. The total score for the 11 OMA's belonging communes is 87.47, resulting in an average of 7.95 points. Compared to the maximum of 25 points that a commune could score according to the methodology, there is an encouraging average mean with reference to its attractiveness.

Compared to the average, there are notable territorial differentiations for the natural resources attractiveness index, which can determine the potential tourists interested in nature to choose a commune, a village, a natural site or more natural attractions for discovery, relaxation and leisure.

The analysis of the attractiveness degree showed that the most attractive from the natural tourist resources perspective within the rural OMA is Sanmartin commune which scored very well at position on relief steps, hydrography and protected areas and totally it reached 11.67 points (figure 5, table 1).

In its content, the work emphasizes decisively not only the favorable situation of the happy combination between the potential for the representation of the hilly relief developed on limestone (with detailed forms for the endo and exokarst relief - the karst microforms complex (lapiez) and avens at Betfia), the deciduous forests and the thermal waters, but also the advantageous geographic position to have Băile Felix and 1 Mai spas in the commune. This is a spur for attraction and less time spent traveling for leisure (tourists, locals and urbanites) to relax and spend their free time in the local natural environment.At the opposite end, the least attractive came out to be Biharia commune with a score of merely 3.97 points (figure 5). It is an important space for the suburban leisure and entertainment opportunities, only the landscape generated by the largely undulated hills and the deciduous woods can attract the potential tourists for walks not far from the communes' villages.

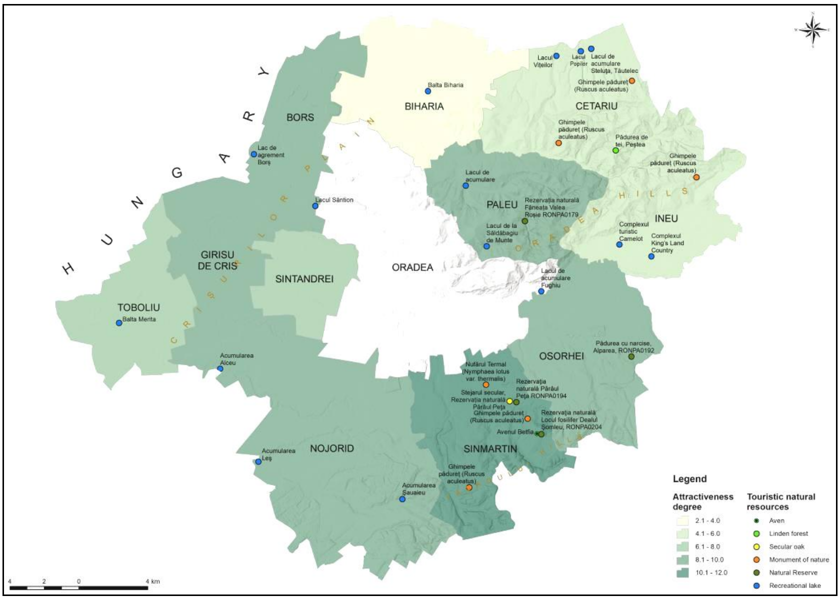

Figure 5. Attractiveness index of the natural tourist resources from the rural Metropolitan Area of Oradea

Table 1. Indexing of natural resouces meant to reveal the attractiveness index of rural OMA

Name of commune	**Position on relief steps** (max. 14 pts)	**Geomor-phology** (max. 1 pts)	**Vegeta-tion** (max 1.5 pts)	**Fauna** (max 1.5 pts)	**Hydro-graphy** (max 3 pts)	**Biocli-mates** (max. 0.66 pts)	**Protected areas** (max. 5 pts)	**Landscape** (max. 3 pts)	**Total** (max 25 pts/every commune)
Biharia	1	0	1	0.5	0.25	0.22	0	1	3.97
Borș	1	0	1	0.5	1.5	0.22	3	1	8.22
Cetariu	2	0.1	1	0.75	1.5	0.22	1	1.25	7.82
Girișu de Criș	1	0	1	0.5	1.5	0.22	3	1	8.22
Ineu	2	0	1	0.5	1	0.22	0	1	5.72
Nojorid	2	0	1	0.5	1.5	0.22	3.3	1	9.52
Oșorhei	2	0.1	1	0.5	1	0.22	3	1.25	9.07
Paleu	2	0	1	0.5	1	0.22	3	1	8.72
Sînmartin	2	0.2	1	0.5	3	0.22	3.5	1.25	11.67
Sîntandrei	1	0	1	0.5	2	0.22	1.8	1	7.52
Toboliu	1	0	1	0.5	1	0.22	2.3	1	7.02
Total	**17**	**0.4**	**11**	**5.75**	**15.25**	**2.42**	**23.9**	**11.75**	**87.47**

In fact, from examining the information in table 1 and figure 5, a certain type of attractiveness for the OMA natural tourist resources stands out. It may be wrong to conclude that in the OMA the hilly relief and the logical association of landscapes customized by a network of streams, forests, meadows, wildlife, protected areas with rare flora or fauna are certainly linked to a maximum attractiveness index. The reality partially confirms this assertion. The communes on the northern side of the OMA are the least attractive for leisure tourism, being deficient in hosting protected areas. The eastern side of the OMA is, however, well-equipped with natural elements (protected areas, lakes for fishing, deciduous forests, shrubs, hay meadows and barbeque areas, rare flora, vineyards and orchards), as well as a good road network that allows easy car travel and spending leisure time. The western part of OMA, although set dominantly in the plain, has significant attractiveness values ranging from 7.02 to 9.52 (table 1). The explanation is related to the favorable nature of many lacustrine environments that encourage fishing (e.g. the Sântion, Borş, Merita, Leş lakes) and some protected areas that can be the purpose of weekly thematic visits (e.g. The Forest of Santău with its species adapted to the humid environment of the willows, black alder, ash, water soldiers, the red belly toad).

CONCLUSIONS

The rural OMA, although in the shadow of Oradea city, abounds in natural elements, despite the risk of its anthropization in the form of a permanent assault by real estate developers, few attempts of small industry and investment in infrastructure. These natural elements configure a pattern of leisure and recreation activities in the OMA space. The activities are oriented according to the number of sites (local nature resources), their importance (especially in the case of protected areas and natural monuments), ease of access (including travelling time to the site) and physical and emotional benefits of the activities. According to the number and density of the sites, local leisure tourism relies on the dominant grouping of natural sites on the eastern and western sectors. The east of the metropolitan area is well-capitalized and the tourists are attracted by a sum of resources given by the undulated hills, deciduous forests, protected areas and natural monuments (from the butcher's thorn, daffodil meadows to avens, etc.), reservoirs on the Crişul Repede river from northern OMA with flowing and still water fish.

All these fit perfectly for discovery activities, light walks, hiking, fishing, barbeque, etc. South-eastern and southern metropolitan areas are dominated by discovery and leisure activities that capitalize on the protected areas of the plain, as well as complex physico-kinetic recovery and relaxation (in the case of thermal waters) and leisure in the waters of the lakes and Crişul Repede (fishing). When it comes to the traveling time, it can be concluded that weekend or leisure tourists follow routes mainly whose attractions are located on the central axis of the OMA (fishing on lakes, forests and meadows, aven, rare flora) for whose reach, between 10-15 minutes can be allocated. There is also a secondary section between the center and the east of OMA, where fishing is eminently enjoyable. Concrete leisure activities dictated by the local natural potential are used in building the attractiveness index. In spite of a significant natural background, the fact that there are no mountain ranges and mountain relief details generates modest results, including an average of 11.67 points (out of 25 possible) of the 11 analyzed communes.

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