UNIVERSITATEA DIN ORADEA

ANALELE UNIVERSITĂŢII DIN ORADEA

Seria GEOGRAFIE

TOM XXXII
Nr. 1/2022 (June)

Editura Universităţii din Oradea

UNIVERSITATEA DIN ORADEA
DEPARTAMENTUL DE GEOGRAFIE, TURISM ŞI AMENAJAREA TERITORIULUI

ANALELE UNIVERSITĂŢII DIN ORADEA

Seria GEOGRAFIE

TOM XXXII
Nr. 1/2022 (June)

Editura Universităţii din Oradea

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

ISSN 1221-1273, E-ISSN 2065-3409

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

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

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

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

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

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

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

Erih Plus

Doaj, Directory of Open Acces Journals

Ebsco

Index Copernicus

Ulrichsweb, Global Serials Directory

Genamics

Scipio

WorldCat

Crossref

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

Google Scholar

Price of journal:

Individual	8 €
Institutional	12 €
Annual subscription	15 €

Address of the Editorial Office:

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

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

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

C O N T E N T S

Analele Universităţii din Oradea, Seria Geografie **XXXII**, no. **1/2022**, pp. **1-15**
ISSN **1221-1273**, E-ISSN **2065-3409** DOI **10.30892/auog.321101-875**

SPATIAL PATTERNS AND DRIVERS IN THE EVOLUTION OF COVID-19 PANDEMIC IN ROMANIA (MARCH 2020-JUNE 2021)

Ionel MUNTELE*
"Alexandru Ioan Cuza" University of Iaşi, Faculty of Geography and Geology, 20A Carol I Av., 700305, Iaşi, Romania;
Romanian Academy, Iaşi Branch, Geographic Research Center, 5 Carol I Av., 700307, Iaşi, Romania;
e-mail: imuntele@yahoo.fr; imuntele@yahoo.fr

Citation: Muntele, I. (2022). Spatial Patterns and Drivers in the Evolution of Covid-19 Pandemic in Romania (March 2020-June 2020). *Analele Universităţii din Oradea, Seria Geografie, 32*(1), 1-15. https://doi.org/10.30892/auog.321101-875

Abstract: The manifestation of the Covid-19 pandemic raised great interest due to the speed with which it spread globally and by outlining specific diffusion patterns. Romania faced off early on the rise in the number of infections, initially, as in other European countries, extremely localized but later expanded nationwide. The analysis of the available information regarding the evolution of the number of infections and deaths caused, over a sufficiently extended period (March 2020-June 2021) allowed the identification of several spatial patterns. Their regional coherence indicates a series of correlations with socio-economic factors, validated by PCA (principal component analysis). The importance of economic development, in connection with the degree of urbanization, employment and labour mobility or population density thus explains the incidence of the number of cases at a level higher than the national average. In the case of death caused by Covid-19, the quality of the health infrastructure played an important role, the counties with a higher level of endowment being less affected. At the same time, the share of the elderly population, in association with the less populated rural area, was not positively correlated with the number of cases or deaths. Lower population interaction, weaker exposure to international mobility has created the premises for a specific pattern of evolution in these areas.

Key words: Covid-19, pandemic waves, regional patterns, disparities, factorial analysis, Romania.

* * * * * *

INTRODUCTION

In an insecure world, increasingly complex and predisposed to unpredictable, unwanted and unavoidable manifestations, the Covid-19 pandemic triggered in a still obscure context is just one of the "black swans" that take human society out of rhythm, through what N.N. Taleb called the "very unlikely impact" (Taleb, 2018). The onset of a pandemic is only a matter of time, a probability among many others, and the way in which the governments have reacted only confirm their untimely nature, which does not necessarily take into account the level of development but is dependent on globalization. From this point of view, Romania, a state located in Eastern Europe,

* Corresponding author

could not be outside the pandemic circuit given its strongest relations at the continental level (mass emigration to countries like Italy or Spain, strongly affected by the "first wave") or transit position to/from the former Soviet Union and the Middle East. Thus, when the WHO declared Covid-19 a global pandemic, on 11.03.2020, Romania already registered 47 cases, of which 18 newly confirmed, only two weeks after the first case confirmed in Gorj County (southwest of the country) as contact of a person from Italy. After only 11 days, the first deaths caused by the new virus were registered, the country thus entering the wake of a dynamic that seemed to get out of control, since March 16 the state of emergency was declared. Subsequent developments have allowed a slight relaxation in the summer of 2020 for the second wave to hit hard in autumn, as in the rest of Europe, imposing restrictive measures targeting the most affected areas. Thus, the epidemic was calmed in the first months of 2021, the measures taken being overcome by the third wave that hit especially the eastern states of the continent, at the same time with the start of the vaccination campaign. Although immunization has not progressed at a rapid pace, as would have been desired, partly due to the reluctance of part of the population, partly due to the lack of determination in the application of immunization measures targeting vulnerable groups, this spring has brought a drastic reduction in both the number of illnesses and deaths caused.

The possibility of a "four wave" is invoked in the political environment, the evolution so far indicating a certain seasonal cyclicality in the manifestation of the pandemic, permanently modified by the genetic mutations of the virus (Audi, et al., 2020; Liu, et al., 2021). During all this time, various variables have been invoked to explain the spread, often specific to the virus, whether we are talking about population structure (advanced aging of the European population for example), the degree of population concentration (urbanization, density) or of particularities of the public health infrastructure. The impact of the restrictive measures adopted, differing from one state to another, although they had a definite role, does not indicate the primacy of a certain pattern, whether we refer to the excessive constraining model from the country where it started the pandemic or more relaxed models like the Swedish one.

LITTERATURE REVIEW

The pandemic triggered by the Covid-19 diffusion generated a wide illustrated scientific interest a wide scientific interest. The approximately 1,220,000 specific entries resulting from a simple Google Scholar search (as of July 1, 2021) illustrate it. The variety of approaches, from the strictly epidemiological to the sociological, economic or psychological ones, makes it difficult to review all the results presented. The swiftness wherewith the scientific world reacted is closely linked to access to information, even if often contradictory, but also to the desire to help identify solutions able to limit the effects of the pandemic.

The purpose of this approach, to test the existence of regional models of diffusion and manifestation of the pandemic in Romania, limits the bibliographic analysis to those works that approached the phenomenon from a spatial perspective.

From the perspective of the spatial diffusion of the pandemic, multidimensional studies have highlighted the fact that there are no fundamental parameters. Bontempi et al (2020 consider that the geographical diversity of contagion diffusion patterns requires the analysis of complex outcomes, te spread of the pandemic being caused by a multiplicity of environmental, economic and social factors (Bontempi, Vergalli, & Squazzoni, 2020). Just like other pandemics, such as the one caused by AIDS, some authors consider that there is a spill over (wildlife-livestock-patient 0) and an international spread, from one country to another and from city to city, imposing an international cooperation and institutional coordination to limit the effects (Wu, 2021). Social distance and quarantine may be needed in the immediate aftermath of an outbreak. The observation from the study that the spread of the recent pandemics follows the same pattern in different regions of the world is not without interest, being a function of population size, the epidemiological model having a fractal structure generated by strong connections between large metropolitan areas (Abbasi, et al., 2020). The importance of population mobility was studied even

in the Romanian case where, at least in the first phase of diffusion, it was closely related to the circular migration for work to Western European countries (Hâncean, Perc, & Lerner, 2020).

Factors associated with Covid-19 diffusion have been extensively analysed, both from the perspective of the multiplication of infection cases and death caused. Although the quality of available information is contestable, there has been some temporal overlap in the magnitude of the pandemic, depending on the ability and effectiveness of public health policies (Jinjarak, Ahmed, & Nair, 2021). The close correlations between economic, social and cultural factors are frequently invoked (Mogi & Spijker, 2021), associated with population density. The latter factor imposes very strict measures of social distancing. It is difficult to notice a general model of factor analysis, the specific studies being limited by the access to information, by their correctness. Differences between states, derived from the different way in which the information is collected and reported, have generated more attention to studies at national or regional level. Since the beginning of the pandemic, there have been studies that have tried to systematize the factors (drivers) involved in its development: pace, global interconnectedness, health sector capacity, state capacity, immediacy which risk cascaded from the health system to economy, societal polarization and fragmentation (Collins, Florin, & Renn, 2020). This is how the indicated solutions for limiting the risk appeared, through investments in resilience, the attention paid to key nodes in the system and immediate action in the initial outbreaks. There were also frequent studies that took into account in the first phase of the spread of the pandemic geographical factors such as climate (temperature, precipitation) or the incidence of pathogens (malaria) along with the incidence of BCG vaccination, without being able to establish strong correlations (Kubota, Shiono, Kusumoto, & Fujinamal, 2020).

Large-scale studies, conducted at the continental level, have captured strong spatial disparities. The heterogeneous impact, both at national and regional level or between cities was explained by factors such as the aging population, the frequency of comorbidities, on the background of quality of life (health and income). Thus, an attempt was made to understand channels through which the pandemic spread and to emphasize the regional socioeconomic dimension (Amdaoud, Arcuri, & Levratto, 2021). Studying 125 regions in the European Union, the cited paper established the existence of strong correlations with gross domestic product, unemployment, quality of medical infrastructure (number of physicians, hospital beds etc.). There were also strong correlations with the presence of events with mass participation or with social trust. The analysis of the specific situation in some states highlighted the importance of isolating the vulnerable population (those over 65 or with comorbidities), targeting this category through the measures taken can ensure the partial preservation.

Of particular interest was the balance between the two risks, epidemic and socio-economic. The economic impact of implementing isolation measures has been strong enough, from an ecological perspective, rather beneficial, reducing energy consumption (Werth, Gravino, & Prevedello, 2021). The search for an optimal equilibrium, by analysing the specific situation in China, the United States, Brazil or Europe, attests to the importance of geographical distribution, considered fundamental in imposing social distance (Abbasi, et al., 2020). In this regard, analysing the situation of measures taken in the European Union in the spring of 2020, the need for a complex intervention package was invoked, including home isolation of cases, household quarantine, school closure, (Vokó & Pitter, 2020). An attempt was also made to analyse the correlation between the severity of the pandemic and governments handling (Imtyaz, Haleem, & Javaid, 2020). Thus, the importance of mass testing and lockdown measures or the imposition of spacing norms was invoked. And in the case of Romania, studies were carried out that tried to observe the effect of control measures (Dascălu, 2020). In this way it was concluded that the fast implementation of control measures successfully averted a surge in the number of Covid-19 cases. The importance of the initial government response was important in the management of the pandemic crisis. Romania had to manage in March 2020, a massive flow of returning citizens who went abroad (over 250,000 this month alone). The same study also indicates the importance of socio-cultural factors in controlling the epidemic, although these are difficult to analyse. Studies

indicating the resurgence of cultural tensions (ethnic, racial) attest to their importance (Creţan & Light, 2020) on the situation of the Roma community in Romania or Shulz, et al. (2020) on the situation of African-American communities in Detroit, in both cases being invoked stronger exposure to the effects of the pandemic). Such studies are important becauze they brought into question health equity, a key factor in the spread of the pandemic and its effects, including access to the vaccine, starting in late 2020.

Based on the considerations presented in the introduction and the conclusions of the analyzed studies, this approach propose an analysis of the evolution of Covid-19 infections and fatal cases over a sufficiently long period of time to allow the delimitation of regional patterns in a medium-sized country such as Romania. The study period, March 2020-June 2021, captures the three epidemic waves established and mainfested globally, including in Romania (Solis, Franco-Paredes, Henao-Martinez, Krsak, & Zimmer, 2020; Fisayo & Tsukagoshi, 2021; Graichen, 2021; Taboada, et al., 2021).

The main hypothesis of the study starts from the observation of the evolution of the Covid-19 infection. This evidence is explained by the existence of favourable or restrictive factors, whose incidence is not unitary in spatial profile. In a synthetic formulation, he study tries to test the hypothesis that the pandemic diffusion patterns and drivers were dependent on Romania's particularities from the perspective of the level of development, population distribution and quality of medical infrastructure.

MATERIALS AND METHODS

To test the hypothesis, information was collected from several well-known sources ((Worldometers, March 2020-June 2021; Coronavirus COVID-19, Romania, March 2020-June 2021; National Institute of Statistics, March 2020-June 2021). Based on these sources, several series of processed data were created, regarding the incidence of Covid-19 infections and the evolution of the number of deaths due to them, as follows:

a) A global database, having as source Worldometers, the information being summed at continental level, related to 100,000 inhabitants. These data are used to establish which was the particularities of Romania in the study period, presenting a contextual interest;
b) A comparative database on the evolution of mortality between January 2015 and April 2021, following the manifestation of a surplus due to the pandemic between March 2020 and April 2021. The information has synthesized at regional level, on the three major historical divisions of the country (Moldavia, Wallachia and Transylvania) to capture the occurrence of some disparities;
c) A database at national level, having as basic source Covid-19, Romania. The data were collected at county level and statistically processed in the form of dynamic typologies that established the manifestation of distinct profiles during the analysed period (March 2020-June 2021). This descriptive analysis serves to substantiate the factor analysis. The data were reported differently, per 100,000 inhabitants in case of infections and per 1,000,000 inhabitants in case of deaths.
d) A factorial data base regarding 12 variables, two of them being taken into account as dependent variables and the other as explanatory variables as follows:
    - the incidence of the number of cases of Covid-19 between March 2020 and June 2021, expressed per 100,000 inhabitants (CS);
    - the incidence of deaths caused by Covid-19 between March 2020 and June 2021, expressed as a percentage of the total number of cases (DCS);
    - the number of physicians, reported per 100,000 inhabitants, in 2019, the last year for which the INS provides data (PHS);
    - the number of average medical staff, reported per 100,000 inhabitants, in 2019 (NRS);
    - the number of hospital beds, reported per 100, 000 inhabitants, in 2019 (HB);

- the gross domestic product in 2020, expressed in lei per capita (GDP);
- the degree of urbanization in 2020, expressed as a percentage of total resident population (URB);
- the density of the resident population in 2020, expressed in inhabitants per km^2 (DNS);
- the mobility of the population (arrivals and departures with residence, including international migration), in 2019, expressed as a percentage of the total population (MOB);
- the share of the elderly population (over 65 years) in the total population, in 2020, expressed as a percentage of the total population (AGP);
- the share of the population with secondary and higher education in the total population over 15 years, according to the 2011 census, expressed as a percentage (SHE). The mentioned census is the last one carried out in Romania;
- the share of the employed population from the active population in 2020, expressed as a percentage (EMP).

All these statistical series, collected from the official databases of INS (National Institute of Statistics, March 2020-June 2021; 2011 Census) were subsequently standardized according to the extreme values. Z-score was used for standardization, obtaining comparable values for each variable, between 0 and 1.

Methodologically, the descriptive typological analysis used AHC model (agglomerative hierarchical clustering), available in Xlstat, the 2015 version produced by Addinsoft. The Euclidean distance and the Ward method were used to separate the classes, aiming that the dispersion of the intra-class values is clearly lower than that between the classes. For both typologies (evolution of the number of cases, respectively evolution of the number of deaths), 6 classes were retained, at a dispersion of intra-class values (within class) of 33.78%, respectively 26.76%. Respecting these criteria, the classes obtained are distinguished by homogeneity and specific profile.

The factorial analyses were performed on the 12 standardized variables, opting for the PCA variant (main component analysis) proposed by the same Xlstat program. The use of the Pearson correlation coefficient, the Chi-square significance test, a p-value lower than 0.0001 and regression coefficients (R^2) as high as possible, ensures the validity of model. The first PCA had as a dependent variable the number of cases of Covid-19 (CS), registered between March 2020 and June 2021 at county level, compared to 100,000 inhabitants. In this analysis, the number of deaths caused was not taken into account, the 10 explanatory variables (PHS, NRS, HB, GDP, URB, DNS, MOB, AGP, SHE, EMP) being selected to illustrate both social and economic or spatial features. No physical-geographical variables were introduced because the climatic differences are relatively small in Romania. Environmental variables such as the degree of pollution or indicators related to the quality of the environment could not be integrated into the model, lacking the information on the study scale used. The second PCA had as a dependent variable the number of deaths caused by Covid-19 (DCS), reported per 1,000,000 inhabitants, including in the list of explanatory variables, the incidence of Covid-19 infections. In order to detect as accurately as possible the relationships between the variables, the statistical program mentioned also operated a Varimax rotation.

The results of the two PCA were processed to obtain graphic and cartographic materials using Adobe Illustrator CS 12.

RESULTS AND DISCUSSIONS

A first analysis presents the global context in which the pandemic took place. The calculation of the quarterly incidence of the number of cases and death caused by Covid-19, based on data from sources mentioned in the previous chapter, shows that Romania has closely followed the trends in Europe (Table 1).

Table 1. Dynamics of the COVID-19 cases and induced deceases between January 2020 and June 2021
(Data source: Worldometers (Worldometers, March 2020-June 2021); Coronavirus COVID-19, Romania (https://covid19.geo-spatial.org, consulted between Mars 2020 and June 2021)

	Cases per 100,000 inhabitants						Deceases per 100,000 inhabitants					
	01-03 2020	04-06 2020	07-09 2020	10-12 2020	01-03 2021	04-06 2021	01-03 2020	04-06 2020	07-09 2020	10-12 2020	01-03 2021	04-06 2021
ROMANIA	**13**	**129**	**530**	**2624**	**1672**	**631**	**2**	**7**	**17**	**67**	**30**	**41**
Europe	66	261	359	2528	2149	1106	12	13	5	44	28	25
Asia	4	47	183	218	172	597	0.3	1	3	3	1	8
Oceania	14	9	52	41	21	54	0.2	0.1	2	0.3	0.2	0.3
Africa	1	31	82	99	112	101	0.1	1	2	2	2	2
South America	5	506	1294	1207	1844	2656	1	27	40	26	37	80
North America	41	537	1040	2594	2182	788	6	24	27	37	30	18
WORLD	**12**	**127**	**309**	**649**	**595**	**694**	**2**	**5**	**7**	**11**	**8**	**14**

The first wave of infections in spring 2020 was significantly lower than the European average, similar to most Eastern European countries, which can be explained both by the firmness of the limitation measures in March 2020 and by lower testing (Sulyok, Ferenci, & Walker, 2020; Mogi & Spijker, 2021). Since the summer of 2020, however, like many neighbouring countries, Romania has entered a phase of accelerating infections, far exceeding the European average incidence, including in terms of deaths. The increase in October-December, constituting the peak of the pandemic, followed the European average but with a much higher mortality rate, determined by the overload of medical infrastructure but also by the ambiguity of limitation measures, generated by the insistence of the deployment at any cost of the planned electoral program. Subsequently, in the first half of 2021, the situation gradually improved, the third wave of infections, manifested in March-April, being much diminished. The same did not happen with the deaths, which remained at a higher level than the European average, which can be explained by the accumulation of a critical mass of serious cases in the intensive care units in early spring. The excess mortality in Romania can be explained by the poor resilience of the public health system (Popic & Moise, 2021).

Compared to the global average incidence, like Europe as a whole, Romania presented by the spring of 2021 much higher values comparable to those in North America. Compared to Asia, the source of the pandemic, the differences are related to the amplitude of infections, the trends being relatively similar, except for the last months (April-June 2021) in which there was a rapid spread of the delta variant. The southern continents (South America, Oceania, partly and Africa) show a certain reversal of trends, with obvious peaks during the cold southern season (Smit, et al., 2020).

However, from the perspective of death caused, Romania is among the most affected states in the world, on July 1, 2021 being on the 23rd place with 1791 cases per 1,000,000 inhabitants, most affected states being located in Eastern Europe and Latin America. Over mortality due to Covid-19 infection, including cases caused by reduced addressability and poor functioning of health services, was even higher, in 2020 the general mortality of the population being 13.5% higher than the average for 2015-2019, a trend maintained in the first five months of this year (Table 2).

Excess mortality is widespread, mainly in urban areas and is only partially explained by the incidence of Covid-19. The much higher level than other European states shows the deficiencies of Compared to the global average incidence, like Europe as a whole, Romania presented by the spring of 2021 much higher values, comparable to those in North America. The public health system in Romania, being highlighted in some studies (Bogos, et al., 2021). Despite all the limitations imposed by the correctness of the information, the regional disparities are explicable. The lower excess mortality in the south and east of the country reflects the preponderance of the rural population and the higher incidence of deaths caused by Covid-19 in Moldavia may be

related to the lower level of development. This evidence is also in line with the results of studies on the evolution of life expectancy at birth in Romania, which indicated a slower growth of this indicator in less developed regions (Muntele, Istrate, Bănică, & Horea-Șerban, 2020). It is assumed that this excess mortality will also lead to a temporary decrease in life expectancy.

Table 2. Evolution of mortality between 2015-2019, in 2020 and in the first five months of 2021, by area of residence and by historical regions
(Data source: Coronavirus COVID-19 on Romania (https://covid19.geo-spatial.org, consulted between Mars 2020 and June 2021); Database Tempo-Online (National Institute of Statistics, March 2020-June 2021); Buletinul statistic lunar al județelor (National Institute of Statistics, March 2020-June 2021))

	The difference between the number of deaths in 2020 and the average for 2015-2019 (%)			Idem for january-may 2021	Covid deaths related to excess mortality (%)	
	Total	Urban	Rural	Total	2020	2021(jan-mai)
ROMANIA	**13.5**	**18.6**	**8.9**	**19.0**	**46.6**	**63.0**
Transylvania	15.1	18.6	11.4	22.7	51.0	63.5
Wallachia	13.3	18.2	8.5	18.0	40.6	57.3
Moldavia	11.6	19.9	6.9	15.7	52.6	65.8

Typology of the evolution of Covid-19 cases and associated deaths

These disparities are even better revealed at regional level by the typology of the evolution of Covid-19 cases and deaths caused by it, according to the territorial database at county level. The existence of a regional profile and a diffusion correlated with the level of economic development is evident both in terms of the evolution of cases and deaths.

The first typology is marked by the relative spatial cohesion of the classes, with a profile similar to the national average, in which the first wave is less expressed and the next two are more clearly marked. The first four classes form a distinct group with values of incidence of cases below average for most of the study period, the last two being distinguished by the virulence of the infections during waves 2 and 3 (Figure 1).

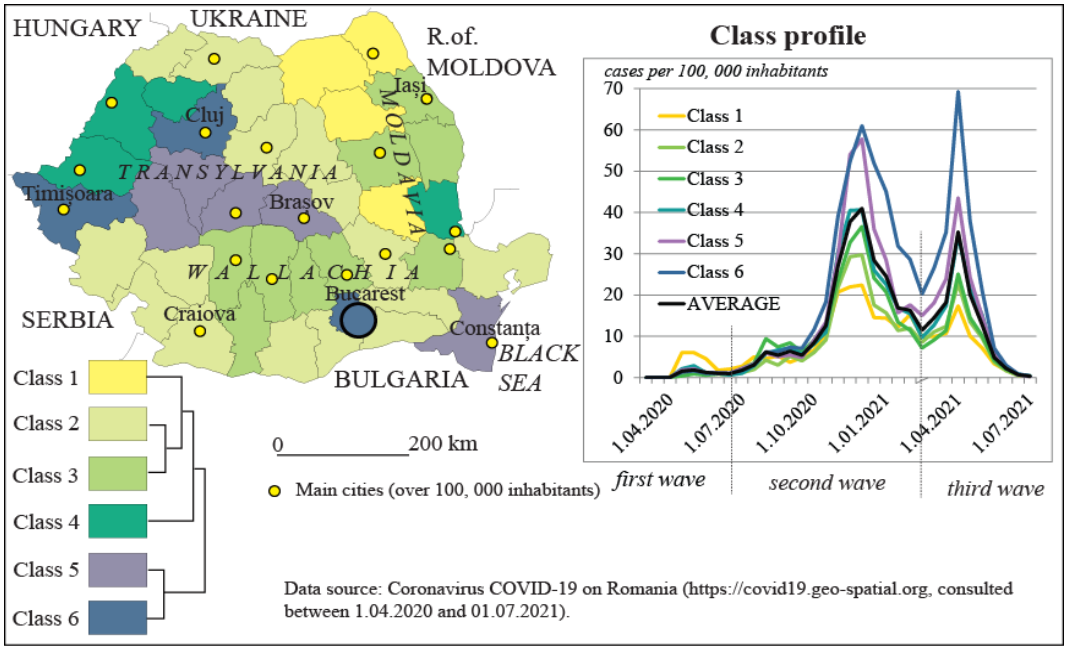

Figure 1. The typology of the evolution of Covid-19 cases in the perioad March 2020-June 2021

Class 1 is the only one in which the first wave is clearly highlighted by a rapid increase in cases in the spring of 2020, simultaneously with the most affected areas in Europe (northern Italy, Spain). It includes the northwest and southwest of Moldavia, with Suceava county in the foreground, in which the epidemiological crisis manifested itself strongly in April-May 2020, attractng from the media the nickname ”Lombardy” of Romania. The precocity of the virulent manifestation of the infection can be attributed to the circular migration as invoked by certain studies (Lobiuc, Dimian, Gheorghiță, Caliman-Sturdza, & Covasa, 2021), the region being known for its magnitude, to which is added the precariousness of the medical infrastructure. Paradoxically, in Romania, the pandemic first manifested itself in predominantly rural areas such as the one mentioned. As the pandemic progressed, in waves 2 and 3, the virulence was well below the national average, probably limited by harsh measures (quarantine of Suceava and neighbouring communes in the first part of 2020).

Classes 2 and 3 are also distinguished by a lower than average incidence, being located in spatial continuity with class 1. They dominate the south and northeast of the country, the difference between them being given by the episodic rise of cases of infection in the summer of 2020 as regard type 3. In contrast, type 2 has always experienced a certain moderation in the evolution of infections. Located in the central-northern part of Wallachia and in the central part of Moldavia, both relatively densely populated, marked by the circular migration of labour, these areas seem to be known in July-September 2020 a late manifestaton of wave 1, possibly favoured by restricting limitation measures. This phenomenon had a general occurrence but in these areas it was much more accentuated. Class 4 corresponds altogether to the national average, showing more obvious accentuation trends since last autumn. Grouped in the northwest of the country, to which is added Galati County in the eastern part, it completes the circular arch that separates the areas most affected by Covid-19.

Classes 5 and 6 are distinguished by the spectacular increase in Covid-19 cases during waves 2 and 3. It forms three distinct cores: one more spatially extended, comprising southwestern Transylvania and part of Banat regions; another characterizing the capital and the neighbouring county of Ilfov; the last, in the southeast it adds Constanța County. The coincidence with the higher level of development of these areas and with strong urbanization cannot be coincidental as the massive insertion in the circuits of international mobility. Class 6 which effectively groups the most dynamic areas of the country (capital, Cluj and Timiș counties) is distinguished by the exceptional peak of the third wave but also by the steep fall that followed, possibly correlated with more active vaccination in these heavily urbanized and developed areas.

The typology of the evolution of the Covid-19 cases highlights, in conclusion, a certain manifestation of some regional models, explicable by the incidence of some socio-economic factors. These patterns are also manifested from the perspective of the evolution of deaths.

The second typology emphasizes more spectacular oscillations and stronger territorial disparities (Figure 2). Under-registration can be raised, but it also manifested itself in terms of case records. Further, strictly local studies may highlight the importance of the quality of public health infrastructure and the readiness of response to pandemic challenges. The fact that the first class groups only Suceava County, in which the extremely high incidence (compared to the national standards at least) in the first phase of the pandemic is required, can be related to the factor invoked above. It is no coincidence that the extreme case of militarized control and prolonged quarantine of maximum risk areas has been reached to reduce what appeared to be a catastrophe. Although contestable, these measures had positive effects over time, third wave manifesting itself more moderately in this county.

Class 2 extends into the central-western part of the country, to which are added more isolated Bistrița-Năsăud in north and Brăila in the southeast. These are distinguished by the much higher than average recrudescence of deaths caused by Covid-19 during second and third wave. These can be considered, along with Suceava, as the most affected areas. The quality of the health public infrastructure in this case is not necessarily poor, compared to the national average, the explanations that can be provided, along with the partial overlap with the areas that recorded the

highest number of infections, rather due to a certain vulnerability created by the specific context, being more urbanized and more developed counties in general, with a high labour mobility.

Class 3 group most of Moldavia and Mureș County, in which the evolution of deaths registered certain precocity, similar to class 1, between May and June 2020 but later evolved rather according to the national average. The spatial homogeneity of this class can be considered representative for Moldavia.

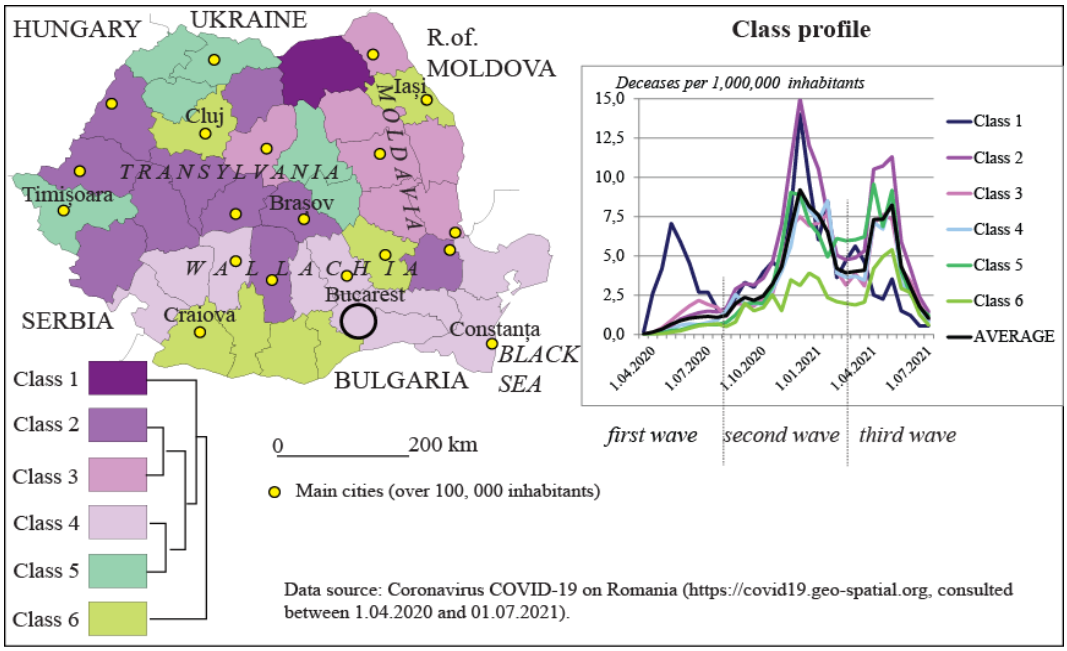

Figure 2. The typology of the evolution of Covid-19 deceases in the period March 2020-June 2021

Class 4, closely follows the national average and is distinguished by the moderation of the second and third waves. The area of expansion, although fragmented, has a certain spatial coherence, covering most of the southern part of the country from Oltenia to Dobruja. It may be considered a southern model, including also the capital, Bucharest.

Class 5, spatially fragmented, includes three rather heterogeneous areas: Timiș County, one of the most developed in the far west; north-western Transylvania, an area strongly marked by circular labour migration to Europe; eastern Transylvania, comprising the two counties with predominantly Hungarian population (Harghita and Covasna), the ethnic factor can be invoked at least in this case by the relative isolation of some communities. The relative increase in deaths, especially during third wave, provides a special profile for this class, constituting somewhat an extension of class 2, together with which it forms the Transylvanian model of evolution.

Class 6 includes a more unitary area, in the extreme south of the country, a predominantly rural area and strongly affected by the aging population, to which is added to the east, with similar features, Buzău County. The counties of Iași and Cluj join through a similar profile, marked by a much lower incidence of deaths caused by Covid-19 even if the number of cases was high. If in the extreme south can be invoked the relative isolation of aging rural population that limited spread of infection, Cluj and Iași counties seem to have responded better to the challenges of the pandemic, being much well equipped from the perspective of medical infrastructure and staff, as university medical centres. The question may arise why Timiș or Bucharest, with similar characteristics, was more strongly affected by fatal cases, but the answer can only be provided by comparative case studies after the pandemic passes.

In conclusion, the typology of the evolution of death cases highlights strong disparities related to the socio-economic specificity and the quality of public health system. The spatial distribution of types is significantly different as a result of the distinct way in which communities have responded to the pandemic challenge.

Factorial analysis of the evolution of Covid-19 cases and associated deaths

In order to test the extent to which the factors related to the socio-economic specificity and the quality of the public health infrastructure, two PCA (principal component analysis) were operated, according to the model set out in the methodology.

The first PCA tries to capture the context in which the expansion of Covid-19 infection took place in territorial profile, having as spatial reference the 41 counties and the city of Bucharest. The dependent variable (CS) is strongly correlated with most of the 10 explanatory variables introduced in the model. Only the NRS variable has a weaker correlation, thus indicating that the insufficiency of the medical assistance staff does not explain the dynamics of the pandemic in the Romanian case. Instead, socio-economic variables such as GDP, SHE, EMP show a close correlation, explaining the virulence with which it manifested itself in second and third pandemic waves in the capital and more developed counties (Timiș, Cluj, Brașov, Sibiu), with a higher employment rate and a higher level of education (Table 3). The correlation with the share of the elderly population is negative, contrary to the conclusions of studies conducted in other countries (Buja, et al., 2020), due to the fact that population aging is more advanced in rural areas, often characterized by a population dispersion that has decreased virus spread. The correlation with the urbanization and population density is also strong enough, thus certifying the importance of the population agglomeration in the diffusion of the studied phenomenon. Among the indicators related to the health infrastructure, the strongest connection is given by the number of physicians, closely related to the others. The elaborated analysis model is validated by a very high value of the coefficient R^2.

Table 3. The correlation matrix between the variables analysed
for the evolution of Covid-19 infections, between March 2020 and June 2021
(Data source: Coronavirus COVID-19 on Romania (https://covid19.geo-spatial.org, consulted between Mars 2020 and June 2021); Database Tempo-Online (National Institute of Statistics, March 2020-June 2021); Buletinul statistic lunar al județelor (National Institute of Statistics, March 2020-June 2021))

Variables	CS	PHS	NRS	HB	GDP	URB	DNS	MOB	AGP	SHE	EMP
CS	1	**0.598**	0.286	**0.427**	**0.851**	**0.683**	**0.603**	**0.450**	**-0.439**	**0.842**	**0.776**
PHS		1	**0.783**	**0.793**	**0.694**	**0.635**	**0.388**	0.303	**-0.398**	**0.802**	**0.637**
NRS			1	**0.840**	**0.495**	**0.617**	0.198	0.115	-0.205	**0.565**	**0.441**
HB				1	**0.585**	**0.639**	0.266	0.151	-0.188	**0.652**	**0.543**
GDP					1	**0.723**	**0.510**	0.261	**-0.406**	**0.928**	**0.865**
URB						1	0.189	0.141	-0.302	**0.780**	**0.780**
DNS							1	**0.477**	**-0.448**	**0.553**	0.302
MOB								1	**-0.313**	0.279	0.086
AGP									1	**-0.495**	**-0.464**
SHE										1	**0.883**
EMP											1
Chi-square (observed value): 453.8719; Chi-square (critical value): 73.3115; p-value <0.0001; R^2 =**0.77997**											

The model used can be simplified by creating synthetic indicators, thus grouping the variables according to their specificity (quality of public health infrastructure, level of economic development, population distribution, and population mobility). The redundancy of virtually overlapping variables (such as GDP and SHE or HB and NRS) would be reduced (Figure 3).

The distribution of the counties according to the score of the two separate factorial axes is also interesting. There is a particularly coherent group from a regional point of view, the

counties of Moldavia and Transylvania having a specific distribution. The south of the country, an area where it is located and the capital, occupies an intermediate position, interspersed between the two groups indicated. The capital and the neighbouring county of Ilfov are distinguished by their unique position. Equally coherent is the grouping of counties according to certain development indicators or the presence of important urban agglomerations, with a developed medical infrastructure (Iași, Timiș, Cluj, Brașov), relatively close to the capital's position. On the other hand, the poorly developed counties in the south and east of the country, less urbanized and a precarious medical infrastructure are also grouped coherently, as seen in the typological analysis (Teleorman, Călărași, Ialomița, Giurgiu etc.). An analysis of the spatial autocorrelation of the indicators used can certify the existence of regional groupings in which, as a rule, the counties having large cities, with a higher level of development and a complex medical infrastructure behaved differently from neighbouring counties but in continuity with these. They generate a kind of local gradient of epidemic vector diffusion closely related to the interactions induced by population mobility.

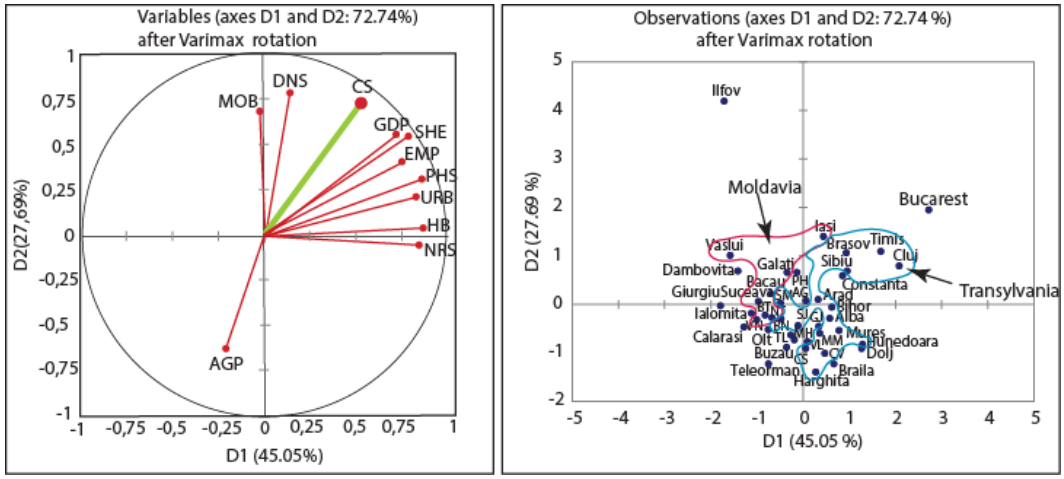

Figure 3. Evolution of Covid-19 cases. Principal component analysis results after Varimax rotation: contribution of factorial axes and the distribution of counties by factor scores

The analysis of the correlation between the deaths due to Covid-19 and the same set of variables, to which is added the number of cases, for the same study period, attests a strong discordance compared to the previous analysis. The relationship between the number of infections and the number of deaths, although strong, is inversely proportional, which can lead to serious reservations about the correctness of the record, both cases and deaths (Table 4, Figure 4).

Of the 10 variables analysed, only 5 show significant values of the correlation, all with negative values, as well as the number of cases. Population density has the highest values and can have a logical explanation, densely populated counties usually have important cities with better medical infrastructure, circumstances in which the level of testing and, implicitly, pandemic control was higher. On the contrary, in sparsely populated counties, usually predominantly rural, even if there was a lower incidence of cases, the death rate was higher due to poor pandemic management and difficulty in accessing specialized services. The other four better correlated variables (PHS, GDP; MOB and SHE) support the same explanations as DNS, expressing strong spatial inequalities. These disparities are likely to be accentuated in the event of a wave 4, given the much higher level of vaccination in large cities (according to (www.vaccinare-covid.gov.ro, 5 July 2021)). The coefficient R^2 has a lower value but can be considered significant enough to ensure an explanatory role to the variables analysed.

Table 4. The correlation matrix between the variables analysed for the evolution of deaths caused by Covid-19 infections, between March 2020 and June 2021
(Data source: Coronavirus COVID-19 on Romania (https://covid19.geo-spatial.org, consulted between Mars 2020 and June 2021); Database Tempo-Online (National Institute of Statistics, March 2020-June 2021); Buletinul statistic lunar al județelor (National Institute of Statistics, March 2020-June 2021))

Variables	DCS	CS	PHS	NRS	HB	GDP	URB	DNS	MOB	AGP	SHE	EMP
DCS	1	**-0.560**	**-0.385**	-0.014	-0.139	**-0.435**	-0.091	**-0.532**	**-0.385**	0.074	**-0.372**	-0.219
CS		1	**0.598**	0.286	**0.427**	**0.851**	**0.683**	**0.603**	**0.450**	**-0.439**	**0.842**	**0.776**
PHS			1	**0.783**	**0.793**	**0.694**	**0.635**	**0.388**	0.303	**-0.398**	**0.802**	**0.637**
NRS				1	**0.840**	**0.495**	**0.617**	0.198	0.115	-0.205	**0.565**	**0.441**
HB					1	**0.585**	**0.639**	0.266	0.151	-0.188	**0.652**	**0.543**
GDP						1	**0.723**	**0.510**	0.261	**-0.406**	**0.928**	**0.865**
URB							1	0.189	0.141	-0.302	**0.780**	**0.780**
DNS								1	**0.477**	**-0.448**	**0.553**	0.302.
MOB									1	**-0.313**	0.279	0.086
AGP										1	**-0.495**	**-0.464**
SHE											1	0.833
EMP												1
Chi-square (observed value): 491.8204; Chi-square (critical value): 85.9649; p-value <0.0001; R^2 =**0.473246**												

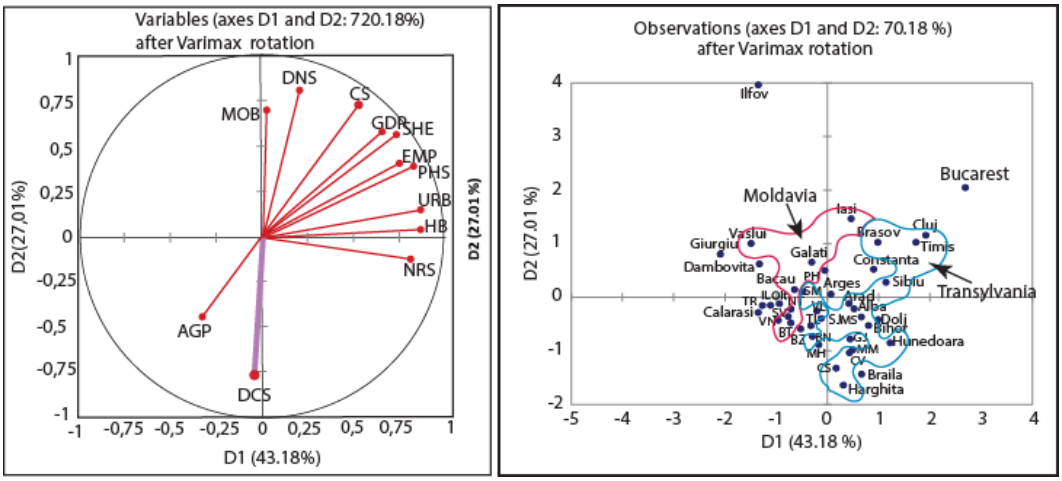

Figure 4. Evolution of deceases caused by Covid-19. Principal component analysis results after Varimax rotation: contribution of factorial axes and the distribution of counties by factor scores

The setting of the variables along the factorial axes is not very different from the analysis of the evolution of cases, the only notable difference being the positioning of the dependent variable. There are small differences in the grouping of variables: EMP is this time almost coincident with PHS, the high level of employment attracting a larger number of doctors; URB and HB are also coincident, in the previous analysis being correlated with PHS and NRS, respectively, explainable by the concentration of hospital units in the cities. These differences certify the somewhat greater dependence of deaths caused by Covid-19 on the level of development of health infrastructure. And in this case, the distribution of counties in the factorial plan distinguishes a grouped arrangement at regional level in Moldavia and Transylvania, the capital and Ilfov County having the same eccentric position. The opposition between the counties with a well-developed health infrastructure and the disadvantaged ones, especially in the south and east of the country, is preserved.

The two principal component analyses certify the manifestation of significant regional disparities in the evolution of the number of Covid-19 cases and of the deaths caused by it. The role of socio-economic factors and the quality of health infrastructure largely validates the study hypothesis.

CONCLUSIONS

Any study on the dynamics of the Covid-19 pandemic and its effects is limited by the quality of the information. The outline of regional models of evolution and the manifestation of some disparities related primarily to the level of development, however, indicate sufficiently clear trends, anchored in the local particularities expressed by the analysed factors. The inaccuracy of the information is rather due to the scale of the phenomenon in terms of the evolution of the number for cases and the absence of a rigorous reporting of deaths caused. The regional amplitude seems to be quite correctly captured by the net detachment of densely populated counties, with a high level of development and stronger mobility, in opposition to the predominantly rural counties, often less populated. The empirical observation of a correlation between agglomeration of the population and the diffusion of pandemic is not a novelty, being part of the natural logic of things. The fact that the information used, with all its limitations, certifies this connection shows that the means available to today's society, even in emerging countries such as Romania, can capture quite faithfully a phenomenon of this magnitude. More debatable is the situation presented by the evolution of death cases, which is in Romania in contradiction with the evolution of infection cases, correlated with strong disparities in the quality of health infrastructure. This discrepancy, which creates an advantage for large hospitals, doubled by poor vaccination in the same disadvantaged areas, is likely to dramatically change the distribution of cases during the inevitable four waves. Official information indicates a very high share of unvaccinated people among those infected after July 1 (82.4%) and all registered deaths were in unvaccinated persons (National Institute of Public Health, July 2021).

The conclusions of the study converge with those expressed in the consulted sources, indicating the manifestation of distinct epidemic waves, whit a specific local development, altogether in line with the trends observed at European level. The observed territorial disparities are sufficiently regionalized to nuance variation in the general pattern of pandemic spread. The explanation of these disparities through principal component analysis certifies the existence of an urban/rural cleavage, depending on the rate of population mobility and the level of socio-economic development. The excess of mortality in the urban environment strengthens this opposition, closely related to the agglomeration of the population. Factors that seem to favour the incidence of the pandemic, such as the aging population, have proved not to have a decisive role in the Romanian case, being a phenomenon present primarily in rural communities, by their more dispersed nature. An interesting result is the certification of the importance of the quality of public health infrastructure. Its concentration in large urban centres has reduced the lethal impact of the pandemic through its superior capacity for intervention, through stricter control. The existence of a private health system, in parallel with public one, ensured a superior availability for the other categories of patients. In contrast, in less developed areas, in many cases hospitals have been blocked to deal with the pandemic. A substantial part of the mortality surplus comes, as it is circulated in the public space, precisely form the impossibility of providing medical care for the chronically ill.

Any conclusions on the pandemic phenomenon generated by Covid-19 can only be preliminary. A complete and correct vision of its development and interference with the socio-economic system can only be issued after eliminating this risk.

REFERENCES

2011 Census. (2011). Retrieved from www.insse.ro

Abbasi, M., Bollini, A., Castillo, J., Deppman, A., Guidio, J., Matuoka, P., . . . Trevisan, L. (2020). Fractal signatures of the COVID-19 spread. *haos, Solitons and Fractals, 140*(1). doi:10.1016/j.chaos.2020.110119

Amdaoud, M., Arcuri, G., & Levratto, N. (2021). Are regions equal in adversity? A spatial analysis of spread and dinamics of COVID-19 in Europe. *The European Journal of Health Economics, 22*(1), 629-642. doi:10.1007/s10198-021-01280-6

Audi, A., Allbrahim, M., Kaddoura, M., Hijazi, G., Yassine, H., & Zaraket, H. (2020). Seasonality of Respiratory Viral Infections: Will COVID-19 Follow Suit? *Frontiers in Public Health, 15*(3). doi:10.3389/fpubh2020.567184

Bogos, K., Kiss, Z., Fronius, A., Temesi, G., Elek, J., Madurka, I., . . . Moldvay, J. (2021). Different Trends in Excess Mortality in a Central European Country Compared to Main European Regionas in the Year of the Covid-19 Pandemic (2020): a Hungarian Analysis. *Pathology & Oncology Research, 27*. doi:10.3389/pore.2021.1609774

Bontempi, E., Vergalli, S., & Squazzoni, F. (2020). Understanding COVID-19 diffusion requires an interdisciplinary, multidimensional approach. *Enviromental Research, 188*. doi:10.1016/j.envres, 2020.109814

Buja, A., Paganini, M., Cocchio, M., Scioni, M., Rebba, V., & Baldo, V. (2020). Demographic and socio-economic factors, and healthcare resource indicators associated with the rapid spread of Covid-19 in Northern Italy: An ecological study. *Plos ONE, 15*(12). doi:10.1371/journal.pone.0244535

Collins, A., Florin, M., & Renn, O. (2020). COVID-19 risk governance: drivers,responses and lessons to be learned. *Journal of Risk Research, 23*(7-8), 1073-1082. doi:10.1080/13559877.2020.1760332

Coronavirus COVID-19, Romania. (March 2020-June 2021). Retrieved from https://covid19.geo-spatial.org

Creţan, R., & Light, D. (2020). COVID-19 in Romania: transnational labour, geopolitics, and the Roma "outsiders". *Eurasian Geography and Economics, 61*(4-5), 559-572. doi:10.1080/15387216.2020.1780929

Dascălu, Ș. (2020). The Successes and Failures of the Initial COVID-19. Pandemic Response in Romania. *Front. Public Health, 10*(1). doi:10.3389/fpubh.2020.0034

Fisayo, T., & Tsukagoshi, S. (2021). Three waves of COVID-19 pandemic. *Postgraduate Medical Journal, 97*(1147). doi:10.1136/postgradmedj-2020-138564

Graichen, H. (2021). What is the difference between the first and the second/third wave of Covid-19? German perspective. *Journal of Orthopaedics, 24*((March-April 2021)). doi:10.10106/j.jor.2021.01.011

Hâncean, M., Perc, M., & Lerner, J. (2020). Early spread of COVID-19 in Romania: imported cases from Italy and human-to-human transmission networks. *Royal Society Open Science, 7*(1). doi:10.1098/rsos.200780

https://covid19.geo-spatial.org. (consulted between Mars 2020 and June 2021). Retrieved from https://covid19.geo-spatial.org

Imtyaz, A., Haleem, A., & Javaid, M. (2020). Analysing governmental response to the COVID-19 pandemic. *Journal of Oral Biology and Craniofacial Research, 10*(1), 504-513. doi:10.1016/j.jober.2020.08.005

INS. (n.d.). Retrieved from www.insse.ro

Jinjarak, Y., Ahmed, R., & Nair, S. (2021). Accounting for global COVID-19 diffusion patterns. *European Economist.* Retrieved from https://european.economicblogs.org/

Kubota, Y., Shiono, T., Kusumoto, B., & Fujinamal, J. (2020). Multiple drivers of the COVID-19 spread: The roles of climate, international mobility and region-specific conditions. *PloS ONE, 15*(9). doi:10.1371/journal.pone.0239385

Liu, X., Huang, J., Li, C., Zhao, Y., Wang, D., Huang, Z., & Yang, K. (2021). The role of seasonality in the spread of Covid-19 pandemic. *Environmental Research, 195*(1). doi:10.1016/j.2nvres.2021.110874

Lobiuc, A., Dimian, M., Gheorghiță, R., Caliman-Sturdza, O., & Covasa, M. (2021). Introduction and Characteristics of SARS-CoV-2 in North-East of Romania During the First COVID-19 Outbreak. *Frontiers in Microbiology, 12*. doi:10.3389/fmicb.2021.654417

Mogi, R., & Spijker, J. (2021). The influence of social and ecomomic ties to the spread of COVID-19 in Europe. *Journal of Population Research*. doi:10.1007/s12546-021-09257-1

Muntele, I., Istrate, M., Bănică, A., & Horea-Șerban, R. (2020). Trends in Life Expectancy in Romania betweeen 1990 and 2018. A Territorial Analysis of Its Determinants. *Sustainability, 12*(9). doi:10.3390/su12093802

National Institute of Public Health. (July 2021). *Raport săptămânal (EpiSăptămâna 29, 2021) (Weekly Report 29, 2021).* Retrieved from www.cnscbt.ro/index.php/analiza-cazuri-confirmate-covid19/2598

National Institute of Statistics. (March 2020-June 2021). *Baza de date Tempo-Online (Tempo-Online Database)*. Retrieved from www.insse.ro

National Institute of Statistics. (March 2020-June 2021). *Buletinul statistic lunar al județelor (The monthly statistical bulletin of the counties)*. Retrieved from www.insse.ro

National Institute of Statistics. (n.d.). *www.insse.ro*. Retrieved from 2011 Census: www.insse.ro

Popic, T., & Moise, A. (2021). Health system resilience in te context of te Covid-19 pandemic: the gap between Eastern and Western Europe. *STG Resilience Papers*. Retrieved from htpps://hdl.handle.net/1814/71699

Shulz, A., Mehdipanah, R., Chatters, L., Reyes, A., Neblett, E., & Israel, B. (2020). Moving Health Education and Behaviour Upstream: Lessons from COVID-19 for Addressing Structural Drivers of Health Inequities. *Health Education & Behavior, 47*(4), 519-524.

Smit, A., Fitchett, J., Engelbrecht, F., Scholes, R., Dzhivhuho, G., & Seijd, N. (2020). Winter is Coming: A Southern Hemisphere Perspective of the Environmental Drivers of SARS-CoV-2 and the Potential Seasonality of COVID-19. *International Journal of Environmental Research and Public Health, 17*(16). doi:10.3390/ijerph17165634

Solis, J., Franco-Paredes, C., Henao-Martinez, A., Krsak, M., & Zimmer, S. (2020). Structural vulnerability in the U.S. Revealed in Three Waves of COVID-19. *The American Journal of Tropical Medicine and Hygiene, 103*(1), 25-27. doi:104269/ajtmh.20-0391

Sulyok, M., Ferenci, T., & Walker, M. (2020). Google Trends Data and Covid-19 in Europe: Correlations and model enhancement are European wide. *Transboundary and Emerging Diseases, 68*(4), 2610-2615. doi:10.1111/tbed.13887

Taboada, M., Gonzalez, M., Alvarez, A., Eiras, M., Costa, J., Alvarez, J., & Seoane-Pillado, T. (2021). First, second and third wave of COVID-19.What have we changed in the ICU management of thes patients? *Journal of Infection, 8*(26). doi:10.1016/j.jinf2021.03.027

Taleb, N. (2018). *Lebăda neagră: impactul foarte puțin probabilului (The Black Swann:The Impact of the Highly Improbable, romanian edition).* Bucharest: Curtea Veche.

Vokó, Z., & Pitter, J. (2020). The effect of social distance measures on COVID-19 epidemics in Europe: an interrupted time series analysis. *GeroScience, 42*(1), 1075-1082. doi:10.1007/s11357-020-00205-0

Werth, A., Gravino, P., & Prevedello, G. (2021). Impact analysis of COVID-19 responses on energy grid dynamics in Europe. *Applied Energy, 281*(1). doi:10.1016/j.apenergy.2020.116045

Worldometers. (March 2020-June 2021). Retrieved from www.worldometers.info

Wu, T. (2021). The socioeconomic and environmental drivers of the COVID-19 pandemic: A review. (R. S. Sciences, Ed.) *Ambio, 50*(1), 822-833. doi:10.1007/s13280-020-01497-4

www.vaccinare-covid.gov.ro. (5 July 2021). Retrieved from www.vaccinare-covid.gov.ro

Submitted:	Revised:	Accepted	Published online
August 16, 2021	February 28, 2022	March 03, 2022	April 11, 2022

Analele Universităţii din Oradea, Seria Geografie **XXXII**, no. **1/2022**, pp. **16-25**
ISSN **1221-1273**, E-ISSN **2065-3409** DOI **10.30892/auog.321102-878**

APPRAISAL OF ENVIRONMENTAL SANITATION PRACTICES IN SELECTED MARKETS IN AKURE, NIGERIA

Rafiu Babatunde IBRAHIM*
Osun State University Osogbo, Department of Urban and Regional Planning, Faculty of Environmental Sciences, P.M.B. 4494, Osogbo, Nigeria e-mail: rafiu.ibrahim@uniosun.edu.ng

Samuel Babatunde ADEDOTUN
Osun State University Osogbo, Department of Urban and Regional Planning, Faculty of Environmental Sciences, P.M.B. 4494, Osogbo, Nigeria e-mail: samuel.adedotun@uniosun.edu.ng

Dele Sunday OGUNDAHUNSI
Osun State University Osogbo, Department of Urban and Regional Planning, Faculty of Environmental Sciences, P.M.B. 4494, Osogbo, Nigeria e-mail: dele.ogundahunsi@uniosun.edu.ng

Waheed Faoziyat IBRAHIM
Osun State University Osogbo, Department of Urban and Regional Planning, Faculty of Environmental Sciences, P.M.B. 4494, Osogbo, Nigeria e-mail: faoziyah1622@gmail.com

Blessing Oluwatunmise AKINBOSOYE
Osun State University Osogbo, Department of Urban and Regional Planning, Faculty of Environmental Sciences, P.M.B. 4494, Osogbo, Nigeria e-mail: akinbosoyeoluwatunmise@gmail.com

Citation: Ibrahim, R.B., Adedotun, S.B., Ogundahunsi, D.S., Ibrahim, W.F., and Akinbosoye, B.O. (2022). Appraisal of Environmental Sanitation Practices in Selected Markets in Akure, Nigeria. *Analele Universităţii din Oradea, Seria Geografie, 32*(1), 16-25. https://doi.org/10.30892/auog.321102-878

Abstract: This study examines environmental sanitation practices of the users in the selected markets in Akure Ondo State, Nigeria. It assesses the socio-economic characteristics of the market users, as well as the factors influencing environmental sanitation practices. The study also examined the relationship between socio-economic characteristics of respondents and environmental sanitation practices. Data were obtained from two purposively selected markets. A traditional (Adedeji) and modern (Nepa) market. Random Systematic sampling techniques was used to administer a total of 151 structured questionnaires for the traders in the study area. Therefore, 57 questionnaires were administered in Adedeji market and 94 questionnaires were administered in Nepa neighborhood market, using the shop/stalls as the sampling units. Descriptive statistics and inferential statistics were used to analyze the data collected. The study revealed that most of the market users in Nepa (67.5%) and Adedeji (61.4%) market were females respectively. It was also revealed that some of the goods selling in the market includes; foodstuff, livestock, electronic, supermarket and textile products. This indicated that waste are generated on daily basis in both markets and collected on daily and weekly basis, where 95.4% of traders adopted waste collection services. Findings reveals that sanitation facilities were fairly (47.7%) provided. Cleaning of toilets, drainage, waste collection among others are the sanitation practices

* Corresponding author

carried out mostly on weekly basis. With mean weighted value of (4.74), avoidance of penalty is the dominant factor influencing participation in the sanitation exercise. Result of Correlation analysis revealed that there is low positive correlation ($r = 0.142$, $p = 0.084$) between socio-economic characteristics of respondents and sanitation practices in the two markets. The study concludes by recommending among others that market management and government should be actively involved in the provision of sanitation facilities in the markets to enhance proper hygiene.

Key words: environment, sanitation, practice, traditional market, modern market.

* * * * * *

INTRODUCTION

Environmental sanitation has remained an intractable problem in the developing nations particularly Nigeria with serious public health consequences. This is due to poor sanitation practice as a result of improper refuse disposal, inadequate water supply and gross inadequacy of sanitary facilities especially in the market areas (Ministry of Health, 2011). Generally, markets occupy an important position in the lives of Nigerians and activities involved in buying and selling generate large quantities of solid waste that contains a large proportion of decomposing vegetable and animal matter (Parks, 2007). Ogwueleka added that market centres do not only serve as places for commodity exchange but also centres of information exchange, local administration, health delivery, education, and entertainment centre, etc. where buying and selling are carried out among others (Ogwueleka, 2009).

These activities generate large quantities of solid waste which cause unpleasant odor, excellent breeding grounds for vectors of communicable diseases including rodents and insects, and also being eyesores which all have direct unpleasant environmental consequences (Ministry of Health, 2011). It is quite common to observe mountains of refuse at market places this heaps of refuse provide excellent breeding grounds for vectors of communicable diseases including rodents, insects, etc. which increases the potential for the spread of infectious diseases (Ayoola, Lawal, & Akinluyi, 2012).

It has been acknowledged that many of the diseases that affect Nigerians such as malaria, tuberculosis and diarrhea are direct effect of poor sanitation and are due to unhealthy environmental conditions which most times are resultant of contaminated food stuffs (National Population Commission, 2004). Thus, poor environmental and sanitary conditions at market centres in the country portend adverse public health implications for and market users.

The term 'environmental sanitation' has been given various definitions by different authors and researchers in different countries and times (Ayoola, Lawal, & Akinluyi, 2012; Ilesanmi, 2009). Environmental sanitation refers to the state of cleanliness of a place, community or people particularly relating to those aspects of human health including the quality of life determined by physical, biological, social and psychological factors in the environment (Acheampong, 2010; Godfred & Ruby, 2019; Fagbemi, Ogungbemi, Philips, Obatuase, & Hassan, 2020). Meanwhile, it also involves the interventions to reduce people's exposure to diseases by providing a clean environment to live and with measures to break the cycle of disease emanating from untidy surroundings (Abejegah, et al., 2013).

Environmental sanitation is a concept explaining activities to ensure safe disposal of excreta, solid waste and other liquid waste and the prevention of disease vectors to ensure a hygienic environment (Acheampong, 2010); which also involves both behaviors and facilities which work together to form a hygienic environment (WHO, 2004). Furthermore, environmental sanitation generally encompasses all conditions that affect health which includes water, wastewater, personal and food hygiene, public health etc.

Hence, activities carried out in public places like markets and other public places of insanitary conditions pose adverse health hazards to the operators in these activity centres (Arthur & Imoro, 2021; Olutegbe & Asubiojo, 2020; Ivan, 2019). This study therefore assesses the existing environmental sanitation practices of markets users in selected markets in Akure, Ondo State, Nigeria.

MATERIALS AND METHODS

The Study Area

Akure is a city in south-western Nigeria and is the largest and the capital city of Ondo state. It is located in the South Western Zone of Nigeria. It is geographically located within Latitudes 70°15'N and 70°28'N North of the Equator and Longitudes 5°06'E and 50°21'E East of the Greenwich Meridian. The increased relative political influence of Akure as a state capital since 1976 has greatly promoted its rapid growth and increased socio-economic activities resulting in its spatial expansion from an area of about 16 squares kilometers in 1980 to about 30 square kilometers in 2000 (Fagbemi, Ogungbemi, Philips, Obatuase, & Hassan, 2020). As a capital city of Ondo state it is a medium-sized urban centre which has three residential settlement patterns the core area, the peripheral neighborhoods to the core and the suburbs. Akure town which is mainly embedded in Akure South Local Government Area has witnessed immense growth in the size of built-up areas, number of immigrants, transportation, and commercial activities and has attracted both major investors and private developers into the city. The last census conducted in 2006 put the town's population at 353,211 i.e. Three hundred and fifty-three thousand, two hundred and eleven (National Population Commission, 2004).

Methods of Data Collection and Analysis

The sample frame for this study comprises of the shop/stall users in Nepa neighborhood market and Adedeji traditional market in Akure. First, the sample size was drawn from two (2) selected markets which are Nepa neighborhood market and Adedeji traditional market in Akure. These were selected by purposive sampling methods. In the market there is identification of lock-up stalls, open stalls and open space. The next stage involves the administration of questionnaire for traders in the selected shops and stalls. Random Systematic Sampling technique was adopted in selecting every 3rd respondent from the lock/open stalls and open space. Using this procedure, a total of 151 questionnaire were administered in the two markets. The data collected were analyzed using descriptive and inferential statistics. For Descriptive statistics, cross tabulation with chi-square was used to examine socio-economic characteristics of market users; environmental sanitation facilities and practices of market users as well as factors influencing market sanitation practices. For inferential statistics, Spearman rank correlation analysis was used to examine relationship between socio-economic characteristics and environmental sanitation practices.

RESEARCH FINDINGS

Socio-Economic Characteristics of Traders

Under this sub-section of the study, attempt is made to examine the socio-economic characteristics of respondents, in this case the market users in Adedeji and Nepa neighborhood market. The knowledge of the socio-economic characteristics of developers will no doubt sharpen our understanding of how they are being enlightened when it comes to the issue of market environmental sanitation practices.

Table 1. Socio-Economic Characteristics of Traders
(Source: Authors' fieldwork, 2019)

Socio-economic variables	Percentage (%)	
	Adedeji Market	Nepa Market
Gender		
Male	20.0	12.5
Female	45.3	22.2
Age		
18-30 years	15.6	84.4
31-40 years	46.3	53.7
41-50 years	48.8	51.2
51-60 years	21.4	78.6
61 years & above	40.0	60.0

Marital status		
Single	29.2	70.8
Married	40.7	59.3
Widowed	0.0	100
Occupation		
Trading	23.9	76.1
Self-employed	48.1	51.9
Civil servant	0	100
Artisan	68.4	31.6
Retired	50.0	50.0
Income		
N18,000 & below	37.2	62.8
N18,000-N40,000	39.5	60.5
N41,000-N60,000	35.0	65.0
N61,000 & above	0	100
Education		
No formal education	70.6	29.4
Primary education	37.5	62.5
Secondary education	39.4	60.6
Tertiary education	22.7	77.3

The gender of respondents as obtained and presented in table1 revealed that most of the respondents (67.5%) are female in both market compared to male (32.5%) respondents. The bulk of the respondents interviewed were between the ages 31-40 years and 41-50 years. It is clearly expressed that most respondents are married. Expectedly, trading is the dominant occupation, where respondent in the Nepa market earns more on monthly basis compared to respondents in Adedeji market. The highest proportion (77.3%) of respondents in Nepa market have tertiary education, while most of the respondents (70.6%) in Adedeji market have no formal education.

The nature of goods sold sometimes determines the level of sanitation in a market. As shown in Table 2, foodstuff, livestock, electronic, supermarket and textile products which generate large quantity of waste were sold by the market users. It was indicated that 33.1% are of foodstuff, 17.8% of livestock, 13.9% operates supermarket, 8.6% engaged in restaurant, 7.9% sells snacks, 6.6% stationery, 3.9% textiles/boutique, 3.3% sells plastics and electronics while 1.3% sells vehicular part in both markets. In Nepa market 35.1% sell foodstuff and 14.9% sells livestock and supermarket, 10.6% rated for restaurant while 7.4% and 5.3% accounted for snacks and stationery and 3.2% accounted for electronics, plastics and textiles respectively. Respondent in Adedeji market also sells foodstuffs (29.8%), livestock (22.8%), operates supermarket (12.2%), snacks and stationery (8.7%), restaurant and textile/boutique (5.2%), electronics and plastics (3.5%) respectively.

Environmental Sanitation Practices of Market Traders

The list of method of waste disposal and the ones adopted by the market users is contained in table3. It can be deduced that 95.4% adopted waste collection service method, 2.6% adopted nearby bush while 0.7% adopted open space dumping. Burning designated dump site, inside drainage, nearby bush, barrow or cart pusher and nearby bush are not adopted by the market users in both market respectively.

Table 2. Types of Goods being sold in the Markets
(Source: Authors' fieldwork, 2018)

Name of Market	Activities and Types of Goods Sold										Total
	Livestock	Foodstuffs	Electronics	Super market	Snacks	Plastics	Stationery	Restaurant	Vehicular Part	Textiles/ Boutique	
Nepa F	14	33	3	14	7	3	5	10	2	3	94
%	14.9	35.1	3.2	14.9	7.4	3.2	5.3	10.6	2.1	3.2	100

Adedeji F	13	17	2	7	5	2	5	3	0	3	57
%	22.8	29.8	3.5	12.2	8.7	3.5	8.7	5.2	0.0	5.2	100
Total F	27	50	5	21	12	5	10	13	2	6	151
%	17.8	33.1	3.3	13.9	7.9	3.3	6.6	8.6	1.3	3.9	100

Table 3. Method of Waste Disposal
(Source: Authors' fieldwork, 2019)

Name of Market	Nearby Bush		Burning	Designated Dumpsite	Open Space		Inside Drainage	Nearby stream	Barrow or Cart Pusher	Waste Collection Service	
	Yes	No	No	No	Yes	No	No	No	No	Yes	No
Nepa F	4	90	94	94	1	93	94	94	94	88	6
% of Rows	4.3	95.7	100	100	1.1	98.9	100	100	100	93.6	100
% of Column	100	61.2	62.3	62.3	100	62.0	62.3	62.3	62.3	58.3	62.3
Adedji F	0	57	57	57	0	57	57	57	57	56	57
% of Rows	0.0	100	100	100	0.0	100	100	100	100	98.2	100
% of Column	0.0	38.8	37.7	37.7	0.0	38.0	37.7	37.7	37.7	38.9	37.7
Total F	4	147	151	151	1	150	151	151	151	144	151
% of Rows	2.6	97.4	100	100	0.7	99.3	100	100	100	95.4	100
% of Column	100	100	100	100	100	100	100	100	100	100	100

Table 4. Sources of Water Supply in the Market
(Source: Authors' fieldwork, 2019)

Name of Market	Sources of water supply				Total
	Tap Water	Borehole	Well Water	Water Vendor	
Nepa F	45	34	15	0	94
% of Rows	47.9	36.2	16.0	0.0	100
% of Column	93.8	94.4	22.7	0.0	62.3
Adedeji F	3	2	51	1	57
% of Rows	5.3	3.5	89.5	1.8	100
% of Column	6.3	5.6	77.3	100	37.7
Total F	48	36	66	1	151
% of Rows	31.8	28.8	43.7	0.7	100
% of Column	100	100	100	100	100

The sources of water supply to the market varies according to the respondents in both markets as shown in Table 4. The study reveals that water is supplied to the Nepa markets through Tap water point and bore hole while Adedeji market source water from well water respectively. Furthermore, 47.9.0% and 36.2% of respondent in Nepa market source water from Tap point and borehole respectively. While 89.5% and 5.3% of respondent in Adedeji market source water from Well Water as shown in Table 4. It can be inferred that, the well water in Adedeji market was provided by the residential houses within and around the market most especially the residential buildings that were converted for commercial use.

Table 5. Access to Toilet Facility
(Source: Authors' fieldwork, 2019)

Name of Market	Access to toilet facility		Total
	Yes	No	
Nepa F	81	12	93
% of Rows	87.1	12.9	100
% of Column	59.6	85.7	62.0
Adedeji F	55	2	57
% of Rows	96.5	3.5	100
% of Column	40.4	14.2	38

Total F	136	14	150
% of Rows	90.7	9.3	100
% of Column	100	100	100

Toilet facility provides a means of disposing human waste of excreta and urine. It is therefore an essential environmental sanitation facility. From the analysis as shown in Table 5, it is observed that 87.1% of the respondent in Nepa market have access to toilet facilities owned and managed by the government while in Adedeji market 96.5% of the respondents acknowledge that they also have access to toilet facilities. Although the toilets are owned and managed by individuals whereby you pay #20 to urinate and #30 to excrete. Hence, in both markets there is provision of toilets.

Table 6. Adequacy of Toilet Facility
(Source: Authors' fieldwork, 2019)

Name of Market	Adequacy of toilet facility				Total
	Fully Adequate	Partially Adequate	Inadequate	Others	
Nepa F	32	43	7	11	93
% of Rows	34.4	46.2	7.5	11.8	100
% of Column	55.2	61.4	70.0	91.7	62.0
Adedeji F	26	27	3	1	57
% of Rows	45.6	47.4	5.3	1.8	100
% of Column	44.8	38.6	30.0	8.3	38.0
Total F	58	70	10	12	150
% of Rows	38.7	46.7	6.7	8.0	100
% of Column	100	100	100	100	100

The adequacy of toilet facility in the selected market as rated by the respondent as presented in Table 6, the respondent revealed that 46.7% is partially adequate, 38.7% is fully adequate, and 6.7% is inadequate. The study further accounted that 46.2% of the respondent in Nepa market rated the provision of toilet facilities as partially adequate, 34.4% rated it adequate. While in Adedeji market 47.4% of the respondent rated the toilet facilities partially adequate and 45.6% adequate respectively. Therefore, the analysis reveals that these facilities are relatively partially adequate.

Table 7. Frequency of Toilet and Drainage Cleaning
(Source: Authors' fieldwork, 2019)

Name of Market	Basis of Drainage Cleaning			Total
	Daily	Weekly	Monthly	
Nepa F	60	28	3	91
% of Rows	65.9	30.8	3.3	100
% of Column	53.6	87.5	75.0	61.5
Adedeji F	52	4	1	57
% of Rows	91.2	7.0	1.8	100
% of Column	46.4	12.5	25.0	38.5
Total F	112	32	4	148
% of Rows	75.7	21.6	2.7	100
% of Column	100	100	100	100

Concerning frequency of toilet and drainage cleaning, it can be inferred that the drains are kept clean on daily basis. 65.9% and 91.2% of respondent in Nepa and Adedeji market respectively reveals that the drains are cleaned on daily basis, as presented Table 7.

Frequency of environmental sanitation exercise is presented in Table 8 indicated that 96.7% of the total respondents says that the environmental sanitation exercise in the selected markets are on weekly basis, specifically every Thursday of the week to be precise within the hours of 7AM and 10AM. Hence, this environmental sanitation exercise is on weekly basis in both markets.

Table 8. Frequency of environmental sanitation exercise
(Source: Authors' fieldwork, 2019)

Name of Market	If yes, when			Total
	Weekly	Fortnight	Monthly	
Nepa F	89	1	4	94
% of Rows	94.7	1.1	4.3	100
% of Column	61.0	100	100	62.3
Adedeji F	57	0	0	57
% of Rows	100	0.0	0.0	100
% of Column	39.0	0.0	0.0	37.7
Total F	146	1	4	151
% of Rows	96.7	0.7	2.6	100
% of Column	100	100	100	100

Table 9. Perception about Cleanliness of the Market
(Source: Authors' fieldwork, 2019)

Name of Market	Perception about market cleanliness			Total
	Very Clean	Clean	Fairly Clean	
Nepa F	45	47	2	94
% of Rows	47.9	50.0	2.1	100
% of Column	95.7	50.0	20.0	62.3
Adedeji F	2	47	8	57
% of Rows	3.5	82.5	14.0	100
% of Column	4.3	50	80.0	37.7
Total F	47	94	10	151
% of Rows	31.1	62.3	6.6	100
% of Column	100	100	100	100

The analysis on the perceived effectiveness of sanitation exercise in the market is presented in Table 9 shows that 50.0% and 47.9% of the respondents in Nepa market rated the effectiveness of environmental sanitation exercise as clean and very clean respectively. In Adedeji market the respondent also rated 82.5% and 14.0% clean and fairly clean respectively.

Table 10. Rating of Efficient Decency of Environmental Sanitation Practice in the Markets
(Source: Authors' fieldwork, 2019)

Name of market		Nepa market		Adedeji market	
Components	Responses	F (94)	%	F (57)	%
Provision of waste disposal facilities	Very effective	46	48.9	48	84.2
	Effective	40	42.6	7	12.3
	Fairly effective	7	7.4	2	3.5
	Not effective	1	1.1	0	0.0
Regular provision of portable and safe water supply	Very effective	1	1.1	0	0.0
	Effective	4	4.3	9	15.8
	Fairly effective	23	24.5	13	22.8
	Not effective	36	38.3	35	61.4
	Not at all effective	30	31.9	0	0.0
Provision of adequate number of toilet	Very effective	3	3.2	2	3.5
	Effective	0	0.0	8	14.0
	Fairly effective	23	24.5	9	15.8
	Not effective	34	36.2	37	64.9
	Not at all effective	34	36.2	1	1.8
Quality of toilet provided	Very effective	1	1.1	0	0.0
	Effective	5	5.3	6	10.5
	Fairly effective	24	25.5	11	19.3

	Not effective	30	31.9	39	68.4
	Not at all effective	34	36.2	1	1.8
Provision of drains for storm water	Very effective	16	17.0	2	3.5
	Effective	44	46.8	4	7.0
	Fairly effective	23	24.5	11	19.3
	Not effective	11	11.7	37	64.9
	Not at all effective	0	0.0	3	5.3
Enforcement of sanitation policy	Very effective	72	76.6	42	73.7
	Effective	17	18.1	10	17.5
	Fairly effective	3	3.2	5	8.8
	Not effective	2	2.1	0	0.0
	Not at all effective	2	2.1	0	0.0

The determinant of effective environmental sanitation practice are based on the presence of adequate facilities and conditions which are said to be important in rating sanitation exercise and its practice within the selected markets. As shown in Table 10. In Nepa and Adedeji market 48.9% and 84.2 % of the respondent rated the provision of waste disposal facilities as an effective of aid efficient sanitation. Efficient sanitation can be achieved in the market area through provision of sanitation facilities such as water, drainage, waste disposal facilities, provision of information on environmental sanitation and enforcement of sanitation policy. These were considered and the respondent's perception about how these can aid efficient environmental sanitation was researched.

The determinant of effective environmental sanitation practice are based on the presence of adequate facilities and conditions which are said to be important in rating sanitation exercise and its practice within the selected markets. As shown in Table 10. In Nepa and Adedeji market 76.6% and 73.7% of the respondent rated the enforcement of sanitation policy as effective component while 24.5% and 19.3% of the respondents rated provision of drainage as effective component that aids market sanitation. 61.4% of respondents in Adedeji market stated that regular provision of water is not at all effective while in Nepa 38.3% respectively. Provision of toilet was rated not effective at 36.2% and 64.9% in both markets.

The respondents in both market also rates as relatively effective enforcement of sanitation policy in the markets.

Factors Influencing Sanitation Practices

It is observed in table 11 that avoidance of sanitation penalty has the highest mean weighted value of 4.74. This implies that avoidance of sanitation penalty is highest factor influencing market environmental sanitation practices in Nepa and Adedeji market. This situation is followed in decreasing order by market sanitation policy which has mean weighted value of 3.45, availability of sanitation facilities (3.92); health purpose/ hygiene (4.11); constant sanitation schedule (4.56).

Table 11. Factors Influencing Sanitation Practices
(Source: Authors' fieldwork, 2019)

S/N	Factors	Ranking					NRF	FWV	MWV	Rank
		5	4	3	2	1				
1	Market Sanitation Policy	495	192	12	0	0	151	526	3.48	5th
2	Availability of Sanitation Facilities	190	288	96	18	0	151	592	3.92	4th
3	Constant Sanitation Schedule	480	192	12	4	1	151	689	4.56	2nd
4	Health Purpose/ Hygiene	250	288	78	6	0	151	622	4.11	3rd
5	Avoidance of Sanitation Penalty	600	104	9	4	0	151	717	4.74	1st
	Total								20.81	

Specifically, it could be observed however, that none of the responses of market users on each of the factor were below average in their opinion on the environmental sanitation practices

within the market. Nevertheless, the overall mean value of responses of factors influencing market sanitation, as obtained from the users is 4.162. This implies that mean responses of the people were far more above average indicating that the factors were highly functional in the study area. This situation is very good because certain factors are meant to influence people to engage in market sanitation.

Relationship between Socio-Economic Characteristics of Respondent and Sanitation Practices

To examine the relationship between socio-economic characteristics of respondent and sanitation practices in the study area, Spearman Rank Correlation Analysis was used. Four (4) variables were identified and used as socio-economic characteristics. They are: gender, age, marital status, highest level of education. It could be noted, however, that four (4) variables were also identified for sanitation practices. These variables are: method of waste disposal, participation of sanitation exercise, component that aid sanitation practice, punishment accorded to those that does not participate in sanitation exercise.

To make these variables suitable for correlation analysis, they have to be summarized into one composite variable through the use of average computation. This was done and variable of socio-economic characteristics of respondent and sanitation practices were statistically obtained. They were thereby correlated and the result is contained in table 12.

Table 12. Correlation Analysis between socio-economic characteristics of respondent and sanitation practices (Source: Author's Computation, 2019)

Correlation		Socio-economic characteristics	Sanitation practices
Socio-economic characteristics	Spearman rank correlation (rs) Sig. (2-taile) p-value N	1.000 - 150	0.142 0.084 150
Sanitation practices	Spearman rank correlation (rs) Sig. (2-taile) p-value N	0.142 0.084 150	1.000 - 150

Table 12 shows the correlation analysis of relationship between socio-economic characteristics of respondent and sanitation in Nepa and Adedeji market. According to the table 4.37 with correlation coefficient of 0.142, it is observed that there is low positive correlation between socio-economic characteristics of market users (respondents) and sanitation practices in Nepa and Adedeji market. This implies that the socio-economic characteristics of the market users, no doubt have influence on the sanitation practices considerably. Moreover, with p-value of 0.084, it is also observed that there is no statistical significant relationship between socio-economic characteristics of market users and sanitation practices at $p > 0.05$ confidence level in the sampled market. However, the observed relationship might be due to chance.

POLICY ISSUES AND CONCLUSION

The study concluded that the level of environmental sanitation practice in the selected markets is high but the sanitation exercise is not convenient for the market users, due to inadequate sanitation facilities and services in the market. Inadequate sanitation facilities were a prime problem they encountered during sanitation exercise in the market thus adequate investment should be made in the provision of necessary sanitation facilities. The government alone cannot provide the needed sanitation facilities; private agency and market association should also be encouraged through incentives to provide such facilities such as toilet and urinal facilities.

Adequate Hygiene behavior and health promotion is crucial in preventing disease. Hence, improving infrastructure and facilities without a basic improvement in hygienic behaviour of market

users will rarely result in effective environmental sanitation practices. Therefore, hygiene education is integral to environmental sanitation. Hygiene education seeks to support sustainable behavior improvements through increased awareness and knowledge. It will influence the extent of the market sellers' adaptation to environmental sanitation regulations, policy issues, use of modern facilities and participation. Hygiene education should therefore be integrated into environmental sanitation planning for market.

REFERENCES

Abejegah, C., Abah, S., Awunor, N., Eluromma, E., Aigbiremolen, A., Duru, C., & Okoh, E. (2013). Market sanitation: a case study of Oregbeni market Benin City, Nigeria. *International Journal of Basic, Applied and Innovative Research, 2*(2), 25-31.

Acheampong, P. (2010). *Environmental Sanitation Management in the Kumasi Metropolitan Area (An Unpublished M.Sc. Thesis).* Kumasi: Department of Planning, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana.

Arthur, E., & Imoro, A. (2021). Knowledge and Practice of Environmental Sanitation andPersonal Hygiene by Traders: A Case Study of Tamale Central Market. *Ghana Journal of Science, 62*(1), 71-82. doi:10.4314/gjs.v62i1.7

Ayoola, H., Lawal, A., & Akinluyi, M. (2012). *An assessment of housing sanitation and Waste Management Practices in the residential Core Areas of Oshogbo, Osun state Nigeria (Conducted in 2006 Final Results).*

Fagbemi, K., Ogungbemi, A., Philips, O., Obatuase, B., & Hassan, Y. (2020). Users' Perception of Environmental Sanitation Exercise in Selected Market in Nigeria Cities. *International Journal of Waste Resources, 10*(2). doi:10.35248/2252-5211.20.10.378

Godfred, S.-A., & Ruby, H. (2019). Practices and Knowledge about Environmental Sanitation and Hygiene among Urban Dwellers in Gomoa East District, Ghana. *European Journal of Earth and Environment, 6*(1).

Ilesanmi, I. (2009). *Pre-Feasibility Assessment of Onsite and Decentralized Sanitation Systems for New Satellite Settlements in Abuja, Nigeria. An Unpublished PhD Thesis submitted to the Doctoral Degree Committee.* Hamburg University of Technology, Germany.

Ivan, B. (2019). *Planning a city for today, tomorrow and the future: Ibadan, Nigeria.* World Bank Blogs.

Ministry of Health. (2011). *Hygiene and environmental health, part 2: Blended learning module for the health extension Program.* Addis Ababa: Ministry of Health.

National Population Commission. (2004). *National Population Commission Census Report.* NationalPopulation Commission.

Ogwueleka, T. (2009). Municipal Solid Waste Characteristics and Management in Nigeria. *Journal of Environmental Health Science & Engineering, 6*(3), 173-180.

Olutegbe, N., & Asubiojo, O. (2020). Appropriate Environmental Sanitation Practices among Agricultural Produce Marketers. *Journal of WasteManagement and Disposal, 3*(2).

Parks, K. (2007). *Textbook of Preventive and Social Medicine* (19th ed.). Banarsidas Bhanot Publishers.

WHO. (2004). *Sanitation and hygiene links to health: facts and figures.* World Health Organization.

Submitted:	Revised:	Accepted:	Published online:
September 29, 2021	February 28, 2022	March 2, 2022	May 02, 2022

Analele Universităţii din Oradea, Seria Geografie **XXXII**, no. **1/2022**, pp. **26-38**
ISSN **1221-1273**, E-ISSN **2065-3409** DOI **10.30892/auog.321103-880**

MONITORING LONG-TERM CORK OAK FOREST SPATIO-TEMPORAL DYNAMICS BASED ON AERIAL PHOTOGRAPHS: A CASE STUDY OF KIADI CORKS OAK FOREST IN AKFADOU MOUNTAIN (ALGERIA)

Tassadit DIB*
Mouloud Mammeri University, Laboratoire de production, amélioration et protection des végétaux et des denrées alimentaires, BP 17, 15000, Tizi-Ouzou, Algeria, e-mail: dib.tassadit@yahoo.com

Samir AIT SAID
Mouloud Mammeri University, Laboratoire de production, amélioration et protection des végétaux et des denrées alimentaires, BP 17, 15000, Tizi-Ouzou, Algeria, e-mail: aitsaidsamir@yahoo.fr

Fazia KROUCHI
Mouloud Mammeri University, Laboratoire de production, amélioration et protection des végétaux et des denrées alimentaires, BP 17, 15000, Tizi-Ouzou, Algeria, e-mail: krfaz@yahoo.com

Citation: Dib, T., Ait Said, S., & Krouchi, F. (2022). Monitoring Long-Term Cork Oak Forest Spatio-Temporal Dynamics Based on Aerial Photographs: A Case Study of Kiadi Corks Oak Forest in Akfadou Mountain (Algeria). *Analele Universităţii din Oradea, Seria Geografie, 32*(1), 26-38. https://doi.org/10.30892/auog.321103-880

Abstract: This paper highlights the importance of remote sensing and GIS techniques applied on aerial photographs for forests spatio-temporal dynamics analysis. An assessment of the changes in the distribution and extension of Kiadi cork oak forest was carried out using historical imagery, covering a period of 35 years. The results indicate that, roadways and building surfaces in Kiadi forest have increased by 9.71 and 3.86% respectively, while the surface initially covered by vegetation decreased by 13.57%, as a result of anthropogenic disturbance. Digital processing of historical aerial photographs proved to be a powerful tool for quantitative analysis of forest dynamics.

Key words: Forest dynamics, Aerial photography, GIS, Remote Sensing, Kiadi forest, Akfadou, Algeria.

* * * * * *

INTRODUCTION

Understanding temporal dynamics of forests is crucial for conservation strategies at regional and local levels. For thousands of years, landscapes have been transformed in order to supply humankind with food, freshwater, fuel, and other essentials. However, the ongoing extents, rates, and magnitudes of land-use and land-cover changes are unprecedented (Ellis & Pontius, 2007; Mertens & Lambin, 2000; Grecchi, Gwyn, Bénié, & Formaggio, 2013; Kweyu, Thenya,

*Corresponding author

Kiemo, &Emborg, 2020). During the last decades, the forest dynamics has been in continuous changes in the Mediterranean region due to a growing population and a changing economy (Hassan & Nazem, 2016). The land cover regressive changes such as deforestation and surface losses have often been related to community instability and anthropogenic pressure (Kweyu, Thenya, Kiemo, & Emborg, 2020; Akobi, Amoussou, Yabi, & Boko, 2018; Kafy, et al., 2021). This has caused important adverse effects on physical and ecological processes, on soil and water resources, on local and global climate systems and on the diversity and abundance of terrestrial species (Giri, Pengra, Zhu, Singh, & Tieszen, 2007).

Previous studies on forest dynamics have focused mainly on ecological aspects and their utilization as drivers of land cover change (Geist & Lambin, 2002; Vu, Le, & Vlek, 2014). Thus, there is a little focus on building extensions and human pressure as underlying drivers to forest changes. Human influence on vegetation cover is measured by the activities he carries out developing his environment (Anthelme, Mato, Boissieu, & Giazzi, 2006; Millogo, Nikiema, Koulibaly, & Zombre, 2017). Whether it is habitat, fields, roads or grazing areas; each of these elements influences vegetation cover in one way or another. In recent decades, accelerated population growth in developing countries, accompanied by unprecedented rates of building extensions, has placed tremendous pressure on the forested lands and their biotic and abiotic resources (Grecchi, Gwyn, Bénié, & Formaggio, 2013). In Algeria it is no less worrying, as the vegetation cover in all the region is in constant regression due to anthropogenic factors: agro-pastoral activities, timber harvesting, human settlements, forest fires, etc. (Meddour-Sahar, Meddour, & Derridj, 2008).

Despite the accuracy and spatial detail achieved by conventional forest field based surveys over large areas, they are still considered mono-temporally difficult (Hernández-Stefanoni, et al., 2012; Khare, Latifi, & Rossi, 2021)or multi-temporally infeasible, due to the vast time, logistic and manpower required (Hernández-Stefanoni, et al., 2012; Khare, Latifi, & Rossi, 2021). This problem can be overcome using aerial photographs (Brünig, 1973; Sanford Jr., Braker, & Hartshorn, 1986; Nakashizuka, Katsuki, & Tanaka, 1995; Miller, Quine, & Hadley, 2000; Morgan, Gergel, & Coops, 2010). Aerial photographs and remote sensing images are largely used to collect quickly accurate information on forests (Küchler & Zonneveld, 1998; Fensham & Fairfax, 2002). Due to an easier accessibility of aerial photographs and a significant decrease of their price as well as of the image analysis on GIS softwares (Paine & Kiser, 2012); these techniques are becoming increasingly popular. Moreover, the combination of RS and GIS technologies saves time and provides accurate information that enables land change evaluation and monitoring (Trolle, et al., 2015; Lillesand, Kiefer, & Chipman, 2015; Fu & Weng, 2018; Niyogi, 2019; Kafy, et al., 2021).

Nowadays, due to the development of high resolution and multispectral images and the increased flexibility of statistical algorithms with remotely sensed data, the spatio-temporal and historical data analyses of land cover dynamics have resulted in significant possibilities in solving the problems associated with forest dynamics (Rahman, 2016). In addition, historical aerial photographs provide crucial data for efficient long term environmental monitoring and change detection (Morgan, Gergel, & Coops, 2010); they offer unique background information at a very high spatial resolution (Forster, 1985). However, reproducible works based on these data can be challenging due to their inherent and heterogeneous properties, such as their spatial and radiometric resolutions (Aber, Aber, & Penner II, 2016; Pain, Pillans, Roach, Worrall, & Wilford, 2012). Furthermore, digital mapping cameras (DMC) are recently introduced to aerial photography; they have much higher radiometric resolution than traditional film cameras. Thus, despite a similarity in the level of spatial resolution, a digital aerial camera can capture much clearer images of the earth surface than a film camera (Yamazaki, Suzuki, & Maruyama, 2008a).Additionally, DMC data are available at a low cost, providing 3D data as well as spectral data of the vegetation (Bohlin, Wallerman, & Fransson, 2012).

Several studies highlighted the use of remote sensing and GIS in forest researches, particularly in forest dynamics studies (Nakashizuka, Takahashi, & Kawaguchi, 1997; Koch, Heyder, & Weinacker, 2006; Yu, Guo, & Wu, 2014; White, et al., 2016; Tanaka, Kajita, Natsume, Saeki, &

Ohno, 2020). There are few examples of topics which have benefited from advances in the generation and handling of digital geospatial data (Avery & Berlin, 1992; Véga & St-Onge, 2009); while, there are studies having developed methods for using digital data (aerial photographs, satellite images, historical maps, and digital elevation models) (Gougeon, 1995; Hyyppa, Kelle, Lehikoinen, & Inkinen, 2001; Khare, Latifi, & Ghosh, 2018; Khare, Latifi, & Rossi, 2021). In Algeria there are relatively few studies which rigorously addressed the spatio-temporal dynamics of forests and its driving factors. And in the case of Kiadi cork oak forest (Akfadou Mountain), to our knowledge, hitherto, there is no published work on this topic and no research having used the historical digital aerial photographs and supervised classification. When the objective is the preservation of natural resources, it is important to understand not only the historical distribution of the forest but also the driving factors of the changes (Da Ponte, Roch, Leinenkugel, Dech, & Kuenzer, 2017). Based on this consideration, this paper aims to investigate decadal forest changes i.e. from 1981 to 2016, in Kiadi cork oak forest which is part of Akfadou forest; using multi-temporal aerial photographs with an attempt to identify the significant driving forces of the forest area changes.

MATERIAL AND METHODS

Study site

The study site (Figure 1) is the so-called Kiadi cork oak forest (36°41'14.49''N to 36°39'54.89'' N latitude to 4°30'31.95'' E and 4°30'49.31'' E longitude), located in the western part of Akfadou forest Mountain, in Tizi-Ouzou province, Northern Algeria. The study site extends over 277.53 ha. Altitude varies between 700 and 960 m above sea level. The climate is Mediterranean, with annual rainfall varying between 900 and 1200 mm (Messaoudene, 1989). The soils are based on simple units consisting of Numidian sandstone. Such forest area is under the authority of Azazga forest district service, which is part of the regional directorate of Tizi-Ouzou forest service. The study site consists in a pure cork oak (*Quercus suber*) cover with various species: *Arbutus unedo, Erica arborea, Phillyrea angustifolia, Cistus salviifolius, Cytisus triflorus, Crataegus monogyna, Rubus ulmifolius, Phillyrea latifolia, Myrtus communis* and herbaceous such as *Ampelodesmos mauritanica* and *Asparagus acutifolius*. Kiadi forest is surrounded by three villages belonging to Idjeur municipality: Bouaouane from the North, Aguarsafen from the South and Tifrit nait oumalek from the Western side. The study area is characterized by both healthy and important forest cover and by relatively large spaces characterized by forest cover loss likely due to the activities of the surrounding populations who cleared the land to extend their houses, install poultry sheds and beekeeping equipments. The study area is also surrounded by 9 uncontrolled landfills

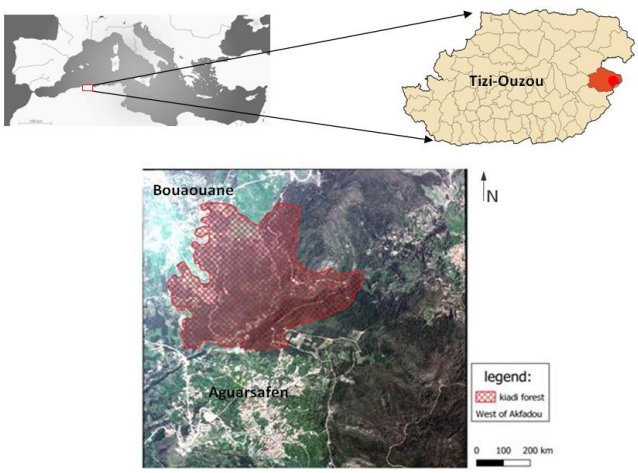

Figure 1. Location of the study area (Kiadi cork oak forest, Akfadou Mountain, Algeria)
(Source: (DIB Tassadit))

Data acquisition and pre-processing

Data acquisition

Datasets were available for 4 time periods (Table 1), the old cover was derived from colour balanced aerial photographs captured from an aircraft in 1981 and 1995 at a scale of 1/20000, whereas the more recent cover was based on colour digital aerial photographs, taken in 2011 and 2016 at a scale of 1/20,000, with a spatial resolutions of 24 cm and 50 cm respectively. Digital aerial photos are becoming common tools for aerial photography. They have better radiometric and spectral resolution than film cameras. Besides, their ground resolution and geometric accuracy are good enough for most applications. The digital aerial photographs presently used were acquired by "l'Institut national de cartographie et de télédetection (INCT, Algeria), i.e. the national Institute of cartography and remote sensing. They were captured with DMC Z/I Intergraph digital aerial camera, with 60% stereo overlap between adjacent images along-track and 30% across track. As pointed out in the literature, both flight altitude and degree of image overlap influence the accuracy of the 3D data produced. Here, DMC images were acquired at the standard altitude while, the aerial photographs, acquired from the same institute, were taken from an altitude of 4100 m, which resulted in a ground sample distance of approximately 1.5 m. The images have three bands (red, blue and green). 5 images were used for year 1981 and 1995 to obtain stereo images and a single digital image was used for year 2011 and 2016 (Table 1).

Table 1. Overview of photographs available in the database of the work
(Source: (DIB Tassadit))

Year	Spectral content	Spatial resolution (cm) GSD	Number of photos	Area covered (ha)	Sources
1981	RGB	150	5	277.53	INCT
1995	RGB	150	5	277.53	INCT
2011	RGB	24	1	277.53	INCT
2016	RGB	50	1	277.53	INCT

Data pre-processing

After the manual photo interpretation, each photo stereo-pair was imported in a GIS environment. The purpose of this computerization was the quantitative analysis of land use data base. This procedure requires scanned photogrammetric aerial photographs on which at least 2 fiducial marks can be distinguished. The photos received on paper version (i.e. those of 1981 and 1995) were scanned at a resolution of 600 dots per inch (DPI) and saved as a JPEG file. Although TIFF format is best for complete data preservation, the JPEG file format generates much smaller file sizes without compromising the ability to precisely locate GCPs at normal compression ratios.

We used PhotoScan professional which is a type of commercial computer vision software to generate a 3D point cloud from the sets of aerial photographs. The software uses the SFM approach for 3D reconstruction from overlapping collection of photographs. The workflow starts with the "Align Photos" step, which is the process used to find the camera position and orientation for each aerial photograph and build a sparse point cloud model [Agisoft LLC. Agisoft PhotoScan User Manual Professional Edition, Version 1.1. available online at: http://www.Agisoft.Com/Pdf/Photoscan-pro_1_1_en.Pdf. We selected "High accuracy" and "Ground control pre-selection" as settings. This step was conducted in the real-world coordinate system, which was Universal Transverse Mercator projection (Zone 31N, WGS 84) based on the camera positions provided by Airborne GPS. We also manually identified ground control points (GCPs) within the aerial photographs to improve the accuracy of the align photos step.

There are various methods for collecting ground control points. Here, GCP's were collected using two different procedures, so that their effect on the accuracy of the georeferencing could be assessed. A first set was collected by measuring the geographic position of some reference points by GPS in the field; a second set was obtained by collecting geographical co-ordinates of recognizable points on Google earth's image. Each dataset consists of at least 20 points, which were sampled systematically regarding both their geographical position and their elevation. On QGIS 3.4.4. software, each scene was reprojected using 20 ground control points (GCP) distributed evenly throughout the study area. Reprojection was performed using nearest neighbor resampling technique which provides an important spatial accuracy. At the end of the pre-processing, a clip by mask was applied to all the aerial photographs in order to delineate the borders of the study area.

Photo-interpretation

The success of aerial photo-interpretation varies with the nature of the objects, the quality of the photographs or images and the training and experience of the interpreter. In the present study, stand delineation and assessment of historical forest occupation were performed through a manual interpretation of the aerial photographs with three spectral bands (red, blue and green) acquired, on different intervals, using a stereo instrument. The stereoscopic view indicated that the ground occupation is visible in the photographs. As mentioned, the aerial photographs were interpreted for Kiadi cork oak forest land-cover and the vegetated spaces by using the standard photo-interpretation key developed on the basis of the target area recognition with aerial photographs. This step relies on the delineation of homogeneous entities on the photos in terms of land cover. The percentage of area covered by the identified units is then visually estimated. The characters of the vegetation cover on aerial photographs reflect, to a large extent, some global ecological aspects. Indeed, the forests appear on the aerial photographs in dark colors and the shades of this color, from dark to light, indicate changes in forest density and in land occupation through the 35 years period.

Supervised classification

The purpose of the supervised classification applied on aerial photography is to extract as much as possible interesting information and to remove all that is unnecessary. At each point of the image, a label from a collection defined previously is assigned. This collection of labels is called classes. In this study, in order to analyze the long-term changes of forest dynamics of Kiadi cork oak forest, a long term analysis of change was conducted using a supervised classification based on series of aerial photographs. We used forest cover layers for four time slices (1991, 1995, 2011 and 2016) to assign progression/regression historical dynamics. Training samples were collected from these mosaics. Around 30 samples were selected for each class in order to produce land cover maps. Selecting training samples from these photos was allowed by the very distinctive signature of the forest. Same samples with slight modifications in each mosaic (addition and removal of few training samples) were used for the classification of all the photo dataset. The aerial photographs pre-processed were classified into four major and well delineated classes such us: a) tree vegetation, b) herbaceous vegetation, c) build-up surfaces and, d) roadways (Table 2) for years 1981, 1995, 2011 and 2016 using the maximum likelihood algorithm in QGIS software. The process was repeated several times in order to refine them and validate the results.

Table 2. Definition of the supervised classification classes

Classes	Supervised classification class definition
Tree vegetation	Area covered by cork oak trees
Herbaceous vegetation	Area covered by a herbaceous stratum
Build-up surfaces	Area occupied by habitation
Roadways	Roads crossing the study area

RESULTS

Land cover status

Data registered in figure 2 and table 3 reveal that both positive and negative changes occurred in the land cover patterns of Kiadi forest. During the last 35 years, the data displays losses and gains in each class, highlighting a clear unprecedented increase in built areas and roadways with a noticeable decline in both the tree cover and the herbaceous vegetation cover.

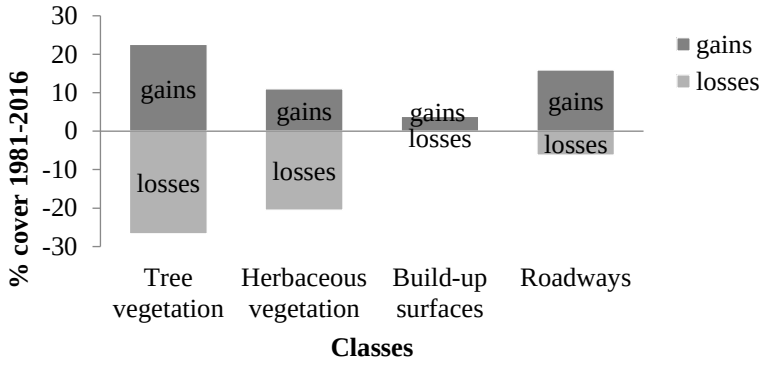

Figure 2. Dynamics of the Kiadi forest over 35 years period based on the percentages of land occupation classes
(Source: (DIB Tassadit))

Table 3. Area estimates of major land cover classes in Kiadi cork oak forest at different periods
(Source: (DIB Tassadit))

Class/Area	1981s		1995s		2011s		2016s	
	ha	%	ha	%	ha	%	ha	%
Tree vegetation	155.61	56.07	101.16	36.45	163.71	58.99	144.18	51.95
Herbaceous vegetation	103.94	37.45	134.57	48.49	81.31	29.3	77.71	28
Build-up surfaces	0	0	2	0.72	10.02	3.61	10.71	3.86
Roadways	17.98	6.48	39.8	14.34	22.48	8.1	44.93	16.19
Total	277.53	100	277.53	100	277.53	100	277.53	100

Over the last 35 years period, the herbaceous vegetation surfaces and tree cover surfaces were reduced by 9.45 and 4.12 % respectively (Table 4). Indeed, the study area experienced varying changes in land cover between 1981 and 2016 (figure 3). Overall, the tree vegetation cover decreased from 155.61 ha in 1981 to 144.18 ha in 2016. During this period, the major losses were in 2016; whereas, build up surfaces increased progressively reaching a peak in 2016. Apart from forested area, the herbaceous vegetation decreased from 103.94 ha in 1981 to 77.71 ha in 2016. Roadways, for their part, represented a relatively important surface (i.e. 44.92 ha) in 2016 within the studied area as a consequence of a relatively high demand for access to the forest.

Table 4. Amount of changes in different land cover categories in Kiadi cork oak forest
(Source: (DIB Tassadit))

Class/change	1981s-1995s		1995s-2011s		2011s-2016s		1981s-2016s	
	ha	%	ha	%	ha	%	ha	%
Tree vegetation	-54.45	-19.62	62.55	22.54	-19.53	-7.04	-11.43	-4.12
Herbaceous vegetation	30.63	11.04	-53.25	-19.19	-3.61	-1.3	-26.23	-9.45
Build-up surfaces	2	0.72	8.02	2.89	0.69	0.25	10.71	3.86
Roadways	21.82	7.86	-17.32	-6.24	22.45	8.09	26.95	9.71
Total	0	0	0	0	0	0	0	0

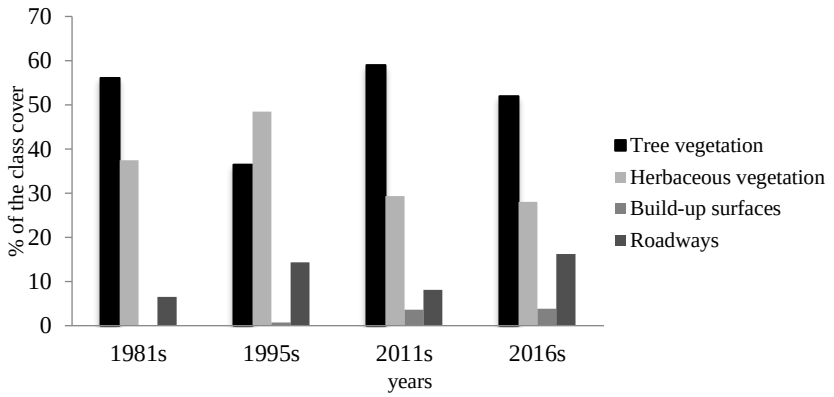

Figure 3. Land cover changes in Kiadi cork oak forest between 1981 and 2016
(Source: (DIB Tassadit))

Intra-decades land cover dynamics

We produced a dataset of annual forest dynamics maps between 1981 and 2016 for the Kiadi cork oak forest based on aerial photographs (Figure 4) then, we analyzed the changes decade by decade in order to evaluate the intra-decades dynamics (Figure 5). Non forested areas are found in the outer periphery of the Southern-West and Northern-West parts of this forest. The major changes were concentrated in the Southern side of the area, and are caused by anthropogenic pressure.

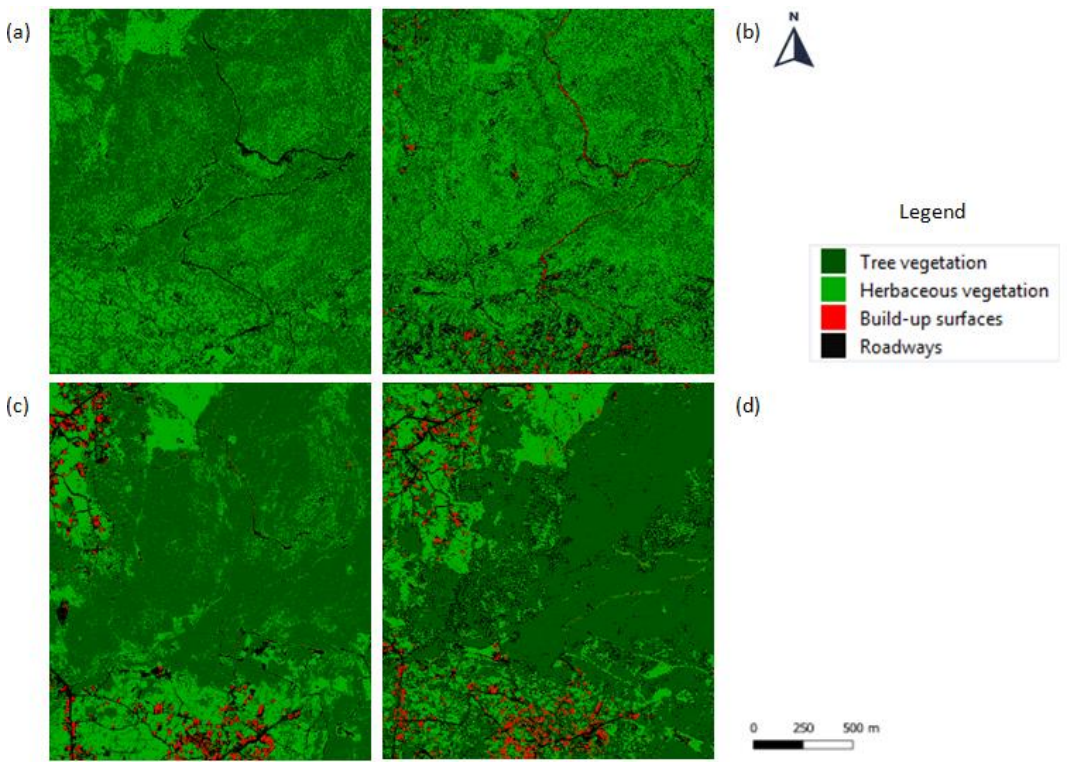

Figure 4. Land cover classification outputs at different years: (a) 1981, (b) 1995, (c) 2011 and (d) 2016
(Source: (DIB Tassadit))

Land cover for 1981-1995 period

During this period, the most significant change was in the green area category corresponding to tree and herbaceous vegetation covers. Tree cover decreased by 19.62% (54.45 ha) between 1981 and 1995, while the herbaceous vegetation area increased by 11.04%. This period coincided with large and moderate forest fires, particularly the fire of 1994, which was devastating. In 1981, no built surfaces were settled (figure 4), all the area was vegetated but in 1995 some houses were observed, which occupied 0.72% of the whole Kiadi surface. Roadways increased and occupied 7.86% of the whole area (Figure 5).

Land cover for 1995-2011 period

In comparison with the previous decade, the best tree cover was observed between 1995 and 2016; gaining about 22.54% (62.55 ha) of the total area. A loss of 19.19 % by the herbaceous vegetation surface was reported in that period; it was converted to forest and houses which started appearing and expanding in this forest, occupying new areas of 2.89% (8.02 ha) (Figure 5).

Land cover for 2011-2016 period

A reduction in forest cover was recorded for this period but at a lower rate compared to the previous period (1981-1995). Cork oak forest decreased by 7.04%, resulting in a loss of 19.53ha of the total forest cover; the same observation applies for the herbaceous vegetation which lost a surface of about 1.3%. In the period 2011- 2016 the built surfaces expanded by 0.25% (0.62 ha) and the roads by 8.09%, pointing out an increase in human activity in this area (Figure 5).

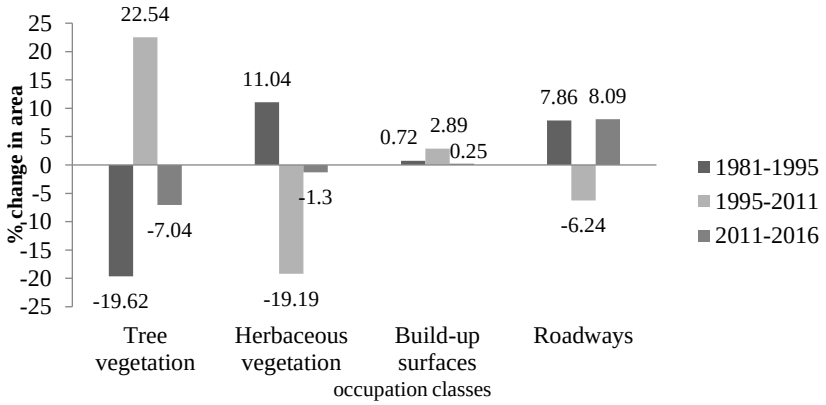

Figure 5. Intra-decade changes in Kiadi cork oak forest area according to land occupation classes (Source: (DIB Tassadit))

DISCUSSION

The study of forest dynamics is concerned by the changes in forest structure and composition over time, including its behavior in response to anthropogenic and natural disturbances (White & Jentsch, 2001). Here, we analyzed the spatio-temporal dynamics of a cork oak forest extending across 277.53 ha for a period of 35 years. Such analysis was based on photo-interpretation and supervised classification. Forest surfaces decreased gradually and were replaced by built areas, herbaceous vegetation surfaces and roadways following population demography which generated additional demand for space and for forest resources.

During the last decades, land use and land cover have changed drastically in Algeria, due to a growing population and a changing economy (Saadi et al., 2021).The present study revealed noticeable changes in Kiadi cork oak forest over the 35 years period with rates of forest cover loss being more important than the gains. Data analyses by decade indicate rates and patterns of change

which differed for the three assessed periods. From 1981 to 1995, the overall changes were less accentuated in comparison with the second interval (1995-2011) characterized by new private houses spreading outside the ancient settlements of the village towards the forest area. However, the surface of tree cover was more important than the second interval pointing out a better situation of the forest during that period. The changes continued during the third interval (2011-2016) with a similar trend but at a higher rate (loss of Tree and herbaceous cover and gains in build-up surfaces and roadways). The quantification of surface loss and gain, during the last decades, indicates that the study area lost 37.66 ha of its green area of which 10.71 ha devoted to building and 26.95 ha devoted to roadways.

The present work indicates that the Northwestern and the Southern sides of Kiadi were the parts of the forest subject to forest cover losses. The displayed forest regressive dynamics is significant due to the surrounding villages of such forest sides and to an easy access for some agricultural activities. Anthropogenic pressure on Kiadi cork oak vegetation cover including logging, overgrazing, fire and clearing, revealed the regressive evolution of cork oak trees in favor of anthropogenic landscapes since such factors are a high candidates for forest regressive dynamics (Kadmon & Harari-Kremer, 1999; Akobi, Amoussou, Yabi, & Boko, 2018). Anthropogenic actions are major factors in forest changes and they affect the structure, composition and dynamics of forests at various spatio-temporal scales (Oloukoi, 2013; Kafy, et al., 2021).

Indeed, the history of Kiadi cork oak forest during the decade of 1981 to 1995 is intimately linked to the political and security context of Algeria. Algerian forests including Akfadou underwent very hard political and unsecured period (Meddour-Sahar, Meddour, & Derridj, 2008). There was an exodus of people from the mountain towards the centers of regions. Consequently during this period, the building class was almost absent and started to appear only after the stability of the country's security situation, in the beginning of the 2000s, coinciding with an exponential increase of the buildings and houses at the expense of the forest area. On another hand, during many years of that period, authorities were sitting up fires for security reasons, causing also forest cover loss. Indeed, Algeria lost 221 367 ha and 271 598 ha of its forested areas in 1983 and 1994 respectively (Meddour-Sahar, Meddour, & Derridj, 2008). Concordantly, Ramade (1997) and Kweyu, Thenya, Kiemo and Emborg (2020) pointed out the role of political disorders in forest cover losses.

Obviously, in Algeria, during the recent decades, urbanization and building of infrastructures and houses became an integral part of the socio-economic system giving rise to building expansion at the expense of forested areas in northern Algerian mountains; hence the importance of spatio-temporal evaluation of the phenomenon (Saadi, Bouder, Benkaci, & Abbes, 2021). Over the 35 years period, the natural Kiadi forest underwent a clearing in relation to the socio-economic changes. Two trends of change were evidently observed, a gradual increase in built areas and roadways from one hand and a loss of tree cover and herbaceous vegetation surfaces from another hand with the buildings taking place over the vegetation cover. According to the data mentioned in the master plan for development and urbanism (PDAU, 2012) (the three villages of Idjeur municipality surrounding the Kiadi forest had a high impact on such forest through both population growth and its sprawl at the expense of forested areas and several agricultural practices. The number of inhabitants rose from 8,222 in 1987 to 10,301 nowadays. This trend is not an exception for the target forest but is of concern also in other parts of the world, which, could be explained by the demographic growth and the unplanned building programs (Weng & Yang, 2004; Carr, Suter, & Barbieri, 2005; Hassan & Nazem, 2016; Akobi, Amoussou, Yabi, & Boko, 2018; Kafy, Rahman, Hasan, & Islam, 2020). Indeed, this phenomenon opens up the forest for encroachments through grazing, timber logging activities, apiculture, aviculture and others(Da Ponte, Roch, Leinenkugel, Dech, & Kuenzer, 2017; Rawat & Kumar, 2015). The PDAU (2012) mentioned the presence of over 18 poultry sheds at the level of the villages surrounding Kiadi forest, of which 14 and 4 at Iguersafene and Tifrit nait oumalek respectively. The same source identified 459 hives, in the same area, of which 159 at Iguersafene, 200 at Tifrit nait oumalek and 10 at Bouaouane.

Forest fires also played a crucial role in the dynamics of Algerian cork oak forests, including the study area where they constitute a scourge that threatens forest sustainability. Although cork oak is a fire resilient species (Pausas, Alessio, Moreira, & Segarra-Moragues, 2016), numerous studies suggest its variable responses to fire (Catry, Moreira, Duarte, & Acácio, 2009; Moreira F. , Catry, Duarte, Acácio, & Silva, 2009; Catry, Rego, Moreira, Fernandez, & Pausas, 2010; Moreira F. , Catry, Rego, & Bacao, 2010). Fire severity plays a significant role in cork oak trees dynamics (González, Trasobares, Palahi, & Pukkala, 2007) and the regressive dynamics of Kiadi forest between 1981 and 1995 can be explained by intensive and recurrent fires sets for security reasons, and some peaks of fire severity such as that of year 1994 may be linked to the xericity of such year (Meddour-Sahar, Meddour, & Derridj, 2008).This phenomenon applies also for other Mediterranean regions, such as Spain (Vélez, 1997) or France (Ningre, 1996). The fires of year 1994 concerned almost the whole Kiadi cork oak forest, decreasing its tree cover surface, one year after, from 155.61 to 101.16 ha. Similarly, during the last studied decade (2011-2016), Kiadi forest lost 19.53 ha of its tree cover surface due to four consecutive fires of 2014 which covered 40ha of the entire area. Indeed, it is worth mention the issue of the uncontrolled landfills in forest areas which is a real cause of forest fires. Kiadi forest is surrounded by 9 landfills, of which, 7 belonging to Iguersafene village, 1 to Bouaouane and another one to Tifrit nait oumalek (PDAU, 2012).

This study proved that the new digital aerial photos are very accurate for studying a small scale forests, however the use of Aerial photographs as data for supervised classification and analysis of the forest dynamics has been generally a success. The photo-interpretation and the digital aerial photos classification coupled with GIS have demonstrated its ability to provide comprehensive information on the nature; type and location of the land cover changes as a result of rapid building expansion and forest fires. However, a certain uncertainty in image classification still remains which may constitute a drawback of such method for two reasons: firstly, the roadways class and the building class have been confused in some results due to their similar spectral signature and this confusion hindered the obtainment of very accurate results; secondly, the image classification method used in this study was not spatially implicit. The method thus, has limitation in improving image classification accuracy of individual classes (Weng, 2002).

CONCLUSION

In conclusion, the study conducted in the cork oak forest of Akfadou Mountain (Algeria) indicates that multi-temporal aerial photographs may help quantifying and analyzing spatial and temporal phenomena which are otherwise not achievable through conventional methods. Forest spatio-temporal dynamics analysis is made possible by these cost effective technologies through time and cost saving and better accuracy.

The results of this study provided data on dynamics of Kiadi cork oak forest between 1981 and 2016. The analysis and the field survey concerning the land occupations revealed the main causes of the forest losses. Based on the major findings the main conclusions are as following:

- Results of the forest change analysis based on aerial photographs revealed a total forest cover loss of almost 11.43 ha (i.e. 7.35%) between 1981 and 2016.
- The outcomes of the time series analysis (by photo interpretation and supervised classification) revealed an important increase of forest losses and changes through the 3 recent decades. According to the history of the region, the present change is due to forest fires (a devastating fire occurred in 1994 and in 2014) and also to the population growth in the surrounding villages which led to deforestation for urbanization.

Further studies could rely on satellite images and high resolution imagery to increase the accuracy of the results, in particular when considering an assessment of forest cover change at a small scale. In addition, with the use of satellite imagery, a change matrix of land use during the given period could be addressed to quantify the land changes. Moreover, it would be interesting to consider additional dynamic information on the state of the forest (such as yearly forest

degradation and regeneration rates) which would add more information with regards to the pressure exerted on forest resources by surrounding populations. The use of multi-temporal information along with ground data are key components for designing and supporting conservation strategies and policies. It is crucial to consider not only the outlook of rural populations but also their influence on the fate of natural resources over time.

REFERENCES

Aber, J., Aber, S., & Penner II, R. (2016). Rapid environmental changes in the nature conservancy wetland at Cheyenne Bottoms, Kansas: A Review 2002–2015. *Transactions of the Kansas Academy of Science, 119*(1), 33-48.

Akobi, K., Amoussou, E., Yabi, I., & Boko, M. (2018). Historique de l'évolution anthropique et dynamique du couvert végétal dans la commune de Bantè au Bénin. *International Journal of Biological and Chemical Sciences, 12*(1), 180-194.

Anthelme, F., Mato, M., Boissieu, D., & Giazzi, F. (2006). Dégradation des ressources végétales au contact des activités humaines et perspectives de conservation dans le massif de l'Aïr (Sahara, Niger). *VertigO-la revue électronique en sciences de l'environnement, 7*(2), 1-12.

Avery, T., & Berlin, G. (1992). *Fundamentals of remote sensing and airphoto interpretation.* New York, USA: MacMillan.

Bohlin, J., Wallerman, J., & Fransson, J. (2012). Forest variable estimation using photogrammetric matching of digital aerial images in combination with a high-resolution DEM. *Scandinavian Journal of Forest Research, 27*(7), 692-699.

Brünig, E. (1973). Species richness and stand diversity in relation to site and succession of forests in Sarawak and Brunei (Borneo). *Amazoniana: Limnologia et Oecologia Regionalis Systematis Fluminis Amazonas, 4*(3), 293-320.

Carr, D., Suter, L., & Barbieri, A. (2005). Population dynamics and tropical deforestation: state of the debate and conceptual challenges. *Population and environment, 27*(1), 89-113.

Catry, F., Moreira, F., Duarte, I., & Acácio, V. (2009). Factors affecting post-fire crown regeneration in cork oak (Quercus suber L.) trees. *European Journal of Forest Research, 128*(3), 231-240.

Catry, F., Rego, F., Moreira, F., Fernandez, P., & Pausas, J. (2010). Post-fire tree mortality in mixed forests of central Portugal. *Forest Ecology and Management, 260*(7), 1184-1192.

Da Ponte, E., Roch, M., Leinenkugel, P., Dech, S., & Kuenzer, C. (2017). Paraguay's Atlantic forest cover loss–satellite-based change detection and fragmentation analysis between 2003 and 2013. *Applied Geography, 79*(1), 37-49.

DIB Tassadit. (n.d.).

Ellis, E., & Pontius, R. (2007). *Land-Use and Land-Cover Change, Encyclopedia of Earth, Environmental Information Coalition.* Washington, DC, USA: National Council for Science and the Environment.

Fensham, R., & Fairfax, R. (2002). Aerial photography for assessing vegetation change: a review of applications and the relevance of findings for Australian vegetation history. *Australian Journal of Botany, 50*(4), 415-429.

Forster, B. (1985). An examination of some problems and solutions in monitoring urban areas from satellite platforms. *International Journal of Remote Sensing, 6*(1), 139-151.

Fu, P., & Weng, Q. (2018). Variability in annual temperature cycle in the urban areas of the United States as revealed by MODIS imagery. *ISPRS journal of photogrammetry and remote sensing, 146*, 65-73.

Geist, H., & Lambin, E. (2002). Proximate causes and underlying driving forces of tropical deforestation tropical forests are disappearing as the result of many pressures, both local and regional, acting in various combinations in different geographical locations. *BioScience, 52*(2), 143-150.

Giri, C., Pengra, B., Zhu, Z., Singh, A., & Tieszen, L. (2007). Monitoring mangrove forest dynamics of the Sundarbans in Bangladesh and India using multi-temporal satellite data from 1973 to 2000. *Estuarine, Coastal and Shelf Science, 73*(1-2), 91-100.

González, J., Trasobares, A., Palahi, M., & Pukkala, T. (2007). Predicting stand damage and tree survival in burned forests in Catalonia (North-East Spain). *Annals of Forest Science, 64*(7), 733-742.

Gougeon, F. (1995). A crown-following approach to the automatic delineation of individual tree crowns in high spatial resolution aerial images. *Canadian Journal of Remote Sensing, 21*(3), 274-284.

Grecchi, R., Gwyn, Q., Bénié, G., & Formaggio, A. (2013). Assessing the spatio-temporal rates and patterns of land-use and land-cover changes in the Cerrados of southeastern Mato Grosso, Brazil. *International Journal of Remote Sensing, 34*(15), 5369-5392.

Hassan, M., & Nazem, M. (2016). Examination of land use/land cover changes, urban growth dynamics, and environmental sustainability in Chittagong city, Bangladesh. *Environment, Development and Sustainability, 18*(3), 697-716.

Hernández-Stefanoni, J., Gallardo-Cruz, J., Meave, J., Rocchini, D., Bello-Pineda, J., & López-Martínez, J. (2012). Modeling α-and β-diversity in a tropical forest from remotely sensed and spatial data. *International journal of applied earth observation and geoinformation, 19*, 359-368.

Hyyppa, J., Kelle, O., Lehikoinen, M., & Inkinen, M. (2001). A segmentation-based method to retrieve stem volume estimates from 3-D tree height models produced by laser scanners. *IEEE Transactions on Geoscience and Remote Sensing, 39*(5), 969-975.

Kadmon, R., & Harari-Kremer, R. (1999). Studying long-term vegetation dynamics using digital processing of historical aerial photographs. *Remote Sensing of Environment, 68*(2), 164-176.

Kafy, A., Rahman, M., Hasan, M., & Islam, M. (2020). Modeling future land use land cover changes and their impacts on land surface temperatures in Rajshahi, Bangladesh. *Remote Sensing Applications: Society and Environment, 18*(1).

Kafy, A., Shuvo, R., Naim, M., Sikdar, M., Chowdhury, R., Islam, M., & Kona, M. (2021). Remote sensing approach to simulate the land use/land cover and seasonal land surface temperature change using machine learning algorithms in a fastest-growing megacity of Bangladesh. *Remote Sensing Applications: Society and Environment, 21*.

Khare, S., Latifi, H., & Ghosh, S. (2018). Multi-scale assessment of invasive plant species diversity using Pléiades 1A, RapidEye and Landsat-8 data. *Geocarto international, 33*(7), 681-698.

Khare, S., Latifi, H., & Rossi, S. (2021). A 15-year spatio-temporal analysis of plant β-diversity using Landsat time series derived Rao's Q index. *Ecological Indicators, 121*(1).

Koch, B., Heyder, U., & Weinacker, H. (2006). Detection of individual tree crowns in airborne lidar data. *Photogrammetric Engineering & Remote Sensing, 72*(4), 357-363.

Küchler, A., & Zonneveld, I. (1998). Floristic analysis of vegetation. *Vegetation Mapping*, 51-66.

Kweyu, R., Thenya, T., Kiemo, K., & Emborg, J. (2020). The nexus between land cover changes, politics and conflict in Eastern Mau forest complex, Kenya. *Applied Geography, 114*.

Lillesand, T., Kiefer, R., & Chipman, J. (2015). *Remote sensing and image interpretation.* New York, USA: John Willey & Sons.

Meddour-Sahar, O., Meddour, R., & Derridj, A. (2008). *Analyse des feux de forêts en Algérie sur le temps long (1876–2007).* Montpellier, France: Les Notes d'analyse du CIHEAM.

Mertens, B., & Lambin, E. (2000). Land-cover-change trajectories in southern Cameroon. *Annals of the association of American Geographers, 90*(3), 467-494.

Messaoudene, M. (1989). *Approche dendroclimatologique et productivité de Quercus afares Pomel et Quercus canariensis Willd. dans les massifs forestiers de l'Akfadou et de Béni-Ghobri en Algérie.* Doctoral dissertation. Marseille, France: Université Aix-Marseille III.

Miller, D., Quine, C., & Hadley, W. (2000). An investigation of the potential of digital photogrammetry to provide measurements of forest characteristics and abiotic damage. *Forest Ecology and Management, 135*(1-3), 279-288.

Millogo, D., Nikiema, A., Koulibaly, B., & Zombre, N. (2017). Analyse de l'évolution de l'occupation des terres à partir de photographies aériennes de la localité de Loaga dans la province du Bam, Burkina Faso. *International Journal of Biological and Chemical Sciences, 11*(5), 2133-2143.

Moreira, F., Catry, F., Duarte, I., Acácio, V., & Silva, J. (2009). A conceptual model of sprouting responses in relation to fire damage: an example with cork oak (Quercus suber L.) trees in Southern Portugal. *Plant Ecology, 201*(1), 77-85.

Moreira, F., Catry, F., Rego, F., & Bacao, F. (2010). Size-dependent pattern of wildfire ignitions in Portugal: when do ignitions turn into big fires? *Landscape Ecology, 25*(1), 1405-1417.

Morgan, J., Gergel, S., & Coops, N. (2010). Aerial photography: a rapidly evolving tool for ecological management. *BioScience, 60*(1), 47-59.

Nakashizuka, T., Katsuki, T., & Tanaka, H. (1995). Forest canopy structure analyzed by using aerial photographs. *Ecological Research, 10*(1), 13-18.

Nakashizuka, T., Takahashi, Y., & Kawaguchi, H. (1997). Production-dependent reproductive allocation of a tall tree species Quercus serrata. *Journal of Plant Research, 110*(1), 7-13.

Ningre, J. (1996). Les feux de forêt en 1996: en France, des surfaces détruites exceptionnellement faibles; les conditions météorologiques de l'été 1996; en Espagne, pas de nouvelles, bonnes nouvelles. *Forêt méditerranéenne, 17*(4), 321-322.

Niyogi, D. (2019). Land surface processes. *Current trends in the representation of physical processes in weather and climate models*, 349-370.

Oloukoi, J. (2013). Scénario socio-économique et écologique des changements de l'occupation des terres au Bénin. *VertigO: la revue électronique en sciences de l'environnemfent, 13*(1).

Pain, C., Pillans, B., Roach, I., Worrall, L., & Wilford, J. (2012). Old, flat and red–Australia's distinctive landscape. *Shaping a nation: A geology of Australia*, 227-275.

Paine, D., & Kiser, J. (2012). *Aerial photography and image interpretation.* New York, USA: John Wiley & Sons.

Pausas, J., Alessio, G., Moreira, B., & Segarra-Moragues, J. (2016). Secondary compounds enhance flammability in a Mediterranean plant. *Oecologia, 180*(1), 103-110.

PDAU. (2012). *Report of the direction of construction and urbanisme.* Direction of Construction and Urbanisme, Algeria.

Rahman, M. (2016). Detection of land use/land cover changes and urban sprawl in Al-Khobar, Saudi Arabia: An analysis of multi-temporal remote sensing data. *ISPRS International Journal of Geoinformation, 15*(2).

Ramade, F. (1997). La conservation des écosystèmes méditerranéens. *Aménagement et Nature, 121*, 24-32.

Rawat, J., & Kumar, M. (2015). Monitoring land use/cover change using remote sensing and GIS techniques: A case study of Hawalbagh block, district Almora, Uttarakhand, India. *The Egyptian Journal of Remote Sensing and Space Science, 18*(1), 77-84.

Saadi, S., Bouder, A., Benkaci, N., & Abbes, K. (2021). The dynamics of the Algiers periurbanization: geomatic tools for multi-temporal study. *Arabian Journal of Geosciences, 14*(11), 1-17.

Sanford Jr., R., Braker, H., & Hartshorn, G. (1986). Canopy openings in a primary neotropical lowland forest. *Journal of Tropical Ecology, 2*(3), 277-282.

Tanaka, H., Kajita, S., Natsume, H., Saeki, I., & Ohno, N. (2020). Spatiotemporal dynamics of cross-field ejection events in recombining detached plasma. *Plasma Physics and Controlled Fusion, 62*(7).

Trolle, D., Nielsen, A., Rolighed, J., Thodsen, H., Andersen, H., Karlsson, I., . . . Jeppesen, E. (2015). Projecting the future ecological state of lakes in Denmark in a 6 degree warming scenario. *Climate Research, 64*(1), 55-72.

Véga, C., & St-Onge, B. (2009). Mapping site index and age by linking a time series of canopy height models with growth curves. *Forest Ecology and Management, 257*(3), 951-959.

Vélez, R. (1997). Les feux de forêt en Espagne en 1997. *Forêt Méditerranéenne, 18*(1).

Vu, Q., Le, Q., & Vlek, P. (2014). Hotspots of human-induced biomass productivity decline and their social–ecological types toward supporting national policy and local studies on combating land degradation. *Global and Planetary Change, 121*(1), 64-77.

Weng, Q. (2002). Land use change analysis in the Zhujiang Delta of China using satellite remote sensing, GIS and stochastic modelling. *Journal of Environmental Management, 64*(3), 273-284.

Weng, Q., & Yang, S. (2004). Managing the adverse thermal effects of urban development in a densely populated Chinese city. *Journal of environmental management, 70*(2), 145-156.

White, J., Coops, N., Wulder, M., Vastaranta, M., Hilker, T., & Tompalski, P. (2016). Remote sensing technologies for enhancing forest inventories: A review. *Canadian Journal of Remote Sensing, 42*(5), 619-641.

White, P., & Jentsch, A. (2001). The search for generality in studies of disturbance and ecosystem dynamics. *Progress in Botany*, 399-450.

Yamazaki, F., Suzuki, D., & Maruyama, Y. (2008a). Use of digital aerial images to detect damages due to earthquakes. *14th World Conference. Earthquake Engineering.* Pavia, Italy.

Yu, X., Guo, X., & Wu, Z. (2014). Land surface temperature retrieval from Landsat 8 TIRS-Comparison between radiative transfer equation-based method, split window algorithm and single channel method. *Remote Sensing, 6*(10), 9829-9852.

Submitted:	Revised:	Accepted:	Published online:
November 25, 2021	February 19, 2022	March 4, 2022	May 02, 2022

Analele Universităţii din Oradea, Seria Geografie **XXXII**, no. **1/2022**, pp. **39-54**
ISSN **1221-1273**, E-ISSN **2065-3409** DOI **10.30892/auog.321104-879**

ASSESSMENT OF WASH IN RIVERINE PRIMARY SCHOOLS IN OJO LOCAL GOVERNMENT AREA OF LAGOS, NIGERIA

Isaiah S. AKOTEYON*
Lagos State University, Department of Geography and Planning
P.O. Box 0001 Lasu Post Office, Ojo, Lagos, Nigeria; e-mail: sewanuakot@gmail.com

Olayinka OTUSANYA
University of Lagos, Akoka, Department of Geography
Post Office, Lagos, Nigeria; e-mail: olaoolu4life@yahoo.com

Citation: Akoteyon, I.S., & Otusanya, O. (2022). Assessment of Wash in Riverine Primary Schools in Ojo Local Government Area of Lagos, Nigeria. *Analele Universităţii din Oradea, Seria Geografie, 32*(1), 39-54. https://doi.org/10.30892/auog.321104-879

Abstract: Adequate water, sanitation, and hygiene in schools are vital to achieving conducive learning and well-being of pupils. The study assessed WaSH conditions in Riverine primary schools in Ojo Area of Lagos, Nigeria. The study employed field observation and administration of questionnaires to 256 pupils using purposive sampling techniques to obtain information on WaSH facilities in private and public primary schools. The data were analysed using descriptive and Chi-square statistics while the study area map and WaSH attributes were plotted using ArcMap and Excel software respectively. The results show that 92.7% of the pupils from the public school are acquainted with WaSH. Most of the schools have adequate water and handwashing facilities. The ratio of boys and girls to toilet facilities exceeded UNICEF standard while learning material on WaSH program was generally poor. The greater percentage of the pupils from public schools indicate their satisfaction with accessibility and the quality of service derived from WaSH facilities while the adequacy of WaSH facilities was rated below average. The majority of the pupils affirmed that adequate WaSH provisions will improve their academic performance. The test statistics show a significant relationship between WaSH attributes, academic performance, and the school type. The study serves as baseline information for policymakers and school management authorities for interventions in areas of greatest WASH needs. We concluded that private schools indicate some deprivation in WaSH conditions. We recommended adequate learning aids on WaSH, toilets, handwashing materials, and waste bins for optimum academic performance and well-being of the pupils with greater priority in the private schools.

Key words: Hygiene, primary school, Riverine, sanitation, water.

* * * * * *

INTRODUCTION

Water, sanitation, and hygiene (WASH) in schools or non-household settings refer to a combination of technical (hardware) such as drinking water, hand washing, and toilet facilities around the school compound and human development (software). Software is components that are

* Corresponding author

necessary to produce a healthy school environment for the development or support of appropriate health and hygiene behaviors such as activities that promote conditions within the school and the practices of children and teachers that help to prevent water and sanitation-related diseases infestation (Kendall & Snel, 2016; Antwi-Agyei, et al., 2017). The provision of adequate WaSH facilities in school settings is critical because of its role in technical support from various levels of government such as; local, national and international organizations, e.g., WHO and UNICEF, through policy and financing (Cronk, Slaymaker, & Bartram, 2015). Similarly, providing adequate WASH facilities for students and teachers is vital to achieving a conducive working and learning environment (Hsan, Naher, Griffiths, Shamol, & Rajman, 2019). It also plays a crucial role in policy formulation and strategies to benchmark service quality to guarantee international standards (Bradley & Bartram, 2013). Proper provision of WASH amenities is essential because it serves to advance human rights and attain Sustainable Development Goals (SDGs) 3 and 6 (UNICEF, 2012a; UN Special Rapporteur on the Human Right to Safe Drinking Water and Sanitation, 2012; Jordanova, et al., 2015; WHO & UNICEF, 2015). Adequate WASH interventions can significantly reduce both the severity and prevalence of diarrhea, infectious diseases, and some vector-borne diseases and decrease child mortality rates around the globe (Prüss-Üstün, Bos, Gore, & Bartram, 2015; McGinnis, et al., 2017). The provision of improved WASH facilities offers tremendous economic benefits by reducing medical treatment costs, mortality reduction, and increased productivity (Prüss-Üstün, Bos, Gore, & Bartram, 2015). According to Hutton (Hutton, 2012), it is estimated that investment in WASH facilities can lead to economic returns of $5.50 and $2 for every dollar spent on sanitation and water, respectively. Globally, approximately one-third of schools do not have access to adequate water supply, while more than 44% lack access to adequate sanitation as of 2015 (WHO & UNICEF, 2015). Poor access to WASH is of significant concern in schools due to the potential impacts of disease transmission among children (WHO & UNICEF, 2015). Lack of improved WASH in schools may contribute to a decline in school attendance (Pearson & McPhedran, 2008) with a significant impact on pupils' academic performance, rise in the number of drop-outs, and delays in academic and social development (Lamdin, 1996). Studies have shown a relationship between WASH and school absenteeism, especially among girls who require facilities for personal hygiene (Pearson & McPhedran, 2008; Freeman, și alții, 2012; Freeman, et al., 2014; Mooijman, 2012; WHO & UNICEF, 2015).

In developing countries, poor access to WASH in non-household settings, such as schools, health care centers, workplaces, and dislocated populations, have a significant impact on the health, education, welfare, and productivity of the populace (Guerrant, Deboer, Moore, Scharf, & Lima, 2013; Jordanova, et al., 2015; Cronk, Slaymaker, & Bartram, 2015; Antwi-Agyei, et al., 2017). These impacts inflict severe effects on specific people, such as physically challenged persons. These people are faced with stiffer physical and social barriers in accessing WaSH with dire consequences such as poor attendance at school, especially among girls due to lack of water and separate toilets (Groce, Bailey, Lang, Trani, & Kett, 2011; WHO, 2011; Adukia, 2013). According to Adukia (Adukia, 2013), the lack of gender-separated toilets in school settings impacts girls' attendance significantly. Inadequate access to WaSH amenities in schools can adversely affect student health, educational performance, and teacher satisfaction (Cronk, Slaymaker, & Bartram, 2015). It was observed that approximately 15% of the disabled persons that make up the global population are confronted with physical and social barriers in accessing WaSH are often prevented from using public services and utilities (Groce, Bailey, Lang, Trani, & Kett, 2011; WHO, 2011).

The available statistics on the performance of the WASH sector in Nigeria are relatively poor (Akpabio & Rowan, 2021). Akpabio and Rowan (2021) noted that around 2000, the proportion of the population with access to water on-premises in Nigeria was 17%, while only 29% had access to improved sanitation. The poor indicators on the WASH sector can be linked to several factors such as; inadequate financing and budgeting, lack of data on the overall status for WASH in school settings, lack of awareness, government policies. Other factors include; cultural values and religious beliefs, competition and poor bureaucracy, unreliable water supply due to erratic power supply,

overpopulation of latrine-to-student ratios, neglect, poor maintenance, and corruption, among others, have significantly impacted the WASH conditions in most schools in Nigeria (Egbinola & Amanambu, 2015; McGinnis, et al., 2017; Akpabio & Rowan, 2021). Despite the challenges confronting the WASH sector in Nigeria, some proactive steps have been made in the National Water, Sanitation, and Hygiene Capacity Building and Research Programme to strengthen human capacity for sanitation and universal access to water and sanitation by 2030. In addition, the recent declaration of a 'State of Emergency in Nigeria's water and sanitation sector by the President in 2018 shows the political will on the part of the Federal government to address Nigeria's water and sanitation crisis (The Nation, 2018; Richard, Dan, & Thomas, 2019).

CONCEPT AND LESSON LEARNED FROM PREVIOUS STUDIES

Theoretical concepts that can be employed to explain this study abound. Among such concepts include; the concept of adequacy and the health belief and trans-theoretical models. According to Obute (2017), the concept of adequacy is viewed as a means of quality and quantity under any given condition. It can be likened to the idea of satisfaction on basic human needs which is crucial for the welfare of an individual. Obute (2017), noted that satisfaction is a feeling of happiness when someone gets what he or she wanted. Obute (2017) observed that satisfaction is a feeling of pleasure because one has achieved something hence, service providers can render specific services to the target population to satisfy their needs. He opined that if the expected level of quality service is obtained, the beneficiaries are satisfied. Obute (2017) inferred that quality service delivery of potable water supply and sanitation enhance the efficacy of productivity and contribute significantly to the standard of living of the populace. He argued that an adequate and satisfactory water supply has socio-economic benefits which can be viewed from the consumptive value, availability and utilization. The health belief model is a way of explaining the preventive and curative health behaviour, to explain the failure of people to participate in preventive health programmes that would protect them from diseases and health-related problems. The model is comprised of four major components namely; perceived susceptibility, perceived severity, perceived benefits and perceived barriers (Rosenstock, Strecher, & Becker, 1994). The trans-theoretical model is also an important concept that is relevant to this study. It is one of the most influential models of behavioural change. The theory holds that an individual passes through six logical stages of the decision-making process such as; pre-contemplation, contemplation, preparation, action, maintenance, and termination before adopting a particular health behaviour (Velicer, Prochaska, Fava, Norman, & Redding, 1998; Obute, 2017). They argued that the position of the stages of behaviour in the theory allows individuals to weigh dangers associated with a health problem in respect of water and sanitation-related diseases.

Studies abound on WaSH practices across the globe. For example, (Aremu, 2012; Biran, et al., 2012; Babalobi, 2013; Freeman, et al., 2014; Antwi-Agyei, et al., 2017). Others examined WASH conditions in rural schools and vulnerable communities (Waddington, Snilstveit, White, & Fewtrell, 2009; Alexander, et al., 2014; Prüss-Ustün, et al., 2014; Jordanova, et al., 2015; Celia, 2019). Similarly, Biran et al. (2012), Philips et al. (2015), and Hsan et al. (2019) assessed WASH as it affects human health and student performance. Rabie and Curtis (2006), Gottfried (2010), Talaat et al. (2011), Lau et al. (2012), Joshi and Amadi (2013), Freeman et al. (2014) analyzed WASH in refugee camps, while Acha-Anyi (2020) examined the relationship between recreation activities and mental health and noted that, participation in recreation activities could stimulate a snowball effect of positive community relations. Previous studies by Lidonde (2004), WHO (2005), Kirk and Sommer (2006) noted high drop-out rates among pubescent-age girls in many schools across the world due to the absence of sanitation/latrines facilities. Also, Lundblad and Hellstrom (2005) opined that the absence of a school latrine might cause children to refrain from eating or drinking, which may cause severe consequences on educational outcomes. Adukia (2013) argued that school sanitation substantially increases enrollment of pubescent-age girls in schools with sex-specific school latrines. Scott and Vanick (2007), Lopez-Quintero et al. (2009) observed that schools with

scarce supplies for handwashing such as water provision, soap, or towels reported less handwashing practices among pupils. Rosen et al. (2006) noted that there is no significant change in rates of communicable illness or absenteeism among pupils despite sustained handwashing behavior after six months. Similar studies by Bowen et al. (2007) and Talaat et al. (2011) on handwashing intervention in schools reported statistically significant declines in illness and absenteeism. Barnes and Maddocks (2002) and Lundblad and Hellstrom (2005) argued that most school pupils avoid toilets due to overcrowding, smelly and unclean nature, and lack of privacy. Durán-Narucki (2008) observed that WASH conditions in schools are related to students' academic success and school attendance. Abrahams et al. (2006) and Sommer (2010) identified travel distance to and fro school during menses, fear of sexual attacks in school toilets far away from school premises, and inadequate WASH facilities as factors affecting school attendance. A similar study by UNICEF (2005) and Birdthistle et al. (2011) also noted that poor school sanitation facilities impede girls' access to quality education. Vernon et al. (2003), Fujiwara-Pichler et al. (2006), and Perez (2010) also noted that lack of adequate sanitation facilities in school poses a significant risk of gastrointestinal and communicable infections to school pupils. Koopman (1978) reported a significant causal relationship between adequacy of (toilets, water, cleanliness, and provision of toilet paper, soap, and towels) and diarrhea and vomiting in the schools, while Rajaratnam et al. (1992) opined that students who used toilets for defecation in school are more likely to develop Hepatitis A due to inadequate sanitation facilities.

Despite the robust studies on WASH conditions in non-household settings both at the local and international levels, there is insufficient knowledge on WASH conditions in riverine private and public primary schools in the study area. To fill this knowledge gap, we examined WASH conditions of public and private primary schools in the riverine communities of Ojo Local Government Area of Lagos, Nigeria, using international standards to assess WASH amenities to strengthen the WASH sector in the study area. The study is significant because it will serve as baseline information to advise policymakers, regulatory agencies, and management authorities for planning and interventions in areas with the greatest WASH needs for improved WASH services that promote personal hygiene and environmental sanitation within the school setting.

STUDY AREA

The study site is situated in Ojo Local Government Areas (LGA) of Lagos State. It is located approximately on Longitudes 20°55'W and 20°12'W to Latitudes 40°15'N and 40°17'N. Amuwo-Odofin and Alimosho LGAs bound the area to the East and North, respectively, Badagry Creek to the South and Badagry LGA in the West. The LGA occupies about 158 Km2 of land with about 598,071 people (NPC, 2006). The LGA is comprised of ten wards. Five of these wards, namely; Irewe, Tafi, Etegbin, Idoluwo, and Sabo, are located in the riverine areas. About 30% of its landmass is occupied by a water body comprised of Riverine settlements (Figure 1).

The regulatory body in charge of primary schools in the state i.e. Lagos State Universal Basic Education Board (LASUBEB) is geared towards ensuring that every child has access to quality elementary education, quality teaching, and learning. The state government has made many investments to ensure that the vision and mission of LASUBEB are achieved. Most of the riverine communities in Ojo are confronted with a series of challenges. These challenges can hinder the realization of the vision and mission of LASUBEB. For example, access to school in the area is a huge task due to the riverine nature of the location. The majority of the pupils spent on average six hours to and fro for an average transport fee of about N300 ($1) per trip. Apart from the time and cost implications, the water mishaps such as boast capsize have further compounded the problems of the high rate of out-of-school children in the area. While most public-owned schools have undergone some rehabilitation and provision of basic amenities, the majority of the private schools still lack major WaSH facilities that will improve the pupils' learning environment. Thus, this situation brings to bear the challenges of basic amenities such as water, sanitation, hygiene facilities confronting the pupils in accessing quality education in the Riverine area.

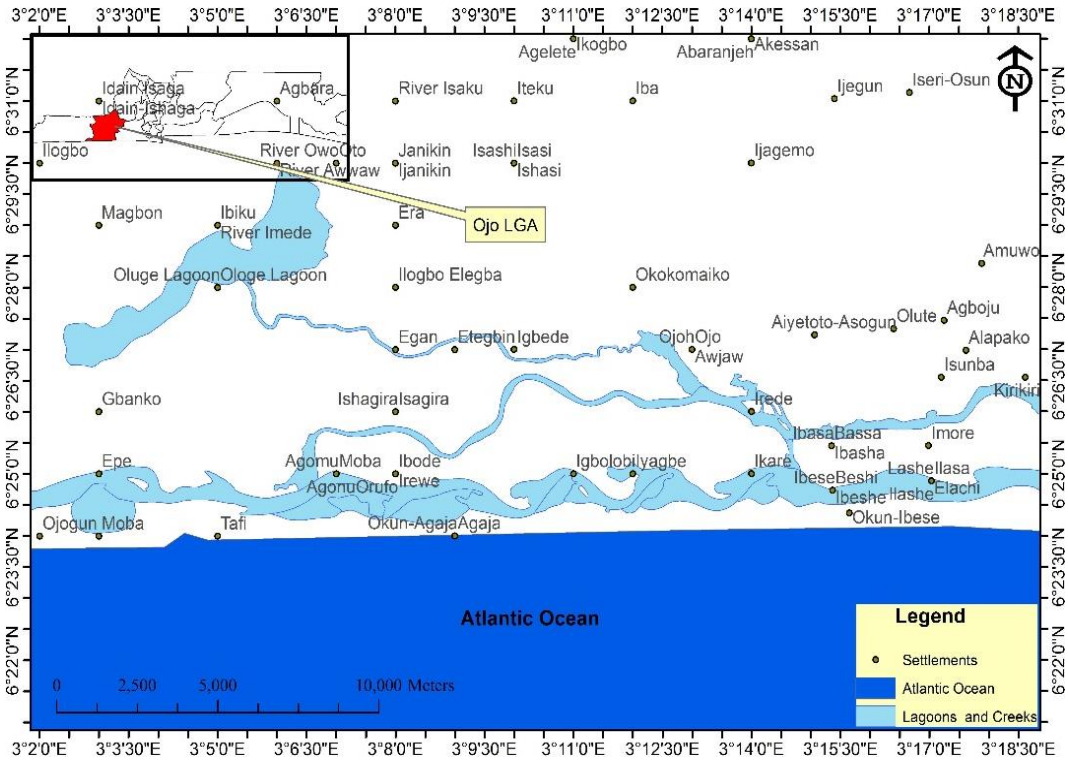

Figure 1. Study area
(Source: Author's, 2019)

METHODS

Study design

A survey questionnaire was designed with on-the-spot observation to assess the status of WaSH amenities in private and public primary schools in Riverine communities of Ojo LGA of Lagos, Nigeria (Table 1).

Table 1. Summary of the statistics of primary schools and distribution of questionnaires across the settlements
(Data source: Author's fieldwork, 2019)

Name of School	Settlement	School Type	No of Reg. pupils	Female	Male	Total No of pupils surveyed	Total No of females surveyed	Total No of males surveyed
Local Authority Nursery & Primary School	Alaguntan	Public	116	57	59	49	29	20
Local Authority Nursery & Primary School	Okolundu	Public	102	59	43	34	21	13
Local Authority Nur & Pry School	Irewe	Public	250	154	96	68	42	26
Life Anchor Nursery & Primary School	Irewe	Private	80	40	40	30	18	12
Saved By Grace Nursery & Primary School	Agaja	Private	87	52	35	38	21	17
New Destiny Nursery & Primary School	Olomometa	Private	64	36	28	37	19	18
Total			699	398	301	256	150	106

A total sample size of 699 was designed to yield a representative sample of 256 pupils in the study area using the Yamane (1973) formula stated in equation 1.

$$n = N/1 + N(e)2 \quad \text{Eq. 1}$$

where,
n = the sample size,
N = the finite population,
e = level of significance (or limit of tolerable error) (0.05) and
1 = unity (a constant).

Sampling technique

Pupils from primary four to six were selected for this study using a purposive method because of their ability to read and write and their consent to participate in the survey. An on-the-spot assessment on the availability of WaSH facilities was carried out in each of the schools. The observation showed that private schools had more WaSH facilities than public-owned schools. It was also discovered that more significant proportions of the WaSH facilities in the public schools were in a poor state due to several years of neglect and poor maintenance. A pilot test was conducted with 25 pupils each from the public and private schools in the study area in November 2019. The survey covered five weeks to collect information from primary school pupils on their awareness, adequacy, accessibility, and satisfaction level on how adequate WASH facilities can improve pupils' academic performance. Data acquired through the survey were inputted into the IBM Statistical Package for Social Sciences (SPSS) version 22 software. Frequency, percentages, and Chi-square statistics were employed to analyze the data. The map of the study and WaSH attributes were plotted using ArcGIS software versions 10.3.1 and Excel software, respectively. The coding measures/scale of the variables is presented in (Table 2).

Table 2. Coding measures and scale of variables
(Data source: Author's fieldwork, 2019)

S/n	Variable	Measure/ scale	Options
1	Awareness about WaSH, availability of water/sanitation and hygiene facilities, availability of soap for handwashing, teaching/learning materials on WaSH, separate toilet for male and female pupils, and availability of waste bin facility	Binary	0=No 1=Yes
2	Available and functional numbers of WaSH facilities, numbers of girls and boys to toilet	Continuous	
3	Frequency of cleaning toilets was measured on three point scale as	3-point	1= once/week, 2 = twice/week & 3 = every day
4	Time taken to access toilet	3-point	1= within school premises, 2 = less than 1000m & 3= above 1000m
5	Source of water supply	6-point	1= River/stream, 2= open dug well, 3= protected dug well, 4= borehole, 5= Public water supply and 6= water vendor
6	Time spent to obtain water from the main source	3-point	1= less than 30 minutes, 2 = 30-60 minutes & 3 = more than 1 hour
7	Sources of toilet facilities	10-point	1= connection to septic system, 2 = pour-flush latrine with connection, 3= simple pit latrine, 4= ventilated improved pit latrine, 5= public or shared latrine, 6= open pit latrine, 7=

			bucket latrine, 8= pour-flush latrine without connection, 9= surface water & 10= open field space
8	Materials for handwashing	6-point	1= none, 2= water only, 3= soap and water, 4= soap only and 5= sanitizer & 6= disinfectant
8	Type of waste bin	4-point	1= piled within the premises, 2 = open drum, 3 = sack & 4 = covered drum
9	Method of waste disposal	6-point	1= burning, 2= burying, 3 = dumping inside the drain, 4 = dumping along the road side, 5 = through vision scape/PSP & 6 = through LAWMA
10	Frequency of waste disposal	4-point	1= once/day, 2 = once every three days, 3 = once/ week & 4 = every fortnight
11	Satisfaction on accessibility to WaSH facilities was measured on a four point scale as	4-point	1= not accessible, 2 = difficult to access, 3 = accessible & 4 = very accessible
12	Adequacy of WaSH facilities	3-point	1= inadequate, 2 = fairly adequate & 3 = very adequate
13	Satisfaction on quality of WaSH facilities	4-point	1= not satisfactory, 2 = fairly satisfactory, 3 = satisfactory & 4 = very satisfactory
14	Impact of WaSH facilities on academic performance of pupils	5-point	1=strongly disagree, 2 = disagree, 3 = uncertain, 4 = agree & 5= strongly agree

RESULTS

Awareness, availability of WaSH facilities, and teaching/learning material

Table 3 presents the awareness, WaSH facilities' availability, and teaching/learning material in the study area. The result shows that 61.3% of the pupils know about the WaSH program. The disparity across the school shows that a more significant percentage of the pupils from the public school, representing 92.7%, have knowledge of WaSH services compared to only 16.2 % from the private school (Table 3). In addition, the availability of WaSH facilities in the study area shows that 58.2% of the pupils claimed they have WaSH facilities in their school. In addition, the variations across the school indicate that the public schools recorded the highest numbers of available WaSH facilities compared to 35.2% from the private school (Table 3).

Regarding the availability of water and toilet facilities, both the public and private schools have appreciable water and toilet facilities. However, the availability of handwashing facilities indicates that a more significant percentage representing 72.3% of the pupils have handwashing facilities in the study area. The variations show that public schools recorded the highest percentage (77.5%), while private schools recorded 64.8% (Table 3).

Availability of soap for handwashing indicates that approximately 53.1% have soap for washing hands in the study area. The disparity revealed that private schools recorded the highest proportion with about 64.8%, while only 45.0% was obtained from the public schools, as shown in Table 3. The provision of teaching/learning materials on WaSH services revealed that only 40.6% of the pupils claimed they have teaching/learning materials on WaSH in the study area. The variations show that 68.9% of the pupils from the public school have teaching/learning material, in contrast to the private schools where there are no provisions for teaching/learning material on WaSH. The provision of separate toilets for boys and girls shows that all the schools have separate toilets in the study area. Though the schools made provision for a separate toilet for the male and female gender, the ratio of boys and girls to toilet shows that it exceeded the recommended guidelines of 1 hole for 50 boys and 25 for girls (UNICEF, 2012b). The toilet compartment ratio for boys is 1:150, while the ratio of 1:199 was obtained for girls. The provision of waste bin facilities shows that only 38.3% of the pupils claimed they have a waste bin in the study area. The variation indicates that 45.0% and 28.6% have public and private schools waste bin facilities, respectively (Table 3).

Table 3. Awareness, availability of WaSH facilities, and teaching/learning material
(Data source: Author's fieldwork, 2019)

Characteristics	Categories	School type		Total
		Public	Private	
Awareness of WASH	No	11 (7.3)	88 (83.8)	99 (38.7)
	Yes	140 (92.7)	17 (16.2)	157 (61.3)
Availability of WaSH facilities	No	39 (25.8)	68 (64.8)	107 (41.8)
	Yes	112 (74.2)	37 (35.2)	149 (58.2)
Availability of Water	No	-	-	-
	Yes	151 (100)	105 (100)	256 (100)
Availability of toilet facilities	No	-	-	-
	Yes	151 (100)	105 (100)	256 (100)
Availability of Handwashing facilities	No	34 (22.5)	37 (35.2)	71 (27.7)
	Yes	117 (77.5)	68 (64.8)	185 (72.3)
Availability of soap for Handwashing	No	83 (55.0)	37 (35.2)	120 (46.9)
	Yes	68 (45.0)	68 (64.8)	136 (53.1)
Availability of teaching/learning material on WaSH	No	47 (31.1)	105 (100.0)	152 (59.4)
	Yes	104 (68.9)	0 (0)	104 (40.6)
Separate toilet for male and female	No	-	-	-
	Yes	151 (100)	105 (100)	256 (100)
Availability of waste bin facilities	No	83 (55.0)	75 (71.4)	158 (61.7)
	Yes	68 (45.0)	30 (28.6)	98 (38.3)

Sources of water, toilet/waste bin types, handwashing material, and waste disposal methods

The primary water supply source in the study area is a borehole with about 73.8%, while an open dug well is the least with about 11.7% in the study area (Figure 2). The public school recorded the highest for borehole while private schools have the highest proportions for River/Stream and open dug well. The primary source of toilet facility is the connection to a septic system, with about 73.4% in the study area. Across the school, the public schools have full access to septic connection systems, while pour-flush latrine predominates in the private schools (Figure 2). The dominant handwashing materials in the study area include soap and water. The variations show that 64.8% of private schools use soap and water while most (55.0%) use only water in public schools (Figure 2).

The main waste collection bin in the study area is an open drum. The disparity across the school shows a similar pattern of waste collection bin with about 71.4 and 67.5% representing private and public schools using open drum waste collection method respectively (Figure 3). The

predominant waste disposal method in the study area is through burning technique. The technique is reflected across the school, with the private school recording the highest (Figure 3).

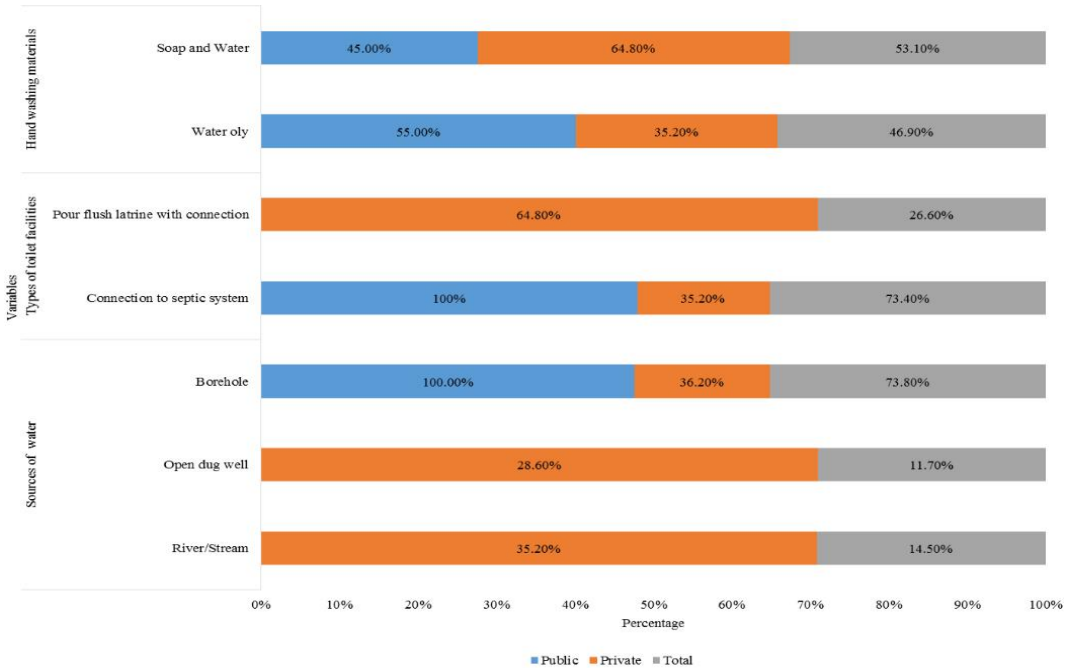

Figure 2. Sources of water supply, types of toilet facilities, and handwashing materials
(Source: Author's, 2019)

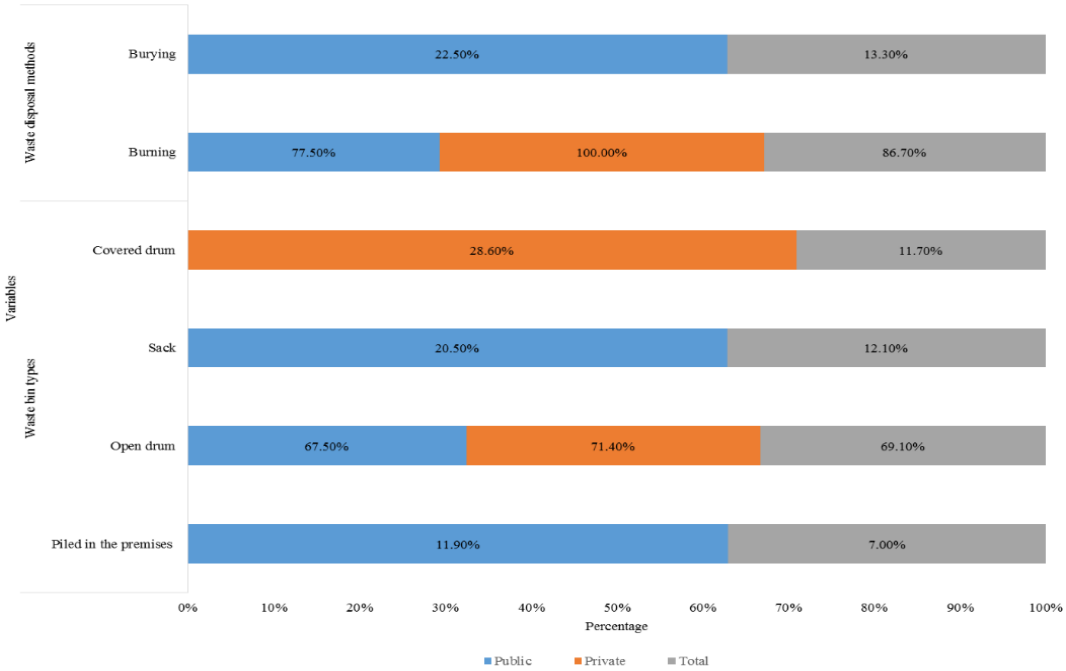

Figure 3. Waste bin types and waste disposal methods
Source: Author's (2019)

Accessibility, adequacy, and quality of WaSH facilities

The satisfaction level of accessibility to WaSH facilities shows that approximately 59.0% of the pupils rated it accessible in the study area, while 41.0% claimed WaSH facilities are not accessible. The disparity across the school shows that public schools recorded the highest satisfaction level while the majority of the pupils representing 64.8% from the private schools, rated it not accessible (Table 4). Based on the adequacy of WaSH facilities in the study area, only 10.4, 87.7, and 1.9% of the pupils rated it very adequate, fairly adequate, and inadequate, respectively (Table 4). The variations across the schools show a similar trend where more than three-quarters of the pupils rated WaSH facilities as fairly adequate (Table 4). Regarding the quality of service delivery of WaSH service, approximately 52.6% and 47.4% of the pupils rated it satisfactory and not satisfactory, respectively, in the study area. Across the school, about 65.8% of the pupils from the public school rated it satisfactory, while 89.2% rated it fairly satisfactory from the private schools (Table 4).

Impact of WaSH on the performance of pupils

The impact of adequate WaSH facilities on the academic performance of the pupils shows that a significant proportion of the pupils representing 82.0%, agreed that adequate WaSH facilities could improve their academic performance. In comparison,18.0% of the pupils strongly disagree with this notion in the study area. A similar result was obtained across the schools with 91.4 and 68.6% of the public and private schools, respectively (Table 4). The test statistics result shows a significant relationship between accessibility, adequacy, quality of service delivery, and academic performance of pupils in school, as indicated in Table 4.

Table 4. Accessibility, adequacy, quality of service delivery of WaSH services and the impact of WaSH on pupils performance
(Data source: Author's fieldwork, 2019)

Variables	Options	School type		Total	Chi-square test
		Public	Private		
Accessibility to WASH	Not Accessible	36 (23.8)	68 (64.8)	104 (40.6)	X^2=44.53, df=3, p<0.001
	Difficult to Access	1 (0.7)	0 (0.0)	1 (0.4)	
	Accessible	109 (72.2)	37 (35.2)	146 (57.0)	
	Very Accessible	5 (3.3)	0 (0.0)	5 (2.0)	
Adequacy of WASH facilities	Inadequate	3 (2.6)	0 (0.0)	3 (1.9)	X^2=6.85, df=2, p=0.032
	Fairly Adequate	98 (83.8)	37 (100.0)	135 (87.7)	
	Very Adequate	16 (13.7)	0 (0.0)	16 (10.4)	
Quality of service delivery of WASH facilities	Not Satisfactory	2 (1.7)	0 (0.0)	2 (1.3)	X^2=36.53, df=3, p<0.001
	Fairly Satisfactory	38 (32.5)	33 (89.2)	71 (46.1)	
	Satisfactory	69 (59.0)	4 (10.8)	73 (47.4)	
	Very Satisfactory	8 (6.8)	0 (0.0)	8 (5.2)	
Impact of WaSH facilities academic performance of pupils	Agree	138 (91.4)	72 (68.6)	210 (82.0)	X^2=21.88, df=1, p<0.001
	Strongly Agree	13 (8.6)	33 (31.4)	46 (18.0)	

DISCUSSIONS

The need for the proper orientation program, and enlightenment on WaSH practices, plays a significant role in hygiene practices and healthy living. Adequate knowledge or awareness of WaSH practices can improve sanitation and increase the rates of student hand-washing practices behaviors among school children after defecation with lower cases of open defecation, and reduce the risk of water and environmental related infectious diseases (Gottfried, 2010; Karon, Cronin, Cronk, & Henrdwan, 2017). In this study, the level of awareness on WaSH was higher than the study conducted by Babalobi (2013), who reported a low level of awareness and knowledge about hygiene practices among primary school pupils in Makoko Lagos, Nigeria. The increased awareness of WaSH in the study area should be sustained and encouraged to achieve the desired result of SDG goal number 6. Availability and the integration of teaching aids on WaSH practices in the school curriculum are critical to equip pupils with decent living conditions. The provision of teaching/learning material on WaSH in school will improve primary school attendance, health, and cognitive development; more excellent girls' participation in school, positive hygiene behaviors, and appreciable equity in schools (UNICEF, 2012c).

The availability of teaching/ learning aids in the study area is below the required standards. However, there are appreciable teaching aids on WaSH in public schools. Non-availability of teaching/learning material on WaSH in schools has implications on safe drinking water, decent sanitary facilities, and hygiene habits of pupils. The observed high level of teaching aid in the public schools can be attributed to the sustained campaign on personal hygiene implemented by the Lagos State Government after the Ebola outbreak in 2014.

The provision of decent toilet facilities in schools helps to improve sanitation conditions. Even though most of the schools in the study area have separate toilets for the male and female gender, the limited availability of these facilities is a vital source of concern because it can compromise hygiene practices (Waddington, Snilstveit, White, & Fewtrell, 2009). The present study shows that the ratio of boys and girls to toilet exceeds the recommended guidelines according to UNICEF (2012b) of 1 drop hole separate for 50 boys and 25 for girls. The toilet compartment ratio for boys is 1:150, while the ratio of 1:199 was obtained for girls. The result is at variance with Alexander et al. (2014), who reported a higher proportion of girls and boys ratio per toilet in rural Kenya. Proactive steps should be put in place by the respective school management authority in collaboration with the parent teachers' association (PTA) and the local/host community as part of social responsibility to provide additional toilets that will serve the current pupils population according to the prescribed standard.

A conducive school environment that is clean and free from communicable or vector-borne diseases provides comfort and attracts students to concentrate on their learning activities (WHO, 2005). The present study results show that waste collection and disposal methods are adequate in the study area. The result does not agree with the findings of Correa and Pinheiro (2017), who reported the proliferation of garbage collection in the Brazilian Amazon. Despite the adequate waste collection bins and efficient disposal methods in the study area, there is the need to intensify more efforts at ensuring that the waste bins are maintained while ensuring adherence to sustainable waste disposal practices. Providing safe water, decent sanitation, and hygienic practices is a veritable tool that promotes improved health and education and contributes to inclusion and equity in schools (Celia, 2019). Adequate water supply in schools for drinking and handwashing plays a vital role in improving the health and education of pupils. For example, proper handwashing practices can prevent incessant sicknesses such as diarrhea and respiratory diseases (Rabie & Curtis, 2006; Bowen, et al., 2007; Waddington, Snilstveit, White, & Fewtrell, 2009; Aremu, 2012; Olukanni, 2013; Seid & Kumie, 2013). It was observed that access to improved WaSH facilities in the study area is relatively high. This study corroborates the findings of (Talaat, et al., 2011; Lau, et al., 2012; Phillips, et al., 2015; Antwi-Agyei, et al., 2017). The result also agrees with the findings of (Cronk, Slaymaker, & Bartram, 2015) who argued that sustained service intervention in schools' WaSH facilities improves pupils' WaSH behaviors and daily habitual handwashing practice. Studies have

revealed that adequate social amenities affect children's cognitive development and influence their academic performance. The role of suitable WaSH facilities on the academic performance of pupils is very high. This result supports the findings of Owoeye and Yara (2011). Based on the relatively high access to improved WaSH amenities in the study area, a concerted effort should be made to ensure the sustainability of the WaSH infrastructure. The school management authority should make budget provisions to maintain infrastructure to avoid neglect and complete decay. The school can also partner with the community association or Non-governmental agencies (NGOs) to maintain WaSH infrastructure.

CONCLUSIONS

The present study examined the conditions of water, sanitation, and hygiene services in Riverine primary schools of Ojo Local Government Area of Lagos, Nigeria, to ascertain compliance with international standards. The study was motivated due to the challenges that may hinder the realization of the vision and mission of LASUBEB in ensuring that every child has access to quality elementary education, quality teaching, and a learning environment. The result shows that a significant percentage of the pupils from the public school representing 92.7 have knowledge about WaSH compared to only 16.2% from the private school. In addition, the availability of WaSH facilities in the school indicates that public schools recorded the highest availability compared to only 35.2% from the private school. In addition, the availability of water, and handwashing facilities in public and private schools were adequate. In addition, the availability of soap for handwashing in private schools is higher in public schools. In addition, the provision of teaching/learning material on WaSH is insufficient in the study area, and virtually all the private schools do not have teaching/learning material on WaSH. The ratio of boys and girls to the toilet exceeded the recommended UNICEF standard of 1 one hole for 50 boys and 25 for girls. In addition, the provision of waste bin facilities in the study area is generally low. Access to water shows that public schools relied on improved water sources (borehole) while the private schools relied on unimproved source (River/Stream and open dug well). All the schools have improved toilet facilities, with the dominance of septic connection system and pour-flush latrine in public and private schools, respectively. Handwashing practice revealed that private schools use soap and water while public schools use only water. The methods of open drum and burning predominate as waste collection and disposal, respectively. The majority of the pupils from public schools were satisfied based on accessibility to WaSH facilities, while the pupils from private were dissatisfied. More than three-quarters of the pupils rated the adequacy of WaSH facilities below average.

Similarly, the quality of service delivery was rated satisfactory and fairly satisfactory in public and private schools respectively. The impact of WaSH facilities on the academic performance of pupils shows that about 82.0% agreed that adequate WaSH facilities will improve their academic performance. The test statistics result shows a significant relationship between accessibility, adequacy, quality, academic performance, and the school type. The study serves as baseline information to advise policymakers, the regulatory agencies, and management authorities for future WASH programs in school. It will also help provide the necessary support for planning and interventions in areas of greatest WASH needs for improved WASH amenities that promote personal hygiene and environmental sanitation within the school setting. The study concluded that WaSH facilities in private schools are poor. Therefore, we recommend urgent intervention to provide teaching/learning aids on WaSH, toilets, handwashing materials, and waste bins for optimum academic performance and the well-being of the pupils.

ACKNOWLEDGEMENT

The authors wish to thank Hoteyin Joseph of the Department of Geography and Planning, Lagos State University, for assisting in data collection and the anonymous reviewers for their valuable suggestions and comments for improving the quality of the manuscript.

REFERENCES

Abrahams, N., Mathews, S., & Ramela, P. (2006). Intersections of 'sanitation, sexual coercion and girls' safety in schools. *Tropical Medicine & International Health, 11*(5), 751-756. doi:10.1111/j.1365-3156.2006.01600.x

Acha-Anyi, P. (2020). Local Community Participation in Recreation and Mental Health Experiences: A Case Study of the Eastern Cape Province – South Africa. *GeoJournal of Tourism and Geosites, 31*(3), 1153–1160. doi:10.30892/gtg.31329-552

Adukia, A. (2013). *Sanitation and Education.* Cambridge: Harvard University. Retrieved March 5, 2022, from http://scholar.harvard.edu/files/adukia/files/adukia sanitation and education.pdf

Akpabio, E., & Rowan, J. (2021). The political economy of coordinating water, sanitation, and hygiene management policies and programmes for Nigeria. *Water International, 46*(3), 365-382.

Alexander, K., Oduor, C., Nyothach, E., Laserson, K., Amek, N., Eleveld, A., & Ombok, M. (2014). Water, sanitation and hygiene conditions in Kenyan rural schools: are schools meeting the needs of menstruating girls? *Water, 6*(5), 1453-1466.

Antwi-Agyei, P., Mwakitalima, A., Seleman, A., Tenu, F., Kuiwite, T., Kiberiti, S., & Roma, E. (2017). Water, sanitation and hygiene (WASH) in schools: results from a process evaluation of the National Sanitation Campaign in Tanzania. *Journal of Water, Sanitation and Hygiene for Development, 7*(1), 140-150.

Aremu, A. (2012). Assessment of sanitation facilities in primary schools within Ilorin, Nigeria. *Journal of Applied Sciences in Environmental Sanitation, 7*(1), 29-33.

Babalobi, B. (2013). Water, sanitation and hygiene practices among primary-school children in Lagos: a case study of the Makoko slum community. *Water international, 38*(7), 921-929.

Barnes, P., & Maddocks, A. (2002). Standards in school toilets - A questionnaire survey. *Journal of Public Health, 24*(1), 85-87. doi:10.1093/pubmed/24.2.85

Biran, A., Schmidt, W., Zeleke, L., Emukule, H., Khay, H., Parker, J., & Peprah, D. (2012). Hygiene and sanitation practices amongst residents of three long-term refugee camps in knowledge, attitude and practice of hygiene and sanitation in a Burundian refugee camp: implications for control of a Salmonella typhi outbreak. *Pan African Medical Journal, 28*(1).

Birdthistle, I., Dickson, K., Freeman, M., & Javidi, I. (2011). *What impact does the provision of separate toilets for girls at schools have on their primary and secondary school enrolment, attendance and completion?: A systematic review of the evidence.* London: EPPI-Centre, Social Science Research Unit, Institute of Education, University of London.

Bowen, A., Ma, H., Ou, J., Billhimer, W., Long, T., Mintz, E., . . . Luby, S. (2007). A cluster-randomized controlled trial evaluating the effect of a handwashing promotion program in Chinese primary schools. *The American Journal of Tropical Medicine and Hygiene, 76*(1), 1166-1173.

Bradley, D., & Bartram, J. (2013). Domestic water and sanitation as water security: monitoring, concepts and strategy. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences, 371*(2002).

Celia, M. (2019). Water, Sanitation and Hygiene (WASH) in Schools in Low-Income Countries: A Review of Evidence of Impact. *nternational Journal of Environmental Research and Public Health, 16*(3). doi:10.3390/ijerph16030359

Correa, L., & Pinheiro, A. (2017). Dynamics of parasitic diseases and the environmental and sanitation context in cities of the Brazilian Amazon. *Journal of Parasitic Diseases: Diagnosis and Therapy, 2*(1), 1-2.

Cronk, R., Slaymaker, T., & Bartram, J. (2015). Monitoring drinking water, sanitation, and hygiene in non-household settings: Priorities for policy and practice. *International Journal of Hygiene and Environmental Health, 218*(8), 694-703.

Durán-Narucki, V. (2008). School building condition, school attendance, and academic achievement in New York City public schools: A mediation model. *Journal of Environmental Psychology, 28*(3), 278-286. doi:10.1016/j.jenvp.2008.02.008

Egbinola, C., & Amanambu, A. (2015). Water supply, sanitation and hygiene education in secondary schools in Ibadan, Nigeria. In D. Szymańska, & S. Środa-Murawska, *Bulletin of Geography. Socio-economic Series* (pp. 31-46). Toruń: Nicolaus Copernicus University. doi:10.1515/bog-2015-0023

Freeman, M., Greene, L., Dreibelbis, R., Saboori, S., Muga, R., Brumback, B., & Rheingans, R. (2012). Assessing the impact of a school-based water treatment, hygiene and sanitation programme on pupil absence in Nyanza Province, Kenya: A cluster-randomized trial. *Tropical Medicine & International Health, 17*(3), 380–391. doi:10.1111/j.1365-3156.2011.02927.x

Freeman, M., Stocks, M., Cumming, O., Jeandron, A., Higgins, J., Wolf, J., . . . Curtis, V. (2014). Systematic review: Hygiene and health: systematic review of handwashing practices worldwide and update of health effects. *Tropical Medicine & International Health, 19*(8), 906-916. doi:10.1111/tmi.12339

Fujiwara-Pichler, E., Maddocks, A., & Barnes, P. (2006). Standards in school toilets: Do extra resources make a difference? *Journal of Public Health, 28*(1), 294–295.

Gottfried, M. (2010). Evaluating the relationship between student attendance and achievement in urban elementary and middle schools: an instrumental variables approach. *American Educational Research Journal, 47*(1), 434-465.

Groce, N., Bailey, N., Lang, R., Trani, J., & Kett, M. (2011). Water and sanitation issues for persons with disabilities in low- and middle-income countries: a literature review and discussion of implications for global health and international development. *Journal of Water and Health, 9*(4), 617–627. doi:10.2166/wh.2011.198

Guerrant, R., Deboer, M., Moore, S., Scharf, R., & Lima, A. (2013). The Impoverished gut—a triple burden of diarrhea, stunting and chronic disease. *Nature Reviews, Gastroenterology and Hepatology, 10*(4), 220–229.

Hsan, K., Naher, S., Griffiths, M., Shamol, H., & Rajman, M. (2019). Factors associated with the practice of water, sanitation, and hygiene (WASH) among the Rohingya refugees in Bangladesh. *Journal of Water, Sanitation and Hygiene for Development, 9*(4), 794–800.

Hutton, G. (2012). *Global Costs and Benefits of Drinking-Water Supply and Sanitation Interventions to Reach the MDG Target and Universal Coverage.* Geneva, Switzerland: World Health Organization.

Jordanova, T., Cronk, R., Obando, W., Medina, O., Kinoshita, R., & Bartram, J. (2015). Water, Sanitation, and Hygiene in schools in low socio-economic regions in Nicaragua: A cross-sectional survey. *International Journal of Environmental Research and Public Health, 12*(1), 6197-6217. doi:10.3390/ijerph120606197

Joshi, A., & Amadi, C. (2013). Impact of Water, Sanitation, and Hygiene Interventions on Improving Health Outcomes among School Children. *Journal of Environmental and Public Health*, Article ID 984626. doi:10.1155/2013/984626

Karon, A., Cronin, A., Cronk, R., & Henrdwan, R. (2017). Improving water, sanitation, and hygiene in schools in Indonesia: A cross-sectional assessment on sustaining infrastructural and behavioral interventions. *International Journal of Hygiene and Environmental Health, 220*(3), 539-550. doi:10.1016/j.ijheh.2017.02.001

Kendall, L., & Snel, M. (2016). *Looking at WASH in non-household settings: WASH away from the home information guide.* IRC.

Kirk, J., & Sommer, M. (2006). Menstruation and body awareness: linking girls' health with girls' education. *Special on Gender and Health, 1*(3), 1-22.

Koopman, J. (1978). Diarrhea and school toilet hygiene in Cali, Colombia. *American Journal of Epidemiology, 107*, 412-420.

Lamdin, D. (1996). Evidence of student attendance as an independent variable in education production functions. *The Journal of Educational Research, 89*(1), 155-162.

Lau, C., Springston, E., Sohn, M., Mason, I., Gadola, E., Damitz, M., & Gupta, R. (2012). Hand hygiene instruction decreases illness-related absenteeism in elementary schools: a prospective cohort study. *BMC Pediatrics, 12*(1), 1-7.

Lidonde, R. (2004). Scaling up school sanitation and hygiene promotion and gender concerns. *School Sanitation and Hygiene Education Symposium. The Way Forward: Construction is Not Enough!*

Lopez-Quintero, C., Freeman, P., & Neumark, Y. (2009). Hand washing among school children in Bogota, Colombia. *American Journal of Infection Control, 99*(1), 94-101.

Lundblad, B., & Hellstrom, A. (2005). Perceptions of school toilets as a cause for irregular toilet habits among schoolchildren aged 6 to 16 years. *Journal of School Health, 75*(4), 125-128. doi:10.1111/j.1746-1561.2005.tb06656.x.

McGinnis, S., McKeon, T., Desai, R., Ejelonu, A., Laskowski, S., & Murphy, H. (2017). A systematic review: costing and financing of water, sanitation, and hygiene (WASH) in schools. *International Journal of Environmental Research and Public Health, 14*(4). doi:10.3390/ijerph14040442

Mooijman, A. (2012). *Water, Sanitation and Hygiene (WASH) in Schools. In A Companion to the Child-Friendly Schools Manual.* New York, NY, USA: UNICEF.

NPC. (2006). *Details of the breakdown of the national and state provisional population totals.* Abuja: National Population Census, Federal Republic of Nigeria.

Obute, J. (2017). *Service delivery, constraints and prospects of potable water supply and sanitation in Benue State: A case study of Wateraid Nigeria.* (Doctoral dissertation).

Olukanni, D. (2013). Assessment of WASH program in public secondary schools in South-West Nigeria. *ARPN Journal of Engineering and Applied Sciences, 8*(3), 222-228.

Owoeye, J., & Yara, P. (2011). School Amenities and Academic Achievement of Secondary School Agricultural Science in Ekiti State, Nigeria. *Asian Social Science, 7*(7), 64-66.

Pearson, J., & McPhedran, K. (2008). A literature review of the non-health impacts of sanitation. *Waterlines, 27*(1), 48–61. doi:10.3362/1756-3488.2008.005

Perez, J. (2010). Minimum standards for school toilets are needed to improve child health. Retrieved from https://www.nursingtimes.net/archive/minimum-standards-for-school-toilets-are-needed-to-improve-child-health-22-06-2010/

Phillips, R., Vujcic, J., Boscoe, A., Handzel, T., Aninyasi, M., Cookson, S., . . . Ram, P. (2015). Soap is not enough: handwashing practices and knowledge in refugee camps, Maban County, South Sudan. *Conflict and Health, 9*(1), 1-8.

Prüss-Ustün, A., Bartram, J., Clasen, T., Colford Jr, J., Cumming, O., Curtis, V., . . . Cairncross, S. (2014). Burden of disease from inadequate water, sanitation and hygiene in low- and middle-income settings: a retrospective analysis of data from 145 countries. *Tropical Medicine and International Health, 19*(8), 894–905.

Prüss-Üstün, A., Bos, R., Gore, F., & Bartram, J. (2015). *Others Safer Water, Better Health: Costs, Benefits, and Sustainability of Interventions to Protect and Promote Health.*

Rabie, T., & Curtis, V. (2006). Handwashing and risk of respiratory infections: a systematic quantitative review. *Tropical Medicine and International Health, 11*(1), 258-267.

Rajaratnam, G., Patel, M., Parry, J., Perry, K., & Palmer, S. (1992). An outbreak of hepatitis A: School toilets as a source of transmission. *Journal of Public Health Medicine*, 72-77.

Richard, W., Dan, W., & Thomas, Y. (2019). *Equal to the task: financing for a state of emergency in Nigeria's water, sanitation, and hygiene sector: A case study. WaterAid report, based on research and analysis from development.*

Rosen, L., Manor, O., Engelhard, D., Brody, D., Rosen, B., Peleg, H., . . . Zucker, D. (2006). Can a handwashing intervention make a difference? Results from a randomized controlled trial in Jerusalem preschools. *Preventive Medicine, 42*(1), 27-32.

Rosenstock, I., Strecher, V., & Becker, M. (1994). The health belief model and HIV risk behavior change. *Preventing AIDS*, 5-24.

Scott, E., & Vanick, K. (2007). A survey of hand hygiene practices on a residential college campus. *American Journal of Infection Control*, 694-696. doi:10.1016/j.ajic.2007.01.009

Seid, H., & Kumie, A. (2013). The status of school sanitation facilities in some selected primary and secondary schools in Dessie City Administration, South Wello Zone, Amhara Region. *The Ethiopian Journal of Health Development, 27*(1), 80-84.

Sommer, M. (2010). Where the education system and women's bodies collide: The social and health impact of girls' experiences of menstruation and schooling in Tanzania. *Journal of Adolescence, 33*(1), 521–529. doi:10.1016/j.adolescence.2009.03.008

Talaat, M., Afifi, S., Dueger, E., El-Ashry, N., Marfin, A., Kandeel, A., . . . El-Sayed, N. (2011). Effects of hand hygiene campaigns on incidence of laboratory-confirmed influenza and absenteeism in schoolchildren, Cairo, Egypt. *Emerging Infectious Diseases, 17*(4), 619–625. doi:10.3201/eid1704.101353

The Nation. (2018). *Buhari declares state of emergency on water sanitation sector.* Retrieved November 9, 2018, from Vintage Press Limited: http://thenationonlineng.net/buhari-declares-state-emergency-water-sanitation-sector/?fbclid=IwAR2TRabItqsQphQjxi_NvgSlipVYHMeC25g1PrkEGlmtgCM5TY29pfRYZpk

UN Special Rapporteur on the Human Right to Safe Drinking Water and Sanitation. (2012). *Report to the General Assembly, Integrating Non-discrimination and equality into the Post-2015 Development Agenda for Water, Sanitation and Hygiene, 8 August 2012.* UN Doc. A/67/270.

UNICEF. (2005). *Lack of safe water and sanitation in schools jeopardizes quality education. Roundtable on Water, Sanitation and Hygiene Education for Schools.* New York: United Nations Children's Fund.

UNICEF. (2012a, October 17). *Raising Even More Clean Hands: Advancing Health. Learning and Equity Through WASH in Schools.* Retrieved March 5, 2022, from Even More Clean Hands Web: http://www.unicef.org/wash/schools/files/Raising

UNICEF. (2012b). *Water, Sanitation and Hygiene (WASH) in Schools.* New York: United Nations Children's Fund.

UNICEF. (2012c). *WASH for School Children: State-of-the-art in Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka.* New York: United Nations Children's Fund.

Velicer, W., Prochaska, J., Fava, J., Norman, G., & Redding, C. (1998). Smoking cessation and stress management: Applications of the transtheoretical model of behavior change. *Homeostasis in Health and Disease, 7*(38), 5-6.

Vernon, S., Lundblad, B., & Hellstrom, A. (2003). Children's experiences of school toilets present a risk to their physical and psychological health. *Child: Care, Health and Development*, *29*(1), 47-53.

Waddington, H., Snilstveit, B., White, H., & Fewtrell, L. (2009). *Water, sanitation and hygiene interventions to combat childhood diarrhea in developing countries.* New Delhi: International Initiative for Impact Evaluation.

WHO. (2005). *Sanitation and Hygiene Promotion. Programming guidance.* Geneva: World Health Organization.

WHO. (2011). *World Report on Disability.* World Health Organization. Retrieved Maech 5, 2022, from http://www.who.int/disabilities/world report/2011/en/index.html

WHO, & UNICEF. (2015). *Water, Sanitation and Hygiene in Health Care Facilities: Status in Low and Middle Income Countries and Way Forward.* Geneva: World Health Organization. Retrieved March 5, 2022, from http://apps.who.int/iris/bitstream/10665/154588/1/9789241508476eng.pdf?ua=1

Yamane, T. (1973). *Statistics: An introductory analysis (3rd ed).* New York: Harper and Row.

Submitted:	Revised:	Accepted:	Published online:
October 29, 2021	February 20, 2022	March 11, 2022	May 02, 2022

Analele Universităţii din Oradea, Seria Geografie **XXXII,** no. **2/2022**, pp. **55-62**
ISSN **1221-1273**, E-ISSN **2065-3409** DOI **10.30892/auog.321105-870**

PERCEPTION OF COMMUTERS ON THE QUALITY OF SERVICE RENDERED BY LAGBUS IN LAGOS STATE, NIGERIA

Nurudeen Adesola MALIK*
University of Ilorin, Department of Geography and Environmental Management,
Ilorin, Kwara State, Nigeria, e-mail: today_2009@yahoo.com

Joel Ayodeji ASAJU
Lagos State University, School of Transport, Ojo, Lagos, Nigeria, e-mail: asajua@yahoo.com

Adetoyese Oluwabunmi OGUNTIMEHIN
Lagos State University, School of Transport, Ojo, Lagos, Nigeria, e-mail: oguntimehinadetoyese@gmail.com

Citation: Malik, N.A., Asaju, J.A., & Oguntimehin, A.O. (2022). Perception of Commuters on the Quality of Service Rendered by Lagbus in Lagos State, Nigeria. Analele Universităţii din Oradea, Seria Geografie, *32*(1), 55-62. https://doi.org/10.30892/auog.321105-870

Abstract: This paper examines the perception of commuters on the quality of services rendered by LAGBUS. Lagos state has continously witnessed unprecedented population growth as well as traffic congestion. This growth has resulted to pressure on existing transport infrastructure which necessitated the introduction of LAGBUS by the state government to improve transport service. The study made use of primary and secondary sources of data. The primary data was obtained through the distribution of one hundred and twenty (120) copies of questionnaire to respondents through random sampling technique to LAGBUS users but only 106 copies were returned. Descriptive statistics including tables cross tabulation and charts were used to analyze the data. The findings showed that 92.5% of the respondents have been using LAGBUS for more than a year due to cheaper cost and stable price of travel as compared to other forms of public transport providers in the state. 37.7% and 39.6% of the respondents were of the view that they patronize LAGBUS due to its comfortability (comfort seats) and restriction of preaching and trading respectively. The rating of the services of LAGBUS showed that 88% and 58.5% of the respondents were of the view that their services were satisfactory and regular respectively. Long waiting time is the most challenging problem faced as revealed by 58.5% of the respondents. The study recommends that more buses should be designated to strategic or populated bus stops to reduce passengers' long waiting time as well as the provision of more road infrastructure such as parking space, alternative routes and road expansion.

Key words: Commuters, Congestion, Infrastructure, Public Transportation, Waiting

* * * * * *

INTRODUCTION

Transport is an indispensable elememt of development and socioeconomic growth of any society. Man, nations, regions and the world would be severly limited in development without

* Corresponding Author

transportation which represents an integral part for physical and economic growth (Oyesiku, 2002). The importance of transportation at local, national, regional and global levels perhaps lead to a statement by Mundy (1968) that there is no escape from transport. African cities over the last three decades have witnessed significant population increases. This is mainly due to increased urbanization and rural exodus. It is projected that by 2020 about 55% of the African population will be living in urban areas (African Association of Public Transport, 2010 as cited in Oshodi, 2016). Such fast growing cities including Lagos face mammoth challenges in terms of infrastructure provision and the need to manage increasing demand for transport. Among these problems related to transport are traffic congestion, longer commuting, public transport inadequacy, less public space, accident and safety, environmental impacts and energy (Aderamo, 2012).

With more than 23 million occupants, Lagos is one of the largest cities in the world, and its population is growing rapidly, at a rate of nearly 3.2% per annum (Oni, 2017). The poor state of the road network and of the public transport system affects severely the development of the city and the working and living conditions of the population, particularly the most vulnerable. Rapid growth of the private vehicle fleet, combined with reliance on commercial vehicles and motorcycles including Danfo, Shared Taxis, Okada, Keke Marwa (local name for privately owned public transport) and boat has resulted in extreme traffic congestion all through the city, and poor quality public transport outlook. Sustainable transport development plans have been replacing the conventional approach of building more roads to alleviate congestion with an integrated transport system which is affordable, space and resource-efficient and minimize environmental impacts and nuisance (Badejo 2014). According to Badejo (2007) cited in Afolabi (2016), public transport plays a social role in the urban environment: it improves access to work places and service infrastructure and at the same time, reduces travel expenses. However, the level of its patronage and acceptance depend opn its level of availability, reliability, comfort and safety. Thus, public transport fare, distance to access points and convenience of accessibility affects its choice over private ridership (Eniola and Yingigba, 2018) Both public authorities and transport operators are involved in policy formulation and implementation in relation to transport services. Since public authorities and transport operators have different goals, regulation plays an important role, especially failing competition (Somuyiwa 2010, cited in Afolabi, 2016).

The Lagos metropolitan area, which has attained the status of a megacity, is by far the largest and most complex urban area in Nigeria (Asenime, 2016). According to Aderamo (2010), before 2007 when LAMATA law as regulator was amended and implementation of LAMATA flagship project, BRT-Lite commenced, public transport in Lagos could largely and best be described as unregulated, chaotic, inefficient, expensive, low quality and dangerous, both in terms of road traffic accidents and personal safety. There are about 2,600 km of roads in Lagos that are frequently congested, with over 1 million vehicles plying the roads on a daily basis (African Association of Public Transport, 2010, LAMATA, 2014).

The importance of an effective transport system to any economy cannot be overemphasized. Hence, most governments tend to provide as puts by Oyesiku (2002) that it is an integral part of the government responsibility to its citizens or populace and subsequently improve the public transport system and a megacity like Lagos State is no exception. Lagos being one of the world's largest cities with a population estimated at approximately 17 million with anticipated growth taking it to 25 million by 2025 (Salau, 2015), the population is highly mobile and largely reliant upon public transport; however, the lack of formally organized public transport network has led to gross inefficiencies in its provision and a low level of service to those forced to use it.

Lagos state in the last few decades has also witnessed an upsurge in private car ownership, a situation which has caused decline in the patronage of public transport which in itself is inadequate (Gbadamosi, 2010). While the use of already old and discarded vehicles in Europe and America has been seen as contributing to the increased level of motorization, many vehicles on the highways are highly deteriorated as a result of the age of the vehicles, coupled with bad road condition, unavailability of original spare parts and decreasing level of disposable income of the population as noted by Joseph

(2016). Remote areas are deprived of public transport services, and where public transport services are deemed to be available, commuters are gradually getting accustomed to long queues waiting for buses at bus stops especially at peak periods despite government establishment of LAGBUS (Oni, Okanlawon &Asenime, 2006). The insufficiency of public transport supply hinders economic activities, and increases the cost of transportation in the city of Lagos. Hence, the aim of this study is to evaluate the perception of commuters on the quality of service rendered by LAGBUS in Lagos State.

STUDY AREA: LAGOS STATE

LAGBUS started operations on the 17th of February 2007. It was created out of the experience of Lagos state over the years to assist in alleviating the transportation issues in the state. Ikorodu road is a major expressway connecting the mainland of Lagos to Ikorodu. The road is designated as A1 highway for its entire 24.5 kilometre length (Oshodi, 2016). For most of Lagos portion, it is a four-lane expressway with two frontage roads parallel to the expressway. The expressway crosses other major expressway such as Apapa-Oworonshoki and Lagos-Ibadan expressway. The expressway also hosts many of the Lagos Metropolitan Area Transport Authority's Bus Rapid Transit (BRT) stops and is actually constructing more BRT stops on the route. Lagbus services are very functional along this corridor (Figures 1-2). Hence, the reason for its choice of location.

RESEARCH METHODS

The two sources of data used in the study were primary and secondary. The primary sources involved reconnaissance survey to identify the Lagbus routes. The research instrument used was a structured questionnaire. The questionnaire was designed for commuters along Lagos-Ikorodu route (Jibowu – Ogolonto). The target population centred on the users of the LAGBUS services along this corridor. From the reconnaissance survey and field observation, an average of 1,200 passengers was recorded daily along this corridor from which the 10% sample size was chosen. The study therefore administered a total of 120 copies of questionnaire to the passengers and about 106 (88%) were returned and used for the analysis. The secondary data were collected from LAMATA office, Geography Department of Lagos State University (LASU) and articles in relevant journals and the internet. The data collected were analyzed using tables, cross tabulation percentages and charts.

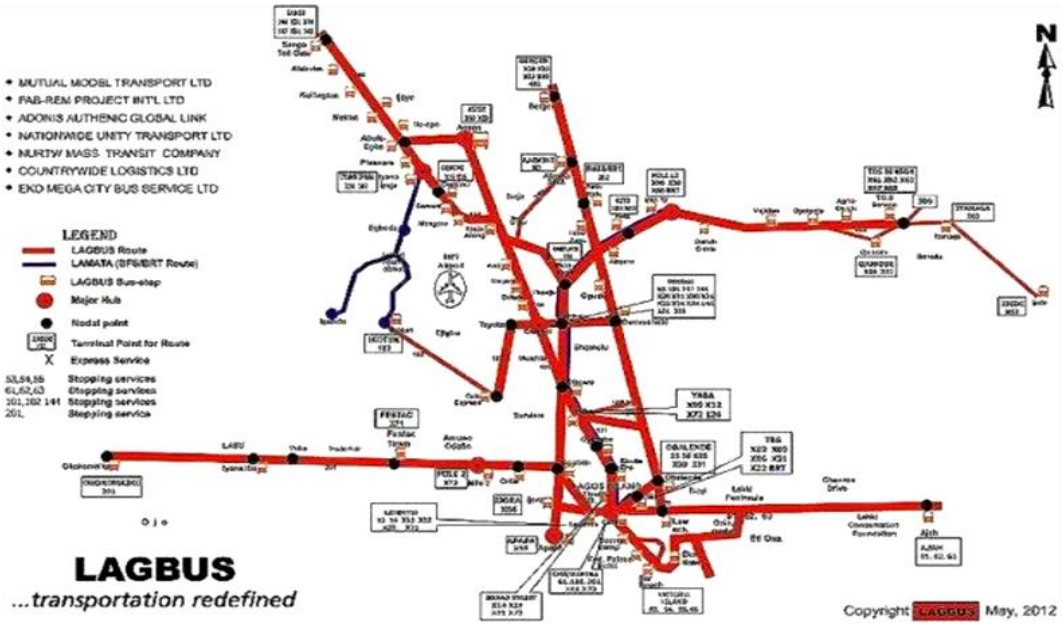

Figure 1. LAGBUS Route map
(Source: LAMATA, 2017)

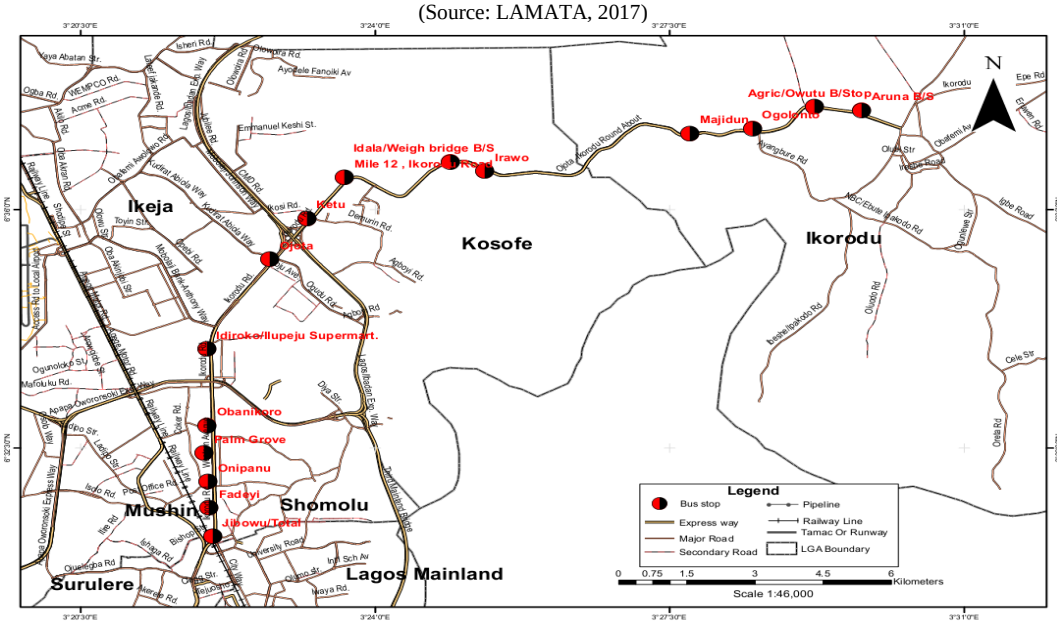

Figure 2. LAGBUS major Bus stops along the study Area
(Source: Geography Department (LASU), 2017)

Socio-Demographic Characteristics of the Respondents

The socio-demographic characteristics of the respondents in table 1 showed that majority of the respondents are male accounting for about 54.7% of the respondents while 52.8% are married. In addition, 75.5% of the respondents are between the ages of 31 and 50 years and 71.7% earn a monthly income between N20,000 and N40,000. Furthermore 34% of the respondents are involved in business while 20.8% and 11.3% are students and civil servants respectively.

Table 1. Socio-Demographic Characteristics of Respondents
(Data source: Researcher Field Study, 2017

Characteristics		Frequency	Percentage
Gender	Male	58	54.3
	Female	48	45.3
Marital Status	Married	56	52.8
	Single	46	43.4
	Others	4	3.8
Age Group	Below 20 Years	4	3.8
	21-30 Years	18	17.0
	31-40 Years	49	45.3
	41-50 Years	32	30.2
	51 Years and above	4	3.8
Monthly Income (N)	Less than 20,000	24	22.6
	N21,000-30,000	32	30.2
	31,000-40,000	20	18.9
	41,000-50,000	10	9.4
	51,000 and above	20	18.9
Occupation	Civil Servant	12	11.3
	Business	36	34.0

	Military/Paramilitary	16	15.1
	Students	22	20.8
	Others	20	18.9

Patronage Level of LAGBUS by Respondents (in Years)

The findings in table 2 revealed that 92.5 % of the respondents agreed to have been using Lagbus for their trip for more than a year while the remaining 7.5 % claimed to have been patronizing the service for less than a year. The Patronage level may be connected to a relatively cheaper cost and stable price of travel accompanied with the level of comfort it affords them compared to other commercial transport providers (Danfo, Taxi, Molue) in the state. Furthermore, this may be connected to the fact that the dedicated route used by LAGBUS provide inftrastructure that are safe, trouble free and efficient which supports Eva and Jana (2013) findings on the importance of infrastructure to efficient transport system.

The respondents were asked on their opinion for using Lagbus. The findings revealed that 37% of them make use of the Lagbus because they have a segregated route which enables the passengers to get to their destination on scheduled time. Also, 26% however choose to use the buses for its comfort ability and convenience relating it to the seats being more preferred and spacious when compared with other commercial buses. Furthermore, 14% of the respondents claimed to patronize the service because it is affordable. The remaining 13% and 11% of the respondents agreed that it is as a result of its reliability and safety respectively (Figure 3).

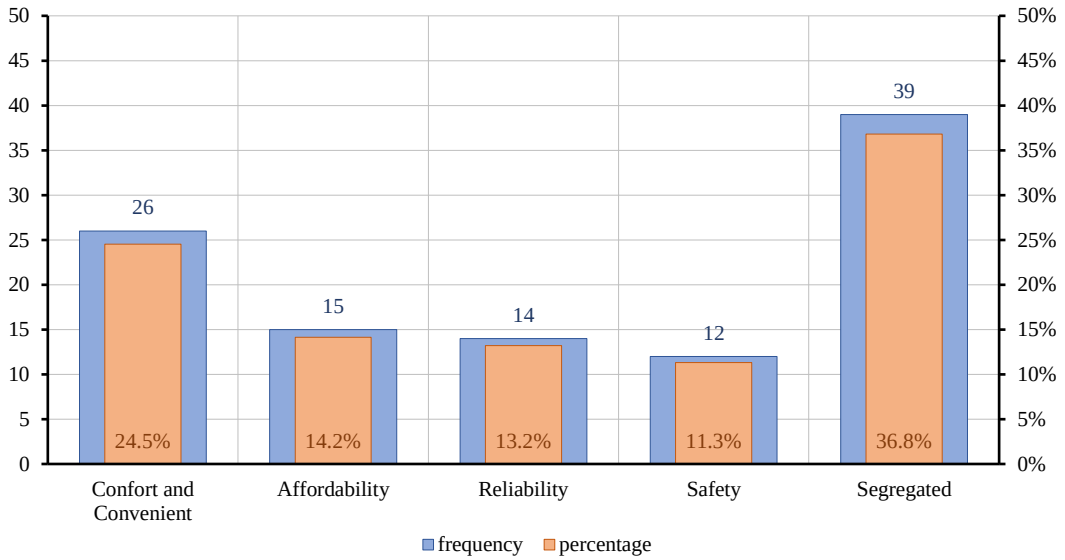

Figure 3. Factor considered by Respondents for Lagbus Patronage
(Source: Researcher Field Study, 2017)

Table 2. Level of Patronage of LAGBUS by Respondents (in Years)
(Data source: Source: Researcher Field Study, 2017)

Patronage Level (in Years)	Frequency	Percentage
Less than a Year	8	7.5
1-3	56	52.8
4-6	36	34.0
7 and above	6	5.7
Total	106	100.0

Respondents Length of stay at Bus Depot and their Perception on Reason for Using LAGBUS

The responses in table 3 showed that 16 (15.1%) and 64 (60.4%) of the respondents had waiting time of less than 20 mins and between 21 and 40 mins respectively. In addition 22.6% and 1.9% of the respondents agreed that they wait for an average of between 41 minutes and 59 minutes and above 1 hour respectively. However, majority of the respondents expressed dissatisfaction having to wait for long periods before buses arrive especially as most boarding points do not have shelter for protection against the rays of the sun as well as heavy downpour (rainfall).

Table 3. Respondents length of stay and Reasons for using LAGBUS
(Data source: Source: Researcher Field Study, 2017)

Responses	Frequency	Percentage
Less than 20 minutes	16	15.1
21-40 minutes	64	60.4
41-59 minutes	24	22.6
1hr and above	2	1.9
Total	106	100.0
Reasons for using LAGBUS		
Air conditioner	2	1.9
On Bus Entertainment	8	7.5
Comfort seats	40	37.7
Restriction on Preaching& Trading	42	39.6
All of the above	14	13.3
Total	106	100.0

The respondents' perception on the reasons for choosing Lagbus showed that 39.6% of them patronize the services of Lagbus due to the restriction placed on preaching and trading in the bus unlike other buses including Danfo and Molue buses. Also, 37.7% of the respondents preferred their services for the comfort it offers in terms of seats and the spacious nature of the bus. Other facilities enjoyed by the respondents include air conditioner bus and on-bus entertainment as it accounted for 1.9% and 7.5% respectively. It is important to note however that in recent times most of these LAGBUS buses do not have air conditioners as well as on the bus stereos. However, despite this, most respondents still patronize the services of the Lagbus because of the seat comfort ability as opposed to the usual overcrowding in the Danfo or Molue buses. In addition, the restriction on preaching and training in LAGBUS buses satisfies the respondents.

Rating of LAGBUS Services and Challenges faced by Commuters

The challenges faced as revealed by respondents for patronozing Lagbus showed that 58.5% of the respondents identified long waiting time at bus terminals while 20.8% of them indicated that no provision for seat while waiting as the major challenge faced. The long waiting time might be connected to inadequate buses as compared to the number of commuters patronizing the service of Lagbus, Other challenges faced according to the respondents include: non challant attitude of the staff (7.5%) and inadequate ticketers (1.9%). Table 4, further revealed that 58.5% of the respondents describe availability of buses as regular while 30.2% claimed that the availability of the buses are irregular. This implies that the respondents still prefer to use the services of the Lagbus due to its comfortability and regularity than other forms of commercial/public transport services in Lagos state.

Furthermore, commuters were requested to express their opinion on the services rendered by Lagbus using a 5 likert scale. The scale range on the quality of the services provided by LAGBUS.The ranking by respondents revealed that about 55% of the respondents were of the view that the services as satisfactory (good and very good). This rating might by respondents might be

linked to some comfort available to them (comfort seats, ban on trading) that are common to other forms of public transport like Danfo and Molue. Furthermore, the findings in figure 4 showed that 33% of the respondents rated their services as average. However, 13% of the respondents were of the view that their services are not good enough (bad) based on their personal experiences with the bus.

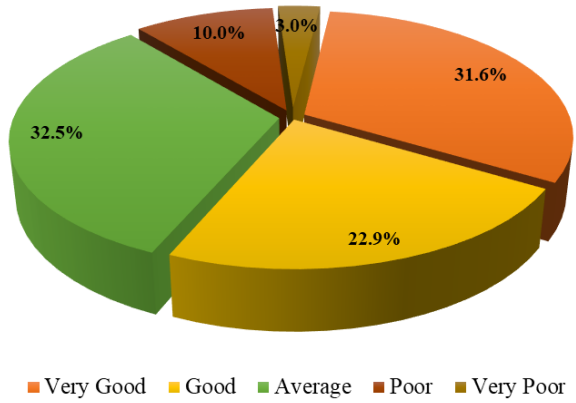

Figure 4. Respondents' Rating of Lagbus Services
(Source: Researcher Field Study, 2017)

Table 3. Challenges of Commuters and Regularity of LAGBUS Services
(Data source: Source: Researcher Field Study, 2017)

Responses	Frequency	Percentage
Challenges faced by Commuters		
Inadequate Ticket	2	1.9
Non-challant attitude of staff to passenger	8	7.5
Rude behaviour by officials to Passengers	6	5.7
Long waiting time	62	58.5
No place to sit while waiting for the bus	22	20.8
All of the above	6	5.7
Total	106	100.0
Regularity of LAGBUS Services		
Regular	62	58.5
Irregular	32	30.2
Occasionally	4	3.8
Indifferent	8	7.5
Total	106	100.0

CONCLUSION

This study has shown that the residents in the study area enjoyed using LAGBUS because of restriction on bus preaching and trading, reduction in cost and time of travelling to their destinations. However, despite these advantages there is need for improvement (in terms of Lagbus services) in order to enhance a better public transportation system in the study area. Furthermore, the assessment of the services of Lagbus can be said to be good as they have contributed immensely to the growth and development of public transport system in the state by providing mass transit for Lagosians at affordable costs and phase out the rickety molue and danfo buses. However, these can be improved upon when all the challenges identified by commuters are addressed.

The study therefore recommends that: LAGBUS management need to work strictly with the Lagos State Traffic Management Authority and other related agencies to ensuring peak period traffic congestion is addressed as it will improve the effective distribution and free movements of the buses

thereby reducing turnaround time. The management also needs to study the peak hour traffic situation to provide traffic interventions. More buses should also be designated to strategic or populated bus stops to reduce passengers' long waiting time; the company should strike a balance between profit-oriented approach and customer satisfaction based operation by interacting more with the passengers of LAGBUS via adverts, promotion offers and government should look at PPP (Public – Private - Partnership) in order to better the public transportation in the state.

REFERENCES

Aderamo, A. J. (2010). Transport in Nigeria: The Case of Kwara State. *African Economic and Business Review*, *8*(1), 19-40.

Aderamo, A.J. (2012). Spatial Pattern of Road Traffic casualities in Nigeria. *Mediterranean Journal of Social Sciences 3*(2), 23-25

Afolabi, O.J. (2016). Commuters Perception and Preferences on the Bus Rapid Transit in Lagos State. *JORIND,* 34-40.

Asenime, C.O. (2016). Bus Rapid Transit and Mobility in Lagos Mega City. *IRF Bulletin Special Edition: Urban Mobility*, 24-25.

Badejo, B.A. (2014). Transporting the Future Portrait of Nigeria. 65th Inaugural lecture, Olabisi Onabanjo University, Ago-Iwoye, Nigeria.

Eniola, O., & Yingigba, C. (2018). Analysis of Traffic Congestion in Lagos/Abeokuta Expressway, Agege Motorway in Lagos Metropolis. *Journal of Environment Earth Science*, *10*(4) 20-024

Eva, I., & Jana, M. (2013) Importance of Road Infrastructure in the Economic Development and Competitiveness. *Economics and Management*, *18*(2), 263-274

Gbadamosi, K. (2010). An Evaluation of the Impact of Bus Rapid Transit in Urban Intra-city Passenger Movement in Lagos. WTCR 2010. Lisbon.

Joseph, C.M. (2016). Wise Cities (A Glocal Think Tank Network). Wise Cities: A new paradigm for urban resilience, sustainability and well-being.

LAMATA (2014) Report on the success story of Lagbus

Mundy, D. (1968) Transport, Harmondo North, Middlesex England: Penguin Books

Oni, P.S. (2017). A Spatio-Temporal Restucturing of Transportation System in Nigeria. Lagos: University of Lagos Press and Bookshop Ltd.

Oshodi, L. (2016). Transportation and Mobility System in Lagos. Retrieved from https://www.google.com.ng/amp/s/oshlookman.wordpress.com/2016/08/12/transportation-and-mobility-system-in-lagos/amp/

Oyesiku, K. (2002). Sustainable Transportation Strategies on intermediate cities in Nigeria. *Journal of the Nigerian Institute of Town Planners*, *5*(2), 15

Oyesiku, O.O. (2002) *From Womb to Tomb* 24th Inaugural Lecture at Olabisi Onabanjo University on 27th August, 2002, Ago-Iwoye. Olabisi Onabanjo University Press.

Oni, S.I., Okanlawon, K.R., & Asenime, C.O. (2006). Institutional Framework for the Transformation of Transport Administration in Metropolitan Lagos. In R. A. Babawale, An Agenda for a New Nigeria "The Imperative of Transformation" (pp. 421-436). Concept Publications Limited.

Salau, T. (2015). Public Transportation in Metropolitan Lagos, Nigeria. *Analysis of Public Transport Users'Socioeconomic Characteristics. Urban, Planning and Transport Research*, *3*(1), 132-139. doi:10.1080/21650020.2015.1124247

The Systems Approach. (n.d.). Retrieved from http://www.landscapemanagementsystem-management/systems.html

Submitted:	Revised:	Accepted:	Published online:
December 20, 2021	March 7, 2022	June 8, 2022	June 27, 2022

Analele Universităţii din Oradea, Seria Geografie
ISSN **1221-1273**, E-ISSN **2065-3409**

XXXII, no. **1/2022**, pp. **63-73**
DOI **10.30892/auog.321106-877**

IMPACT OF URBAN EXPANSION ON URBAN TRANSPORT IN THE CITY, STUDY CASE: CITY OF BORDJ BOU ARRERIDJ, ALGERIA

Derradji KADRI*
Assistant Professor A, University of Mohamed Boudiaf, M'sila e-mail: derradji.kadri@univ-msila.dz

Boudjemaa KHALFALLAH
Professor of higher education, University of Mohamed Boudiaf, M'sila e-mail: boudjemaadz@yahoo.fr

Citation: Kadri, D., & Khalfallah, B. (2022). Impact of urban expansion on urban transport in the city, study case: city of Bordj Bou Arreridj, Algeria. *Analele Universităţii din Oradea, Seria Geografie*, *32*(1), 63-73. https://doi.org/10.30892/auog.321106-877

Abstract: Urban transport is one of the most dynamic and a vital element within the urban sphere, as it has a significant impact on the growth and development of cities in all respects; it determines the size and direction of urbanization and directs it properly as well. Bordj Bou Arreridj is an Algerian city that witnessed a spectacular urban expansion, which resulted in great difficulties in terms of urban transport. This resulted in the inability to fulfill the role assigned to it, especially with regard to the urban expansion of the city, given the insufficient means of urban transport, especially collective ones - Old urban bus barns – and thus, meeting the growing demand for transport due to the large demographic growth. In addition to that, the fragility of the urban transport system as a whole has led to lack of harmony and interconnectedness of all parts of the city, and to the imbalance in the management of the sector. The study concluded that the urban area of the city is characterized by an important network of roads and streets that ensure good connectivity between its parts, but the existing urban transport network does not cover all its components (49% is the covered area in the city), as some areas lack urban transport service, especially those located on its suburbs as a result of the rapid urbanization. In order to redress this phenomenon, it was necessary to reconsider the general urban transportation system on both management and organizational sides, taking into account all urban components of the city, especially future expansions, in order to reach a harmonious and interconnected city under a balanced and effective transportation system.

Key words: urban expansion, urban transport, city, Bordj Bou Arreridj

* * * * * *

INTRODUCTION

Transportation is an important part in most of the ancient societies, and will remain so in the future. Transportation and its systems are an accurate measure and an equitable indicator of the extent of the development and growth of states and peoples.

Urban transport is also one of the main pillars of the peoples' daily lives of any given city, as it greatly contributes to the evolution of societies, boosts economy and bolsters social prosperity.

* Corresponding Author

However, it has witnessed, at the present time, the world cities deeply suffer from many complex problems, including traffic jam and high levels of pollution in urban centers. Those problems became more and more drastically alarming because of the excessive increase in the population of the city urban centers, causing motionless as well as creating suffocating condition in the streets due to the traffic congestion, which forced residents of
city centers to spread around the outskirts. This situation widened the urban area of the outskirts, which in return, made it difficult to link outskirts to each other, as well as to the city center ,leading to the emergence of areas that enjoy vitality and dynamism; an advantage that other parts unfortunately don't.

The city expansion and its urban development cannot possibly happen without an effective urban transportation system that connects all parts of the city to each other. In many modern studies that deal with subjects related to transportation and mobility within urban areas, researchers have urgently raised topics that aimed primarily at improving the conditions for the better movement of persons within the urban area.

The main purpose of this study is to determine the causes of the deterioration of urban transport and the extent of its impact on the urban expansion of the city; and therefore, to highlight the interactive relationship between urban expansion and urban transport.

MATERIALS AND METHODS

To accomplish this study, the descriptive approach has been adopted to accurately describe the phenomenon by supporting the study theoretical section with concepts and fundamentals using a set of different references, as well as a data analytical approach. To collect and analyze these data, the focus was on field investigation "survey method" through a question form and interviews, especially with administrators and officials specialized in transportation, as well as the simple observation. As for the selection of the samples, two methods were followed; the first one is a selected sample that represents both private and public urban transport workers (196 forms), and the second one, a random sample representing urban transport bus users. So we relied on a 15% proportion of the number of passengers per urban bus, the sample size was as follows:

E = N x 15%

E: The sample volume

N: The number of places available in buses.

Hence, the sample size was 1477,80 ~1500 Form

In order to study the phenomenon of the general trend of the city's expansion spatially, we relied on the spatial analysis of geographic information systems, using the ArcGIS program, where we will obtain the oval shape of the standard deviation (Dr Rasha Sabar Nofal, 2020), which determines the direction and size of urban expansion.

RESULTS

This element is to present the results of the field work by diagnosing the reality of urban transport in the city of Bordj Bou Arreridj in light of the great urban expansion that it is witnessing, so the work was made on two levels; the first one, related to the urban aspect, and the second one, deals with the urban transportation. Then, the findings will be discussed.

The city of Bordj Bou Arreridj is an Algerian city, located on the western side of the eastern high plateaus between longitudes 4°44' and 4°47'50" East and latitudes 36°02'55" and 36°05'40" North, with an altitude of 928 Meters from sea level, on an area estimated at: 18.93 km², bounded by:

North: Ain Zerika village. East: Akhrouf village and the southern village.

South: Solite village. West: Lashbour village (Figure 1).

What distinguishes the field of study Bordj Bou Arreridj is its diversity of agricultural and industrial activities, equipment and service (Nacer, F & Dridi, H. 2021) on the one hand, and on the

second is the good connection with road facilities especially the east-west highway with a length of 92 km, in addition to the national roads N°05, N°45, N°76 and N°106, and a set of state roads N°42, 43 and 44. The city has a strategic position in regional and national relations, linking the East with the West and the North with the South. This connectivity had a clear impact on the dynamic movement within the city, in addition to the city being an industrial pole par excellence, as it is considered the capital of the electronic industry at the national and even African level, which highlights the large volume of movement within it.

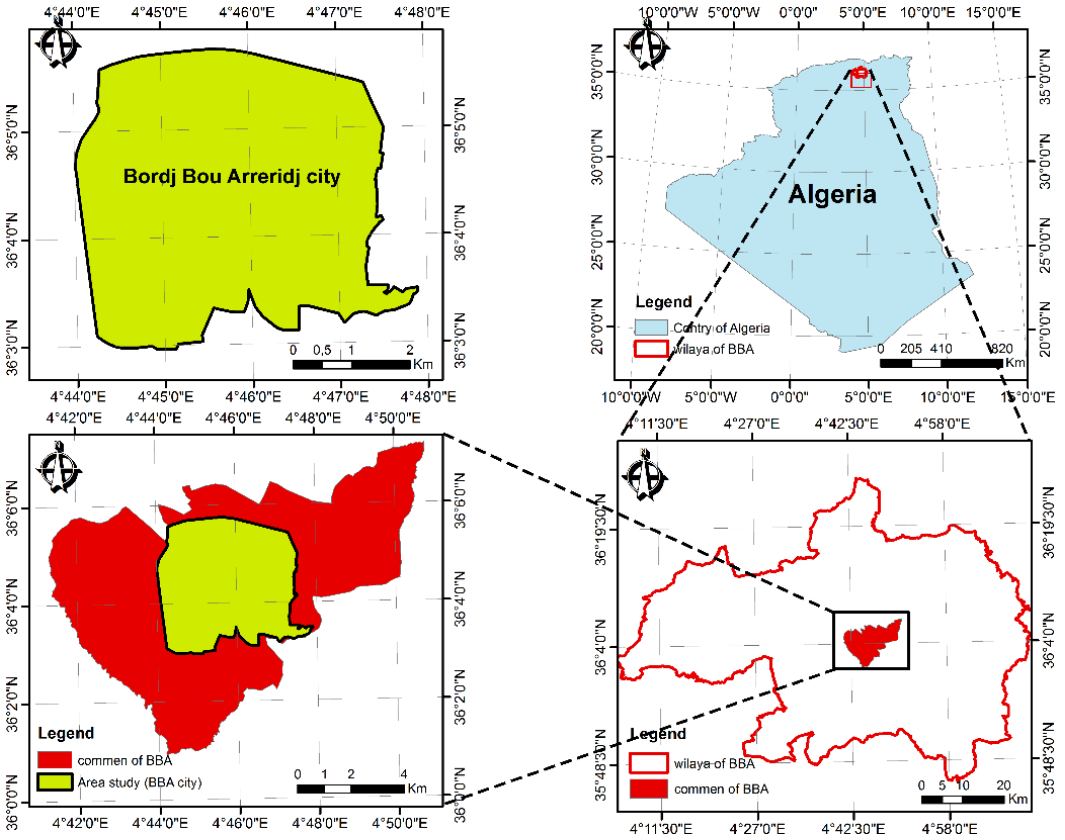

Figure 1. Location of the field of study City of Bordj Bou Arreridj
(Source: Treatment of the researchers, 2019)

The general plan of the city is of the planned type where the government intervene in directing, organizing and equipping the urban construction with public utilities (Abdallah A, 2001)

Defining the general plan of the city of Bordj Bou Arreridj is somewhat difficult at first glance, but one can find out that it is about a clear radiographic plan, as there is the city center, from which all the main roads branch radially, with semicircular streets crossing these roads.

The general structure of the city depends mainly on five main axes; which are the national road N° 05 that connects the east and the west, called Houari Boumediene Street, the national road N°76 linking the city to its north, the national road N°45 linking the city and its south, the national road N°106 that connects the city to Bejaia, the state road N°42, which also connects the city to its south, in addition to the municipal road linking Bordj Bou Arreridj and Bir al-Sanab; the city is structured on these major axes. While all other secondary roads are combined for traffic in the city, which gave these roads great importance, both in terms of urban organization and traffic.

These roads are the axes that direct the urban growth of the city. most of the commercial, service and even industrial activities are concentrated on them, which made movement on them very intensive, increasing their capacity, and increasing pressure on them, making it difficult for residents of some neighboring areas to reach their homes or places of work without delay (The master plan for the preparation and reconstruction of Bordj Bou Arreridj-Final Report, 2014).

Urban expansion consists of a rational expansion out of the city whether horizontally or vertically, and a natural reflection of the growth and the city increasing needs for new areas, in order to meet these needs in the short, medium and long term (Abdel Fattah M.O, 2003).

The first nucleus of the city of Bordj Bou Arreridj was formed in the city center since the colonial period, then the city witnessed a rapid urban expansion after independence in all directions, and some chaotic neighborhoods appeared, after that, the first urban residential area appeared in the east, west and the northern side, after which the urban growth of the city stopped in the east, south and west, due to the obstacles preventing urban sprawl (Figure 2).

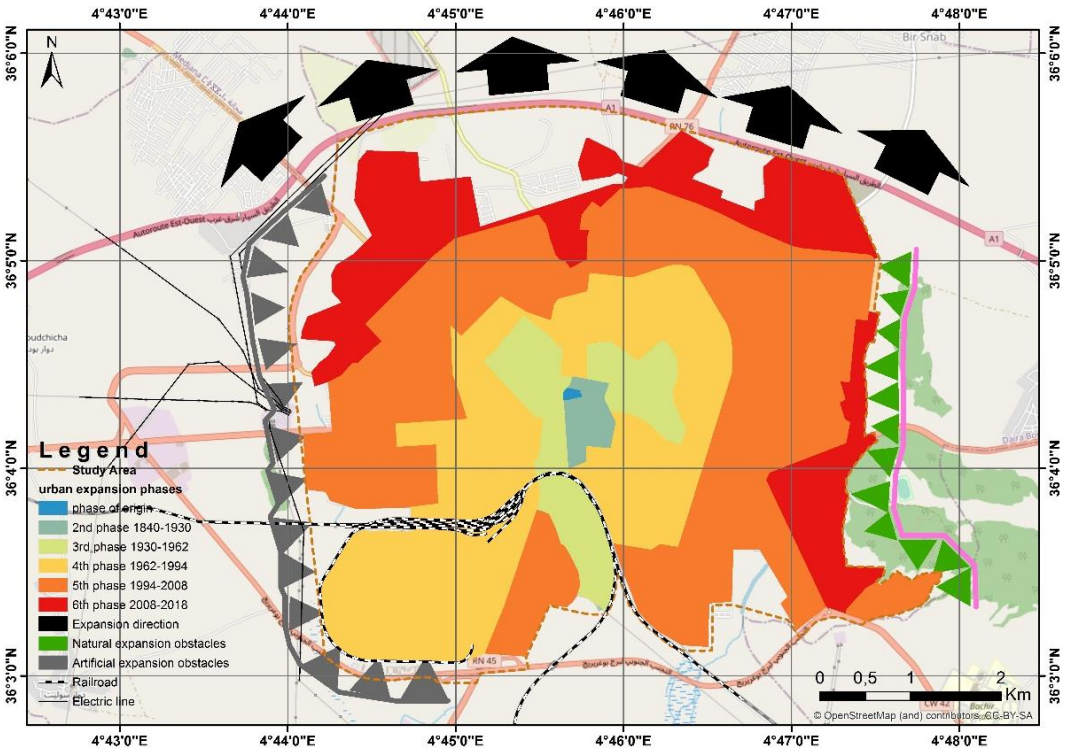

Figure 2. The Phases of urban expansion of Bordj Bou Arreridj city -Directions and obstacles-
(Source: Treatment of the researchers 2019)

The analysis of the physical characteristics of the road network in Bordj Bou Areridj is based on the collection of information and observations from the field. The analysis includes the number of roads and the direction of flow, the width of the roads and sidewalks and the condition of the roads and sidewalks coverage. In our research, we relied on statistics taken from the traffic plan for the city of Bordj Bou Areridj, giving us some indicators on the current road conditions.

The city of Bordj Bou Areridj includes an important network of roads that qualifies it to play a major role in the development of the national economy and connects it with the various neighboring provinces. The length of the urban network is 303.50 km, in addition to the East-West

Highway that passes along the city of Bordj Bou Areridj from the north side; these roads are distributed as follows:

- Main roads**:** which guarantee the connection between the city and its surrounding areas and allow linking the distribution roads.
- Distribution roads**:** allow connection or exchange between the city center and the rest of its surrounding neighborhoods.
- Interconnection roads**:** allow access to residential neighborhoods. This type of network has no difficulty in moving.

The spatial analysis using GIS technique, where the oval shape of the standard deviation appears, and depending on the structured roads of the city, the trend of the expansion phenomenon towards the northwest with an angle of inclination of 105 degrees (Figure 3).

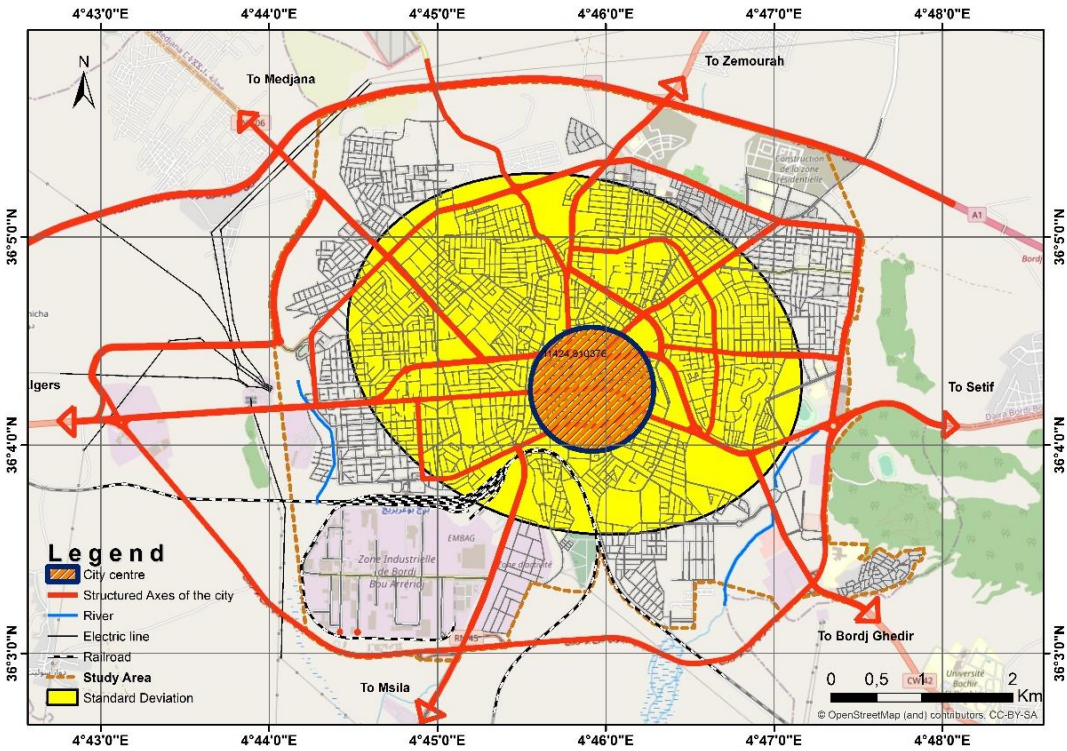

Figure 3. City plan and the trend of expansion (Standard Deviation)
(Source: Treatment of the researchers 2019)

The condition of the sidewalks is mostly good, but during the frequent field visits, especially inside the urban center, we noticed some bad behavior from vendors who display various commodities along with the sidewalks, which makes it necessary for pedestrians to walk on side of the road, causing injuries and accidents.

The city has a large number of roads and streets with different mechanical movement in their directions, which are subject to the traffic system in the city on one hand, and to the daily activities of residents and attractions on the other hand, most of which are in the city center.

In the field inspection of the various roads, we found that the mechanical movement is concentrated in high density along Houari Boumediene Street, as it is the main axis (formerly National Road N°05) and along August 20 Street, Prince Abdelkader Street, and Abdelkader Al

Bariki Street. In addition to the national road N°106, the national road N°45 towards the activities zone, the northern, and the southern avoidance roads (heavy weight roads).

The city is a hotspot that causes a lot of traffic accidents and extends the waiting time, the road infrastructure and the transport network have not been able to handle traffic flow, especially during rush hours.(Abdelmoumene, M., & Mahdi, K. 2020), this is due to the absence of well-studied ,or even special lines that allow the movement to be distributed and directed.

Due to the centralization of the various facilities intended by most of the residents of the city center on Houari Boumediene Street, the density of pedestrian traffic is high in this area and its vicinity, the conflicts of pedestrian /mechanical movement (causes of traffic accidents).

To find out the density of pedestrian movement in places crowded with residents, we conducted a field survey of some of these areas:

- Near of the market: highly crowded with pedestrian movement caused by shoppers;
- Said Zarooqi High School (Entry and exit of teachers and schoolboys),
- The municipality (City Hall) of Bordj Bou Areridj
- Bouzidi Lakhdar and the August 20 stadiums (in time of sports demonstrations).

There is a collective urban transport barn in the city of Bordj Bou Arreridj, with 196 buses distributed on both private and public customers (Table 1):

Table 1. Collective urban transport barns
(Data source**:** Transportation Plan Final Report, September 2019, p. 5)

	Number	Number of Vehicles	Number of Available Places
Private Customers	158	176	7816
Public Customers	001	020	2036
Total	159	196	9852

There is a barn for this number of new and old mass transit buses. Although this barn came into service 14 years ago on average, it is somewhat old. Only 61% of the barn area is in service: This reflected negatively on the urban transport service, in addition to its many faults, which affects the control of covering the needs of transportation in a fixed size, especially at peak times.

The urban transport planning process aims at laying down the necessary rules to ensure the permanent stability of transportation systems compatible with the continuous urban development in accordance with programs and goals that meet as much as possible the residents' desires to move smoothly, safely, and with an appropriate level of service (Sabah, 2002)

Fourteen (14) lines, distributed cover the urban transport network in Bordj Bou Arreridj. According to specific directions, some lines are saturated and others limited (Table 2):

Table 2. Lines and directions of urban transport in Bordj Bou Areridj city
(Data source**:** Transportation Plan Final Report, September 2019, p. 5-10)

Line N°	**Origin**	**Path length**	**Destination**	**Bus stop**
01	the University	7 Km	Northern Village	15
03	700 dwellings avenue	10 Km	Axis of rotation Philips	15
05	Passenger transport terminal	9 Km	Industrial zone	16
06	Boumzoug Bashir district	8 Km	Northern Village	22
07	Ouine Zerika	10 Km	700 dwellings District	16
09	Hadaj flats	17 Km	Passenger transport terminal	20
10	Ain ben Oumrane, eastern side	7 Km	130 housing District	21
14	Ain ben Oumrane, western side	5 Km	City1008	7
15	Farhat Abbas High School	11 Km	Passenger transport terminal	31
16A	Passenger transport terminal	14 Km	Passenger transport terminal	33
16B	Passenger transport terminal	13 Km	Passenger transport terminal	29

1A	the University	8 Km	northern village Ouine Zerika	16
3A	El amasser	5 Km	Abdel Moumen Elwiam tunnel	11
12A	700 dwellings	9 Km	Northern Village	25
14 urban lines		**133 Km**		**277**

Through the field research conducted on the first category of the "private and public" transporters sample, estimated at 196 buses, it was noted that most of lines are very appropriate except for 39%; This category represents the connecting tracks between the city center and the suburbs, due to the overlapping of the lines, in addition to the presence of unprepared parking spaces, most of which are located on the road sides, and some random parking spaces (table 3).

Table 3. Transporters' opinion on the used line
(Data source**:** Investigation Field (Researchers, 2019))

Line	Number of buses	Rate %
Appropriate	120	61
Inappropriate	76	39
Total	196	100

However, the number of buses is considered insufficient due to the increasing demand for transportation caused by the great demographic growth that the city is witnessing on one hand and the expansion of its geographical area on the other hand; so it is necessary to reconsider the number of buses and the organization of lines .

There are two types of plans for the management and organization of urban transport in the city. The first one is overall, which is the transport plan according to (Law N^{o} 01-13, 2001) and it is defined as a technical means in which field programs and investments are established in studied time horizons, and the management of various transport systems which is more comprehensive than the study of base structures, and The second traffic and circulation plan was completed according to (Law N^{o}01-14, 2001) and aims to regulate movement and traffic within the geographical area of the city.

According to the table 4, the first most used means of transportation by urban transport users is the bus, as being an appropriate and popular means for people with limited income, at 60%. Then, walking comes second at 20%, and the taxi at 15%, that the high-income category uses the most, eatch type of transport has its own gathering and dispersion areas (Atoui, 2001)

Table 4. The means used for transportation
(Data source: Investigation Field (Researchers, 2019)

Means of transportation	Sample	Rate %
Bus	900	60
Taxi	225	15
Walk	300	20
Other	75	5
Total	1.500	100

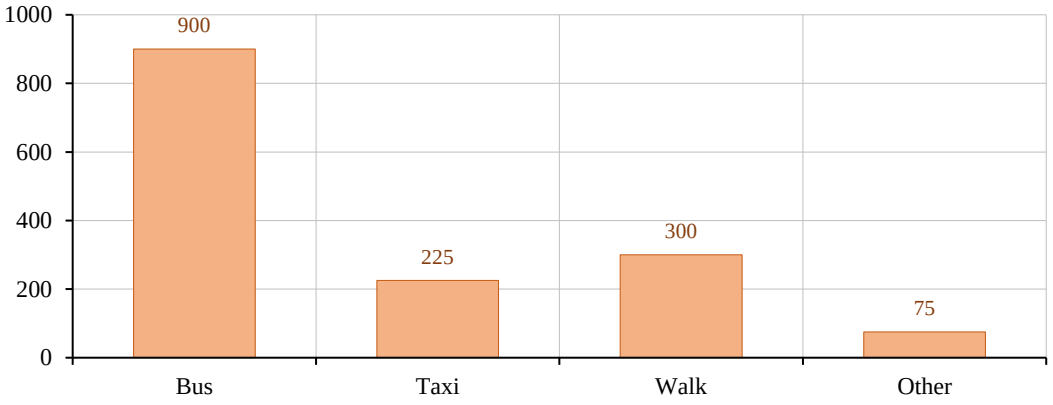

Figure 4. Means used by Users of urban transportation
(Source: Treatment of the researchers 2019)

The house-work transportation constitute most of the movements within the city, especially during peak hours, there the workers choose the type of means of their transportation, which depends on their financial condition and the distance traveled (the private car, or the collective transportation), In the second place come the transportation for study. Primary school students move on foot to near the education centers. As for university and secondary students, they use mechanical means of transportation, most of which are mass transit buses, then comes the transportation for other purposes such as shopping, treatment and picnics (Ali, 1994) (Figure 5).

The return to modes of transport public was more than necessary to reduce the effect of the "all car" (Diabi et al ,2021)

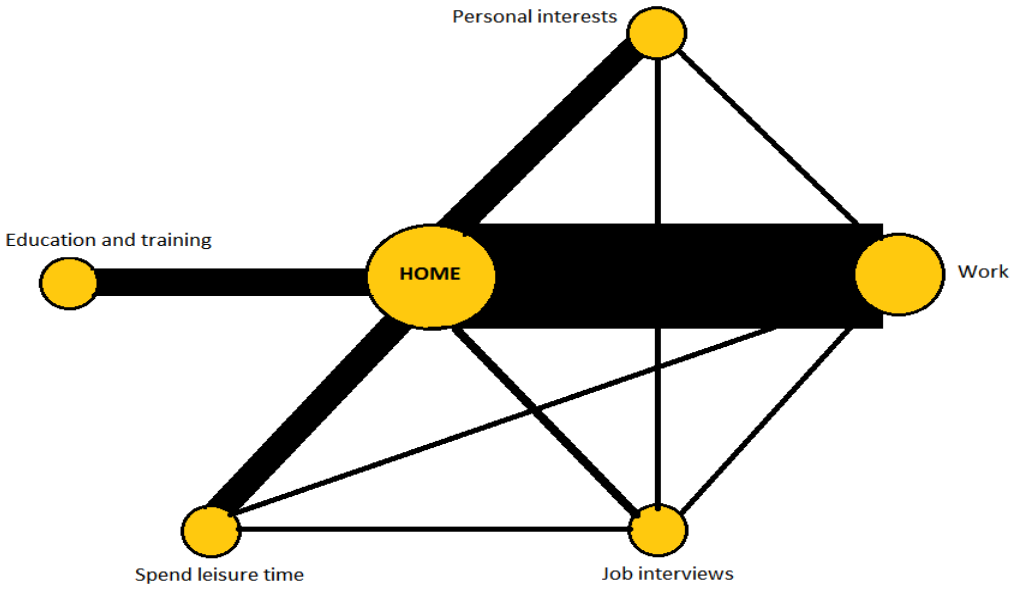

Figure 5. The most important urban transportation within the city
(Source: Ali M.A .H,1994)

The most of the daily movement of the population revolves mainly around a work-study-shopping triangle where we find that 41% of the studied sample move for work, the category of students comes second at 22%, then that for shopping purposes in third place at 19% (Table 5).

Table 5. Reasons for daily travels
(Data source*:* Investigation Field (Researchers, 2019)

Reason	Sample	Rate %
Work	615	41
Study	330	22
Treatment (Health)	180	12
Shopping	285	19
Picnics	90	6
Total	1500	100

Through the field research that we conducted on the studied sample, it became clear that there are three categories of inhabitants on the outskirts of the city; the first category, that includes residents who live in the area between the city center and the periphery represents 17% declared that transportation is available. The second category that includes residents who live in the nearby representing 23%, indicates that the transport service is available but not enough sufficient. Those who live in the far suburbs, at 53%, represent the largest and most affected category from urban transport services; they complain that there is no means of transportation (Table 6).

Table 6. Availability of suburban transportation
(Data source: Investigation Field (Researchers, 2019)

Opinion	Sample	Rate %
Available	250	17
Available but not enough	350	23
Not available	800	53
No answer	100	7
Total	1500	100

Urban transport affects and is directly affected by the expansion of the city and its urban growth; it is considered as the main factor in linking the various segments of society, and has also a major role in linking all parts of the urban environment with each other (linking the center with the outskirts of a given city and linking the outskirts with each other), achieving thus coherence and harmony in the city, and suppressing marginal or isolated neighborhoods.

The absence of lines on some important axes, obliging the residents to walk a long distance to get the bus stop they need, or to use taxis to reach their destinations. Although this network has a significant (14 lines, 196 buses), it only covers 49% of the total area of the city, i.e. 51% is not covered by urban transport services (Figure 6, Table 7).

Table 7. Urban transport network and coverage ratio
(Data source: Investigation Field Researchers, 2019)

Coverage ratio %	Covered area	Total area city	Length (km)	N° of buses	N° of lines
49	10.80 Km^2	22 Km^2	133	196	14

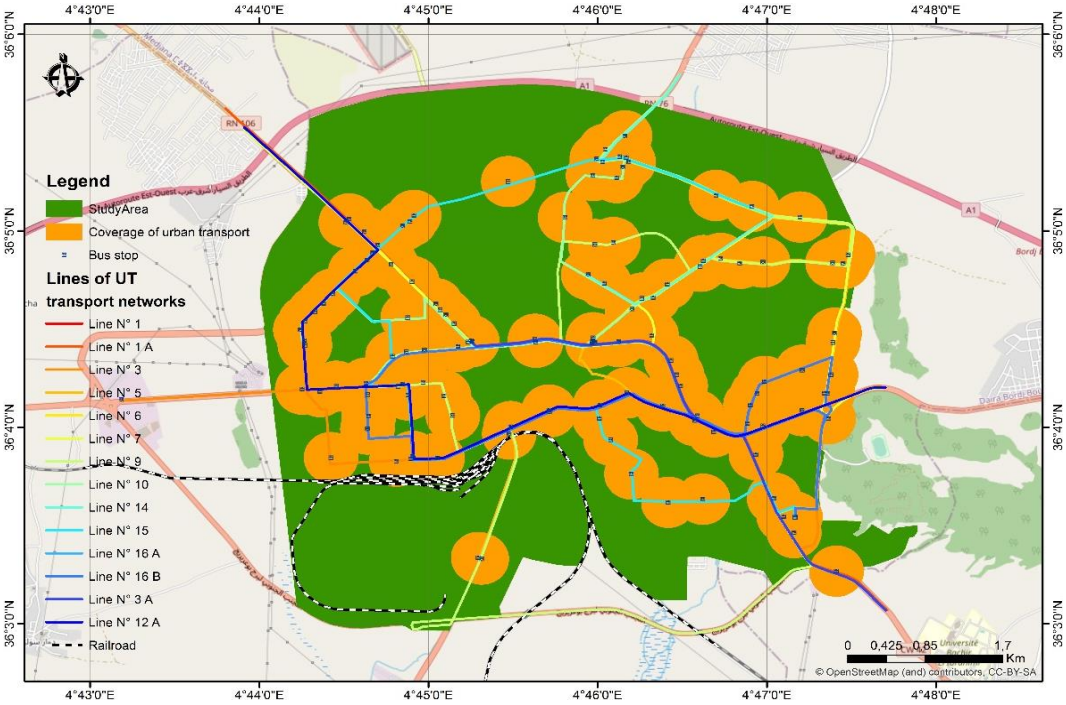

Figure 6. Coverage of urban transport networks in Bordj Bou Arreridj city
(Source: Treatment of the researchers 2019)

In order to reach a balanced urban development, it is necessary to know the extent of the disruption of this system suffers from in order to draw up a strategy that achieves a state of harmony among its components in order to reach a developed urban system (Achraf, 2021)

The goal of development of urban public transportation today is not only to meet the required traffic capacity, but also to improve the quality of service, in order to provide secure, fast, comfortable, and convenient transportation (Huiyu and Hongwei. 2020).

The transformations that currently characterize urban mobility (increase in the distances to be traveled and in the number of trips, improvement in the quality of the means of transport, etc.) are concomitant with urban dynamics (densification, sprawl, etc) (Ndeye, 2021).

DISCUSSION

The city is growing and expanding on the north and north-west (105-degree standard deviation) because there are natural obstacles on the east side such as the forest and on the south is a flood zone, and an artificial one on the west such as high-tension power lines,

This expansion has generated a great demand for urban transport, especially collective transport, as the available means transport (196 buses) is insufficient to respond at the increasing demand, which is explained by the low coverage rate estimated at only 49% of the urban area, while the largest percentage (51%) Not covered by urban transport services. The absence of lines on some important axes, obliging the residents to walk a long distance to get the bus stop they need, or to use taxis to reach their destinations.

Lack of accuracy in choosing the lines for the collective transportation, as we find some of them reach saturation such as overlapping lines that pass through the urban center, while others are almost rare like those at the edges.

The old urban bus barns as the average age approximates 14 year, has significantly affected at the level of service (lack of comfort, and long trip time) reducing the use of this mode, and forcing some users to change the mode of transportation either by car or walking

The poor organization of the urban transport network in the city and the absence of transportation lines at suburbs, which makes it difficult for people to move around.

Reluctance of some private transporters to occupy the urban lines for the suburbs, on the pretext that there is little demand for transportation.

Absence of a specialized official body to supervise urban transport (the Directorate of transport is responsible for granting operating licenses only).

Accordingly, the results of the analysis have been included in the form of a general conception of the city plan, in which the extent and relationship between urban expansion to urban transport is highlighted, as the bigger the geographical area of the city, the somewhat less urban transport service becomes.

CONCLUSION:

This study concluded that urban transport affects and is affected by the urban expansion of the city, and that their relationship is complementary, as the urban transport network is the driving element in the city; it embraces most of the daily activities of the population, and bears a great pressure that exceeds its capacity in most cases, and the transport network extends over the most important traffic axes that cover all the urban fabric of the city. However, the deficit in the field of urban transport remain on the table, whether it is related to the insufficiency of its means or to the weakness of its system in achieving harmony and interconnection between the city center and the suburbs, which hinders urban transport in general from achieving its ultimate goal of linking parts of the city to each other to facilitate movement within it.

The study recommended encouraging the use of collective urban transport by:

Creating major parkings on the outskirts of the city in its four directions, and connecting the center with collective transport.

Restricting the passage of private vehicles in the city center, by completely preventing them or allowing them to move during limited hours outside peak periods.

Thinking about establishing new urban lines by advanced means of transportation, such as the tramway, especially since the region's topography allows it.

Allocating some narrow or crowded downtown streets to pedestrians only, and preventing all vehicles from entering, except for service vehicles (police, ambulance, fire ... etc.).

Establishing the principle of "polluter must be fined".

Creating a specialized body to oversee the management of urban transport (the principle of delegated management)

Assigning the exploitation of urban transport lines, especially collective transport, to a single institution that enables good control and optimum utilization of all lines (unifying the type of vehicles, unifying color, etc.)

Acknowledgements

We would like to express our deep gratitude and sincerely regards to the staffs of the transport directorate of Bordj Bou Arrerdj state for their cooperation and providing the necessary information to complete this paper, also the Dr Ahmed Ben Abdenour who is honored to language correction for this research paper.

REFERENCES

Abdallah, A. (2001). Urban Geography ,Dar Al-Nahda Arabiya Printing and Publishing, Beirut, Lebanon, 253.

Abdelfattah, M.O. (2003). Urbanism geography, Dar annahdha, Amman - Jordan, 146.

Abdelmoumene, M., & Mahdi, K. (2020). Geomatics Contribution to Road Network Characterization Case Study: Batna City. *Analele Universităţii din Oradea, Seria Geografie, 30*(2), 157-156. https://doi.org/10.30892/auog.302105-817

Achraf, A.A. (2021). Urban system network in Egypt, *Arab Geographical Journal, Geographical Research Series*, N° 166, 109.

Ali, M.A.H. (1994). Transport and Traffic Engineering ,Dar arratib House, Amman, Jordan, 9.

Diabi, A et al. (2021). Urban transport systems and intermodality practices in Constantine the cas of tramway, *Algerian journal of human and social science*, University of Constantine 3, Volume: 5/ N°: 2 ,310-325.

Directorate of Transport of Bordj Bou Arreridj. (2019). Transportation Plan Final Report, 5-10.

Huiyu, Z., & Hongwei, G. (2020). The impact of urban morphology on urban transportation mode: A case study of Tokyo, *Case Studies on Transport Policy Journal*, *8*(1), 202. https://doi.org/10.1016/j.cstp.2018.07.005

Law N°. 01-13 of August 7, 2001, relating to directing and organizing road transport - Official state journal, N°: 44

Law N°. 01-14 of August 19, 2001, relating to Traffic Regulation - Official state journal, N°: 45

Nacer, F., & Dridi, H. (2021). The Creation of Development Regions as Input to the Regional Development in the North-East Wilayas (Departments) of Algeria. *Analele Universităţii din Oradea, Seria Geografie*, *31*(1), 1-10. https://doi.org/10.30892/auog.311101-852

Ndeye, N. (2021). Mobilités et politiques publiques de transport à Dakar. Géographie. Normandie Université, France, 16 https://tel.archives-ouvertes.fr/tel-03575154

Rasha, S.N. (2020). Spatial analysis in geographic information systems, University Ain shams, Amman, Jordan, 60.

Sabah M M. (2002). Introduction to Urban Transport Planning, El-Warraq Foundation for Publishing and Distribution, Amman, Jordan, 7.

The master plan for the preparation and reconstruction of Bordj Bou Arrerid 2014, Final Report, 75.

Submitted:	Revised:	Accepted:	Published online:
Septermber 29, 2021	March 9, 2022	June 8, 2022	June 27, 2022

Analele Universităţii din Oradea,
Seria Geografie

TOM XXXI, Nr. 1/2022 (June)

C O N T E N T S

ISSN 1221-1273, E-ISSN 2065-3409