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ELABORATION OF AN EROSION MAP USING THE ANALYTICAL HIERARCHY PROCESS (AHP) CASE OF THE REGION OF CONSTANTINE (ALGERIA)

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Abstract: A multi-criteria Analytical Hierarchy Process (AHP) analysis was carried out using a geographic information system (GIS) integrating several factors, namely slope, geology, annual average rainfall and land use, which effects interfere and act on erosion dynamics of the Wilaya (province) of Constantine. The objective of this study is to better understand this phenomenon through an accurate assessment and spatialization of the level of vulnerability in this region.

Key words: AHP, Constantine, erosion dynamics, GIS, vulnerability

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INTRODUCTION

Soil erosion consists of the detachment and transport of soil particles through the usually combined mechanical action of rainfall and runoff (Dumas, 2010). This phenomenon is widespread among the different Mediterranean basin countries (Kheir et al, 2001). The factors involved in the erosion process are grouped into four domains: topography, soil, land use and climate (Wischmeier et al., 1978).

Constantine is one of the Algerian Wilayas where erosion poses a serious threat, as it is located in a very sensitive sector given the presence of a pronounced relief, soft lithology, propitious climatic conditions and a land use that does not meet the prevailing landscape

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conditions. We have tried to summarize in this work the effect of these factors, which are different in nature, using an AHP analysis in order to spatialize the vulnerability of the landscape to erosion in a precise way. AHP is a method of spatial analysis that combines several criteria, of a different nature, in order to obtain a cartographic result indicating areas more or less capable of solving the problem (Balzarini et al., 2011).

The adopted method is AHP. The analytical hierarchy process (Saaty, 1980) is a multicriteria decision analysis method that solves decision making problems by ranking alternatives according to several criteria (Cozannet et al, 2013). This method has been worldwide applied in many domains to determine the importance of certain factors in solving some problems or making important decisions (Hapciuc et al, 2016). The selection of criteria that has spatial reference is an important step in spatial multicriteria decision analysis (Malczewski, 1996).

STUDY AREA

The Wilaya of Constantine is located in Eastern Algeria, 431 km east of the capital, Algiers. It covers an area of 2,248.44 km², between 35° 7' and 36° 9' north and between 6° 20' and 7° 29' east. The climate is of continental type and is characterized by hot dry summers and cold and wet winters with annual rainfall varying between 450 and 780 mm and a maximum daily precipitation exceeding 160 mm. The territory of this region is essentially agricultural.

The reliefs can be subdivided into three large sets namely:

- a mountain range north of the Wilaya with an altitude of up to 1200 m, with a majority of formations being limestone and dolomite;
- just below the central area, there is a relief formed by hills, foothills and plains mainly made of relatively soft lithologic formations.
- a mountain range south of the Wilaya which altitude varies between 1000 and 1300 m which is characterized by a complex lithological structure and morphology.

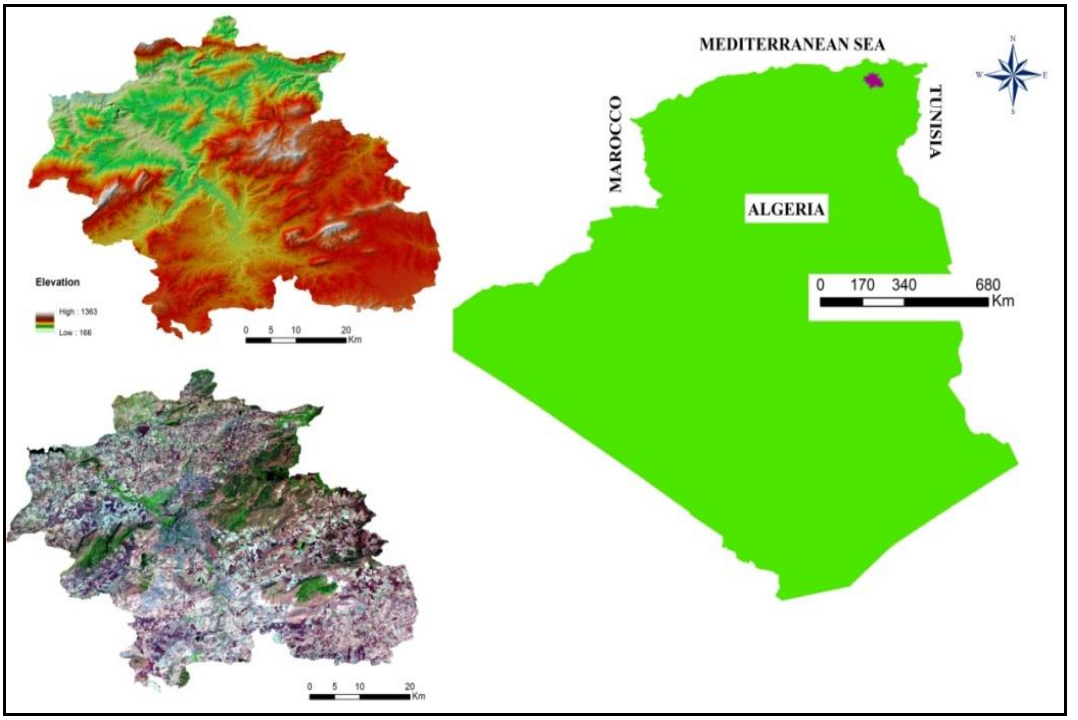

Figure 1. Study area
(Source: Guellouh Sami)

MATERIALS AND METHODS

The adopted method is AHP. It's i a popular method used as a tool for multi-criteria decision making (MCDM) or as a technical estimation (Taibi et al., 2017). This method has mathematical properties and allows total ranking, it requires a hierarchy of the decision problem and a pairwise comparisons of entities in every node of the hierarchy (Saaty, 2008). AHP involves the following steps: (1) structuring possible factors for the problem into a hierarchy; (2) arranging the factors for each alternative; (3) developing the criteria for alternatives; (4) evaluating the importance of alternatives; and (5) analyzing the weight of each factor (Chen et al, 2011).

The factors involved in the spatialization of vulnerability to the local erosion are listed in order of priority in the table below.

Table 1. Factors involved in the analysis

Factors	weights
Slope	C 1
Lithological units	C 2
Average annual rainfall	C 3
Land use	C 4

The slope

The topographic slope strongly influences the amount and severity of runoff. Once the slope is sufficient to allow water to run off, the land is vulnerable to water erosion (Kheir et al., 2001). It greatly influences the importance of erosion by its gravitational action and provides water its erosive energy (Dumas, 2010).

Slope is a key factor in this analysis because areas in steep and very steep sectors are areas prone to erosion risk.

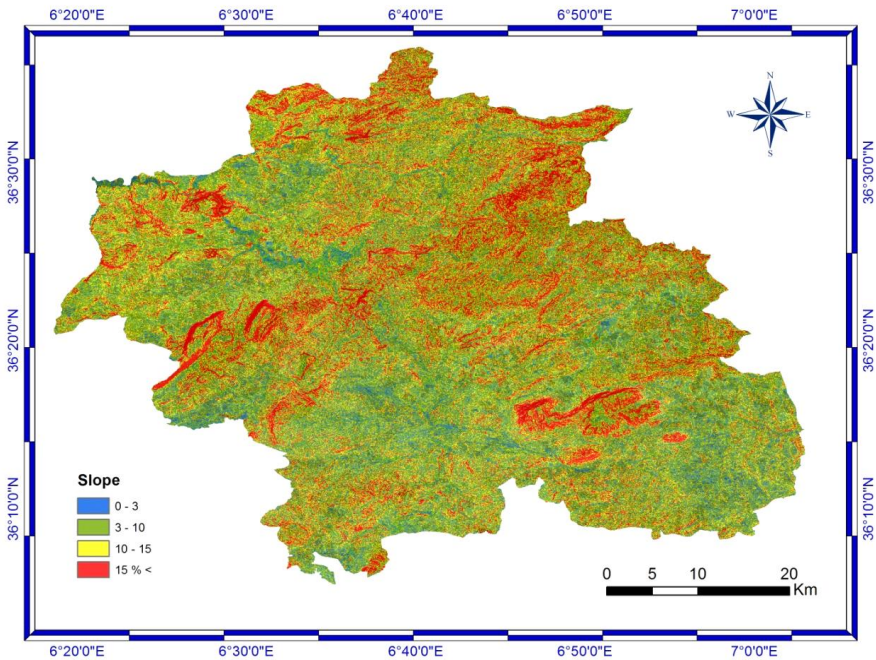

Figure 2. Slope map
(Source: DEM: Digital Elevation Model)

Table 2. Ranking of slope Influencing

	Class of parameters	Ranking
0 – 3	Gentle	1
3– 10	Moderate	2
10 – 15	Steep	3
15 <	Very Steep	4

The lithological formations

The lithological quality of the formations and their spatial articulation determine the level of erodability of the reliefs and guides the action of the erosive processes.

On the basis of a 1/500 000 geological map of East Algeria, we were able to classify the soils according to their resistance in four classes.

Table 3. Friability classes of lithological formations

Lithological formations	Materials friability	Ranking
Dolomitic limestones	Resistant materials	1
Limestones with marl and clay infills	Moderatelyresistant	2
Sandstones and conlomerates	Vulnerablematerials	3
Red clays and alluvium	Highly vulnerable materials	4

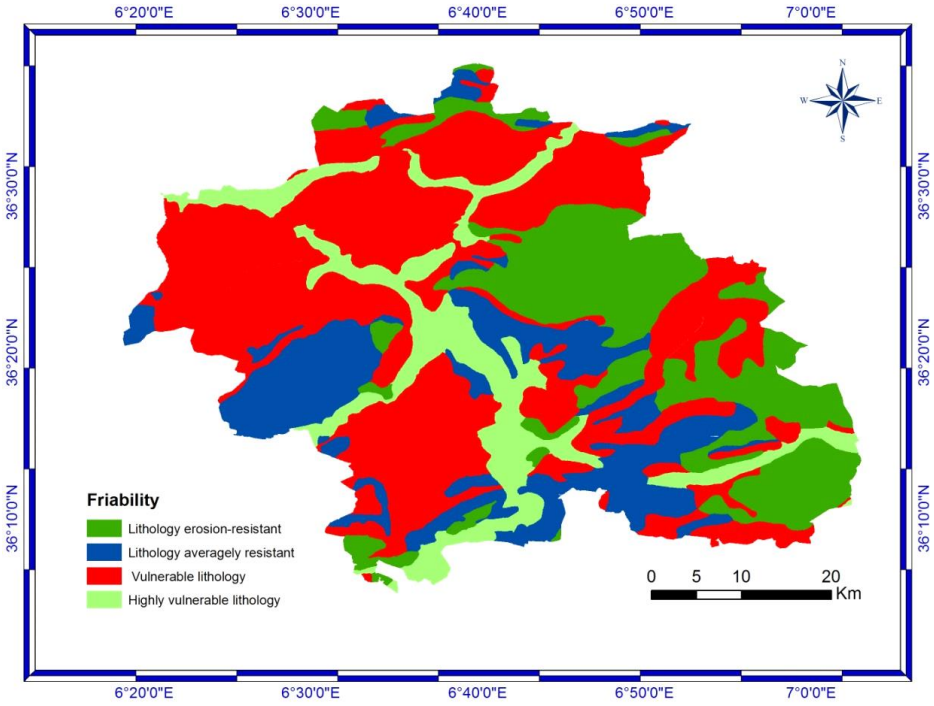

Figure 3. Friability map of lithological formations
(Source: 1/500 000 geological map of East Algeria)

Average annual rainfall

The intensity and the spatio-temporal distribution of rainfalls are at the root of the onset of the erosion phenomenon.

When the runoff gathers in nets, the friction forces with the soil surface decrease; the runoff then acquires its own abrasive power and digs deeper and deeper channels (Roose, 1984).

Table 4. Ranking of rainfall Influencing

Rainfall (mm)	Ranking
445.3 – 500	1
500 – 600	2
600 – 700	3
700 – 770.5	4

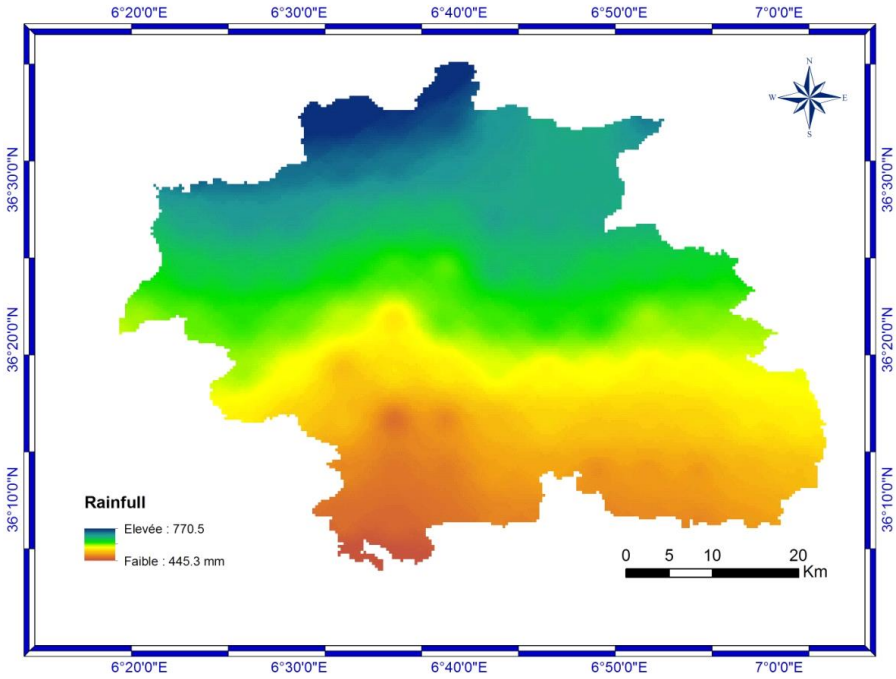

Figure 4. Annual average precipitations
(Source: Guellouh Sami)

Land use

Land cover strongly controls all morphogenic processes. The erosion process is closely related to the land use pattern, which largely contributes to its erosion or mitigation. Land cover determines the degree of soil protection (Dumas, 2010). The land cover map was established by a supervised classification of a 30 m resolution ETM+ Land SAT 8 satellite image covering the entire study area.

Based on this classification, we were able to extract information about the spatial distribution of each land-use element.

Table 5. Ranking of land use influencing

Land use	Ranking
Dam	0
Urban area	0
Forest	1
agricultural land	3
Bare ground	4

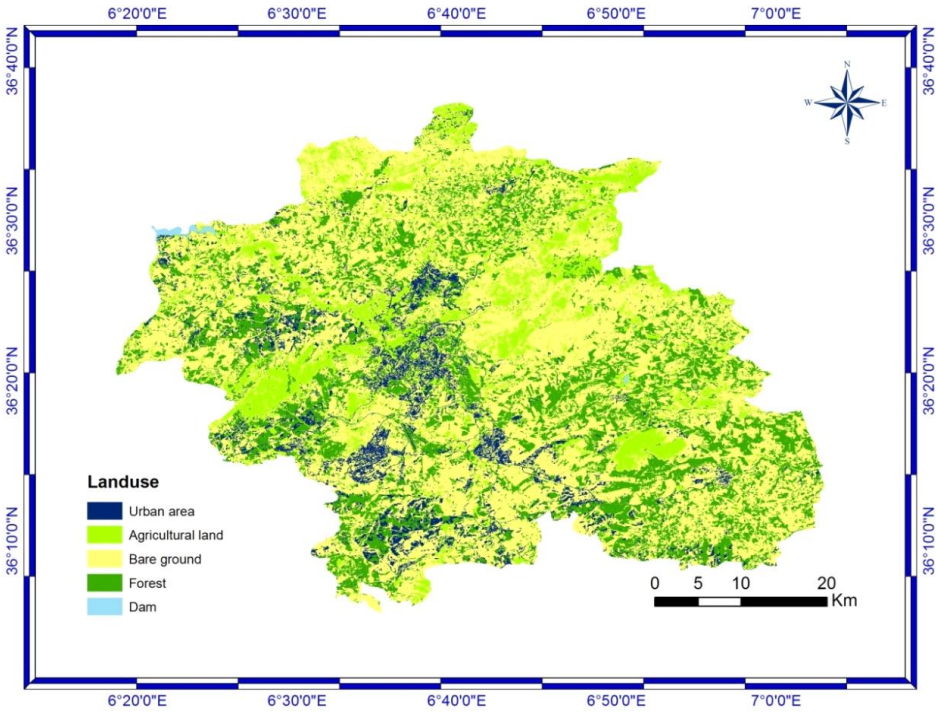

Figure 5. Land Cover Map
(Source: Land SAT 8 satellite image classification)

The pairwise comparisons of criteria are made using a scale of absolute judgments, commonly called Saaty's scale, which indicates how much one item predominates over another with respect to a given attribute (Cozannet et al, 2013). This scale transforms qualitative assessments into numerical values from 1 to 9 which are used to fi t the matrices. The priority scales are then derived by calculating the eigenvector associated with the main eigenvalue of each comparison matrix (Saaty, 1980).

Table 6. Pairwise comparison scale (Saaty, 1980)

Importance	Definition	Explanation
1	Equal importance	Two elements contribute equally to the objective
3	Moderate importance	Experience and judgment slightly favor one Parameter over another
5	Strong importance	Experience and judgment strongly favor one Parameter over another
7	Very strong importance	One parameter is favored very strongly and is Considered superior to another; its dominance is Demonstrated in practice
9	Extreme importance	The evidence favoring one parameter as superior to Another is of the highest possible order of affirmation
2, 4, 6, 8	Can be used to express intermediate values	

It should be noted that urban areas and aquatic environments (dams, lakes, etc.) are excluded from the analysis (zero vulnerability) and the weighting for the different classes of the same criterion is obtained in the same way as with the criteria between themselves.

RESULTS AND DISCUSSIONS

The primary reason for the popularity of AHP for mapping the risk and its components is that the implementation of this technique within the GIS environment is straight forward, enabling the users to quickly derive the weights associated with criteria map layers (Malczewski, 2007). GIS with its capacity for storage, management, analysis, modeling and display of spatially referenced data, but also by its possibilities for integrating multicriteria spatial analysis methods, is presented as the tool more appropriate for understanding spatial decision-making problems (Chakhar, 2006).

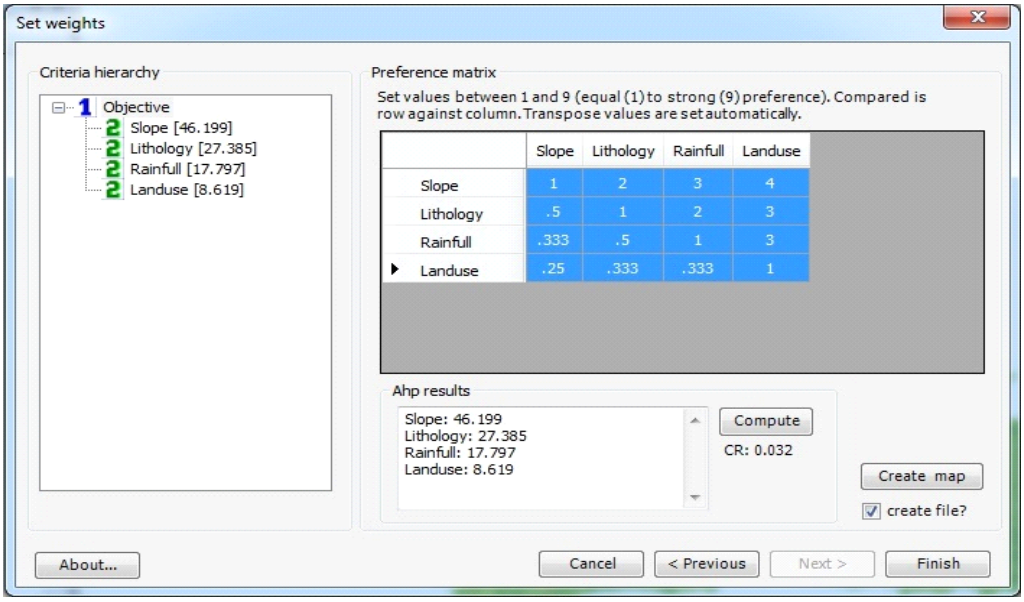

Figure 6. Comparison matrix under Arc Gis
(Source: Guellouh Sami)

To ensure the consistency level of the judgments and that the data structures are logically related to each other, the ratio of coherence CR must be lower than the value 0.10. The higher ratio of the value 0.10 indicates a higher level of inconsistency. In our case the CR = 0.032 (figure 5), which means an acceptable level of coherence.

The vulnerability to erosion is calculated according to the following formula:

Vulnerability = 0.461 Slope + 0.273 Lithology + 0.177 Rainfall + 0.086 Land use

The use of a GIS database allowed us to spatially quantify the level of vulnerability to erosion in a quantified way and to map complex phenomena from the data interaction (figure 7), which means that the methodology used can be used to carry out various planning tasks, allowing for a large amount of data to be used at different scales (Ramos et al, 2014).

Table 7. Surfaces and percentages of vulnerability classes

Vulnerability	Areas in km^2	Ratio
Zero	163.54	7.27 %
Low	123.32	5.48 %
Medium	609.28	27.09 %
High	961.11	42.75 %
Very high	391.28	17.40 %

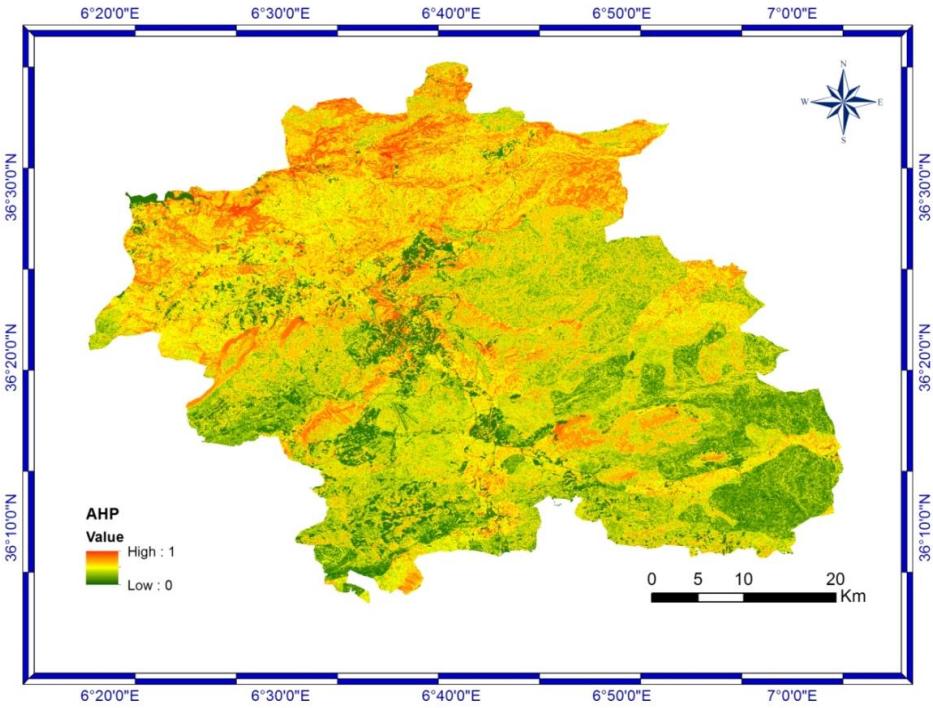

Figure 7. Erosion vulnerability map
(Source: Guellouh Sami)

Field visits are necessary to validate this study and to ensure the reliability of the results of this method. The results show that surfaces showing high to very high vulnerability occupy more than 60% of the total area of the study area.

CONCLUSION

This study outlines the results of the application of the AHP method under a geographical information system (GIS) to map erosion vulnerability in the Wilaya of Constantine. The use of GIS is mainly based on the interaction of different types of data in order to extract relevant information on erosion vulnerability in cartographic form.

More than 60% of the surface of the Wilaya is recorded as being in a heavy to very heavy vulnerability area; this situation is favoured by the important cumulative influence of the different factors responsible for the triggering and the dynamics of the erosion process.

This method has shown reliability in the mapping of erosion vulnerability by several authors and can provide important assistance in terms of erosion control planning. It remains, however, subject to discussion on some aspects.

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*** 1/500 000 geological map of East Algeria.

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FROM SIMPLE TOURISM TO SMART TOURISM: THE BET FOR THE DEVELOPMENT OF A RESPONSIBLE AND SUSTAINABLE TOURISM. CASES IN THE ZIGUINCHOR REGION (SENEGAL)

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Abstract: Tourism has become an essential activity for the economies of the countries, and it is an activity that has a long way to go. Thus, this activity, previously uncontrolled in the face of what is nowadays called responsible tourism, is nowadays a sector followed with rules and standards to be respected. Tourism activity has gone from what was mass tourism, to a new form of tourism which is required in relation to the management of both tourist flows and also to the protection of the environment. We are now talking about sustainable tourism or responsible tourism. So we were thinking here about the evolution of tourism; from simple displacement to rational and responsible displacement.

Key words: tourism, displacement, environment, sustainable, economy

* * * * * *

INTRODUCTION

Developing countries have been welcoming a significant number of visitors for some time. The result of this development of tourist arrivals is not only in terms of job creation, but also in terms of foreign exchange injected into the places visited. However, we must not lose sight of the fact that the development of this activity has negative consequences both in environmental and societal terms. It is therefore vital to rethink this activity in order to benefit from it and reduce its negative effects. "The 2018 World Tourism Organization, Tourism Highlights show that international tourist arrivals totaled 1,326 million in 2017, some 86 million more than the previous year, reaching a new record (WTO, 2018). The sector has experienced an uninterrupted growth in arrivals for eight consecutive years.

* Corresponding Author

The increase in 2017 was the strongest since 2010, with the European and African regions topping the picture, with 8% and 9%, respectively, increasing arrivals“ (WTO, 2018). The WTO predicts an increase in the arrival of international tourists to reach 1.6 billion by 2020. These figures show that the desire to travel and discover is becoming more and more important in the world, and that people want to go and see what is happening on the other side of the usual environment. As an uncontrolled turn, tourism, too, if poorly managed, often leads to upheaval in visiting communities. And very often, the countries visited are poor countries where the cost of living is much lower than that of the countries of origin of the visitors, with a very fragile environment. Tourism means the displacement of people outside their usual environment for a consecutive period of no more than one year. At first, this activity was reserved for a bourgeois class who did what they called "Grand Tour". Today we note a democratization of this activity. That is, everyone can go sightseeing when you have free time. Tourism has become an industry whose management requires knowledge and mastery of many of its workings.

The Ziguinchor region in the south of Senegal is known for its greenery, its lush vegetation and its diversity of fauna. The latter is an undeniable asset that attracts many visitors to the region. Thus; it is high time, with the rapid development of tourism, to think about the rational management of the natural heritage within the framework of a regional or local tourism policy.

The main idea of this activity, which concerns the players in the sector, is to fill up in their accommodation or catering establishments.

This is only the positive side of tourism. Yet culture and the environment are the biggest losers in all of this. So to protect this natural and cultural heritage, we are now talking about sustainable tourism, responsible tourism. In this type of tourism the environment is at the heart of all its promotion.

It should not be forgotten that forests must be destroyed at times for the sole purpose of building hotels or certain tourist establishments. The arrival of visitors can also lead to a cultural conflict that sometimes leads to a total rejection of this new activity. The local architect may also be disrespected, which may change the postcard or the originality of the locality. We can name it as we like, but the need to take all the problems of management and protection of the environment into account is now an obligation for all hotel developers and even all the players in tourism.

What is to be banned is to believe that environmental protection is the responsibility of the state, not far from it everyone must feel concerned about this environmental degradation. In tourism, the players focus much more on the policies of promoting destinations while neglecting the protection side, both of the environment and of the heritage. And yet, to put in place a good policy of environmental management, would be an asset both in terms of marketing of the destination and also in terms of finance. So we're here in an environmental or ecological management system: eco-management.

The environmental or (eco-management) management “It is not enough to allow nature and the market economy to do so by suggesting that an economic life can be born and developed by the sole attraction of the territories privileged by nature, history or geography” (Deprez, 2006, p. 45) of a tourist equipment is a condensed version of two seemingly contradictory principles: save natural resources and maximize the return on exploitation.

However, it would be necessary to make it compulsory for all players in the hotel-tourism and catering industry to respect the requirements of the environment and that these requirements be considered as a standard. So we talk about sustainable development. Sustainable development is therefore a long-term management policy that advocates other ways of producing and consuming. While recognizing that some major hotel groups such as Accor have established a hotel environment charter. This implies an awareness of integrating the environment into their policy of opening hotels. This concept is based on a logic modeled on the development of science.

Analyses and synthesis of research papers and direct interviews following with some of the tourism actors from Ziguinchor region level.

TOURISM AS A GROWING ACTIVITY

Tourism activity is increasing and international arrivals are increasing. For those hosting companies that are directly linked to this activity, there is a need or a duty to respect the environment in which tourism takes place (Herman et al., 2016b, 2017, 2018; Ilie et al., 2017; Lincu et al, 2018). Even customers have become aware of environmental protection. They are now and increasingly opting for a clean destination. This would mean that the concept of sustainable tourism is no longer a vain word, but a reality that could be of interest to business marketing managers. The hotel, tourism and catering sector is one of the leading providers of jobs. This means that a lot of people work there. For example, an institution that is intended to be "green" must also put in place a new policy within the company and with its shareholders to strengthen its status as an "eco-hotel". "This news gives in the apprehension of tourism as a factor of development is emerging and the whole of this talk applies to include tourism in a true process of sustainable development" (Laurent, 2009, p. 43).

While the relationship between man and his environment is a perfect illustration of his historical past, it is undeniable that the advent of certain activities such as tourism or the technological revolution has had many positive and negative consequences. In fact, the problems caused by the use of natural spaces for the construction of hotels, for example, have increased enormously in recent years. For example, consider a tourist area such as Cape Skiring in the Ziguinchor region of Senegal “The tourist economy, far from being a danger to the environment, must be one of the first national, regional, communal and inter-communal expressions of environmental policy” (Deprez, 2006, p. 84), where all the land is sold to build accommodation establishments. The anarchic construction that is noted is as worrying as the degradation of the environment. The local population continues to grow as the living space shrinks. What should be done? The situation is becoming increasingly unlivable. If you want to develop a tourist activity at all costs, you risk killing it. Because, you have to know that tourism itself contains what can make it disappear. Very often rural populations suffer the most from this environmental degradation. Developing countries are not left behind in the development of tourism.

Tourism has thus become a global phenomenon that brings all the countries of the world together. Therefore, it is necessary, if not essential, to establish agreements between the countries of the south and those of the north in order to learn from the positive experiences of the latter.

According to Alain Laurent (2009), "Decentralized cooperation is therefore playing an important role and will play an increasingly important role in international relations. Indeed, it has many advantages: it is built over time, from territories of proximity and individual will, and shows institutional and democratic legitimacy, territorial roots, sustainability; it remains controllable and measurable in actions; it allows the citizens of different countries to come together. It is simply human-sized" (Laurent, 2009, p. 386).

We may sometimes be tempted to ask ourselves the question of the development of tourism in conjunction with the protection of the environment or heritage in general. So trying to give an answer to this problem could lead us to make a small retrospective of the birth of tourism. One thing is for sure, that the heritage was there long before the tourist activity. Heritage is for tourism what gasoline is for the car. He's used as a fuel to move forward. That is why Olivier Lazzarotti said: "Tourism and heritage are currently engaged in an uninterrupted and intertwined dialog. Sometimes in agreement, sometimes in disagreement, and most often both“ (Lazzarotti, 2011, p. 73).

Education for sustainable development or sustainable tourism is required today (Ruhanen et al., 2015; Herman et al., 2016b; Ilieș et al., 2017a; Tătar et al., 2018) at the level of all major hotel groups. It is based on the ownership of the concept of eco-management. The customers that these companies must target will have to prove that they are part of this concept. So a new type of tourism can be created. This involves the tourist who first thinks of the environment and only after that thinks about his stay. “Tourism became mirage. Nothing could stop him, no one dared to raise any doubt. He had free ground. It represented progress, the future, the end of poverty” (Laurent, 2009, p. 17).

The number of tourists who are constantly increasing at the international level and the impact on the visited areas deserve to be well assessed. Indeed, globalization, which has reached its highest peak, the possession of the right information, also gives us control. The more tourists know the area through the media, the better they will get ready before arriving at the destination to visit. The quest for discovery is also a quest for knowledge. Tourism can therefore contribute to the protection of the environment and more generally to heritage.

Table 1. Effects of tourism on the environment
(Data source: Saida Merasli 2012)

Effects	Examples
Air pollution	Transport sector, increased electricity consumption
Water pollution	Water pollution Wastewater from hotels and boats, oil spills from motor boats.
Solid waste	Solid Waste Discarded by tourists and tourism industry workers, and garbage they produce
Loss of natural spaces and biodiversity	Loss of natural spaces and biodiversity Building of buildings (installation and accommodation for tourists), infrastructure (roads, trails,) Tourism behavior
Noise	Noise Increased traffic, airplanes, recreational vehicles, entertainment facility

Today, sustainable development is seen as a value for the quality of business or hotel. For this purpose, a number of lodging establishments are given an environmental label.

"Now, the need for ethics, fairness and safeguarding of resources is also evident in the company. This means an affirmation of a social role for the company ..." (Merasli, 2012, p. 52).

Tourism, which is known as a factor of economic development of countries, is based on these assets of the territories to develop its activity. This is a social fact and links culture and economics. This characteristic of tourism joins that of sustainable development, which also encompasses the environmental, economic and social aspects. To meet the new requirements of the competition market, tourist destinations must take all these criteria into account.

For, it is often said that managing is predicting; so the sense of anticipation and forecasting is paramount in a sector as competitive as tourism.

The motivations and tastes of the customers change, so this evolution must be followed in order to bring to the market a supply adapted to the demand. Even being far from the territory to visit; tourism has a major influence on the choice of offers to be placed on the market. Tourism now requires a more qualitative and environmentally friendly offer (Gozner et al., 2017).

In all tourism wants another new mode of tourism different from the years of mass tourism.

Mass tourism was in some ways a tourist activity where the number of visitors was not controlled or channeled well. Visitors travel without the application of the load capacity of the sites visited. This causes huge damage at the end of the visitor's stay. In the implementation of sustainable tourism indicators, strict application of load capacity standards is mandatory. The maximum number of visitors a site can receive at the same time is the capacity of the load. The practice of tourism cannot be designed without taking into account the particularities or specificities of the territory concerned. The term "sustainable" has become an essential term in destination sales. This could explain the exploitation of local resources without any consequences in the future. The development of sustainable tourism also requires that the benefits of this activity be shared equally. Tourism that does not contribute to local development is not sustainable tourism. In this sense, Bernard Schéou states that: "Tourism is undoubtedly an effective means of economic enrichment for its beneficiaries, but having financial means is far from systematically driving development, it is only one of the many conditions necessary to achieve development“ (Schéou, 2009, p. 138).

States should not only look at the interests of their offers, but also at the interests of the people. For developing tourism without taking into account the interests of the local population is

bound to fail. And according to Schéou (2009), "Governments often fish through their desire to increase tourism revenues by maximizing the number of visitors rather than engaging in the search for a form of tourism that would benefit the population" (Schéou.2009, p. 140).

This policy would be totally contradictory to a sustainable development policy. This environmental policy has had enormous constraints, given the disparity in awareness among some hoteliers regarding the importance of being "green". The current situation in the Cap Skiring area is an example of this. The anarchic construction of tourist accommodation facilities is at the height of its disasters. Access to the beach has become virtually impossible for the local population, and yet it is exactly what has welcomed these investors who have become "persona non grata".

It is imperative that the State take measures in this regard to avoid cocoa in the years to come. However, in order to reach the entire territory in relation to this policy, it would be necessary to implement it at the local level, because the local dimension can be an example of success that could be expanded at the national territorial level.

"With decentralization, the initiative is left to local, public and private actors in a much wider way, and it becomes necessary to put in place posteriori mechanisms to monitor compliance with the rules defined at national level" (Barraqué and Theys, 1998, 11).

The hotel and tourism industry in some of the peripheral areas, which have had to suffer a massive exodus of its population, cannot establish a clear policy of its needs. These areas do not have a strategy to defend their environment, they simply consume everything that investors or large hotel groups offer them. We note that most of the projects that are located in environmentally sensitive areas are projects by sector of activity.

In a logical sequence of a project package, it is first of all the responsibility of the project developer to carry out a field study, to inform the local populations of the interest of the project. Non-involvement of local people in a project may lead to its failure. So the population needs to participate in the discussion in order to put in place a plan that could help to keep the population at the local level, thus curtailing the rural exodus. For example, a sustainable tourism project that respects the environment (Ilies et al, 2017a; Ilies et al, 2017b).

However, the implementation of such a project must respect a specific approach strictly related to the equipment to be used. It would therefore be necessary to set up a program that informs on social, economic and cultural issues in order to integrate tourism into local life.

ENVIRONMENTAL CONSIDERATIONS IN TOURISM PROMOTION

For tourists who arrive in an environmentally sensitive area, standards of compliance with the minimum level of attendance are put in place so as not to cause damage that can sometimes be irreversible. This is what has been called "load capacity" at the top. Of course the load capacity differs from one area to another and according to the specific characteristics of the area. “Tourism is transforming the place. This may explain the frequency with which tourism is blamed for all the evils, but, also and paradoxically, it is summoned to solve all the evils and is often seen as the last bulwark against the inevitable decline of some agricultural and industrialized places in crisis” (Violier, 2008, p. 43).

This means, therefore, that the load capacity, also known as hosting capacity, is not limited only to a fixed number, but rather to well-defined patterns of the distribution of tourist arrivals on a site. When it comes to environmental protection, this is not only limited to nature, not far from it, making tourism in other ways means that both visitors and business owners have to manage rationally all the waste, some of which were mentioned in table 1. In underdeveloped countries, water is the subject of many tensions between populations. There is indeed a lack of water that it would be foolish to tolerate its waste by certain hotel groups. It is impossible to imagine that in a hotel, the owner uses as many cubic meters of water to water his golf course, while a few kilometers from the establishment people die of thirst, or they barely have good quality water. "In any case, it is common for many powerful interest groups like many governments to consider

improving the performance of the water industry through reorganizations or changing its position within or outside the public sphere" (Barraqué and Theys, 1998, p. 91).

Tourism cannot be done without taking the environment into account, it would be part of the sudden death of this activity. We talk about green tourism, eco-tourism, all to show the attachment of tourism to nature. Marie-Pierre Hage said, "The freedom of the individual is associated with the love of nature, and to be able to reconcile nature and freedom, one must escape society" (Hage, 2015, p. 35).

In other words, to claim to be an "Ecolo" hotel, it is necessary to integrate environmental management into its policies. If hotel developers and all tourism players gave some consideration to nature and the environment in general, human life might be saved. In the fight for the protection of the environment, governments should put in place strict rules to be followed by any promoter of a tourist project and, above all, wishing to establish a place in rural areas, for pollution has become the worst enemy of man today. Large cities have become traveling tombs, a purely ecological problem that traces the consequences of poor environmental management and overexploitation of natural resources. So, to address this growing scourge, we are talking about sustainable development, sustainable tourism or responsible tourism. In this tourism, the aim is to set up classification criteria in order to provide institutions with a framework to follow in order to become green again. Both government and private authorities are concerned with the global threat of "global warming" and tourism, which is a social fact, affects the environment. "The debate on environmental issues calls for our attention to the extent that it is an opportunity for questioning; of a philosophical scope, economic, social and political institutions of the contemporary world" (Vaillancourt, 1992, p. 27).

Developed countries must now clearly identify their donations to underdeveloped countries. The intervention of the European powers in the underdeveloped countries must be controlled because, in some cases, obsolete products arrive without any control at the level of the underdeveloped countries. What is called "aid to underdeveloped countries" is much more like "aid to pollution." For a society that advocates tourism development, it is important that political choices or decisions that affect the public or public good be explained and that the public be able to express their views on those choices. Because the consequences of a poor choice can be felt at the population level. To get the population's perspective, you just have to take a survey and look at your questionnaire before you get the right conclusion. "The economic analysis on which concrete solutions to environmental problems are based takes into account first and foremost the technological factors which are not easy to analyze" (Vaillancourt, 1992, p. 73).

Indeed, economic issues will always be the focus of discussion when talking about the environment. The biggest problem we face is that of making a proper assessment of the level of environmental degradation. While it is known that methods exist and cost each environmental assessment, it is also necessary to agree that the environment has no exchange value. He has no price. Therefore, the realization of certain political decisions on the protection of nature must necessarily be based on the basis, i.e. at the local level. Particular consideration should be given to how this can be achieved in order to make concerted decisions on a resource at risk.

Tourism is an activity that makes people move outside their environment, so the territory is inseparable from this activity. “Modern tourism, which seeks, outside its home and workplace, a framework of escape that may attract it, must be considered increasingly likely to seek the preservation of all pollution, where it hopes to find a change of scenery and enjoy rest and freedom” (Deprez, 2006, p. 88).

The territory is both the starting point and the center of the tourist activity. The place and role of the natural space as a whole, both ecological and human, are at the heart of the relationship with the development of tourism. Tourism cannot be developed without a territorial base.

The promotion of a destination is done within the geographical boundaries of the country or region. Each territory has its own particularity, its assets. This represents its apparent part or even the first tourist attraction of the area. This is like confirming that landscape protection is the key to success of any tourism development. Because without the landscape, or a healthy

environment point of tourism. "In most tourist communications, whether commercial or promotional, landscapes occupy a privileged place... Today, even landscapes as far away as those of the Arctic or Antarctica have become advertising images for touristic tours or hikes..." (Lozato-Giotart et al., 2012, p. 29).

From the first stage of the design of a tourist project, a feasibility study is necessary in order to be able to make an assessment of all the attractive potential of the area as well as the possible limits of occupancy at the level of the territory. This means that an analysis of the possibility of setting tourism or the "tourist" of the territory will be carried out due to its assets and attractions. However, it must be recognized that an assessment of the tourist potential of all places where you want to invest is not always an easy thing. In fact, very subjective judgments and quick reviews were given against certain sites. Thus, it was sufficient for a destination to have some assets even if they are not highlighted, such as a beach, sun, a landscape, and to embark on a tourist development. To say that a destination has a rich heritage means somewhere that this heritage is well protected. The destination may be full of heritage or attractions and not a popular destination. For a destination to be known and appreciated, it is necessary to highlight its heritage and then put it on the tourist market. Simply put, a product that does not enter the market is a non-existent product. We are talking about heritage, but what we must remember is heritage is not only what is built. Indeed, heritage can have an intangible dimension that has a direct connection with the customs and customs of local populations. Nowadays, it is not possible to get into this activity without a preliminary field study, of putting into tourism the existing potentialities, in order to pretend to make sustainable tourism. The introduction of tourism also means the establishment of sufficient accommodation infrastructure that meets the standards of quality. Without this, the destination can have all the tourist assets possible but will never be a popular destination.

The bed capacity is an indispensable component in the development of tourism. Since almost all of them are dependent on European countries, the developing countries are building their tourist policy in line with the "foreign" tourist. Indeed, if we take the example of Senegal in general and the Ziguinchor region in particular, tourism is much more dependent on international tourists, mostly French tourists than national tourists. Therefore, by calculating the departure frequency and arrival frequency, it is concluded that Senegal is a receiving country. It receives more tourists than it emits. Tourism seems to be a cultural factor, even if we note a globalization of this activity (Herman, 2016a).

At the accommodation level, some employees are able to distinguish between a French tourist and an English tourist. "Culture, in fact linked to the concept of travel and hospitality, plays a fundamental role in determining an individual's needs and partly shapes his behavior" (Lozato-Giotart et al., 2012, p. 47).

In tourism, the management of the tourism supply-demand confrontation is of paramount importance. The intersection of the two concepts demonstrates the need to place on the market (supply) a product that meets the expectations of consumers (demand). The OMT in its publications projects an increase in the influx of international tourists, which could reach 1.6 billion by 2020. This increase in the number of arrivals must be accompanied by an increase in air traffic. This means that in order to make more aircraft available to travelers, especially long-haul aircraft, a reflection on the emission of gas by aircraft is necessary in order to minimize pollution. The development of tourism cannot be achieved without the joint participation of public and private actors. Tourism is a factor in democracy.

Despite geopolitical tension, crises and terrorist attacks, tourism seems to be one of the sectors that best resists these scourges. As the world struggles with global warming, the danger of the disappearance of certain landscapes, it would be necessary to think about a new type of tourism. What type of tourism can we think about without nature? This question may seem trivial to us, but it has several meanings. In some places where tourism is developed, CO^2 emissions from travel are very often noted, causing pollution. In the face of this environmental disaster and the lack of ideas from our politicians for the protection of nature, in the face of the worries that the

world will one day fall on our heads, the new type of tourism must try to find answers to all these questions (how could we travel, visit or even live without a healthy environment). Despite its significant financial and economic impact, tourism also has negative environmental impacts on the areas visited (Ilies et al., 2017c; Tătar et al., 2017, Wendt et al., 2019).

So governments and also tourism players have understood the imbalances that this activity can cause if it is mismanaged. "Environmental impacts are a question, social and societal responsibility is called upon to take these phenomena into account. We are back in the so-called co-responsible years where all actors (citizens, professionals, communities) must integrate the new environmental variables for new ways. To practice tourism otherwise will become a must" (Babou and Callot, 2012, p. 12).

We pointed out at the outset that there is a notable difference between making sustainable development of tourism and focusing on the sustainable development of a destination or territory as a whole. It is also about the contribution of tourism to the sustainable local development of a territory. Tourism planning is much more oriented nowadays by the concept of sustainability. This requires a policy of planning the tourist activity oriented towards the protection of the environment and local development. Now and in most countries, the natural environment is at the center of all their policies to promote and develop tourism.

"Based on a democratic decision-making process, tourism planning also raises the question of the authority of the various stakeholders in the tourism phenomenon. Planning appears to be constrained by various economic and political pressures that can deter it from its priorities (environmental sustainability versus economic challenges in terms of jobs, for example)" (Cooper and Hall, 2011, p. 122).

The cross-cutting nature of the tourist activity, which involves several other sectors, can be seen from all the elucidations at the top. Indeed, tourism is inseparable from geography or sociology. There's more and more talk about the geography of tourism, or the sociology of tourism. However, some researchers who advocate a "tourism science" think that tourism activity is much more oriented towards human or social science. This could be positive, because what makes tourist activity unique are individuals moving to an unusual place. So tourism is above all a social fact, however, the word social tourism, although it has resisted time, has not imposed itself over time. No tourist claims to be social.

CONCLUSIONS

Tourism is undeniably an activity that affects the whole world. Indeed, it is almost impossible to see a corner of the planet that has never been visited by a tourist. By a corner of the planet, we understand a destination or a country. The travel of the tourist is based on his motivation, it is clear that every tourist has his preferences or his purpose of the trip. Tourism is a form of development based on both cultural and environmental resources. It is also another way for individuals and societies in general to better understand and master their environment and past.

The analysis of the phenomenon at various levels has revealed some problems or contradictions in its way of functioning.

It is clear that today tourism is considered to be a well-organized activity that works in line with the evolution of the technological world. Some believe that culture is the basis for any development of tourism, but we can say that the environment is the most important factor in the development of tourism. The fact that the environment has a role to play in economic development is obvious, but its contribution is indirectly through tourism and human development. In this article, we wanted to speak out against the way in which certain tourist companies or destinations claim to decide in a non-rigorous way, another way of promoting their destination or business.

The whole world is now talking about sustainability. All the actions that must be taken today must not jeopardize the future of future generations. It is in this sense that we have been able to make some arguments, because we are convinced that this activity of tourism can claim a better classification among activities that act in sustainability, in general in the protection of the

environment and heritage in general. Whether tourism occupies the place that the "Tourismologists" will give it or eclipse itself in a much more undifferentiated subset. In order to be able to do tourism in a different way, it was necessary to raise awareness among the authorities of the importance of implementing a policy of "labeling" companies that act in a sustainable way. The destinations as well as the tourist players are not left out. Overall, involving the tourist in the study of the tourist phenomenon is a laudable idea. The tourist who can be called "modern" has to be an environmentally friendly tourist. It should be noted that tourism, which has become an international phenomenon, the protection and management of the natural heritage of the destinations must be considered as a fight of international relations.

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ASSESSMENT OF WASH AND RESIDENTIAL CONDITIONS IN AJEROMI-IFELODUN AND LAGOS MAINLAND LOCAL GOVERNMENT AREAS

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Abstract: The study assesses WASH and residential conditions in Ajeromi-Ifelodun and Lagos Mainland Local Government Areas of Lagos State. Three hundred questionnaires were administered to households in the study area using a systematic sampling technique. Both the descriptive and bivariate statistical techniques were employed for the data analysis. The result shows that the majority of the households are low-income earners with moderate household size within the 1-5 groups. The predominant bathroom facility is makeshift. More than three-quarter of the households have a waste bin in their dwelling. Open land waste disposal predominates in the study area. Significant dependence relationship exists between waste disposal method, and the LGAs obtained as χ^2=18.568; df =4; p<.001. Approximately three-quarter of the dwellings are surrounded by stagnant water. The major source of water is borehole. About 74.0% and 72.7% of the respondents have access to improved sanitation and water respectively. Almost 50% of the respondents lack sanitation facility within their dwelling. The study concluded that the dominance of stagnant water and open land disposal method poses serious environmental and human health challenges. The study recommends the enforcement of sanitary laws and developmental control and public enlightenment for sustainable socio-environmental and healthy residential.

Key words: access, hygiene, Lagos-Nigeria, residential condition, sanitation, water

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INTRODUCTION

Poor residential and sanitary conditions, the deplorable state of basic infrastructure characterized most of the informal settlements in developing countries (George, 1999). The paucity of the provision of decent housing, basic amenities, and poor sanitary conditions has contributed to

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the alarming rise in water-borne and vector-borne diseases in most parts of the developing cities. Water-borne and vector-borne diseases have social and economic effects which have been responsible for the current poverty level and underdevelopment in most developing countries. Poor residential conditions also have a serious implication on the economy and productivity of a nation's workforce (Olukolajo et al., 2013). The role of environmental sanitation is crucial in any human settlement because if properly handled, it will guarantee hygienic condition and promote public health, welfare, and quality of life in a sustainable manner (Ekong, 2015).

The importance of decent residential conditions is very vital for any society because it plays a major role in the health and well-being of an individual. One of the burning environmental issues confronting developing countries like Nigeria is deplorable housing and infrastructural challenges. The term, the environment can be broadly used to describe components such as water, air, soil and, the social and economic conditions (Ekong, 2015). The adverse effects of these environmental factors can result in serious health challenges in humans if not properly managed (Ekong, 2015). Most of the housing units lack adequate space, ventilation, waste collection, and disposal facility, sanitation, electricity, water supply, sanitation, and hygiene. According to Habib et al., (2009) decent housing remains one of the critical indicators of human health, comfort and well-being. A decent housing unit is expected to provide basic amenities such as adequate space, ventilation, waste collection, and disposal facility, sanitation, electricity, water supply and general environmental quality (Bashir, 2002; WHO, 2004; Udoh and Uyanga, 2013).

Housing standards vary from one country to another and also depend upon the climate, culture, level of urbanization, and the socio-economic condition (Adeoye, 2016). According to Onokerhoraye (1985), housing standards in Nigeria can be classified into two major categories namely; space standard, which deals with housing intensity development in relations to plot sizes, a number of buildings/ unit area of land and occupancy sizes. The second category deals with the performance standard, which emphasizes the quality of the environment. According to Ebong (1983) some criteria that can be employed in classifying housing quality include; aesthetics, ornamentation, sanitation, drainage, age of building, access to basic housing facilities, burglary, spatial adequacy, noise level within the neighborhood, sewage and waste disposal, air pollution and ease of movement among others. These broad classifications have been grouped into five based on certain basic criteria which any housing unit must possess. They are; lack of serious disrepair, energy-efficient, availability of modern facilities and services, healthy, safe and secure (Adeoye, 2016). These indicators comprised of variables such as; access to basic housing facilities, the quality of infrastructural amenities, spatial adequacy and quality of design, fixtures, and fittings, building layout and landscaping, noise and pollution control as well as security (Adeoye, 2016).

Literature abounds on sanitary and residential conditions studies. Majority of these studies focused on three major areas namely; the relationship between environmental quality of housing units and users' well-being, secondly, housing and its environment vis-a-vis user satisfaction and perception and thirdly, environmental quality as a factor in housing price structure (Morenikeji et al., 2017). Examples include housing and sales prices (Alkay, 2009), housing and inequality in socioeconomic characteristics (Wray et al., 2005, Owens, 2012), urban environmental quality and human well-being (Pacione, 2003) among others. Other scholars emphasized measures of housing quality and deterioration e.g. (Fiadzo, 1982; Bunch, 1996; Milroy et al., 2001; Khatun, 2009, Morenikeji et al., 2017). Most of these studies employed variables such as floors, wall and roofing materials, type of toilet facility, sources of water and lighting, drainage, street quality, proximity to other facilities and socio-economic variables such as education, income, religion, and race, etc.

Studies have shown that there exists a close relationship between human health and their residential conditions (Ineichen, 2003; Harker, 2006). According to FMH (2010), the health indicators for the citizens of Nigeria ranked among the worst in the world. Also, most of the vital health indicators in the country have either stagnated or worsened (WHO, 2005). A similar study by Asenso-Okyere (1994) in the Greater Accra region of Ghana showed that mosquitoes,

dirty surroundings, unsafe water, poor air quality, and unhygienic conditions have a close link with poor housing condition.

Despite the vast research on residential conditions, there is a gap in knowledge in studies that incorporate the environmental aspect alongside housing quality in the study area. Hence, this study is aimed at assessing WASH and the residential conditions in Ajeromi-Ifelodun and Lagos Mainland Local Government Areas of Lagos state with a view to proffering policies that will guarantee the enforcement of sanitary laws and developmental control, upgrading of basic amenities and public enlightenment on the need for sustainable socio-environmental and healthy residential conditions of the populace were recommended.

THE STUDY AREA

The study area comprised of Ajeromi/Ifelodun, (AJIF) and Lagos Mainland (LML) Local Government Areas (LGAs) of Lagos state. The area is located between Longitude 3°20'0E and 3 °24'0'E and on Latitudes 6° 27'0'N and 6°33'0N. The area is bounded on the East by Lagos Island and Lagos Lagoon, in the North by Shomolu, while Mushin and Surulere LGAs forms its western boundary. The southern part is flanked by Amuwo-Odofin and Apapa LGAs (figure 1).

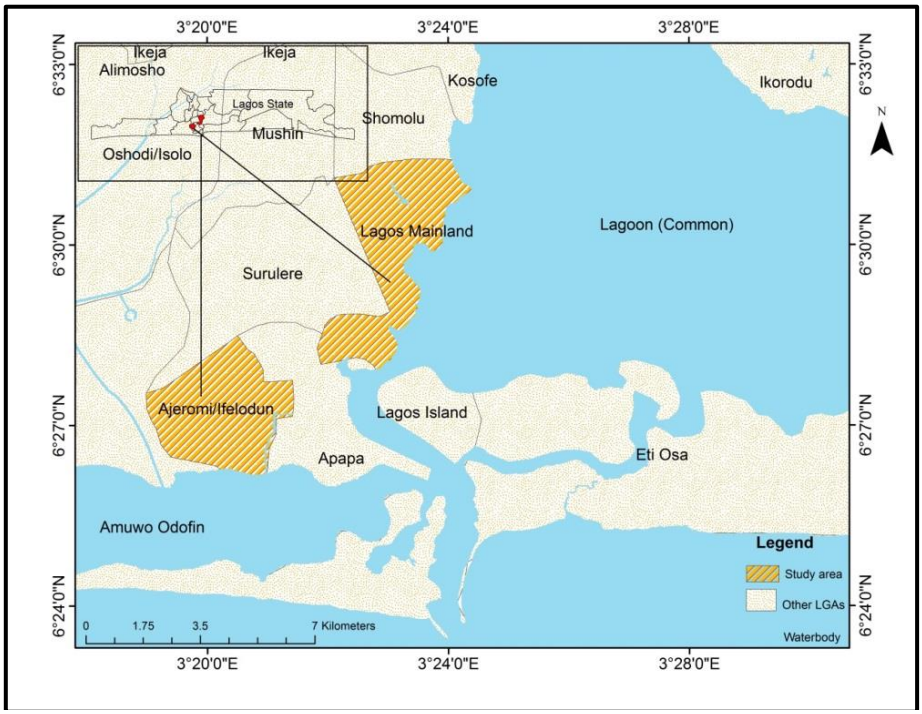

Figure 1. The study area
Source: Author's (2015)

The study area occupies about 87.0 km^2 area of land while the population density (inch/km^2) is estimated to be about 71,796. The climate is the tropical type with a mean daily temperature of about 30^{0}C while the annual mean rainfall is about 1,532 mm (Odumosu et al., 1999). There are two major seasons namely; the dry season between November and March and the wet season spanning between April and October (Adetoyinbo & Babatunde, 2010). The major vegetation consists of tropical swamp forest (freshwater/mangrove swamp forests and dry lowland rain forest). The drainage system consists of Lagoons occupying almost 22% of the state's total landmass. poses at the center, River Osun towards the east while it is drained by River Yewa in the

west. The population is about 2,268,869 people (NPC, 2006). The major slum settlements in the study area include; Amukoko, Badia, Ilaje, Makoko, Oko-Agbon, and Iwaya. The settlements are characterized by poor water infrastructure, sanitation facilities, and poor drainage and road networks. There are no well-defined street layouts, the buildings are clustered with poor ventilation and lack of open space among others. The sources of water in the area comprised both improved and unimproved sources. The improved sources include; borehole, piped water connection, public standpipe, protected dug well and rainwater harvesting while the unimproved source consists of; unprotected dug well, Stream/River and vendor-provided water, sachet water, bottled water, etc. (UNICEF and WHO, 2014). In terms of sanitation facilities in the study area, two major types are recognized namely; improved sanitation e.g. connection to public sewer, connection to septic system, pour-flush latrine, simple pit latrine and ventilated improved pit latrine while the unimproved sources are; public or shared latrine, public or shared latrine and bucket latrine (UNICEF and WHO, 2014).

MATERIALS AND METHODS

A social survey was conducted through the administration of structured questionnaire directly at the household level during April to May 2015 covering Ajeromi-Ifelodun (AJIF) LGA and Lagos Mainland (LML) Local Government Areas of Lagos State. The survey aimed at assessing WASH and residential conditions in the study area. One hundred and fifty households each were interviewed in AJIF and LML LGAs totaling three hundred in the study area using a systematic sampling technique. The survey focused on four broad issues that are relevant to the aim of the study. They include; socio-economic, residential conditions, sanitary condition, and water, sanitation, and hygiene (WASH). A reliability test of the instrument used was employed using a standardized Cronbach's Alpha method (table 1).

Table 1. Reliability estimates of the instrument
Data source: Author's fieldwork (2015)

Instrument	Scale Statistics					Reliability Statistics (Cronbach's Alpha)
Source	No of items	No. of Samples	Mean	SD	CV	R_s
Socio-economic status	14	300	29.92	8.243	0.28	0.832
Residential conditions	13 (6)	300	31.96	6.889	0.22	0.719
Sanitation and hygiene	14	300	33.87	6.625	0.20	0.722
Access to water sources	12	300	19.87	5.475	0.28	0.709

KEY- SD- Standard Deviation, CV- Coefficient of Variation

The result of the reliability test of the sanitary and residential conditions in the study area indicates that the instruments are reliable, since the Cronbach's Alpha statistics obtained for each of the composite variables; 0.832 (83.2%), 0.719 (71.9%), 0.722 (72.2%) and 0.709 (70.9%) is > 70% threshold value. The results are supported by the coefficient of variation (CV) values; 0.28, 0.22, 0.20 and 0.28 which are respectively less than 0.50 threshold value, indicating homogeneity on how the respondents rated the items. Hence, there is an internal consistency of the responses from the respondents and therefore the data do not violate the assumption of reliability. The benchmark according to UNICEF and WHO (2014) was adopted for the definitions of improved water source and improved sanitation.

Data collected from the field were inputted into the IBM statistical package for social sciences (SPSS) version 22 for analysis. Frequency and percentages, chi-square, independent samples T-Test were employed for the data analysis. Chi-square was employed to establish the interdependence of the variables while the independent samples T-Test was employed to determine whether there is a significant difference between the two study areas. The results were presented in tables and charts using Excel 2003 software while ArcMap 10.3 was used to generate the map of the study area.

RESULTS AND DISCUSSION

Socio-demographic characteristics of households

The result of the socio-demographic characteristics of the respondents is presented in table 2. The result shows that gender distribution indicates that approximately 50% each of the respondents were either male or female. On the marital status, 56.3% of the households were married. The age distribution of respondents interviewed indicated that the majority representing 32.3% were above 35 years. The educational attainment reveals that majority of the households 58.3% were secondary school certificate holders. The occupational distribution showed that traders were the majority representing 51.3 percent. The dominant ethnic group is the Yoruba tribe with 62.3%. The household's members were largely low-income earners with about 30.7% within 20,000 to 24,000 income group. The household size is relatively moderate with the majority within the 1-5 groups.

Table 2. Socio-demographic characteristics of households
Data source: Author's fieldwork (2015)

Variables	Options	Frequency	Percentage
Sex	female	148	49.3
	male	152	50.7
Marital status	widow	8	2.7
	single	121	40.3
	married	169	56.3
	divorced	2	0.7
Age	20-25 years	63	21.0
	26-30 years	64	21.3
	31-35 years	76	25.3
	>35 years	97	32.3
Education	no formal education	53	17.7
	primary	27	9.0
	secondary	175	58.3
	tertiary	45	15.0
Occupation	Unemployed	54	18.0
	farming	3	1.0
	artesian	81	27.0
	civil servant	8	2.7
	traders	154	51.3
Ethnic group	Foreigners	37	12.3
	Yoruba	187	62.3
	Hausa	12	4.0
	Igbo	64	21.3
	no response	2	0.7
Household size	1-5	247	82.3
	6-10	42	14.0
	11-15	5	1.7
	above 15	4	1.3
Income	<10,000	64	21.3
	10,000-14000	35	11.7
	15,000-19,000	70	23.3
	20,000-24,000	92	30.7
	>25,000	39	13.0

The result of the economic status of the household shows that a greater percentage own a colored television set with 77.3% and 64.7% representing AJIF and LML LGAs respectively (table 3). More than three-quarter of the households do not subscribe to any form of newspaper in the study area (see table 3). The predominant regular mode of transportation in the study area is public transport with approximately 94.75% and 91.3% from LML and AJIF LGAs respectively. The majority use a personal phone for their regular communication (table 3).

Table 3. Economic status of household in the study area
Data source: Author's fieldwork (2015)

Variable	LGA	Option	Frequency	Percentage
Television type	AJIF	none	29	19.3
		black and white	5	3.3
		colored	116	77.3
	LML	none	49	32.7
		black and white	4	2.7
		colored	97	64.7
No newspapers subscription	AJIF	none	118	78.7
		one	27	18.0
		two	3	2.0
		three	2	1.3
	LML	none	123	82.0
		one	25	16.7
		two	2	1.3
		three	2	1.3
Mode of regular transportation	AJIF	foot/bicycle	1	.7
		public transport	137	91.3
		personal car/ taxi	12	8.0
	LML	foot/bicycle	2	1.3
		public transport	142	94.7
		personal car/ taxi	6	4.0
Mode of regular communication	AJIF	friend/ families	9	6.0
		postage	3	2.0
		public phone booth	2	1.3
		personal phone	136	90.7
	LML	friend/ families	5	3.3
		postage	4	2.7
		public phone booth	1	.7
		personal phone	140	93.3

Residential conditions in the study area

The housing status, type, and age of the building are presented in figure 2. The result shows that the majority are tenants with almost 90.0% and 65.3% residential in a rented apartment in LML and AJIF LGAs respectively. The implication of this is the majority will settle for cheap accommodation with which often lack basic amenities. A study conducted by Oni and Durodola (2010), in the urban core of Akure, revealed that low-income earners have a peculiar taste for tenement properties because of its low rent. Their findings corroborate the result of this study because the majority of the households are low-income earners and consequently tenants. Single room predominates in AJIF while room and parlor is the dominant dwelling type in LML. The majority of the buildings were constructed more than 9 years ago. This has implication for habitability because is a strong correlation between habitability of housing and their age. This has been reported by Omole (2010) in his study at Akure. He argued that buildings erected in more recent times tend to be more habitable compared to the earlier ones because it has direct effects on the state of health, socio-economic well-being and emotional stability of the residents.

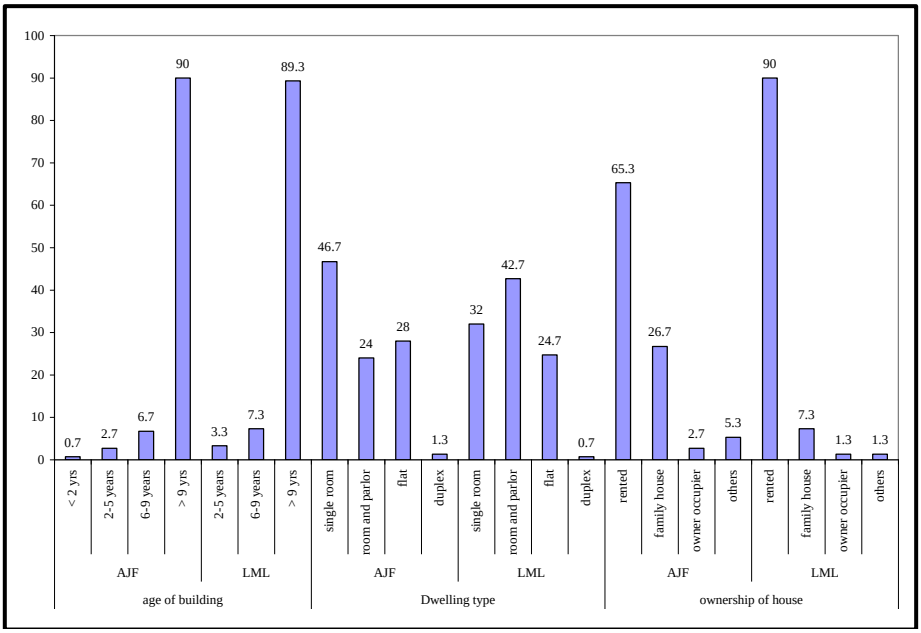

Figure 2. Housing status, type, and age of the building

Source: Author's (2015)

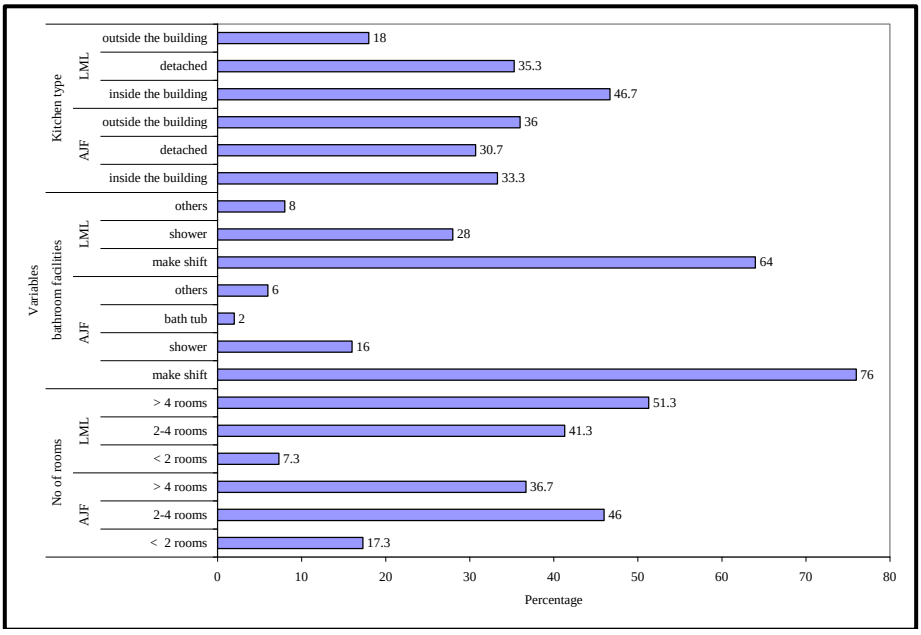

Figure 3. Housing facilities

Source: Author's (2015)

Figure 3 presents the housing facilities in the study area. The results show that the buildings in LML were designed for four rooms and above while those in AJIF ranged from 2 to 4 rooms. The majority of the households use the makeshift bathroom with about 76% and 64% representing

AJIF and LML LGAs respectively (see figure 3). Households in AJIF have their kitchens outside the building whereas, in LML, the kitchens are constructed inside the building.

Sanitary conditions in the study area

The sanitary condition in the study area indicates that more than three-quarter of the households have a waste bin in their dwelling for waste collection (figure 4). The predominant waste disposal method in the area is open land with approximately 96.7% and 82% of the households from LML and AJIF LGAs respectively. Significant dependence relationship exists between waste disposal method and the LGAs obtained as χ^2=18.568; df =4; p<.001. The occurrence of solid waste pile around dwelling is more predominant in AJIF LGA compared to LML. More than three-quarter of the dwellings are surrounded by stagnant water (see figure 4). The entire study area is devoid of the waste network.

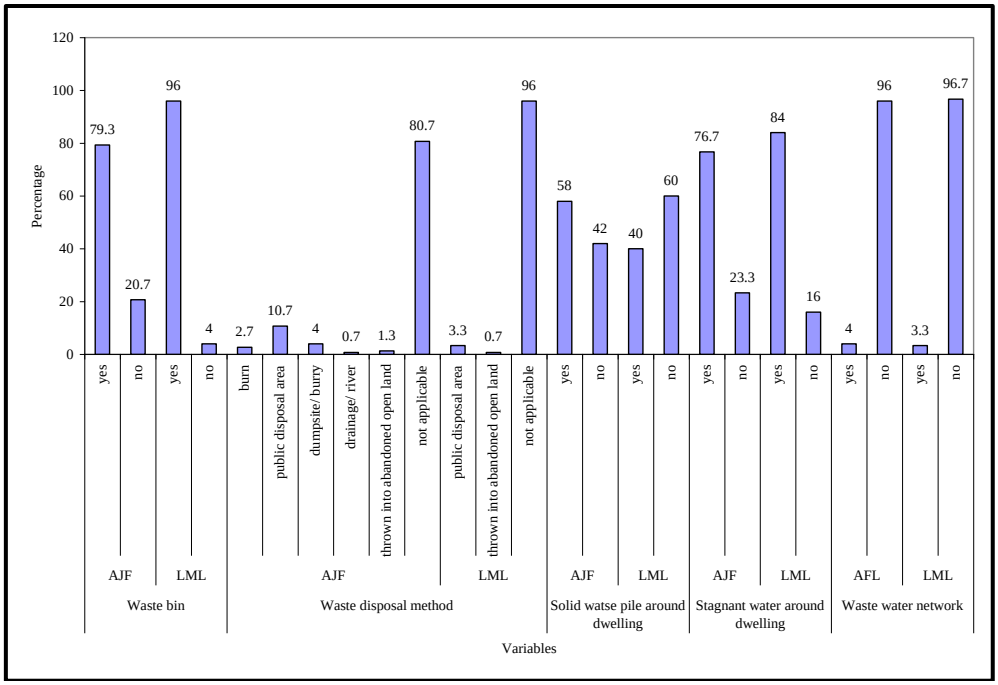

Figure 4. Sanitary condition in the study area

Source: Author's (2015)

The result of the descriptive statistics of the independent samples T-test is presented in table 4. The result indicates that the response score on economic status is obtained as 3.04 for AJIF and 3.01 for LML. The mean response score on housing quality is obtained as 8.91 and 8.79 respectively for AJIF and LML. The mean response score on households' sanitation and sanitary conditions is obtained as 9.65 and 9.70 respectively for AJIF and LML, while the mean response score on households' access to water sources is obtained as 1.71 and 1.80 respectively for AJIF and LML. The independent samples T-test for significant difference between the two study areas on the composite variable show that there is no significant difference between AJIF and LML based on households' socio-economic status, residential conditions of the residents, sanitation and sanitary conditions, and households access to water sources given as t = 0.215, 1.162, -0.515 and -1.752 (since p = 0.830, 0.246, 0.607 and 0.081 > 0.05 significance level) respectively (table 5). The result implied that the residential condition of residents in the two LGAs is the same.

Table 4. Descriptive statistics of independent samples T-test of the variables
Data source: Author's fieldwork (2015)

Variables	LGAs	N	Mean	Std. Deviation	Std. Error Mean
Socio-economic status	AJIF	150	3.0400	1.44650	.11811
	LML	150	3.0067	1.23428	.10078
Residential conditions of residents	AJIF	150	8.9133	.94788	.07739
	LML	150	8.7933	.83784	.06841
Households sanitation and sanitary condition	AJIF	150	9.6533	.82728	.06755
	LML	150	9.7000	.73958	.06039
Households access to water	AJIF	150	1.7133	.45372	.03705
	LML	150	1.8000	.40134	.03277

Table 5. Independent Samples T-test of the variables
Data source: Author's fieldwork (2015)

Variable (Equal variances assumed)	t-test for Equality of Means						
	t	df	Sig.	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
						Lower	Upper
Socio-economic status	0.215	298	.830	.03333	.15526	-.27221	.33888
Residential conditions of residents	1.162	298	.246	.12000	.10329	-.08328	.32328
Households sanitation and sanitary conditions	-0.515	298	.607	-.04667	.09060	-.22497	.13164
Households access to water	-1.752	298	.081	-.08667	.04946	-.18400	.01067

ACCESS TO WATER AND SANITATION IN THE STUDY AREA

Sources of water supply and access to improved water in the study area

The major source of water in the study area is borehole representing 50.3% and a marginal 25% for vendor-provided water while rainwater accounted for the least. Based on access to the improved source, 72.7% of the respondents have access to improved water in the study area (figure 5). The disparity over the LGAs shows that 87.3% and 58% have access to improved source in LML and AJIF LGAs respectively. The chi-square test indicates that there is significant dependence between the sources of water and the LGAs obtained as $\chi^2 = 88.504$, df = 8, p<. 000. Regarding safe water source (piped public tap, public standpipe, borehole connection and protected dug well connection), about 62.3% of the respondents have access to a safe water supply. The variations over LGAs show that 84% and 40.7% of the respondents have access to safe water supply in LML and AJIF LGAs respectively (figure 5).

Types of sanitation facilities and access to improved sanitation in the study area

The available sanitation facilities in the study area show that half of the respondents interviewed do not have any form of sanitation facility within their dwelling. Connection to septic system predominates with 15.8% followed by pour-flush latrine (13.8%). The least sanitation facility is open-pit latrine with 0.8%. Access to sanitation in the study area shows that 74.0% of the respondents have access to sanitation facilities (figure 6). Across the LGAs, CSS, and PSL predominate in LML representing 44.7% and 32.7% respectively. The dominant toilet faculties in AJIF are PFL and SPL (figure 6).

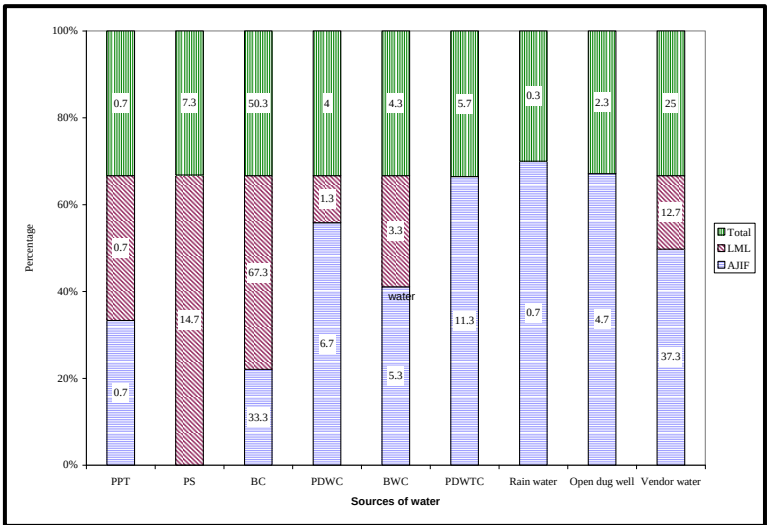

Figure 5. Access to water supply in the study area
Source: Author's (2015)
KEY- PPT- piped public tap, PS- public standpipe, BC- borehole connection, PDWC- protected dug well connection, BWC- borehole without connection, PDWTC- protected dug well without connection

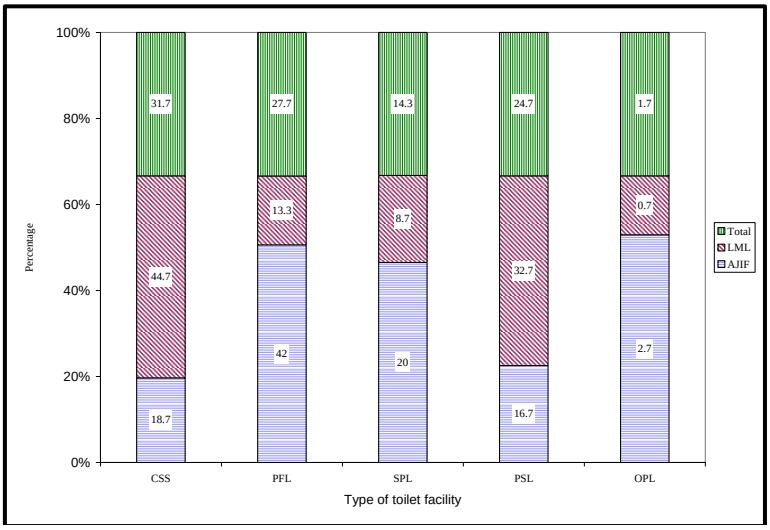

Figure 6. Access to sanitation facility in the study area
Source: Author's (2015)
KEY- CSS- connection to septic system, PFL- pour-flush latrine, SPL- simple pit latrine, PSL- public or shared latrine, OPL- open pit latrine

CONCLUSION

The result of the socio-demographic characteristics shows that the household's members were largely low-income earners while the household size is relatively moderate with the majority within the 1-5 groups. The majority of the respondents are tenants. The dominant dwelling type is single room/room and parlor in AJIF and LML respectively. Most of the buildings in the study area are relatively old based on their age. Makeshift bathroom predominates in the study area while households from AJIF and LML have their kitchens constructed outside and inside the building respectively.

More than three-quarter of the households have a waste bin in their dwelling for waste collection and the dominant waste disposal method is open land. Significant dependence relationship was established between the waste disposal method and the LGAs. The occurrence of solid waste pile around dwelling is more predominant in AJIF while approximately three-quarter of the dwellings have stagnant water around their dwellings. The independent samples T-test between the two study areas on the composite variable shows that there is no significant difference between AJIF and LML based on households' socio-economic status, residential conditions, sanitation, and sanitary conditions, and access to water.

The major source of water in the study area is borehole while rainwater is the least source. More than three-quarter of the respondents have access to improved water in the study area. The chi-square test indicates that there is significant dependence between the sources of water and the LGAs. Safe water provision in the study area revealed that more than half of the respondents have access. About half of the respondents interviewed do not have any form of sanitation facility within their dwelling. More than three-quarter of the respondents have access to sanitation in the study area. The study concluded that the dominance of stagnant water and open land disposal method poses a serious threat to the environment and human health. Additionally, the non-availability of sanitation facility within the household has an implication on hygiene. Policies that will guarantee the enforcement of sanitary laws and developmental control, upgrading of basic amenities and public enlightenment on the need for sustainable socio-environmental and healthy residential conditions of the populace were recommended.

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CRIME PATTERN AND DISTRIBUTION IN REGIONAL ENVIRONMENT: A CASE OF CRIME HOT-SPOT AREAS OF OSUN STATE, SOUTHWESTERN NIGERIA

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Abstract: This work assessed the pattern and distribution of criminal activities in Osun State Nigeria. It selected ten famous black-spots crime-area in the State using structured questionnaires and secondary data for household-heads and security outfits to obtain relevant data. Factor analysis and multiple regression techniques were employed to analyse data obtained.The findings indicated that most urban residents exhibited a significant higher-level of uncertainties but still want to remain in their ancestral-homes. Suggestions were put forward to governments and security agencies to play priority roles in securing people in their residential areas to conform to other cities of the world.

Key words: crime distribution, black-spots, pattern, ancestral-homes, government, Osun State

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INTRODUCTION

Lots of studies have been carried out on crime incidence in urban environment around the world. In Africa in particular, the studies by Osaghae (1994), Ahmed (2010) provide a tactically and articulate background to such studies in the urban environment where hitherto studies of that nature have been rather sparsely available (Osaghae, 1994; Aguda, 2001). Expectedly in Nigeria, studies on urban crime have been recent and sparse. Some of the few studies include Albert (1995) on Kano, Adisa (1994) on Lagos, Aguda (1994) on Ile-Ife and Ahmed (2010) on Southwestern Nigeria among others. All these studies reveal that crime and violence at the regional areas is expected to continuing to rise because, as urban environment continue to grow into regional areas, so does the social malaise pervade. The growth in urban crime rate in Nigeria is one of the major social problems facing the country in recent time. The dominance of crime in developing countries increases the volatility of the issue, for it pyramids one uncertainty upon others. The concentration of violent crimes in major urban centers worldwide is therefore heralded as an indicator of the breakdown of urban systems. In many urban environment in developing countries today, criminal activities and violence are assuming dangerous tendencies as they threaten lives and property, the

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national sense of well-being and coherence, peace, social order and security; thus, reduces the citizens' quality of life (Aderamo, 2000; Agbola, 2000; Ahmed, 2010). The fear of armed robbery, kidnapping and unlawful arms' possession and militia menace keep Nigerians sleepless at night and they tend to live one day at a time with the fear of whether they may not see the light of any other day, make them assess life as being valueless. Nigerians find it difficult to put their trust on police protection because Nigeria is under policed with an average of one policeman to 5000 Nigerians, compared to that of one policeman to 400 persons in the developed world. Nigerian police are, at times, in collusion with the men of the underworld to unleash terror on their fellow countrymen (Agbola, 1997; Ahmed, 2010).

The Nigeria regional environment consists of diverse groups who arrived at their locations at different times. In most cases, different groups settled at contiguous but distinct locations and in the process of expansion, the earlier settlements grow to absorb each other. Usually in Yoruba land of Southwestern Nigeria, the first settlers constitute the traditional families and land owners (Aguda, 2001). The result is that in many urban environments in the region, new groups are not usually given automatic recognition and they remain the weaker elements for a long time. Also in the world over, discrete communities are known to exist within the cities making urban community cleavages that have become a significant part of the political relationship of the different units. The main interest of this writer is that, issues which relate to these cleavages and segregation have location components and need proper investigation. Trident Press International 2003 - defines crime as any grave offense against morality or social order iniquity. While, crime according to Dambazau (1994) is something which offends the morality of society, or that violates the divine law. The consensus approach to defining crime thus presents it as; offence that is committed by omission, commission or deliberately.

The main focus of this study is centered on socio-economic and political movements that transformed Nigeria between 1985 and 2000. The country had witnessed series of crime waves that transposed a new dispensation into the so-called 'modern democratic government.' Hence, Nigeria witnessed different modes of governance from military to civilian regimes before these periods. The military, in the first instance, solely took advantage of its professional training by using violence to usurp power through coups and counter coups. The politicians in their turn, and in their bids to absorb power, used hired-thugs, or paid assassins/hired killers to perpetrate violence and instill fears on their opponents. The frustrated masses took to formulation of militant groups as witnessed in the uproar of the youths from South-South and establishment of insurgency - Boko-haram/Herdsmen sects from the North-Eastern path of the country who totally disregarded the law. In view of the above, there is therefore, the need to look critically at the pattern and distribution of crime ascendant in the country (Ahmed, 2010). There are also problems of corruption in all ramifications and within all sectors of economy in the private or government sectors in the country. All these encourage many people to take solace in crime, because almost all systems are tending towards not functioning properly or not functioning at all.

There were series of measures taken by government and its agencies such as; the Resource Endowment and Economics of Crime (REEC), the Economic and Financial Crime Commission (EFCC); the National Drug Law Enforcement Agency (NDLEA); the Independent Corrupt Practices and other Related Offences Commission (ICPC) among others, in order to curtail various problems emanating from the national adversities. Therefore, the main objectives of this work are focused on the variations in the pattern and distribution of urban crime and, assessment of factors responsible for the prevalence of different crimes in Osun State Nigeria.

In the light of the foregoing, some questions are raised and should be clarified to articulate the problem and objectives of this study: What pattern formed and distribution tendency shown by crimes committed in Osun state Nigeria in the years under investigation? To what extent are the police and security agents are able to contain crimes perpetrated in the study area and what are the societal/institutional failures that have significantly contributed to the upsurge in the rate of criminal engagements in selected urban environment of Osun State among others?

THE STUDY AREA

Osun state was created on August 27, 1991 along with others states in the federation. The state consisted of Osun, Ife, and Ijesa provinces. The state on its creation was made up of 23 LGA's inherited from old Oyo state. Osun State is situated within the tropics and most of the areas fall within wet and dry seasons. The rainy season occurs between April and October, while the dry season, lasts for about November to March annually. Further to this, the rainfall pattern starting from Lagos area and Ijebu-Ode which shows a tendency towards a double maximal separated by a short dry season. There is marked uniformity in the thermal regime in Osun State Southwestern Nigeria. The mean annual temperature exhibits a temperature that increases by 1º from 27^0C in the interior of southwestern area. All these attributes emphasized not only the population distribution but also socio-economic development of study area.

Alluvial, ferrisols/ferralitic and ferruginous are the main soil types in Osun State. Accordingly, most soils in Osun State contained very limited reserves of weather able minerals due to intensive leaching. Where soils are good there are concentration of population who use the soil for intensive agricultural practice in the study area. However, among Yoruba of southwestern Nigeria lands are most prominent and valuable assets but sometimes it may lead to liability and conflicts among kinfolk where they cannot compromise (Adeyemi, 1992).

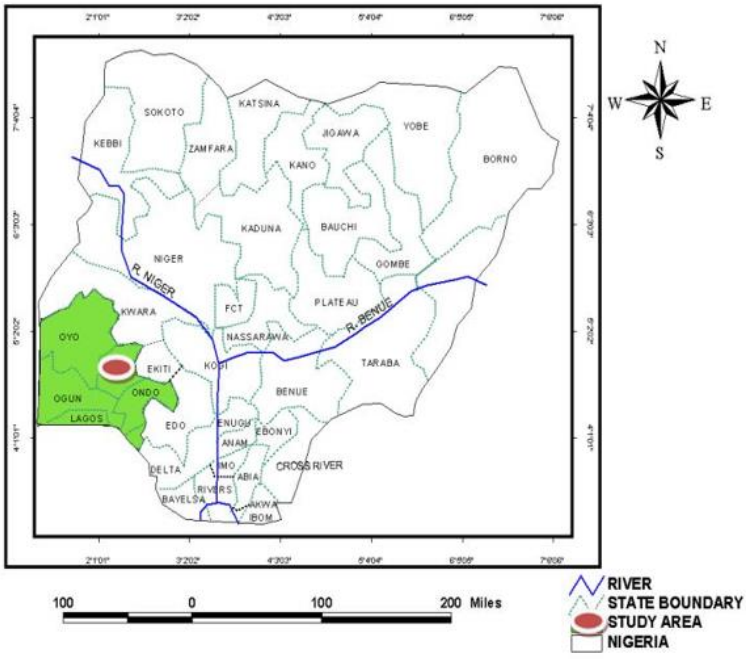

Figure 1. Showing major urban centers in Osun State
Source: Author's Fieldwork

METHODOLOGY

The data used for this study were obtained from both primary and secondary sources majorly acquired from Zone Eleven of the Police Zonal Command Southwestern Nigeria that comprises - Oyo, Osun, Ogun, Ondo and Lagos States. Twenty three set of variable data were generated from this zones and they were categorized into new indicators - Crime against person, Crime against property and Crime against Lawful authority (see tables 1, 2). These twenty three variables were later re-written in an attempt to identify the most salient variables to adapt in explaining the main pattern/distribution of crimes in the study area using Factor Analysis statistical method. Olawepo and Ahmed (2003) used a similar method in their work on 'Factorial Ecology of

a Traditional Urban Centre in Ilorin'. Thus the method is considered as the most suitable for the task of separating factors and identifying development indices for explaining factors affecting distribution of crime in ten selected urban centers in Osun state, Nigeria. Multiple regression analysis was also used to find a way of isolating the most important factor-defining variables sustained from the factor analysis technique (see tables 4, 5, 6). Therefore, this method was adopted to assist in deriving a new model home, and for effective distribution of urban crime wave / patterns in Osun state, Nigeria.

The secondary data-base collected from the police were analyzed using descriptive statistical tool such as; illustrations, tabulation and cross-tabulation of data. This step was used in order to obtain frequency distribution and calculate for each of the variables contained in the questionnaires. It also helped in pulling together the major information for the work. This attempt assists to identify the most salient variables that were adapted in explaining the pattern, and found out the likely causes of crime under investigation. The final step involved the use of Multiple Regression Analysis to explain the factors- determining incidence of crime in the combined selected areas of study. This method was used as a backup, it allows us to assess the relationship that existed between two or more variables while controlling for the effects of others (Nachmias and Nachmias, 1996). The approach also helped in isolating the most important factor-defining variables sustained from the factor analysis technique, and in deriving new model of crime patterns. In other words, the results from the factor scores derived through the use of factor analysis technique served equally as input into multiple regression models (see table 3, 4, 5).

The multiple regression models are defined as:

$$Y = a + b1\ x\ 1 + b2\ \ x2 + b3\ x\ 3 + bn,xn + e \quad \text{.....(eq.4.1)}$$

Where a = intercept,
Y = dependent variable
bi = partial regression coefficients
xi-xn = independent variable
e = error term.

Table 1. Categorization of Offences in Selected Urban Environment
Source: Adapted from Olumodeji, (1994) and modified by the Author

Crime Against Persons	**Crime Against Property**	**Crime Against Lawful Authority Local Acts.**
Murder	Armed robbery	Cheating
Manslaughter	Extortion /with menace	Coining Offence
Attempted murder	Theft and stealing	Gambling
Suicide and attempted suicide	House breaking	Breach of public peace
Grievous harm and wound	Store breaking	Perjury
Assault	False Pretence	Bribery and corruption
Child stealing	Forgery	Escape from lawfulcustody
Child labour / slavery	Receiving stolen property	Traffic offence
Rape and indecent assault	Unlawful possession of property	Liquor Offence
Kidnapping	Arson	Fire-arm offence
Aberrant offence	Computer Scams	Narcotic offence
Others	Others	Others

Table 2. Incidences of Crime Rate in Southwestern Nigeria
Source: The Nigeria Police Force Abstracts of Crime and Offences' Statistical Reports

Year	Offence Against Persons	Offence Against Property	Offence Against Lawful Authority	Offence Against Local Acts	Total
1985	**24,404**	66,436	2,667	989	94,506
1986	**29,677**	79,606	2,944	1,076	113,303
1987	**33,821**	49,117	3,660	2,181	88,779
1988	**21,580**	57,003	6,787	1,949	87,319
1989	**19,111**	88,580	9,332	1,199	18,222
1990	**29,643**	111,333	11,943	2,066	154,985
1991	**36,201**	130,709	13,580	3,711	184,202
1992	**96,761**	153,986	15,185	5,682	271,614
1993	**93,772**	179,885	15,499	6,722	295,878
1994	**90,278**	138,007	13,806	4,947	247,038
1995	**86,744**	138,486	11,790	4,896	241,916
1996	**92,666**	132,333	11,361	3,994	240,354
1997	**90,347**	206,750	11,181	2,673	310,951
1998	**94,947**	396,404	12,099	5,001	508,451
1999	**104,646**	556,388	19,885	4,577	685,496
2000	**96,733**	441,962	14,333	3,070	556,098
Total	**1, 041,331**	**2,926,985**	**176, 062**	**54,733**	**4,199,111**

RESULTS AND DISCUSSIONS

In order to assess the relationship that exists between the selected variables of crime under investigation, a correlation matrix for each factor executed was put into computerized form. The correlations among the twenty three variables were dispensed accordingly (see table 3, 4, 5). By putting into consideration values that are larger than +0.60, we can observe that many of the variables are closely related. Though, the pattern of values that are significant are shown in two levels,those correlations that are significant at 0.01 (99% at 2-tailed) level and at 0.05 (95% at 1-tailed). But the higher significant levels are seen to have common with 0.01 significant levels. For example, there is high correlation at about twelve different levels. Thus: between murder and attempted murder between Grievous wound and assault, rape, theft and stealing, as well as armed robbery. Also between burglary and grievous wound, receiving of stolen goods; assault, theft and grievous. Also between house breaking and theft; breach of public peace and arson, computer scam; as well as between breach of public peace and house breaking.

Table 3. Rotated Component Factors
Source: Author's Computer Output

Offence	Unemployment Rate Factor (I)	Rural/Urban Migration Syndicate (II)	Inadequate No.of Police Factor (III)	Family Obligation Factor (IV)	Drug Abuse/ Trafficking Factor (V)
Murder	.23	.08	-.04	.81	-.01
Attempted murder	-.07	-.01	.14	.79	.19
Suicide	-.01	-.017	.05	. 15	. 65
Grievous wound	.68	18	-.04	17	.04
Assault	.61	-.32	-.30	-.07	-18
Child stealing	.27	.20	-.02	-.06	58
Rape	.80	- .08	.14	.15	-.03
Kidnapping	-.08	.01	.69	-.05	.15

Aberration	-.20	-.09	.78	-.00	..15
Armed robbery	.40	-.05	-.07	.45	-.44
Demand by menace	-.07	.67	-.00	-.19	.08
Theft/stealing	.80	-.21	-.12	-.09	.05
Burglary	.80	.09	.15	.17	.02
House breaking	.79	-.43	-.02	-.07	-.16
Forgery	.28	-.18	.48	.11	-.17
Bribery	.05	.07	.40	.08	.60
Perjury	-.14	.29	.59	.02	.03
Receiving stolen items	.18	.48	-.13	.34	-.40
Unlawful arms Possess	.49	-.23	.56	-.05	.24
Arson	-.03	.78	-.15	.05	-.09
Preach of peace	.65	-.58	-.00	-.05	- 07
Escape from custody	-.00	.79	.37	.08	.04
Computer scam	.82	.16	-.13	.13	-.07
Eigen Value	**5.17**	**2.89**	**2.53**	**1.82**	**1.74**
% of Variance	**22.55**	**12.57**	**11.01**	**7.93**	**1.74**
Cumulative %	**22.55**	**35.12**	**46.13**	**54.06**	**61.62**

Table 4. Distribution of the Component Scores on Measures of Crime in Osun State
Source: Author's Computer Output

S/No.**Variance**	**ComponentI**	**ComponentII**	**ComponentIII**	**ComponentIV**	**ComponentV**
1. Child Stealing	0.000	0.852	0.000	0.128	0.000
2. Forgery	0.000	0.844	0.210	0.000	0.000
3. Perjury	0.000	0.778	-0.173	0.000	0.000
4. Suicide	0.186	0.733	-0.115	0.160	0.122
5. Aberration	0.186	0.641	-0.197	0.253	0.111
6. House Breaking	0.234	0.575	-0.245	0.473	0.000
7. Computer Scams	0.241	-0.154	0.786	0.000	0.125
8 Armed Robbery	0.118	0.000	0.622	0.000	0.538
9. Assaults	0.304	0.504	-0.604	0.158	0.249
10.Theft/Stealing	0.300	0.544	-0.599	0.233	0.000
11.Burglary	0.307	0.281	-0.574	0.530	-0.110
12.Demand by Menace	0.000	0.536	0.000	0.305	-0.106
13.Escape custody	0.000	0.115	0.000	0.873	0.000
14. Arson	0.140	0.177	-0.110	0.869	0.105
15.Bribery	0.340	-0.154	0.601	0.164	0.000
16.Receiving Stolen goods	0.141	0.437	0.214	0.501	-0.214
17. Unlawful arms possession	0.181	0.253	-0.422	0.370	0.000
18.Attempted murder	0.000	0.208	0.000	0.890	0.121
19. Kidnapping	0.775	0.011	0.122	0.000	0.000
20. Murder	0.000	0.000	0.533	-0.151	0.660
21. Rape	0.787	-0.126	0.000	0.000	0.000
22. Preach of peace	0.636	0.296	0.465	-0.215	0.000
23. Grievous wound	0.572	0.101	-0.203	0.153	0.360

Factors Explanation

All the variables that are responsible for the causes and effects of crimes commitment in the study area are relatively important. Though, there is variability in the contributions of each of these factors which could be obviously seen as the 'eigen values' are greater than one (see table 3). We can equally say that when interpret the components as representing groups of variables, the considering component loadings is greater than +0.60 and labelled the components accordingly. For our attention, factor I accounts for 22.55% of the total variance explained with its significant positive loading. This factor is tagged 'Condition of Unemployment Rate'. The characteristics of this factor tend to show that there are more people that take into crimes when they are unable to earn good standard of living that can meet their family needs (see tables 4 and 5).

Table 5. Matrix of Inter-Correlation on Crime Measures in Osun State
Source: Author's Fieldwork

Murder	1.000																					
Attptmrd	.395*	1.000																				
Suicide	.0180	.122	1.000																			
Grivwoun	.296*	0.87	0.000	1.000																		
Assault	.073	-033	.120	.494*	1.000																	
Childstolen	-031	.086	.044	.205	.030	1.000																
Rape	.260*	.115	.091	.403*	.304	.101	1.000															
Kidnappin	.052	.028	.095	-038	-230	.061	.048	1.000														
Aberration	.039	.129	.201**	.111	.113	.230**	.496**	.281**	1.000													
ArmRobbe	436*	.162	-.215*	.224**	.316**	-.040	.384**	-.058	.281**	1.000												
Dd Menace	-.069	-.085	-.101	-.115	-.316**	.088	-.031	.096	-.005	-.103	1.000											
Theft/Stole	.113	-.071	.070	.441**	.543**	.166	.601**	-.143	-.203	.261*	-.187	1.000										
Burglary	.362**	.085	.006	.508**	.387**	.167	.652**	.075	-.054	.355*	.001	.465*	1.000									
HousBreak	.185	.017	.149	.409**	.551**	.185	.632**	-.056	-.136	.249*	-.300**	.776*	.584**	1.000								
Forgery	.051	.164	.034	.114	.041	.001	.339**	.097	.169	.089	-.086	.232*	.212*	.230*	1.000							
Bribery	-.024	.165	.288**	.033	-.132	.151	.053	.337**	.278*	-.237	-.009	-.044	.098	.063	.091	1.000						
Pejury	-.044	.061	.060	-.014	-.289**	.025	-.120	.133	.387*	-.114	.009	-.194	-.029	-.208*	.115	.231*	1.000					
R.stoleGood	.306**	.053	-.200**	.261**	-.021	-.099	.194*	-.209*	-.167	.285*	.185	.015	.201*	-.123	.039	-.173	.017	1.000				
Pre.peace	.039	.129	.201**	.111	.113	.230**	.496**	.281**	.279*	.127	-.183	.361*	.467**	.504**	.305**	.289**	.184	-.250**	1.000			
Arson	.085	.006	-.170	.019	-.209**	.139	-.086	-.138	-.139	.083	.379**	-.135	-.039	-.349*	-.172	-.140	.281**	.248*	-.246*	1.000		
Unlarmposs	.098	-.024	.102	.347**	.569**	.070	.530**	-.096	-.186	.201*	-.378**	.624*	.442**	.749**	.208*	.032	-.300**	-.218*	.370**	-.463**	1.000	
EscPrison	.015	.098	-.007	.140	-.309**	.082	.001	.234**	.280*	.000	.423**	-.159	.040	-.346*	.030	.234*	.406**	.295**	.019	.495**	-.450**	1.000
CompScam	.286**	.065	-.012	.626**	.459**	.098	.605**	-.141	-.273*	.307*	-.096	.549*	.638**	.531**	.142	-.081	-.152	.260**	.288**	.084	.385**	.084	1000

* Correlation is significant at the 0.05 level (2-tailed
* * Correlation is significant at the 0.01 level (2-tailed)

Factor II exhibited a high positive loadings and accounts for 12.57% of the total variance. The factor is termed 'Rural/Urban Migration Syndicate'. Due to the belief that there are more employment opportunities in major urban centers, many able bodied youths drift to the urban centers/cities like Osogbo, Ife, Odo-otin and other areas in Osun State Nigeria. Factor III on the other hand, explained 11.01% of the total variance that has significant positive loadings on different crimes committed and reported. Most of the crimes committed could have been curtailed if there are adequate security personnel in the selected areas of Osun State; hence this factor is referred to as 'Police Inadequacy Factor.' More importantly, Factor IV accounted for 7.93% of the total variance explained. This factor has to do with notable crimes affecting individual personality-(Crime Against Persons). Thus is labeled 'Family Responsibility/Obligation Factor'. Most of the obligations are not met due to meager income of the household heads.

Lastly, Factor V accounted for 1.74% of the total variance and is basically an aggregate measure of positions which some people uphold in the community. For instance, some individuals aid or abet crime like; drug abuse and trafficking. Thus, this factor is termed 'Drug Abuse/Trafficking Factor'. Factor V is also significant because it influences other variable factors to work. Criminals use drugs as aid in order to commit crimes. This factor accounts for 1.74% of the total variance.

INCIDENCE OF NEW CRIME MODEL AND PLANNING IMPLICATIONS

Modeling of crime incidence is imperative simply because it assists in explaining vividly all sorts of crime problems in Osun State and Nigeria as a whole. Thus, as a new model was developed, it further aids the prediction of crime perpetration in as to render good planning by the governments of all categories for the citizens in the country at present and in the near future for a better crime management. Therefore, the pattern/distribution of crime incidence in Osun State was not by accident but by finding. In addition to the above, Multiple Regression Analysis (see table 6) was put forward in order to find a way of isolating the most salient factor defining variables

sustained from the factor analysis technique as discussed early. This model is interpreted as; selected five variables which is accessibility to condition as: Unemployment rate, Rural-urban migration, Police inadequacy, Family obligation and Drug abuse/trafficking as tabulated above. The planning implications therein indicated what real happens all over the world most especially among the developing countries. Implications such as; crimes perpetration, their spatial pattern and distribution, and above all its consequences on individuals, communities, governments and other stakeholders are its focus.

Table 6. Multple Regression Between Total Crime and Factor Defining Variables
Source: Author's Computer Output

List of Variables and Intercepted	Regression Coefficient	Standard Error	R	R^2	Total Contribution (%)	T-Test Value
Intercept	2464177	3.1122	-	-	22.09	0.001
X1.Unemployment Rate	375363	0.6911	0.47	0.2209	22.09	0.001
X2. Rural-Urban Migration	47526.23	.03455	0.55	0.3025	30.25	0.01
X3. Inadequate No. of Police	42487.5	.03026	0.35	0.1225	35.00	0.566
X4. Family Income/Obligation	4527.9	.03110	0.44	0.1936	19.36	0.233
X5. Drug Trafficking/Abuse	14695.1	.03340	0.14	0.0196	1.96	0.001

Another implication is that geographers, urban planners and political leaders can make use of the model as reference point in their bid for proper programme execution for the citizens.

Multiple Regression Model.
Equation I (Predictive Model)

Y= 3691344.4 – 289265 CONUMRATE + 457743.9 RURMIGRATE - 214200.5 POLINADQUACY + 243433.5 FAMOBLIGATION - 59518.3 DRUGTRAFFICK. (eq. 1)

(R^2= 80.6% std. error 24.4)

CONCLUSION AND RECOMANDATIONS

This work has eventually served as eye-opener to some hidden facts and planning implications about criminal activities in some local government areas/zones of Osun State, Southwestern Nigeria. The work has demonstrated the effect of social structure on human beings leading to crime incidence in various hot-spots in the state. The reaction of human beings for survival within the social structure has constituted a corpus of knowledge relevant to examination of youths' engagement in urban violence. Youths who are found in criminal activities absorb crime as a method of adjusting to social malignant. To eradicate crimes therefore, fundamental societal survival techniques must be dissociated from crime. This requires a fundamental restructuring of the society towards productive engagement in the sector that can provide the need and positive aspiration of the people in cities all over the world. Positive achievement is obtained through educational institutions, community participation in productive engagements, and above all, where governments perform its tasks appropriately. To reduce youths' perceived negative attitude, societal negatives must be ameliorated.

The incidence of crime wave and its intensity has been on increasing not only in Nigeria but all over the world. Therefore, urgent needs for safety and security through diverse means are overdue in order to make global cities' environment livable. The spread of crime in cities world-wide are becoming a foremost phenomenon and a proper consideration by all stakeholders such as; the government, the security personnel and the communities' participation in crime reduction is duly warranted.

To make all suggestions work in the areas studied, Nigeria, and in developing world as a whole, therefore, it is recommended that:

- residents of cities need to maintain positive attitude and remain calm at any crime alert condition; they should not feed their minds with much fear from unnecessary apprehension and panic (Ahmed, 2010). They must always remain unruffled, steadfast, and help one another especially when there is a need for help in their neighborhoods.

- people should always mind their own business, but be cautious and vigilant about all that go around them mostly among the people living in cities.

- residents of cities in Nigeria should avoid carrying or displaying some criminogenic items such as; huge sum of money or attractive wares that can invite criminals to their neighborhoods.

- efficient security coping mechanism should be taken up by the government and by the security agents, such that the police patrols is extended to all nooks and corners of the city centers, local government areas, and at the regional settings among others.

- security awareness should be taken seriously on new settlers' settlements, among the communities especially when building new residential quarters. The use of day and night vigilantes or community guards should take a paramount role in the living areas of the cities and neighborhoods. It is when all these suggestions are put in place that cities in Nigeria would attract a more stable society which encourages investment (domestic and international), a more secure community with abundant opportunities for all ethnic groups in the country. Any contrary propositions to the above would not enhance a free flow of commerce and ideas, freedom of speech and the press, as well as new innovation into the country.

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A MULTI-CRITERIA ANALYTICAL HIERARCHY PROCESS (AHP) TO FLOOD VULNERABILITY ASSESSMENT IN BATNA WATERSHED (ALGERIA)

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Abstract: A multi-criteria Analytical Hierarchy Process (AHP) analysis was carried under a geographic information system (GIS) integrating several factors, namely slope, maximum daily precipitation, for a 100-year return period, drainage density, permeability and vegetation cover whose purpose is to better understanding, evaluate and mapping the vulnerability to flooding in Batna watershed. This analysis assesses the level of this phenomenon according to several criteria of different nature; these criteria were recorded and weighted on the same scale. The results show that several areas are extremely vulnerable requiring the implementation of priority actions to address this risk.

Key words: AHP, Batna, flood, GIS, vulnerability, watershed

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INTRODUCTION

Hydrological risks pose a threat to people and property in most parts of the world. The optimal management of floods requires prior knowledge of the cause of the phenomenon and a good mapping of its extent (Wade et al., 2008; Herman, 2009, 2010).The methodology adopted for

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the characterization and delimitation of flood vulnerability in the Batna watershed is based on multi-criteria analysis by integrating several factors where each one has a weight depending on their importance and their influence on the gravity of the phenomenon.

Multicriteria analysis is a decision support tool developed to solve complex multi-criteria problems that include qualitative and/or quantitative aspects in a decision-making process (Mendozaet al., 2000). This method makes it possible to provide answers to several difficulties posed by the evaluation (Grivault et al., 2007). We chose T. Saaty's method, which has the advantage of proposing an easily comprehensible model of data organization reflecting the natural tendency of the mind to sort the elements of a system into different levels and to group similar elements on one level to solve unstructured problems (Barczak et al., 2007).

The factors involved in the analysis depend on the availability of data. The slope is the major factor that influencing flooding; the areas of low to very low slope are areas prone to flooding and submersion. The precipitation is the factor that generates flow and triggers flooding. Rainwater accumulates in low-lying areas and converges towards the downstream; these areas represent the drainage network which can take third place in the weighting.

Permeability is explained by the lithological nature and by the land cover, waterproofing of the soil is one of the factors that favours surface flows. When water infiltration into soil is permanently reduced, the risk of surface runoff is increased (Montoroi, 2012).

Finally, the vegetation cover exerts an important limiting effect on surface runoff. It regulates stream flow and dampens low- and medium-amplitude floods. However, its effect on extreme flows caused by catastrophic floods can be reduced (Saley et al., 2005). Degraded vegetation cover is a favourable factor for surface flows and promotes the watershed's hydrological response. Runoff is strongly accentuated for soils with scattered vegetation cover (Montoroi, 2012).

We used an index parameterized approach where each parameter is in fact a numerical index translated by a code used for modeling.

STUDY AREA

The catchment area of Batna figure 1, located in eastern Algeria, covers an area of 802.68 km², between latitudes 35°25' and 35°47' North and between longitudes 6°5' and 6°29' East.

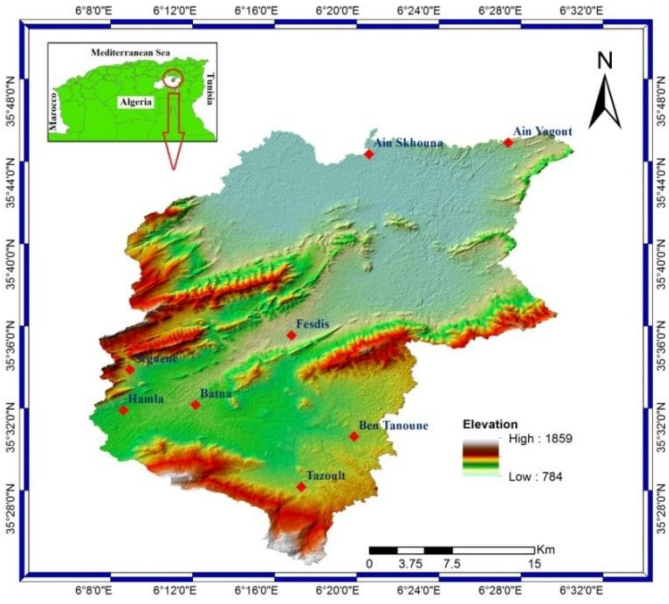


Figure 1. Study area
(Source: Guellouh Sami)

The climate of the region is classified as semi-arid, characterized by irregular rainfall. (Sami et al., 2016). Its geography makes it possible to identify several categories of land use, each characterized by strong specificities and great diversity.

MATERIALS AND METHODS

To map the vulnerability to flooding in the Batna watershed, several thematic maps have been drawn up beforehand. The factors involved in the analysis, their sources and the method of acquisition are summarised in order of priority in the table below.

Table 1. Data Sources and Acquisition Method

Parameters	Data Sources	Acquisition Method
Slope	DEM	Extraction
rainfall	Rainfall National Water Resources Agency (ANRH)	Interpolation
Drainage density	DEM	Extraction
Permeability	Geological map of Algeria 1/ 500,000	Scan
vegetation cover	Satellite image 30 m	Supervised classification

The adopted method is AHP. It's i a popular method used as a tool for multi-criteria decision making (MCDM) or as a technical estimation (Taibi and Atmani, 2017). This method has mathematical properties and allows total ranking, it requires a hierarchy of the decision problem and a pairwise comparisons of entities in every node of the hierarchy (Saaty, 1991). AHP involves the following steps: (1) structuring possible factors for the problem into a hierarchy; (2) arranging the factors for each alternative; (3) developing the criteria for alternatives; (4) evaluating the importance of alternatives; and (5) analyzing the weight of each factor (Chen et al., 2011).

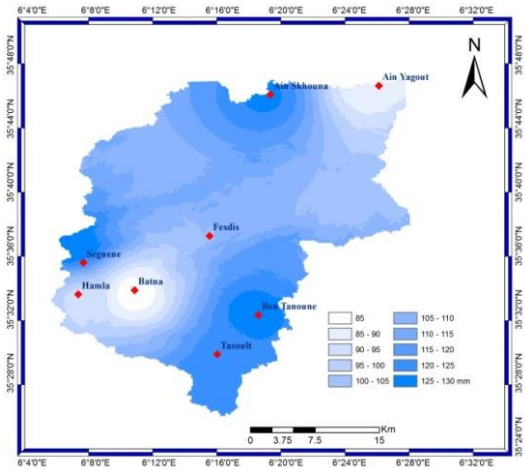
Table 2. Fundamental AHP judgment scale with integers 1 to 9 and their definition

Jugement	Definition	Comment
1	Equal importance	Two activities contribute equally to the objective
3	Moderate importance	Experience and judgment slightly favor one activity over another
5	Strong importance	Experience and judgment strongly favor one activity over another.
7	Very strong or demo-started importance	An activity is favored very strongly over another; its dominance demonstrated in practice.
9	Extreme importance	The evidence favoring one activity over another is of the highest possible order of affirmation..
2, 4 ,6 et 8	Values associated with intermediate judgments	Where a compromise is necessary.

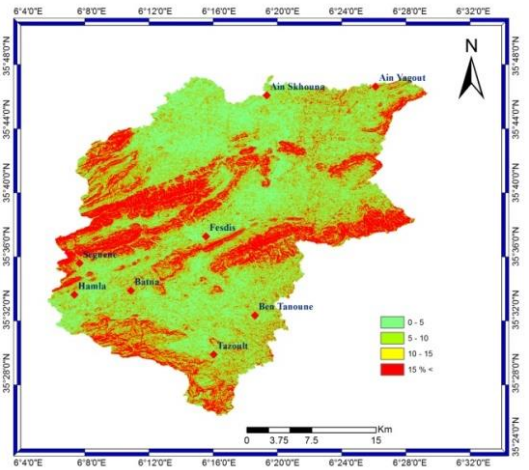
Table 3. Pair Comparison Matrix (Judgment Matrix)

	Slope	rainfall	Drainage density	Permeability	vegetation cover
Slope C1	1	2	4	5	7
Rainfall C2	½	1	3	5	6
Drainage density C3	¼	1/3	1	3	4
Permeability C4	1/5	1/5	1/3	1	3
vegetation cover C5	1/7	1/6	¼	1/3	1
Total	2.09	3.7	8.58	14.33	21

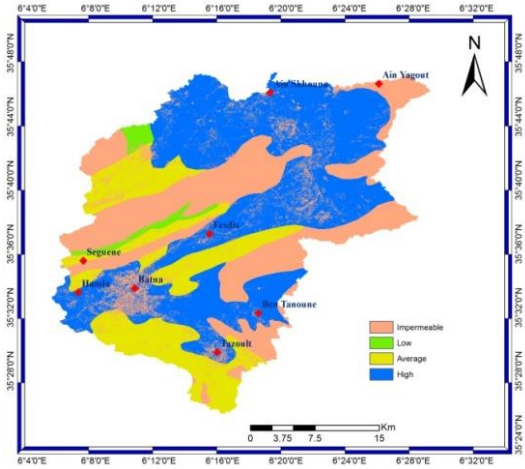
We divided each element of the matrix by the column total by the total value of the column and we calculated the average of the elements of each row.



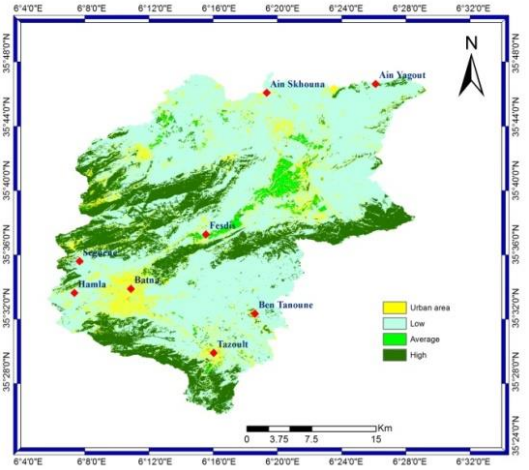
(A) Rainfall



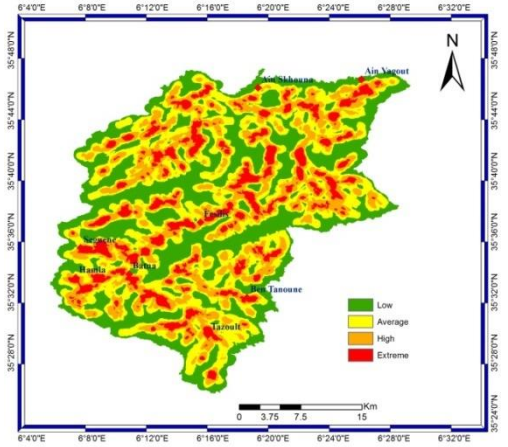
B) Slope



(C) Permeability



(D) vegetation cover



(E) Drainage Density

Figure 2. Thematic maps

Table 4. Determination of the weight of each criterion

	C1	C2	C3	C4	C5	The weight
C1	0.47	0.54	0.46	0.35	0.33	0.437
C2	0.24	0.27	0.34	0.35	0.28	0.302
C3	0.12	0.09	0.11	0.20	0.19	0.142
C4	0.095	0.054	0.038	0.07	0.14	0.075
C5	0.068	0.045	0.029	0.023	0.047	0.041
Total	1	1	1	1	1	1

The results from AHP are scores equal to 1 (Griot, 2007).After calculating the relative importance and determining the weight of each factor in the hierarchy, the vulnerability is calculated using the following formula:

Vulnerability = 0.437 Slope + 0.302 rainfall + 0.142 Drainage density + 0.075 Permeability + 0.041 vegetation cover.

We note that the weighting for the different classes of the same criterion is based on the following principle:

Table 5. Weighting for different classes of the same criterion

Parameters of Classes	**C1**	**C2**	**C3**	**C4**	**C5**
Classe 1	Weight C1 X 1	Weight C2 X 1	Weight C3 X 1	Weight C4 X 1	Weight C5 X 1
Classe 2	Weight C1 X ½	Weight C2 X ½	Weight C3 X 1/2	Weight C4 X 1/2	Weight C5 X 1/2
Classe 3	Weight C1 X 1/3	Weight C2 X 1/3	Weight C3 X 1/3	Weight C4 X 1/3	Weight C5 X 1/3
Classe 4	Weight C1 X ¼	Weight C2 X ¼	Weight C3 X 1/4	Weight C4 X 1/4	Weight C5 X 1/4

RESULTS AND DISCUSSIONS

With Arc GIS software and its extensions, we were able to attach weights to the different thematic maps and to create the map of vulnerability to floods in Batna watershed.

To verify the level of consistency of judgments and to ensure that the data are logically related to each other, a consistency ratio R below 0.10 is considered permissible, the higher ratio of 0.10 indicates a higher level of inconsistency. In our case R = 0.048 (figure 3, 4).

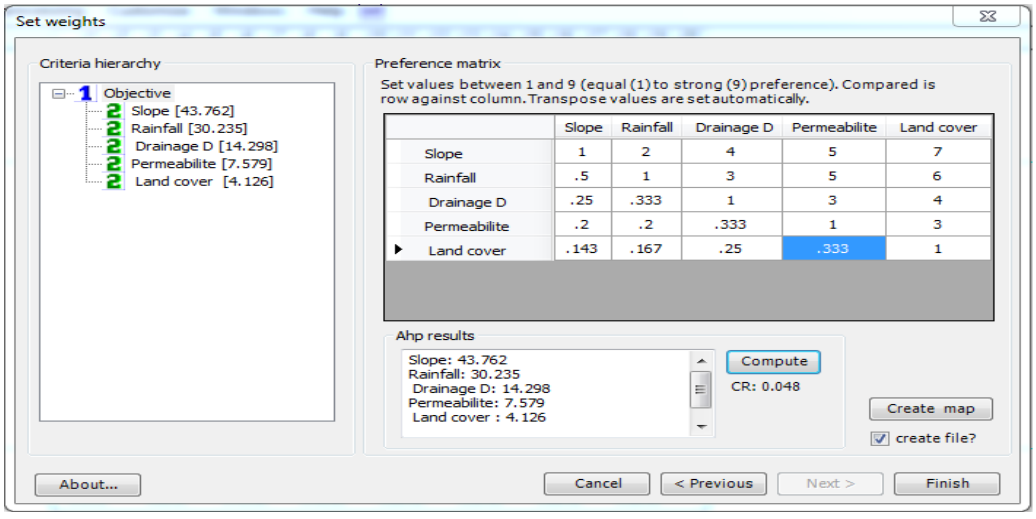


Figure 3. AHP extension under Arc Gis

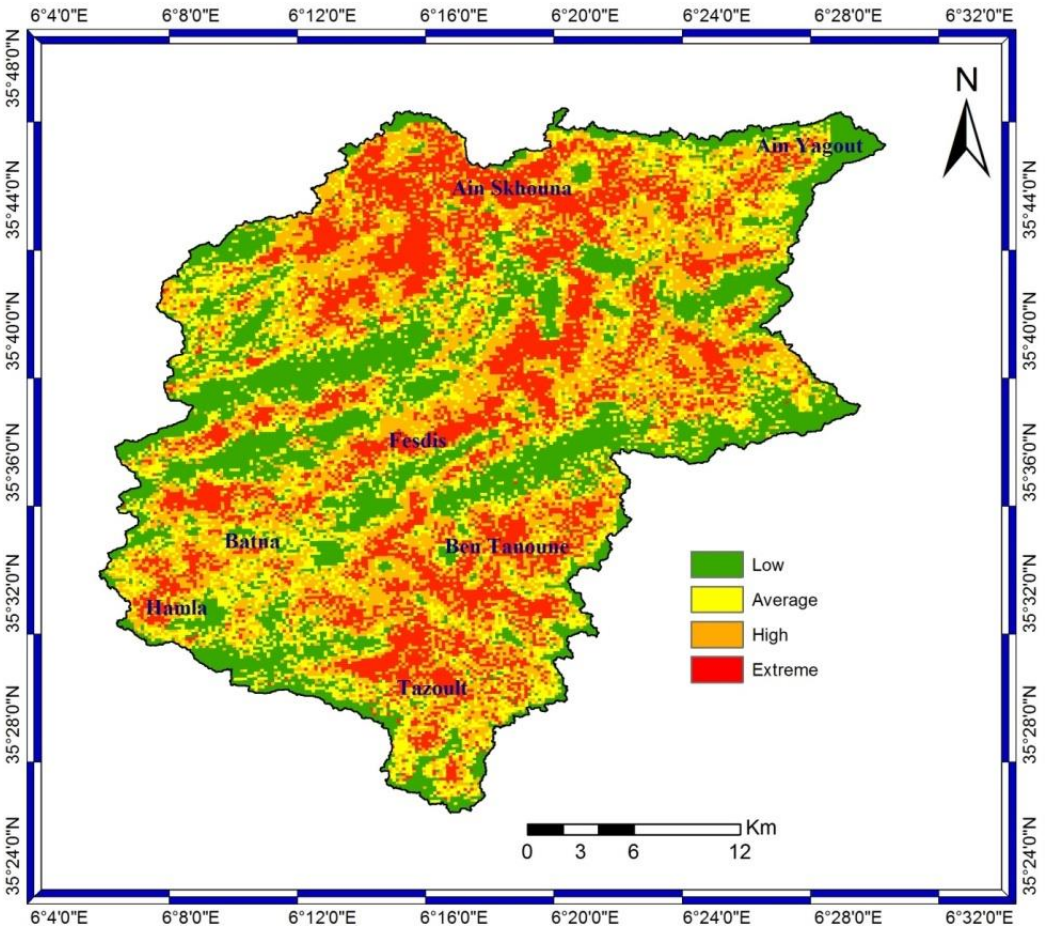


Figure 4. Vulnerability to flooding in the Batna watershed

The vulnerability to flooding in the Batna watershed is classified into four levels, from low to very strong going through the medium and the strong.

The map shows that several areas are listed in a strong and very strong vulnerability, notably Tazoult, Batna, the plain of Fesdis and Ain Skhouna, and this essentially comes back to the very low slope (less than 5%). The use of multi-criteria analysis under a GIS can be a useful tool for the spatialization of this vulnerability.

CONCLUSION

Accurate and prior knowledge of the physical characteristics of the study area is an essential step in the study of flood vulnerability.

The hierarchical multi-criteria analysis method provided reliability in delineating flood vulnerability by weighting each criterion involved in the analysis several areas are in significant vulnerability (Batna, Tazoult, Fesdis Plain and Ain Skhouna Plain) and its mainly due to the nature and form of the physical characteristics which have a significant influence on the flows, particularly the very low slope (0-5%) and the characteristics of the river system related to the drainage density which strongly favor the duration of submersion.

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ASSESSMENT OF PHYSICO-CHEMICAL QUALITY OF BORE WELL WATER SAMPLES OF SAGAR CITY, MP, INDIA

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Abstract: Bore well water is one of the major resources of the drinking water in Sagar city (M.P.). In the present study samples collected from different localities in Sagar (MP) were analyzed for their physico-chemical characteristics were carried out during different months of the pre monsoon, monsoon and post monsoon seasons in July 2018 to Aug 2019 Results shows that all the samples are under Indian standard limit for drinking purpose. The statistical analysis of the collected samples yielded the Matrix of Pearson Correlation. On the basis of analyses parameters, the results indicated the, satisfactory water quality of the Bore well samples.

Key words: Physico-chemical quality, Bore well water

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INTRODUCTION

Water is the elixir for life. Adequate supply of potable safe water is absolutely essential and is the basic need for all human being on the earth (Romocea et al., 2018; Herman et al., 2019 a, b). The quality of water may be described according to their physico-chemical characteristics (Astel et al., 2006; Shrestha and Kazama, 2007).

For effective maintenance of water quality through appropriate control measures, continuous monitoring of large number of quality parameters is essential. However it is very difficult and laborious task for regular monitoring of all the parameters even if adequate manpower and laboratory facilities are available. Therefore, an attempt based on statistical correlation, has been used to develop mathematical relationship for comparison of physico-chemical parameters.

A number of investigations attempted before to check the water quality assessment with reference to drinking purpose have been carried out in Sagar city (Kowalkowski et al., 2006; Papatheodorou et al., 2006; Barczak and Grivault, 2007; Pathak and Limaye, 2011; 2012; Pathak, 2012; Pathak et al., 2011).

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MATERIALS AND METHODS

The present work aims to evaluate the bore well water suitability for drinking purpose. 06 sampling places were selected for this study and these are wide spread in the study area. bore well water was collected from July 20018 to Aug. 2019. The water samples were collected in 500 ml polyethylene bottles. All the chemicals used were of AR grade. Analysis was carried out for various water quality parameters such as water temperature measured by using mercury-glass thermometer, pH, conductivity measured by using standard pH meter and conductivity meter respectively. Total solids (TS) by gravimetric method, total dissolved solids (TDS) by digital conductivity meter, chloride content by argentometric method; Total hardness was calculated by complexometric titration using EDTA titrimetric method, alkalinity by titrimetric method. Dissolved oxygen by Winkler method. by as per Apha (APHA, 2005). The value of the physico-chemical parameters were compared with desirable/permissible limit of IS: 10500 drinking water specification (IS-10500:1991). The statistical analysis such as Pearson correlation matrix has been performed using by SPSS 11.0 Statistical Software.

Table 1. Sampling locations and corresponding habitats
Latitude 23°51'16"N, Longitude 78°47'04"E

Station code-Sampling Locations	Collection Place	Sample Source
S1- I. Deendayal Nagar	Residential Area	Bore well water
S2-Makronia chouraha	Residential Area	Bore well water
S3- Raja khedi	Residential Area	Bore well water
S4- Civil line	Residential Area	Bore well water
S5-Gopalganj	Residential Area	Bore well water
S6- Moti Nagar	Residential Area	Bore well water

RESULTS AND DISCUSSION

The analytical results of physical and chemical parameters of Bore well water were compared with the standard guideline values as recommended by the IS:10500 for drinking and public health purposes. Most Bore well water found in the Sagar city has pH value ranging from about 7.1 to 8.5 is found to be alkaline in nature. Most of the bore well water samples are within the maximum permissible limit for drinking as per the IS:10500 standard. The value below 510 mg/l of TDS, indicating low content of soluble salts in Bore well water water which can be used for drinking without any risk. Site wise estimated values of 10 water quality parameters for 06 Bore well water samples are presented in below tables 2, 3, 4.

Table 2. Water quality physicochemical parameters of different locations of Sagar City at Monsoon (July 2018 to October 2019)
Water Temp. (^{o}C), Colour (Hz.u.), Odour, pH -

Station code	Physico-chemical parameters									
	Water Temp.	pH	DO	Conductivity	Alkalinity	Total Solids	TSS	TDS	Chloride	Total Hardness
S1	22	6.55	4.12	0.505	96	316.7	8.12	308.58	45.10	230.3
S2	24.2	7.31	4.67	0.552	141	333.68	6.35	337.23	43.21	188.56
S3	23.5	7.53	3.05	0.534	151	342.66	16.52	326.14	34.7	192.54
S4	24.4	7.33	3.62	0.581	135	378.25	22.21	356.04	30.4	186.78
S5	24.5	6.62	5.18	0.507	152	335.35	25.25	310.10	58.8	204.85
S6	23.5	7.43	4.63	0.674	134	428.7	16.46	412.24	69.5	172.45

Table 3. Water quality physicochemical parameters of different locations of Sagar City at postmonsoon (November 2018 to Feb. 2019)

Station code	Physico-chemical parameters									
	Water Temp.	pH	DO	Conductivity	Alkalinity	Total Solids	TSS	TDS	Chloride	Total Hardness
S1	20.4	7.44	7.6	0.448	105	303.52	5.64	297.88	34.23	223.56
S2	19.9	8.15	8.2	0.484	158	321.54	16.52	305.02	33.26	169.76
S3	21.0	7.87	6.7	0.483	166	313.45	8.47	304.98	25.90	176.54
S4	21.3	7.85	6.9	0.433	144	330.15	9.56	320.59	26.30	172.25
S5	22	7.83	6.7	0.471	174	317.16	7.53	309.63	24.61	200.4
S6	18.3	8.22	8.4	0.364	140	338.61	17.63	320.98	35.43	163.46

Table 4. Water quality physicochemical parameters of different locations of Sagar City at premonsoon (March 2019 to June 2019)

Station code	Physico-chemical parameters									
	Water Temp.	pH	DO	Conductivity	Alkalinity	Total Solids	TSS	TDS	Chloride	Total Hardness
S1	23.2	7.16	5.27	0.488	150	424.11	17.95	406.16	48.96	242.23
S2	25.1	7.95	5.20	0.500	146	329.68	8.56	321.12	49.97	208.52
S3	23.4	7.82	4.35	0.499	158	248.23	9.75	238.48	38.97	295.56
S4	24.6	7.63	5.84	0.525	164	315.24	9.46	305.78	40.97	201.45
S5	24.4	7.54	4.05	0.507	151	311.93	8.47	303.46	59.97	213.46
S6	25.3	8.0	5.15	0.526	150	424.11	17.95	406.16	80.97	185.12

It may be suggested that the Bore well water quality of study area can be checked regularly. some prominent correlations exist between water qualities parameters and from correlation values presented in the tables 5, 6, 7.

Table 5. Matrix of Pearson Correlation for different Parameters in the Borewell waters Samples of in and around Sagar City (Monsoon 2018)

	P-1	P-2	P-3	P-4	P-5	P-6	P-7	P-8	P-9	P-10
P-1	1	0.261	-0.307	-0.147	0.261	-0.02	-0.049	-0.019	0.164	-0.025
P-2	0.261	1	0.37	0.62	0.412	0.691	0.763	0.002	0.638	0.123
P-3	-0.307	0.37	1	0.475	0.049	0.462	0.497	0.332	0.371	0.408
P-4	-0.147	0.62	0.475	1	-0.097	0.632	0.592	-0.278	0.315	-0.174
P-5	0.261	0.412	0.049	-0.097	1	0.402	0.359	0.217	0.588	0.293
P-6	-0.02	0.691	0.462	0.632	0.402	1	0.686	-0.163	0.65	-0.015
P-7	-0.049	0.763	0.497	0.592	0.359	0.686	1	0.019	0.661	0.174
P-8	-0.019	0.002	0.332	-0.278	0.217	-0.163	0.019	1	-0.143	0.979
P-9	0.164	0.638	0.371	0.315	0.588	0.65	0.661	-0.143	1	0.021
P-10	-0.025	0.123	0.408	-0.174	0.293	-0.015	0.174	0.979	0.021	1

Table 6. Matrix of Pearson Correlation for different Parameters in the Borewell waters Samples of in and around Sagar City (PostMonsoon 2018)

	P-1	P-2	P-3	P-4	P-5	P-6	P-7	P-8	P-9	P-10
P-1	1	0.267	0.188	0.537	0.266	0.934	0.836	0.935	0.491	0.916
P-2	0.267	1	0.108	0.004	0.071	0.001	0	0.994	0.002	0.605
P-3	0.188	0.108	1	0.034	0.836	0.04	0.026	0.152	0.108	0.074
P-4	0.537	0.004	0.034	1	0.683	0.003	0.006	0.235	0.175	0.463

P-5	0.266	0.071	0.836	0.683	1	0.079	0.12	0.357	0.006	0.21
P-6	0.934	0.001	0.04	0.003	0.079	1	0.001	0.492	0.002	0.951
P-7	0.836	0	0.026	0.006	0.12	0.001	1	0.938	0.002	0.463
P-8	0.935	0.994	0.152	0.235	0.357	0.492	0.938	1	0.549	0
P-9	0.491	0.002	0.108	0.175	0.006	0.002	0.002	0.549	1	0.931
P-10	0.916	0.605	0.074	0.463	0.21	0.951	0.463	0	0.931	1

Table 7. Matrix of Pearson Correlation for different Parameters in the Borewell waters Samples of in and around Sagar City (PreMonsoon 2019)

	P-1	P-2	P-3	P-4	P-5	P-6	P-7	P-8	P-9	P-10
P-1	1	0.416	0.247	0.356	-0.276	-0.41	0.513	0.226	0.293	0.166
P-2	0.416	1	0.321	0.632	0.064	0.185	0.782	0.11	0.405	0.34
P-3	0.247	0.321	1	0.366	0.225	0.179	0.176	-0.521	0.257	-0.357
P-4	0.356	0.632	0.366	1	-0.076	-0.131	0.479	0.082	0.126	0.264
P-5	-0.276	0.064	0.225	-0.076	1	0.497	0.086	-0.202	0.176	-0.048
P-6	-0.41	0.185	0.179	-0.131	0.497	1	0.051	-0.262	0.45	-0.036
P-7	0.513	0.782	0.176	0.479	0.086	0.051	1	0.295	0.597	0.444
P-8	0.226	0.11	-0.521	0.082	-0.202	-0.262	0.295	1	0.058	0.884
P-9	0.293	0.405	0.257	0.126	0.176	0.45	0.597	0.058	1	0.203
P-10	0.166	0.34	-0.357	0.264	-0.048	-0.036	0.444	0.884	0.203	1

CONCLUSION AND RECOMMENDATIONS

The major conclusions derived from this study, carried out in the Sagar city are as follows. The physical and chemical parameters of the Sagar citys results shows that all the samples are under recommended limit for drinking purposes. On the basis of detailed chemical analysis, it may be suggested that the regular monitoring must needed for bore well water supply of study area, quality can be checked effectively from the results of the present study, it may be said that, the overall bore well water quality of Sagar is chemically fit for domestic as well as drinking purpose.

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VARIATIONS IN PHYSICO-CHEMICAL PROPERTIES OF SHALLOW GROUNDWATER AQUIFERS ACROSS RURAL-URBAN DIFFERENTIALS

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Abstract: The quality of groundwater is controlled mostly by geology, lithology and depth of aquifers. However, anthropogenic activities can also influence the chemical characteristics of groundwater and this relates directly or indirectly to land use/land cover characteristics. To this effect, this study aimed at evaluating the effect of land use/land cover on the quality of shallow groundwater aquifers in Yenagoa City and its Environs, Bayelsa State, Nigeria. Fifteen groundwater samples were collected randomly from each of the urban and rural land use types making a total of 30 water samples from hand-dug wells that tap into shallow aquifers in the study area. The water samples were subjected to laboratory analyses for Temperature (T), pH, Salinity (Sal), Electrical Conductivity (EC), Total Dissolved Solids (TDS), Nitrate (NO_3), Chloride (Cl^-), Sulphate (SO_4^{2-}), Total Alkalinity (TA), Total Hardness (TH), Iron (Fe), Manganese (Mn), Fluoride (F) and Arsenic (As). Factor analysis and Independent samples t-test were employed for analyses in the study. The results revealed that all minimum concentrations of physic-chemical contaminants analyzed were recorded in the rural land use type with exception of pH and Iron (Fe) while all maximum concentrations were recorded in the urban land use type with exception of Fluoride, Sulfate and Total Hardness. Independent samples t-test show that there is a significant difference in the groundwater physico-chemical characteristics between urban and rural land use types.

Key words: Land use/Land Cover, physicochemical contaminants, shallow groundwater aquifers

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INTRODUCTION

The concentration of contaminants in groundwater is largely a function of both natural and anthropogenic activities (Romocea et al., 2018; Beketova et al., 2019). Serious health hazard could be the outcome when such contaminants level exceeds the recommended standards set by water quality regulating bodies like Federal Environmental Protection Agency (FEPA), Environmental Protection Agency (EPA) and World Health Organization (WHO) may result in serious health hazards (USEPA, 2002; Olusola et al., 2017; Herman et al., 2019a, 2019b).

Shallow aquifers are more vulnerable to contamination from various land uses than deep aquifers. The susceptibility of shallow aquifers to contaminants from surface sources depends on the permeability of the overlaying rock/soil units (Narayanan, 2007) and depth to the water table (Ifabiyi, 2008). These factors are variable especially in areas where anthropogenic inputs are remarkable. Yenagoa is underlain by a sedimentary basin characterized by an unconfined aquifer with rainfall being the direct recharge source (Etu-Efeotor and Akpokodje, 1990). The aquifer is sensitive to changes in land use because the water table is close to the surface (about 3-4 m) during the dry season and during the rainy season the water table rises considerably, in some cases to the ground surface. This makes the shallow aquifer in the area vulnerable to contamination from various land use. Rapid urbanization and population growth are the major threat to groundwater contamination (Olusola et al., 2017) especially shallow aquifers as found in the study area. Due to the attendant population increase in the area, unprecedented waste generation and indiscriminate disposal have become major environmental issues. Landfills within Yenagoa and its environs are mostly in the form of uncontrolled residential dumps with refuse piling up with increasing residency time. Solid waste in landfills decomposes and most often than not pollutes underlying groundwater through seepage or percolation (Offodile, 2002). Other threats to shallow aquifers are point sources of pollution such as leaking septic systems, industrial discharge (liquid waste), oil spillage and pipeline vandalisation (Egboka et al., 1989; Majolagbe et al., 2011; Fashae et al., 2019) and saltwater intrusion (Smith, 1988; Postel et al., 1996; Majolagbe et al., 2011; Morris et al., 2003). It has been posited that unpalatable high concentration of salt particularly chloride renders groundwater non-potable (Majolagbe et al., 2011), while saline water intrusion is mostly enhanced by over-extraction of fresh groundwater resources due to attendant population increase and rapid urbanization of coastal cities (Smith, 1988; Postel et al., 1996). In Morris et al, (2003), it was confirmed that seepage from contaminated surface waters (rivers, lakes and creeks) can also impair the quality of shallow aquifers and that the presence of chloride, sulphate and other inorganic chemicals can be indicators of pollution. However, contaminants introduced at the land surface can readily enter the underlying aquifer and affect nearby wells that are screened near the water table (Eckhardt and Stackberg, 1995; Fashae et al., 2019). Although the movement and fate of subsurface contaminants depend on the rainfall pattern, depth of water table, distance from the source of contamination and soil properties like permeability, the composition of recharge components as well as geology and hydrology of the area, the greatest concern bothers on the number of pollutants present on the land surface.

From the foregoing, this study is aimed at assessing the physico-chemical characteristics of groundwater from shallow aquifers. To effectively achieve this aim, the study will examine the concentrations of physico-chemical parameters of groundwater in the study area based on recommended standards (World Health Organization, WHO); map the spatial distribution of physic-chemical characteristics of groundwater across rural-urban differentials.

Study Area

The study area lies between latitude 4° 54'N - 5° 08'N of the Equator and between longitude 6° 05'E - 6° 23' East of the Greenwich meridian (figure 1). The study area cuts across three Local Government Areas of Bayelsa State, Nigeria. They are Yenagoa, Kolokuma/Opokuma, and Southern Ijaw Local Government Areas. The total land area is 84 989 km^2. The area under study is bounded by Sagbama Local Government Area in the North, in the South by Ogbia Local Government Area, in

the West by Ekeremor Local Government Area and in the East by Rivers State. Part of the study area falls within the state capital, Yenagoa.

The study area has an equatorial hot-humid climate which is characterized mainly with wet and dry seasons. The annual rainfall experience is usually between (2500 mm-3000 mm). The mean temperature is 30±2˚C, relative humidity is 80% and above (Iloeje, 1972). The vegetation of the area is characterized by rainforest, marshes, back swamps, mangroves and wetlands. The vegetation is comprised of a multitude of evergreen trees that yield tropical hardwoods such as Mahogany and Abura (Macrophylaciliata). The study area lies within the freshwater forest swamps and back swamps geomorphic unit of the Niger Delta. The Niger Delta is an alluvial plain formed by the deposition and build-up of fine-grained sediments eroded and transported to the area by River Niger and its distributaries (streams). The Coastal Plain Sands of the Benin Formation are the main regional and most important aquifer in the study area (Short and Stauble, 1967). Groundwater in the coastal plain sands occurs mainly under phreatic (unconfined) conditions. The lithology of this formation is dominated by loose sands (fine-medium-coarse), while gravel and pebbles constituting minor components. Thin clay horizons and lenses create discontinuities in the vertical and lateral continuity of the porous sands and gravel. This condition results in the presence of local perched aquifers. Rainfall is the direct recharge source of the groundwater (Short and Stauble, 1967; Etu-Efeotor and Akpokodje, 1990).

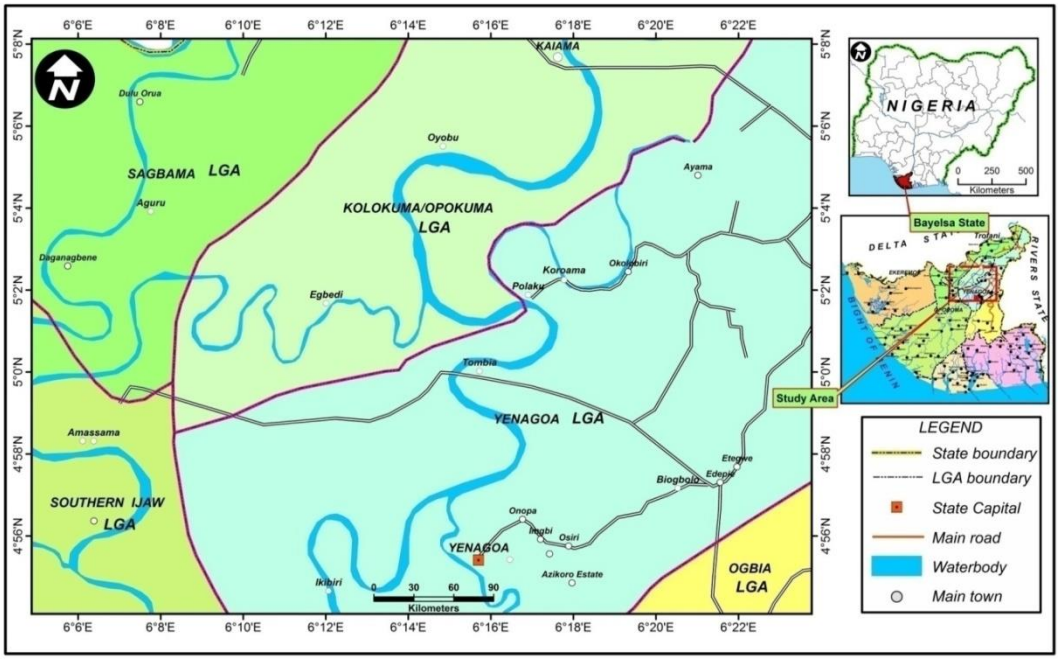

Figure 1. The Study Area Map
Source: Office of The Surveyor General

MATERIALS AND METHODS

Water Sampling

Water samples were collected from wells and kept in 1.5 liter plastic bottles. A total of 15 water samples were collected randomly from each urban and rural land use types in the study area (figure 1) with their respective locations taken with the aid of a GPS (Garmin GPS_{MAPS} 78s). During sampling, precautions were taken to avoid contamination and to achieve a reflection of the collected sample in the laboratory analyses.

Laboratory Analysis

Groundwater samples collected were analyzed in the Central Research Equipment Laboratory (Niger Delta University, Wilberforce Island, Bayelsa State) for Temperature, pH, Salinity, Electrical Conductivity, Nitrate, Chloride, Sulfate, Total Hardness, Total Alkalinity, Iron, Manganese, Fluoride and Arsenic. Temperature, pH, Electrical Conductivity (EC), Salinity of the water samples were measured with the aid of a Wagtech Digital Thermometer/pH Meter/Conductivity/Salinity Meter respectively. The Total Dissolved Solids (TDS) was measured using a JENWAY 3540 Bench TDS meter (UK). Titration method was also used in the determination of Total Hardness and Total Alkalinity. Wagtech Spectrophotometer was used in the determination of Nitrate (NO_3^-) and Sulphate SO_4^{2-} at wavelengths of 5000 nm and 425 nm respectively. Fluoride and Arsenic concentrations of the water samples were determined using the Atomic Absorption Spectroscopic method. This was done with the aid of the Wagtech UV/VIS Spectrophotometer equipment.

Statistical Analysis

A simple descriptive statistic summary table was generated from the laboratory results using mean, standard deviation and coefficient of variation of the physic-chemical datasets Independent samples T-test is used to assess the difference in groundwater characteristics between the urban and rural land use types. A plot of loadings of the Factors (components) was done in rotated space to categorize as well as to characterize the hydro-chemical characteristics of the analyzed groundwater parameters in the study area. The SPSS 15.0 (Statistical Product and Service Solutions) was used for the statistical analysis.

RESULTS AND DISCUSSION

Landuse/land cover classification

Five major land use types were identified within the study area. These are: minor built-up areas, major built-up areas, open space, vegetation cover and water bodies (figure 2). The minor built-up areas represent the rural/undeveloped areas within the study area (table 1). The rural lands/minor built-up areas accounted for about 1493 km^2 (1.5%) of the study area (table 1). The dominant activities in this area are farming, fishing and boat making. There is also an existence of a periodic market in the area. The major built-up areas represent the capital city (Yenagoa) where major industrial and commercial activities are predominant. Hence, the major built-up areas represent the urban/developed lands (table 1). The industrial, commercial and landfill areas were all classified under this land use category since they are within the Major Built-up areas. The major built-up areas/urban lands accounted for about 2241 km^2 (2.3%) of the study area (table 1, figure 2). This area is closer to the Atlantic Ocean than the minor built-up areas. The Vegetation cover represents the rainforest areas, mangroves, wetlands and swamps within the study area.

Table 1. Land Use/Land Cover Classifications in the Study Area

S/N	Land Use Type	(m^2)	(Km^2)	(%)
1	Minor built-up area	14917243	1493	1.5
2	Open space	2260430	226	0.2
3	Vegetation (mangrove)	810933596	89012	91
4	Water body	49026383	4904	5
5	Major built-up area	22416907	2241	2.3

This area accounted for about 89 012 km^2 (91%) of the study area (table 1, figure 2). This is the largest land use type in the study area. Hunting and lumbering are the predominant activities within this. The open space accounted for the smallest land use type in the study area with an area extent of about 226 km^2 (0.2%) of the study area. Water Bodies accounted for 4904 km^2 (5%) of the study area (table 1, figure 2). The Water bodies also accounted for the second-largest land use

category in the study area. The water bodies in the area include; rivers, lakes, creeks and small streams. The major river in the area is the Nun River which is a network of River Niger. The lakes are Lake Efi, an Ox-bow Lake. The Creeks are Epie and Taylor Creeks. The water bodies are constantly being used for transportation, fishing and recreational purposes. Dumping of solid waste into the water bodies is a regular occurrence especially the creeks (Izonfuo and Bariweni, 2001).

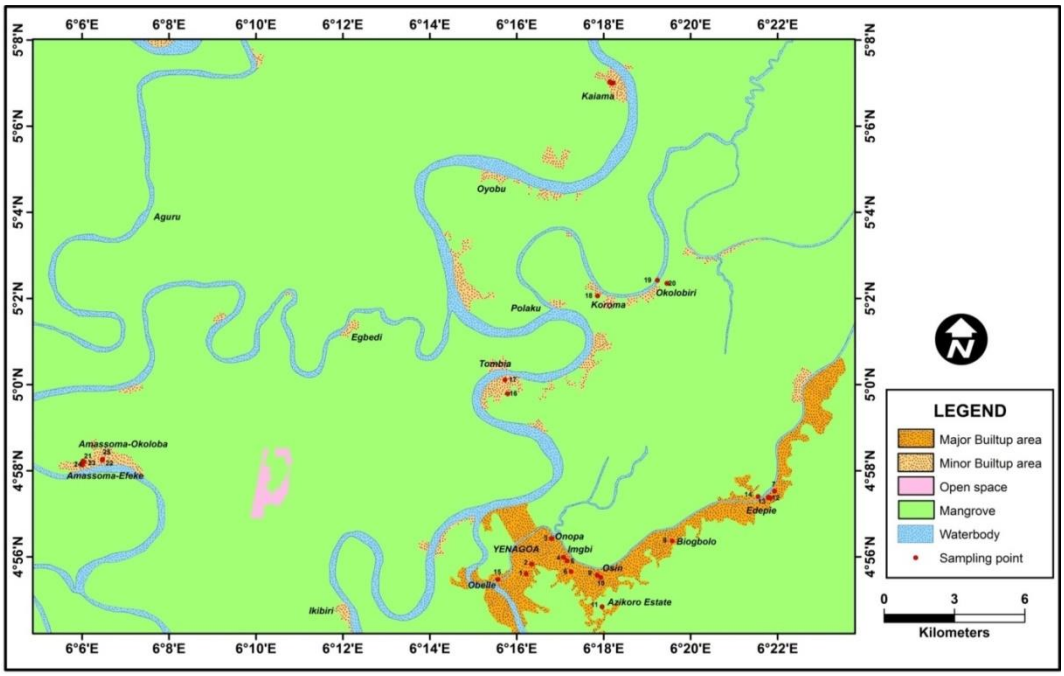

Figure 2. Land use/land cover map of the study area showing sampling points

Physical and Chemical Analysis of Groundwater from the Shallow Aquifers

From the observed values of pH in table 2, the minimum and maximum values were 6.97 and 7.6 respectively. It was also observed that both minimum and maximum values of pH were recorded in the urban land use type. The pH of all water samples from the shallow aquifers in the study area recorded a mean value of 7.38 (table 2) which is within the recommended drinking water guideline (table 3). These pH values obtained in the study (table 2) are similar to previously reported values (Nwala et al., 2007; Manilla and Tamuno-Adoki, 2007; Bolaji and Tse, 2009; Chindah et al., 2011) in the Niger Delta region, Nigeria. Saline water intrusion is inevitable since the study area is close to the Atlantic Ocean. It was observed from all the samples that the minimum and maximum salinity levels in the shallow aquifers were 0.02 mg/l and 0.39 mg/l respectively (table 2) with a mean value of 0.195 mg/l. The minimum salinity level (0.02 mg/l) was reported in the rural land use type while the maximum salinity level was reported in the urban land use type. The minimum and maximum electrical conductivity (EC) were 71 µs/cm and 775 µs/cm respectively (table 2). The mean conductivity for all samples in the study area was 405 µs/cm (table 2). It was observed that the minimum conductivity for all samples was recorded in the rural land use type while the maximum conductivity was recorded in the urban land use type. Though there is no recommended guideline for conductivity by WHO (2008), the Standard Organization of Nigeria (2007) recommended a maximum limit of 1000 µs/cm in drinking water supplies. All samples recorded values below this threshold. Electrical conductivity values tend to be slightly high in the study area. This is an indication of high total dissolved solids (TDS). Places that recorded high conductivity also recorded high TDS values. As expected, an increase in dissolved solids will increase conductivity and

corrosivity of the water. Changes in conductivity with time, or high conductivity values can both indicate that the water has become contaminated (e.g. from saline intrusion, fecal pollution or nitrate pollution). Over time, the contamination can become very inimical to both aquatic life and human beings (Olusola et al., 2017; WHO/UNICEF, 2010; Fashae et al., 2019) and also affect water conduits.

It was observed from the groundwater samples that the minimum and maximum TDS concentrations were 36 mg/l and 388 mg/l respectively, with the minimum level (36 mg/l) been recorded in the rural land use while the maximum level (388 mg/l) was recorded in the urban land use (table 2). The mean concentration of TDS was 202.9 mg/l. It was generally observed that the TDS concentrations were relatively high which accounts for the high value in EC. High conductivity values were recorded in locations with high TDS values as expected. The high TDS values obtained (table 2) are similar to those reported by (Ozoemenam, 2012; Okiongbo et al, 2014; Fashola, 2013) in the Niger Delta region. It is a known fact that shallow aquifers within this area and the larger Niger Delta region serve as a domestic water supply source especially in communities where these sources are not polluted by hydrocarbons (oil spills). However, the negative effect of consuming water with high TDS is largely inconclusive (WHO, 2008).

The minimum and maximum nitrate concentrations as observed in the collected samples within the study area (table 2) are 0.09 mg/l and 0.38 mg/l respectively. The values obtained are similar to those reported by Nwala et al, (2007) and Manilla and Tamuna-Adoki, (2007). A mean concentration of 0.23 mg/l was recorded within the study area. The minimum and maximum chloride concentrations as observed in the shallow aquifers in the study area are 1.40 mg/l and 10.50 mg/l respectively (table 2). The rural land use type in the study area recorded the minimum concentration (1.40 mg/l) while the urban land use type recorded the maximum concentration (10.50 mg/l). Chloride concentration in the study area had a mean concentration of 5.32 mg/l. The chloride values obtained (table 2) are within the range of values reported by Ekpete (2002) and Nwala et al., (2007); but are below the values reported by Manilla and Tamuno-Adoki (2007), Bolaji and Tse (2009) in the Niger Delta region. Nitrate and chloride concentrations are all within the acceptable limits (table 3).

It was observed that the minimum and maximum concentrations of Sulphate (SO_4^{2-}) in the shallow aquifers in the study area are 0.30 mg/l and 3.80 mg/l respectively (table 2). Both minimum and maximum concentrations of Sulphate (SO_4^{2-}) were reported in the rural land use type. A mean concentration of 2.0440 mg/l was recorded.

The mean concentration of total alkalinity (TA) as observed in (table 2) was 2.33 mg/l. The alkalinity values obtained in the study area (table 2) are below reported values by Koinyan et al., (2013) and Okiongbo et al., (2014) in the Niger Delta region. The total hardness mean concentration in the study area was recorded as 12.54 mg/l (table 2). Total hardness (TH) values obtained in the study area (table 2) are quite low and are below reported values by Agbalagba et al., (2011), Koinyan et al., (2013) and Okiongbo et al., (2014) in the Niger Delta region. The World Health Organization (WHO) International Standard for Drinking Water (1998) classified water with a total hardness of $CaCO_3$< 50 mg/l as soft water, 50 to 150 mg/l as moderately hard water and water hardness above 150 mg/l as Hard water. Based on this classification, all water samples in the study area can be regarded are soft water since all values were below 50 mg/l of $CaCO_3$. The groundwater in the study area is therefore not suitable for drinking based on total hardness. Soft waters with a hardness of less than about 100 mg/l have a low buffering capacity and may be more corrosive to water pipes (WHO, 2008) which in most cases leaves residues or particulate matter in the water.

As observed in (table 2), Iron (Fe) recorded a minimum and maximum concentration of 0.02 mg/l and 0.82 mg/l respectively. Both minimum and maximum concentrations were reported in urban land use in the study area. Iron (Fe) in the study area recorded a mean concentration of 0.139 mg/l for all groundwater samples. As observed in table 2, the minimum and maximum Fluoride concentrations were 0.20 mg/l and 1.50 mg/l. Both maximum and minimum concentrations of Fluoride were reported in rural land use. A mean concentration of 0.64 mg/l was recorded which is within the health-based guideline of 1.5 mg/l recommended by WHO (WHO, 2008). It was observed that the fluoride concentration in the study area is relatively low. This may be as a result of the

moderate pH values in the study area. Fluoride increases with a significant increase in pH (Amini et al., 2007). The minimum and maximum concentrations of Arsenic in the study area were (-0.001 µg/l) and (0.010 µg/l) respectively (table 2). It was observed that Arsenic concentrations in the shallow aquifers of the study area were very low. Some locations gave a negative sign which indicates that the concentration of Arsenic in those locations was below detectable limits. A mean concentration of 0.001433 µg/l was recorded, with a standard deviation and coefficient of variation of 0.0030 and 0.000 respectively. A health-based guideline of 10 µg/l (0.01 mg/l) is recommended by (WHO, 2008). Elevated concentration of Arsenic in drinking water has some carcinogenic effects.

Table 2. Descriptive statistics of the physical and chemical analysis of groundwater from the Shallow Aquifers in the Study Area
Source: WHO (2008)

Parameters	Minimum	Maximum	Mean	Std Dev.	Coeff. Var
T (T^0C)	25.50	27.50	26.2503	.54974	.302
pH	6.97	7.60	7.3820	.12702	.016
SAL (mg/l)	.02	.39	.1953	.09250	.009
EC (µscm-1)	71.00	775.00	405.333	178.570	31887.264
TDS (mg/l)	36.00	388.00	202.900	89.2130	7958.972
$N0_3^-$ (mg/l)	.09	.38	.2287	.08072	.007
Cl^- (mg/l)	1.40	10.50	5.3233	2.06493	4.264
SO_4^{2-} (mg/l)	.30	3.80	2.0440	1.03095	1.063
TA (mg/l)	1.10	4.70	2.3367	.83397	.696
TH (mg/l)	2.20	27.80	12.5367	5.89614	34.764
Fe (mg/l)	.02	.82	.1387	.15704	.025
Mn (mg/l)	.00	.04	.0182	.00915	.000
F^- (mg/l)	.02	1.50	.6447	.43042	.185
As (µg/l)	-.001	.010	.00143	.003002	.000

Temperature (T), pH, Salinity (Sal), Electrical conductivity (EC), Total Dissolved Solids (TDS), Nitrate ($N0_3^-$), Chloride (Cl^-), Sulphate (SO_4^{2-}), Total Alkalinity (TA), Total Hardness (TH), Iron (Fe), Manganese (Mn), Fluoride (F^-) and Arsenic (As)

Table 3. World Health Organization (WHO) Guidelines
Source: WHO (2008)

S/N	Parameters	Mean	WHO Guidelines
1	Temperature (T°C)	26.2503	Not defined
2	pH	7.3820	6.5-8.5
3	Salinity (SAL) mg/l	0.1953	Not defined
4	Electrical Conductivity (EC) µscm-1	405.3333	Not defined
5	Total Dissolved Solids (TDS) mg/l	202.9000	1000 (taste concerns)
6	Nitrate (NO_3) mg/l	0.2287	50
7	Chloride (Cl^-) mg/l	5.3233	250 (taste concerns)
8	Sulphate (SO_4^{2-})	2.0440	200
9	Total Alkalinity (TA) mg/l	2.3367	Not defined
10	Total Hardness (TH) mg/l	12.5367	200 (scale deposition)
11	Iron (Fe) mg/l	0.1387	0.3
12	Manganese (Mn) mg/l	0.0182	0.4
13	Fluoride (F^-) mg/l	0.6447	1.5
14	Arsenic (As) µg/l	0.00143	10 µg/l (0.01 mg/l)

Factor analysis of groundwater samples

Factor analysis (FA) of the studied groundwater samples was performed in other to get an overall impression about assembling the samples in a multi-dimensional space defined by the analyzed parameters. The results were (0.609) for Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO) and (566.505) for Bartlett's Test of Sphericity ($p<0.0001$). This indicates that the results are significant and that Factor Analysis may be useful in providing significant reductions in dimensionality. From the analysis performed five factors (components) explaining 80.179% of the total variance were estimated based on Kaiser criterion (Kaiser, 1960) of the eigenvalues greater or equal to one (1) (table 6) and from a Cattel Scree plot. The Scree plot (figure 3) shows the eigenvalues sorted from large to small as a function of the factor number.

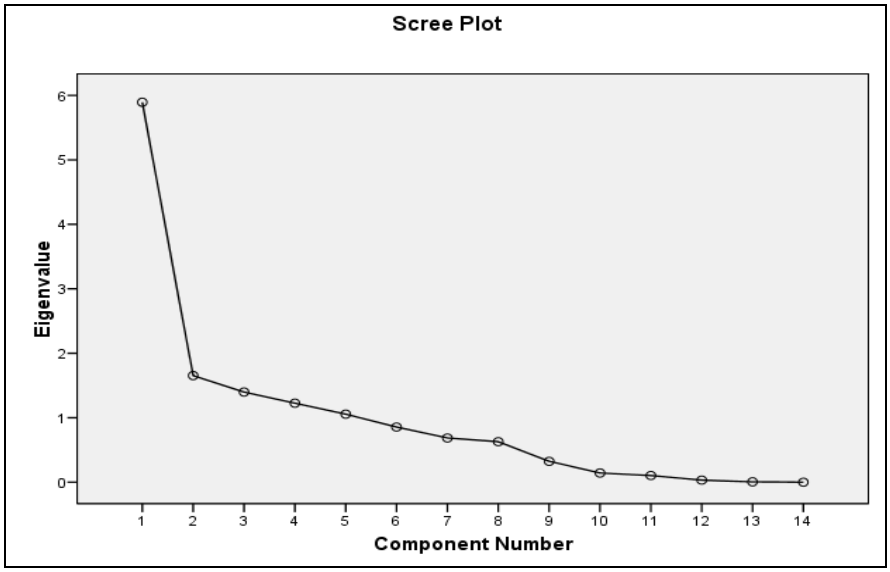

Figure 3. Scree Plot Test

Table 4. Factor loading matrix of physico-chemical parameters

PARAMETERS	FACTORS				
	1	2	3	4	5
T	.106	-.140	.149	.843	.064
Ph	.089	.602	.669	.009	.256
SAL	.948	.015	.215	.091	.108
EC	.953	.043	.210	.115	.082
TDS	.953	.044	.210	.114	.082
$N0_3$	.639	-.077	.058	.182	.304
Cl^-	.888	.192	.003	.087	-.209
SO_4^{2-}	.819	.215	-.144	.028	-.200
TA	.717	-.120	.313	-.177	.414
TH	.469	.304	-.353	-.007	.118
Fe	-.083	-.932	-.008	-.048	-.010
Mn	.299	-.038	.819	.051	-.120
F^-	.125	.408	-.152	.698	.084
As	.040	.103	-.066	.121	.890
Eigen value	5.894	1.653	1.398	1.225	1.055
% Variance	42.099	11.810	9.983	8.752	7.535
Cumulative %	42.099	53.910	63.893	72.644	80.179

Temperature (T), pH, Salinity (Sal), Electrical conductivity (EC), Total Dissolved Solids (TDS), Nitrate (NO_3), Chloride (Cl), Sulfate (SO_4^{2-}), Total Alkalinity (TA), Total Hardness (TH), Iron (Fe), Manganese (Mn), Fluoride (F) and Arsenic (As)

As observed from (table 4), SAL, EC, TDS, NO_3, $C^{l-,}$ SO_4^{2-} and TA are marked factor one (1), which explained 42.099% of the total variance. Factor 1 showed a high positive loading in SAL, EC, TDS, NO_3, Cl^-, SO_4^{2-} and TA. High positive loadings indicate a strong linear correlation between the factor and parameters. Most highly correlated with Factor 1 were SAL, TDS and EC, with TDS and EC recording strong positive loadings. Thus factor 1 can be termed conductivity index. This is an indication that the groundwater in the shallow aquifers in the study area is contained with high levels of dissolved inorganic salts which must have originated from high saline water, possibly saline water intrusion since the study area is close to the Atlantic Ocean. Increased saline intrusion can increase densities of shallow aquifers in the study area and this may in the long run affect ocean circulation. Also, Cl^-, Nitrate and SO_4^{2-} are pollutants that help in increasing conductivity and consequently affecting salinity, hence, their correlation is as expected. Dissolved inorganic constituents can also come from leaking septic systems (soak away pits), sewage, urban runoff, leachates from landfills and industrial wastewater (WHO, 2008). Conductivity, especially specific conductance is a first-order measure as regards water quality parameters especially in zones with shallow water aquifers. It is an early indicator of change in a water system. Salinity, as expected, is associated with conductivity and hence, marine organisms' tolerance depends largely on their osmotic processes. Based on their tolerance range, marine organisms (saltwater, euryhaline, anadromous, catadromous and freshwater) respond differently to varying levels of salinity. The varying levels affect the metabolic activities of these organisms. This implies that an increase in SAL, EC and TDS will increase NO_3, Cl^-, SO_4^{2-} and TA in the shallow aquifers in the study area (Liu et al., 2003).

Factor two (2) with a high loading of pH and Fe explained 11.810% of the total variance with loadings of 0.602 and -0.932 respectively (table 4). This indicates that factor 2 is positively correlated with pH but negatively correlated with Fe. This also means that both (pH and Fe) have an inverse relationship. This again confirms the moderately acidic nature of the groundwater in the study area being neutralized by salt contamination to a large extent (Chindah et al., 2011), therefore resulting in (Fe) having a negative correlation with pH in factor 2. This factor can be termed an oxidizing index.

The third factor is strongly correlated with Mn and pH, which accounted for 9.983% of the total variance with factor loadings of 0.819 and 0.669 respectively (table 4). It also implies that Mn and pH exhibit relationship and as expected this is particularly true of low-relief areas abutting the coast. This can be termed manganese-toxicity index.

Factor four (4) was responsible for 8.752% of the total variance and strongly correlated with Temperature (T^oC) and Fluoride (F), with factor loadings of 0.843 and 0.698 respectively. In factor 4, T^oC showed a strong correlation ahead of Fluoride, implying that T^oC has a strong positive relationship with factor 4. This can be termed a physical attribute index.

Finally, factor five (5) was correlated with only As, which accounted for just 7.535% of the total variance with a factor loading of 0.890 (table 4). This indicates that As has a strong positive relationship with factor 5. The results also reveal that As has no linear relationship with any other parameter in the study area. This indicates that the traces of As concentration in the shallow aquifers in the study area may have originated from other factors. WHO (2008) noted that As may originate from anthropogenic sources, such as sewage, mining and other industrial activities. This factor can be termed an anthropogenic-pollutant index.

In essence, across shallow aquifers in sedimentary basins around coastal regions especially in tropical environments, determination of water quality should focus mostly on conductivity parameters (salinity, electrical conductivity, chloride, sulphate, etc), followed by oxidizing agents such as pH, iron, then manganese-toxicity tests. These three indices account for over 60% of the total variance in the factor analysis tests (table 8). The other two indices, physical attributes and anthropogenic-pollutants, accounts for about 15%. Therefore, water quality studies around this region should focus more on the first three indices in determining the level of water quality (Liu et al., 2003).

Rural-urban differentials in groundwater quality

Independent samples T-Test was carried out to examine the difference in shallow groundwater quality between urban and rural land-use types (table 5). The result shows that there is a significant difference in the level of the following parameters: temperature ($t=2.719$, $df=28$, $p<0.05$); salinity ($t=2.182$, $df=28$, $p<0.05$); Total Dissolved Solids ($t=2.371$, $df=28$, $p<0.05$); and manganese ($t=3.894$, $df=28$, $p<0.05$). Possible explanations to these observed differences can be tied to rapid urbanization, population density especially in the urban areas (Olusola et al., 2017; Fashae et al., 2019), saltwater intrusion causing significant differences in SAL, TDS, EC and Mn, water recharge source(s) to the shallow aquifers mixed with anthropogenic activities (Liu et al., 2003). Mixing is an important process that influences the chemical composition of groundwater. Mixing occurs when groundwater moving along a specific flow path encounters other water that has evolved independently. If the mixing waters have chemical compositions different from each other, the constituent concentrations and proportions in the resulting mixture will be intermediate to the constituent concentrations and proportions of the original waters. Water that may mix with groundwater includes water from another aquifer e.g., saline groundwater especially in areas very close to the sea; groundwater that has travelled along a different flow path within the same aquifer; and surface water or water-related to human activity that infiltrates into the aquifer. Sources of surface water can include rivers, streams, lakes, reservoirs, canals, and ponds which can have different chemical compositions. Water-related to human activity includes animal, human and food processing wastewater, irrigation water, and other water that have significantly different chemical compositions.

Table 5. Independent Samples T-test for physico-chemical properties across rural-urban areas

	Location	N	Mean	Std. Deviation	T	df	Sig. (2-tailed)
T	Urban	15	26.497333	.6245852	2.719	28	.011
	Rural	15	26.003333	.3242941			
PH	Urban	15	7.405333	.1516512	1.006	28	.323
	Rural	15	7.358667	.0962041			
SAL	Urban	15	.230000	.0935796	2.182	28	.038
	Rural	15	.160667	.0799524			
EC	Urban	15	477.200000	177.5343830	2.374	28	.025
	Rural	15	333.466667	153.1870317			
TDS	Urban	15	238.766667	88.8483593	2.371	28	.025
	Rural	15	167.033333	76.3924236			
$N0_3$	Urban	15	.245333	.0838252	1.137	28	.265
	Rural	15	.212000	.0766439			
CL	Urban	15	5.886667	2.1179055	1.528	28	.138
	Rural	15	4.760000	1.9149040			
SO_4	Urban	15	2.242667	.8575086	1.058	28	.299
	Rural	15	1.845333	1.1754687			
TA	Urban	15	2.480000	.6950848	.939	28	.356
	Rural	15	2.193333	.9557844			
TH	Urban	15	12.466667	6.1781489	-.064	28	.950
	Rural	15	12.606667	5.8165364			
Fe	Urban	15	.176667	.2053105	1.344	28	.190
	Rural	15	.100667	.0763887			
Mn	Urban	15	.023533	.0075675	3.894	28	.001
	Rural	15	.012867	.0074342			
F	Urban	15	.710000	.4009809	.827	28	.415
	Rural	15	.579333	.4624078			
As	Urban	15	.002000	.0041404	1.035	28	.309
	Rural	15	.000867	.0009155			

Significant at $p<0.05$ significance level(2-tailed)

Temperature (T), pH, Salinity (Sal), Electrical conductivity (EC), Total Dissolved Solids (TDS), Nitrate (NO_3), Chloride (Cl), Sulphate (SO_4^{2-}), Total Alkalinity (TA), Total Hardness (TH), Iron (Fe), Manganese (Mn), Fluoride (F) and Arsenic (As).

CONCLUSION

From the study, it was observed that the concentration of groundwater parameters from shallow aquifers is significantly influenced by seawater intrusion within the study area. The groundwater in the study area is moderately acidic in nature but a possibility of saline water intrusion, is making it alkaline and in turn influencing the chemical characteristics of other groundwater parameters in the study area. An increase in salinity has resulted in an increase in pH from an acidic state to an alkaline state. The chemical make-up of groundwater within the study area across rural-urban differentials revealed that the determination of water (ground) quality rests on five major indices. There are: conductivity, oxidising, manganese-toxicity, physical attributes and anthropogenic-pollutants. There first three indices (conductivity, oxidizing and manganese-toxicity) account for over 60% of the variance based on factor analysis. Therefore, this study confirms that within shallow aquifers in sedimentary basins abutting the coast, conductivity, oxidizing and manganese-toxicity indices are the main parameters that should be examined for determining groundwater quality.

There is equally a need for constant monitoring of the underground water quality to ensure that water quality parameters do not build up to levels that will be of environmental concern especially in areas with a growing population and infrastructural developments. There should be a coordinated sampling and monitoring program to check the quality of underground water regularly.

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THE AVAILABILITY OF PHYSICAL EDUCATION FACILITIES AT PUBLIC EDUCATION INSTITUTIONS IN HUNGARY

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Abstract: Taking into account the importance of exercise the main aim of this paper is to examine the availability of physical education facilities at Hungarian primary and secondary schools, and their territorial characteristics. As a result it can be stated that the situation of these institutions in this regard is fundamentally favourable. On the other hand the spatial characteristics of these facilities is influenced by different factors from which in the case of districts the level the development and the number of population and on settlement level the number of population plays the most decisive role.

Key words: physical education, public education facilities, spatial characteristics, Hungary

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INTRODUCTION

Nowadays the increasing role of sport geography can be witnessed within the field of geography (Bánhidi, 2011; Ilies et al., 2014; Wise and Koche, 2020). One of its topics is the examination of the spatial distribution of sport facilities (e.g. Kozma, 2014; Hoekman et al., 2016), since these infrastructural elements represent an important condition of increasing the physical activity of society. Among sports facilities, a special role is played by relevant spaces in public education institutions, since the purpose of these is to provide the given age group with an opportunity to engage in regular physical exercise, which is of key importance for a number of reasons (see later).

In the spirit of the above, this paper intends to examine the availability of physical education (PE) facilities at Hungarian public education institutions (primary and secondary schools), as well as the territorial characteristics of the above, to identify which administrative districts/settlements are in the worst position, unable to satisfy the conditions prescribed by the relevant provisions of law, as well as what factors influence the location of the territorial units concerned.

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The paper fundamentally consists of three larger parts. The first part discusses the significance of physical education in public education institutions (with special attention to the requirements in effect in Hungary), which is followed by an analysis of the current Hungarian situation. The last part summarizes the most important findings.

THE SIGNIFICANCE OF PHYSICAL EDUCATION

Physical education in schools plays an important role in the development of the age group concerned for a number of reasons (Mikulan, 2013). Firstly, achieving the amount of physical activity, as established by researchers (e.g. Strong, et al., 2005) as the daily minimum (60 minutes at the age of 5 to 18), especially in today's digital world, is often only possible with the help of the physical education classes (Tassatino et al., 2010; Dobi and Bácsné Bába, 2018), which has a favourable influence on both the health and psychological condition of students (Dubbert, 2002; Tsang, 2011; Baidog and Herman, 2018; Tătar et al., 2018; Papp et al., 2019; Erdely et al., 2020). Secondly, both the study summarizing the findings of research projects on this topic (Marques et al., 2017), and also concrete case studies have come to the conclusion that physical activity generally has a favourable effect on students' academic performance. They have pointed out, among other things, that students' cognitive capabilities (e.g. verbal argumentation), as well as their academic results (e.g. their grades in mathematics, literature and foreign languages) improved as a result of more intensive physical activity (Van Dusen et al., 2011; Ardoy et al., 2014).

Thirdly, positive experiences gained in physical education classes have a significant force on shaping students' personalities (Gordon-Larsen et al., 2000; Polet, 2019), and they reinforce their commitment to active lifestyle (which is particularly important because physical education classes in school often do not provide sufficient time for necessary daily physical exercise). Fourthly, lessons that provide for the exercise of various body parts and muscles, as well as getting acquainted with different physical/sporting activities, make the harmonic development of the human body possible (Hagger et al., 2003).

What gives special significance to the research project is that, as a result of the factors discussed earlier, the Hungarian government, in power since 2010, devotes great attention to physical education. This is reflected by the fact that, pursuant to Act CXC of 2011, everyday physical education was introduced from 1 September 2012; at the same time, organizing this posed a major challenge for the schools. The concrete requirements are included in Ministerial Decree 20/2012 (VIII. 31.) EMMI (Ministry of Human Capacities) on the Operation of Public Education Institutions and on the Use of Names of Public Education Institutions, according to Annex 2 of which, schools must have the facilities suitable for this purpose (table 1).

Table 1. The requirements of Ministerial Decree 20/2012 (VIII. 31.) EMMI on the facilities of institutes of public educations related to physical education
(Data source: Ministerial Decree 20/2012 (VIII. 31.) EMMI)

School type	Facility type
primary schools, general grammar schools	1 gym/school (at the registered seat and branches)
vocational grammar schools, vocational secondary schools, trade schools, if they teach general academic subjects	1 gym/school (at the registered seat and branches)
trade schools only, if they have a capacity over 120 students	1 gym/school (at the registered seat and branches)
vocational secondary schools, vocational grammar schools, if they are not required to have a gym, or the gym is at the registered seat and it is not possible to use it	1 gym room or half gym/school (at the registered seat and branches)
all school types	1 sports yards (tracks)/school (at the registered seat and branches, can be substituted by free space suitable for the purpose, outdoor facilities)

DATABASE AND METHODS USED

In the course of the research for this paper, the most important source of information was the KIR (Public Education Information System) database of the Educational Authority, which includes information on the physical education facilities (gym room, gym, swimming pool, sports yards) in a breakdown according to campuses (or "places of task performance," to use the relevant legal term) in case of schools consisting of several such units. The difference between a gym and a gym room is one of size: according to the relevant Hungarian rules, a gym must be at least 18 x 30 metres in size, while smaller facilities are classified as gym rooms.

In the course of the territorial analysis, in order to ensure comparability, we assigned points on the basis of the various types of facilities available (table 2), and then calculated a cumulative value from these for the counties, districts and settlements.

Table 2. The calculation of points for the territorial-level analysis
(Data source: own work)

types of facilities available	points
there are not any facilities	1
sport yards only	2
gym room only	2
gym only	3
gym room and gym	4
gym room and sport yards	4
gym and sport yards	5
both of them	6

RESULTS

We can draw several important conclusions in connection with the availability of physical education facilities in primary and secondary schools (table 3). In terms of the general characteristics, firstly, we can conclude that the availability of swimming pools is very low, as less than 3% of all institutions provide this possibility (consequently, this type of facility will not be dealt with subsequently). Secondly, it is positive finding that the figure concerning the capacity of the institutions and the actual number of students enrolled is higher in almost every case than the relevant value calculated in case of the number of the institutions, which suggests that the lower level of availability with respect to the PE facilities is fundamentally true for schools operating with fewer students. Thirdly, among the data pertaining to the number of institutions and the number of students, the smallest difference can be found in case of gym rooms, which indicates that these are primarily typical of institutions operating with the smallest number of students.

A comparison of the two types of schools reveals that primary schools are better equipped with PE facilities; at the same time, it is also true that in terms of the capacities and especially the actual number of students enrolled in these institutions, the difference is already much smaller.

Table 3. The availability of physical education facilities at public education institutes (%)
(Data source: KIR database of the Educational Authority)

	primary schools			secondary schools		
	1	2	3	1	2	3
has a gym room	40.0	42.3	42.9	33.1	35.9	40.6
has a full-scale gym	70.7	82.5	84.3	63.0	73.0	80.4
has sport yards	63.3	70.7	72.1	53.5	60.4	66.0
has a swimming pool	2.3	3.3	3.6	2.4	2.1	2.5

1 – in terms of the number of institutions, 2 – in terms of the capacity of the institutions, 3 – in terms of the actual number of enrolled students

Analysing the availability of facilities in a complex manner (table 4), a much more detailed picture can be painted. Fundamentally, it can be regarded as favourable that, on the one hand, more than 50% of the schools have both outdoor (sports yard) and indoor (gym room or gym) facilities for their students, and on the other hand, more than 2/3 of all students attend these schools. The biggest difference between the two types of schools can be found in case of institutions that do not have suitable infrastructural conditions at all, which is basically due to the fact that several grammar schools have such campuses, operating on a settlement other than the registered seat of the institution, with only a low number of students enrolled, where they do not have the possibility to provide the necessary conditions for physical education.

Table 4. The complex availability of physical education facilities at public education institutes (%)
(Data source: KIR database of the Educational Authority)

available facilities	primary schools			secondary schools		
	1	2	3	1	2	3
there are not any facilities	6.8	4.0	3.7	26.7	19.0	12.9
sport yards only	3.9	2.6	2.3	2.7	2.0	1.5
gym room only	9.6	5.0	4.3	3.8	2.7	2.2
gym only	15.1	13.2	12.5	11.3	12.2	12.1
gym room and gym	5.0	7.0	7.3	4.7	5.7	6.7
gym room and sport yards	8.8	5.8	5.3	3.8	3.2	3.0
gym and sport yards	34.2	37.9	38.6	26.1	30.9	32.8
both of them	16.6	24.6	26.0	20.9	21.2	28.7
total	100.0	100.0	100.0	100.0	100.0	100.0

1 – in terms of the number of institutions, 2 – in terms of the capacity of the institutions, 3 – in terms of the actual number of enrolled students

The analysis of the relationship between the availability of facilities and the number of pupils enrolled fundamentally confirms the above (table 5): schools with fewer than 100 pupils are in the worst position (in case of secondary schools, more than 50% are not able to offer any facilities), while nearly 3/4 of the largest schools have both outdoor and indoor facilities that satisfy the relevant requirements.

Table 5. The availability of physical education facilities at schools as a function of students enrolled (%)
(Data source: KIR database of the Educational Authority)

	primary schools				secondary schools			
	1	2	3	4	1	2	3	4
there are not any facilities	13.6	6.6	2.7	1.1	58.3	33.1	12.9	7.1
sport yards only	5.5	5.2	1.7	0.0	3.9	4.0	2.9	0.5
gym room only	24.2	6.7	2.9	1.4	4.8	7.6	2.7	1.0
gym only	16.1	19.0	11.0	6.7	9.2	9.9	13.1	12.5
gym room and gym	2.8	3.3	8.3	9.2	1.4	6.0	3.2	7.8
gym room and sport yards	14.5	10.3	3.5	1.4	3.4	6.3	4.3	2.0
gym and sport yards	18.4	39.2	38.6	43.7	12.6	19.5	35.4	34.3
both of them	4.8	9.8	31.3	31.6	6.4	13.6	25.5	34.8
total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

1 – less than 100 pupils, 2 – 101-250 pupils, 3 – 251-500 pupils, 4 – more than 500 pupils

On the county level, no clear tendencies can be identified on the basis of an examination of the availability of facilities (figures 1 and 2). If we examine the two types of institutions combined, the territorial units with the best results (Zala, Somogy, Csongrád, Jász-Nagykun-Szolnok counties, as well as Budapest) are scattered across the country, while many of those in the worst position are located in the middle of the country, along a wide North-South axis. In case of

primary schools, the territorial units in the most favourable position are scattered across the country, while in case of secondary schools, it is mainly the counties along the western border of the country that are in this category.

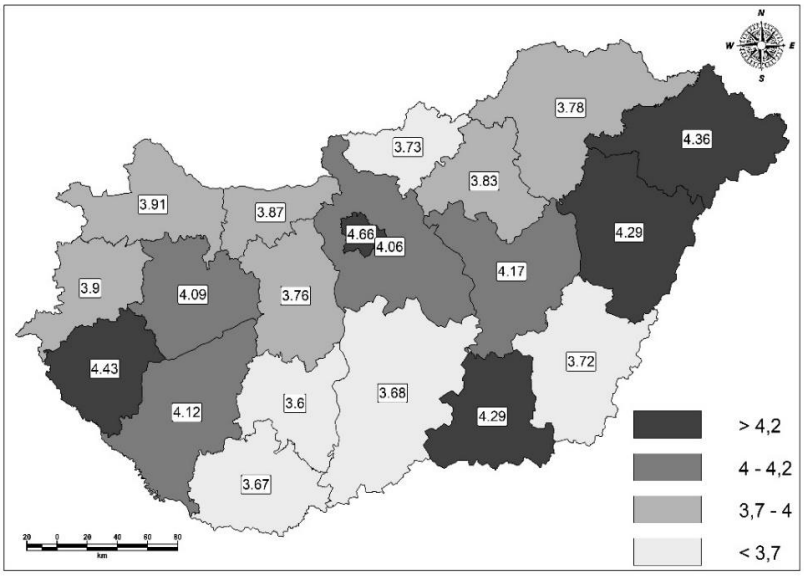

Figure 1. The availability of PE facilities in primary schools on the county level in Hungary (on the basis of the method described in Table 2)
Source: KIR database of the Educational Authority

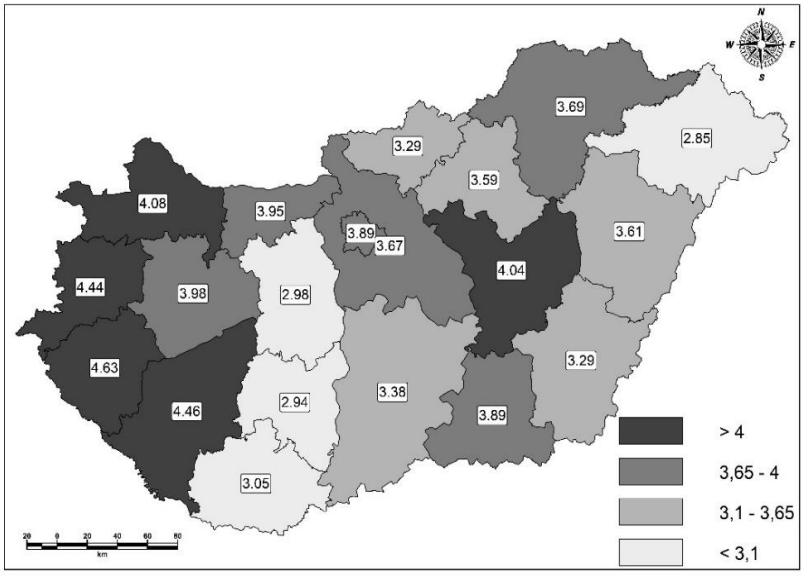

Figure 2. The availability of PE facilities in secondary schools on the county level in Hungary (on the basis of the method described in Table 2)
Source: KIR database of the Educational Authority

When carrying out the analyses on the district level (figure 3 and 4), a significant difficulty was posed by the fact that in nearly half of the districts (i.e. a total of 78 districts), there was not a high enough number of schools (at least 4) that would have allowed a reliable analysis to be carried out; therefore, the analysis was restricted to 96 districts.

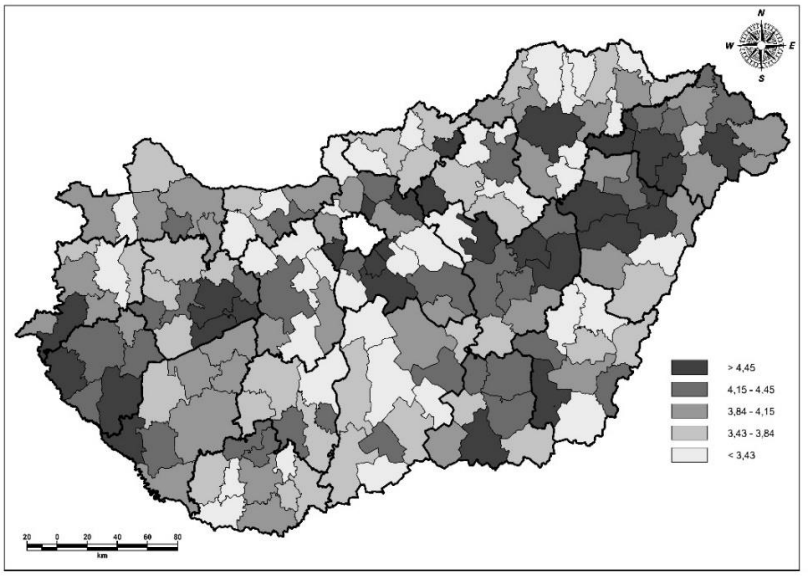

Figure 3. The availability of PE facilities in primary schools on the district level in Hungary (on the basis of the method described in Table 2)
Source: KIR database of the Educational Authority

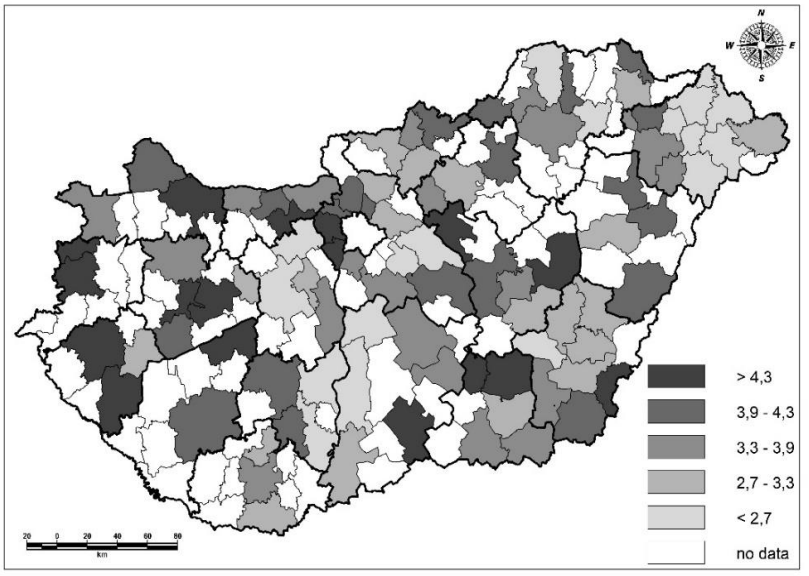

Figure 4. The availability of PE facilities in secondary schools on the district level in Hungary (on the basis of the method described in Table 2)
Source: KIR database of the Educational Authority

The results show a highly varied picture: both in case of primary and secondary schools it can be observed that even in the counties that are in the best position there are some districts that have unfavourable indicators, and conversely, even in the counties with the worst results there are some districts with good scores. This fact necessitates further, more in-depth research.

Based on the result of our earlier examinations (Kozma, 2020), we devoted more attention to two of the factors influencing the availability of PE facilities at schools in the individual districts: the level of socio-economic development in the given territorial unit and the average population size of the settlements in that unit.

In case of primary schools, the organisation of the data into deciles did not reveal any clear tendencies (table 6): even though the availability of PE facilities increases in a parallel way with the level of development and the average population size of the settlements, we can still observe 1 or 2 groups lagging behind in both cases.

At the same time, the use of various mathematical indicators shows a much clearer picture (table 7): the values of both Spearman's and Pearson's correlation coefficients are higher in case of settlements with an average population size. However, it should also be noted here that the values fundamentally refer to a relationship that is weaker than medium.

Table 6. The availability of PE facilities in primary schools as a subject of the districts' level of development and the average population size of the district's settlements (on the basis of the method presented in Table 2, the average score assigned to the schools in the given decile)
(Data source: KIR database of the Educational Authority, 290/2014. (XI. 26.) on the classification of beneficiary districts, National Territorial Development and Spatial Planning Information System)

	the level of development of the district	the average population size of the settlements in the district
first decile	3.62	3.59
second decile	3.74	3.93
third decile	3.64	3.90
fourth decile	3.79	3.89
fifth decile	3.91	3.71
sixth decile	3.78	3.90
seventh decile	3.86	4.06
eighth decile	4.10	3.80
ninth decile	4.14	4.14
tenth decile	4.48	4.23

first decile - the least developed 10 percent of districts; tenth decile - the most developed 10 percent of districts, according to Government Decree

Table 7. The coefficients showing a relationship between the availability of PE facilities in primary schools, as well as the level of development of the district and the average population size of the settlements in the district
(Data source: KIR database of the Educational Authority)

	Spearmann rank correlation coefficient	Pearson correlation coefficient
primary schools – the level of development of the district	0.217[1]	0.220[1]
primary schools – the average population size of the settlements in the district	0.352[1]	0.242[1]

1 – significant at 0.01 level, 2 – significant at 0.05 level

In case of secondary schools (table 8 and 9), the availability of PE facilities has a stronger link with the level of developments of the districts. In my opinion, the difference between the two types of institutions can be traced back to the fact that it is particularly true for primary schools that the institutions operating on larger settlements have more students, which – as mentioned before – can provide better conditions.

Table 8. The availability of PE facilities in secondary schools as a function of the districts' level of development and the average population size of the district's settlements (on the basis of the method presented in Table 2, the average score assigned to the schools in the given decile)
(Data source: KIR database of the Educational Authority, 290/2014. (XI. 26.) on the classification of beneficiary districts, National Territorial Development and Spatial Planning Information System)

	the level of development of the district	the average population size of the settlements in the district
first decile	3.14	3.39
second decile	3.14	3.72
third decile	3.09	3.25
fourth decile	3.37	2.96
fifth decile	3.93	3.49
sixth decile	3.35	3.51
seventh decile	3.41	3.50
eighth decile	4.05	3.80
ninth decile	3.83	4.11
tenth decile	4.08	3.74

first decile - the least developed 10 percent of districts; tenth decile - the most developed 10 percent of districts, according to Government Decree

Table 9. The coefficients showing a relationship between the availability of PE facilities in secondary schools, as well as the level of development of the district and the average population size of the settlements in the district
(Data source: KIR database of the Educational Authority)

	Spearmann rank correlation coefficient	Pearson correlation coefficient
secondary schools – the level of development of the district	0.375[1]	0.374[1]
secondary schools – the average population size of the settlements in the district	0.201[2]	0.122

1 – significant at 0.01 level, 2 – significant at 0.05 level

Table 10. The proportion of institutions other than general grammar schools in districts at different levels of socio-economic development
(Data source: KIR database of the Educational Authority, 290/2014. (XI. 26.) on the classification of beneficiary districts)

the level of development of the district	proportion of institutions other than general grammar schools
first decile	60.9
second decile	61.6
third decile	60.3
fourth decile	62.5
fifth decile	64.8
sixth decile	63.8
seventh decile	65.7
eighth decile	66.7
ninth decile	65.9
tenth decile	69.4

first decile - the least developed 10 percent of districts; tenth decile - the most developed 10 percent of districts, according to Government Decree

By contrast, in case of secondary schools, in more developed districts, there is a higher proportion of institutions (table 10) other than general grammar schools (vocational grammar schools and vocational secondary schools), which are in a better position in terms of the availability of PE facilities than grammar schools (the relevant value is 3.67 in case

of the former and 3.57 in case of the latter). The proportion of the territorial units concerned within more developed districts can be attributed to the fact that in most cases they include one or two larger settlements which have experienced significant socio-economic development in the past few decades (including the period before 1990). At the same time, in the framework of the above – in addition to the earlier existing general grammar schools – numerous other new vocational grammar schools and trade schools have been established in the interest of satisfying the needs of the economy and these have been built with suitable sports infrastructure.

An examination of the availability of PE facilities at settlement level reveals the outstanding role played by the size of the settlement both in case of primary and secondary schools (table 11 and 12): with the increase of population size in a settlement, the availability of PE facilities also improves significantly. This situation can be explained by similar factors in case of both institution types: on the one hand, larger settlements are characterized by schools with larger student bodies, which are in a better position in terms of the availability of PE facilities, as shown in Table 5. On the other hand (and partly this is what justifies the previous point), the majority of institutions on larger settlements were built in the past few decades, when bigger attention was already devoted to the construction of schools with suitable sports facilities.

Table 11. The availability of physical education facilities at primary schools as a function of the population size of the settlements
(Data source: KIR database of the Educational Authority, National Territorial Development and Spatial Planning Information System)

population size of settlements	score indicating the availability of facilities
less than 500 inhabitants	2.45
501 - 1,000 inhabitants	3.17
1,001 - 1,500 inhabitants	3.47
1,501 - 2,000 inhabitants	3.81
2,001 - 3,000 inhabitants	3.96
3,001 - 5,000 inhabitants	4.33
5,001 - 10,000 inhabitants	4.17
10,001 - 25,000 inhabitants	4.26
25,001 - 50,000 inhabitants	4.62
50,001 - 100,000 inhabitants	4.71
more than 100,000 inhabitants	4.63
Budapest	4.66

Table 12. The availability of physical education facilities at secondary schools schools as a function of the population size of the settlements
(Data source: KIR database of the Educational Authority, National Territorial Development and Spatial Planning Information System)

population size of settlements	score indicating the availability of facilities
less than 3,000 inhabitants	2.41
3,000 - 5,000 inhabitants	2.60
5,000 - 7,500 inhabitants	3.30
7,500 - 10,000 inhabitants	3.24
10,000 - 25,000 inhabitants	3.65
25,000 - 50,000 inhabitants	4.02
50,000 - 100,000 inhabitants	3.99
100,000 fő felett	3.97
Budapest	3.99

CONCLUSIONS

The most important findings of the study could be summarised as follows. The availability of physical education facilities at Hungarian educational institutions is fundamentally favourable: a significant proportion of the students attend schools that have both indoor and outdoor facilities. With the increase in the number of students enrolled in the schools, the capabilities of schools providing for the needs of physical education classes at a proper level significantly improve. Examining the territorial conditions on the district level, in case of primary schools, it is the average population size, while in case secondary schools, it is the level of development of the districts that are the most important factors. The analysis of the data at settlement level revealed that institutions operating on settlements with a larger population can generally offer better conditions for physical education.

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SPATIO-TEMPORAL ANALYSIS OF THE PRACTICE OF URBAN AGRICULTURE IN LAGOS METROPOLIS AND THE IMPLICATIONS FOR URBAN PLANNING

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Abstract: The study examined the practice of urban agriculture and changes in agricultural land use in the last three decades, and assess the implications of these changes for urban planning in Lagos Metropolis, a mega city in Sub-Saharan Africa. Multistage sampling technique was used to collect primary data from four Local Government Areas. Landsat Thematic Mapper (TM) image of 1986, Landsat Enhanced Thematic Mapper Plus (ETM+) image of 2000, Landsat 8 of 2016 as well as Google Earth image of 2015 was processed using ArcGIS 10.3.1, IDRISI and ERDAS Imagine 9.2 software. An inventory of the spatial extent, the rate of change and the pattern of conversion of urban farmlands to other land uses over the years in consideration were also carried out. Findings from the study showed that variation exists in the practice of urban agriculture among the sampled LGAs in terms of gender ($\chi^2 = 33.108$, $p < 0.001$), age distribution ($\chi^2 = 37.744$, $p < 0.001$), marital status ($\chi^2 = 26.051$, $p < 0.002$), level of education ($\chi^2 = 28.172$, $p < 0.001$) and farming experience ($\chi^2 = 52.837$, $p < 0.001$). Cultivated lands decreased by 28.70% between 1986 and 2000 and by 19.25% between 2000 and 2016. So also between 1986 and 2000, 89.48% of urban farmlands had been converted to other land uses, and also between 2000 and 2016, 75.64% had been converted to other land uses. The results of this study gives an indication that food security is under threat in Lagos Metropolis as the land available to urban farmers continue to shrink. The study therefore recommends a new planning approach that will accommodate sustainable urban agriculture.

Key words: urban agriculture, conversion, change detection, food security

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INTRODUCTION

Food production in and around cities is an integral part of the urban fabric in much of the developing world. In these regions, urban and peri-urban agriculture (UPA) plays an important role in diversifying urban diets and providing environmental services in urban and peri-urban areas (Sy et al., 2014). Urban agriculture is a rather discreet but cosmopolitan phenomenon, resulting from the quest by urban households to enhance their means of livelihood. Discreet because it is often practised in inconspicuous vacant lands or open spaces, cosmopolitan because it is practised in every city of both developed and developing countries.

Urban agriculture have been variously defined by researchers as any agricultural enterprise within or on the fringes of a town, city, or metropolis that grows, processes, and distributes food and non-food products (Moustier, 1999; Mougeout, 2006; Lovell, 2010). Smit et al., (2001) referred to urban agriculture as 'metropolitan-intensive agriculture' and comprehensively defined it as an industry that produces, processes, and market food, fuel, and other outputs, largely in response to the daily demand of consumers within a town, city, or metropolis, on many types of privately and publicly held land and water bodies found throughout intra-urban and peri-urban areas.Within the context of this study, urban agriculture is defined as agricultural activities involving the growing and marketing of different types of crops and animals, either on a subsistence or commercial scale, within or at the periphery of a town, city or metropolitan area.

Inherent in all these definitions is the fact that urban agriculture is a spatial attribute of every metropolitan city and the fact that urban agriculture contributes significantly to the socio-economic development of towns and cities throughout the world. Urban agriculture has benefits as well as risks to the environment and health. These benefits and risks have been the focus of many researchers (Mougeot, 2000; Afrane et al., 2002; Faraqui et al., 2004; Veenhuizen, 2006). However, UA is a phenomenon that is prone to change. Indeed, due to the often transitory nature of urban agriculture, it is often considered to be a new phenomenon. The space and resources available to UA practitioners vary both quantitatively and qualitatively over short periods of time, as has been noted by some researchers (Losada et al., 1998; Arturo and Simon, 2003; Foeken, 2012). An in-depth understanding of the spatial and temporal dynamics of urban agriculture is therefore necessary to put the practice in its proper context.

Urban agriculture can occur on many types of private or public land or water bodies both within and on the edges of cities, taking on many forms depending on the local context to yield an array of land- water- and air-based biodiversity, contributing to the food security, health, livelihood and habitat of all living beings and systems. It can be a transient or permanent feature in both developed and developing nations (Rabiul and Chamhuri, 2012). Although many farms changed their location over time, other open areas- usually those unsuitable for housing or other developments- have been under continuous cropping for the past 20 - 50 years as reported from West and East Africa (Drechsel and Dongus, 2010). Urban agriculture contributes to a wide variety of urban issues and is increasingly being accepted and used as a tool in sustainable city development. Currently the challenge is its integration into city planning and facilitation of its multiple benefits for urban inhabitants (Veenhuizen, 2006; Omisore and Olaleye, 2011). To this extent many studies have been conducted on urban agriculture and urban food security providing data on the presence and persistence of urban agriculture in cities and its importance for urban food security and income generation for the urban poor (Veenhuizen and Danso, 2007; Nsangu and Redwood, 2009; Ajadi et al., 2011; Akinmoladun and Adejumo, 2011). A number of these studies have focused on urban agriculture as a livelihood activity and have provided important insights (Duressa, 2007; Aina et al., 2012). This present study therefore, examined the practice of urban agriculture, in Lagos Metropolis, assess the spatial and temporal variability of agricultural land use and the implication of these for urban planning.

STUDY AREA

Lagos State is geographically positioned between Longitude 2^0 42' and 4^0 20' East and Latitude 6^0 22'and 6^0 42' North. It is bounded on the West by the Republic of Benin, in the North and

East by Ogun State and in the South by the Atlantic Ocean. It has a population of over 10 million people (NPC, 2007), and a population density of 5,926 persons per square kilometer (Komolafe et al., 2014). Lagos metropolitan area is one of the most rapidly urbanizing areas in the world and as such has been designated the second megacity in Africa. The metropolitan area comprises of seventeen out of the twenty Local Government Councils which make up the State. These include: Lagos Island, Eti-Osa, Lagos Mainland, Surulere, Ikeja, AjeromiIfelodun, Amuwo-Odofin, Alimosho, Apapa, Ojo, Somolu, Kosofe, Mushin, Oshodi-Isolo, Agege and Ikorodu (Akinmoladun and Adejumo, 2011) (figure 1).

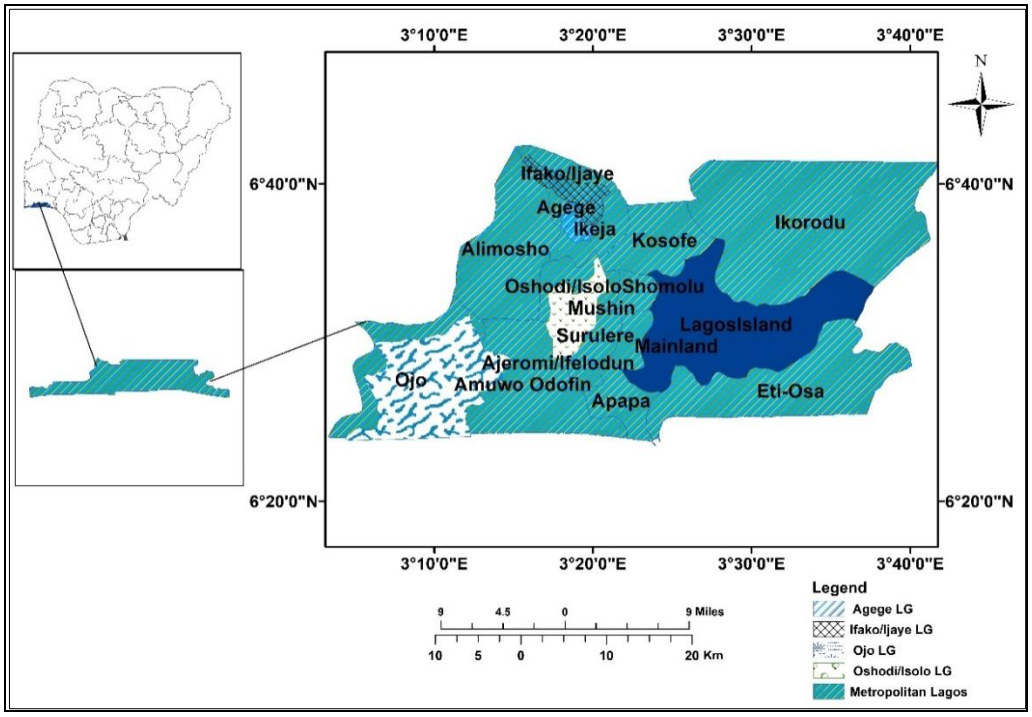


Figure 1. Map of the study area
(Source: Authors' GIS data procesessing 2018)

The state is located within the sub-equatorial zone, which is characterized by rainfall throughout the year with two maxima (May to July and September to October). December and January have very little rain, and the annual rainfall is between 1500 to 2000 mm. The effective temperature (ET) is between 32°C and 36°C. However, the highest diurnal range of temperature in the dry season (mid –November to mid-March) is 20°C while the mean range is about 10°C during the warm and wet season (May to October). The highest air temperature occurs in April/May and the lowest occurs in December through February. The mean annual temperature is about 27°C while the annual range does not exceed 6°C (Ekanade, 1985). It lies within the rainforest belt dry lowland rainforest.

The vegetation of the region is swamp and marsh forest, part of which had given way to the construction of houses, markets and other infrastructure. Tree species here consist of typical colonizer or invaded species. These are plants with numerous and easily dispersed seeds and capacity for fast and vigorous establishment in cleared or open location. The river channels are characterized by vegetation of the wet southern segment of the rainforest belt. The characteristic vegetation include tall trees like *Tarriefautilis, Geophilasp., epiphytic ferns (placycerinasp.), Tuchomanessp. Nephrolepissp. Mosses* and *Lierworts* (Ogunbajo, 2005).

MATERIALS AND METHODS

Landsat Thematic Mapper (TM) (r191p055/56), acquired on 24th December, 1986, Landsat Enhanced Thematic Mapper Plus (ETM+) (r191p055/56), acquired on 6th February, 2000, Landsat 8 (r191p055), acquired on 18th December, 2016 were obtained from the United States Geological Survey (USGS) website, as well as Google Earth image of 2015, which was used for groundtruthing.

Based on the information obtained from satellite imagery in combination with the list of registered urban farmers obtained from the Lagos State Agricultural Development Authority, urban farms were randomly selected for enumeration. Target groups for this study were urban crop farmers in Lagos State. Four local governments councils (figure 2) were purposively selected out of the seventeen local government councils that make up the Lagos Metropolitan Area. Subsequently urban farmers in the local government councils were selected using simple random technique. A total of 526 registered urban farmers in Agege LG, 925 in Ifako-Ijaye LG, 829 in Oshodi-Isolo and 569 in Ojo LG were obtained based on the information collected from the Lagos State Agricultural Development Programme (LSADP). Ten percent of the registered urban farmers from each local government council were randomly selected. A preliminary survey was carried out to identify, delineate and locate potential farm sites for the study. The survey was carried out using the high resolution Google Earth Map and a handheld Global Positioning System (GPS) between May and September 2015.

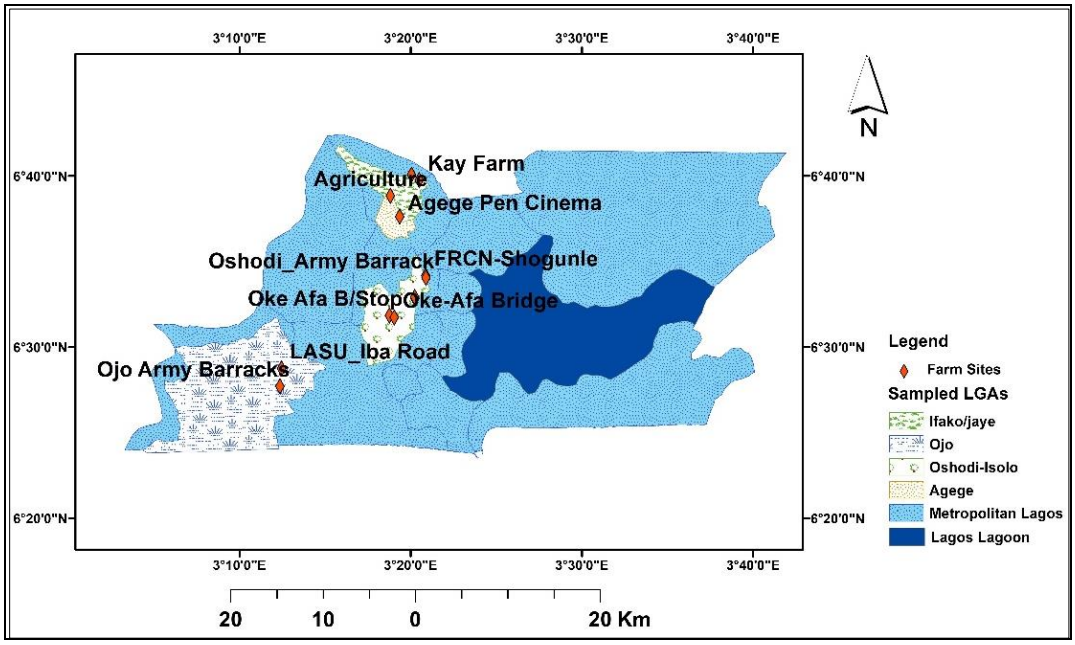


Figure 2. Map showing the locations of urban farms in the selected LGAs

(Source: Authors' GIS data procesessing 2018)

The Landsat images were pre-processed to correct them for spectral variation resulting from sensor differences before the study area was extracted from each dataset. False colour composite (FCC) was created using near-infrared, red and green bands of each of the images. The selection of band combination was done to enhance our ability to clearly distinguish vegetation types from urban land use (Enaruvbe and Atedhor 2015).

A combination of image composite, supervised image classification, and field survey were used for image analysis. The land cover categories are farmlands, built up, wetlands, open space, light forest, shrub and water body. The ERDAS Image Software Accuracy Assessment Utility was

used to perform an accuracy assessment for the classified images. Thus for the 1986 land use/land cover classification the overall accuracy of 64.29% and an overall kappa statistics of 0.58 was generated. On the other hand for both the 2000 and 2016 land use/land cover the overall accuracy was 85.71% and overall kappa statistics was 0.82. The Kappa coefficient expresses the proportionate reduction in error generated by a classification process compared with the error of a completely random classification. The rate of environmental change was determined by computing the percent average rate of change using equation (1) thus:

$$\left[\frac{\left(\frac{d}{t_1}\right) * 100}{y_2 - y_1}\right] (1)$$

Where d is the difference in the value of area covered by a land cover category at the initial time point and final time point while t1 is the value of the area covered by a land cover category in the initial time point and y_1 and y_2 are base year and final year respectively (Enaruvbe and Atedhor, 2015).

Change Detection Analysis

The point by point analysis involved the actual topological overlay of the various classified land use/land cover maps generated within the IDRRISI software, to produce change maps (Change Detection Exercise). This was done to generate the nature, location and magnitude of the changes in urban farmlands. In addition, the topological map overlay resulted in the generation of a two-dimensional change matrix within the GIS environment. This two-dimensional matrix shows the nature of the land use and land cover changes for two given sets of years.

RESULTS AND DISCUSSION

Socio-Economic Profile of Respondents

As presented in table 1, the practice of urban agriculture cut across both male and female gender, thus 50.6%; of the urban farmers in Metropolitan Lagos were female while 49.4 were male. Similar findings have been reported by Smit et al., (2001) and Sy et al., (2014), Smit et al argued that because feeding the family is the responsibility of the woman she is more immediately conscious of food insecurity and malnutrition as well as food quality, and is typically the first to seek opportunities to augment the food supply. It was also revealed that majority (76%) of the farmers were married, thus it is observed that most urban farmers in Metropolitan Lagos engaged in agricultural practice as a means of augmenting their families' food intake. The table also indicates that most of the urban farmers (54.8%) had primary education. Perhaps the low level of education of the farmers may be a reflection of the rudimentary and subsistence nature of their farming activities, which may however affect the adoption of new technology and innovation as noted by Salau and Attah (2012).

Bellwood-Howard et al., (2015) made similar observation in their study of urban farmers in Ouagadougou (Burkina Faso) and Tamale (Ghana) where they reported that 62% of 1,056 surveyed adults have not received any formal education.

Furthermore, 44.9% of the farmers were within 31-45 years of age, which implies that the urban farmers were within the economically active age. Meanwhile the mean household size of the farmers was 6 person, which fairly agree with that of Duressa (2007) who reported an average household size of 7 members in Adis Ababa, Ethiopia. The study however, showed that variation exists in the practice of agriculture among the sampled Local Governments in terms of gender (χ^2 = 33.108, P=0.000), age distribution (χ^2= 37.744, P= 0.000), marital status (χ^2= 26.051, P = 0.002), level of education (χ^2= 28.172, P = 0.001) and farming experience (χ^2= 52.837, P= 0.000).

Table 1. Socio-Economic Characteristics of farmers
(Data source: Author's Field work, 2018)

Characteristics	Frequency	Percentage (%)
Gender		
Male	130	50.6
Female	133	49.4
Marital Status		
Single	19	7.2
Married	200	76.0
Widowed	39	14.8
Divorced	5	1.9
Education Level		
No Formal Education	25	9.5
Primary Education	144	54.8
Secondary Education	82	31.2
Tertiary Education	12	4.6
Age Distribution		
16-30	23	8.7
31-45	118	44.9
46-60	108	41.1
Above 60	14	5.3
Household size		
1-5	119	45.2
6-10	138	52.5
11-15	6	2.3
Farming Experience (Years)		
1 to 10	56	21.3
11 to 20	103	39
21 to 30	79	30
above 30	23	8.7

Spatial Extent and Rate of Change in Agricultural Land Use (1986, 2000 and 2016)

As shown in table 2, the entire study area covered 163,343.68 ha, in 1986, cultivated lands which is the focus of this study, constituted 20,654.40 ha (12.64%), and in 2000 it constituted 14,727.18 ha (9.02%), while in 2016 it occupied 11,924.56 ha (7.30%) of the study area. Thus, it could be observed that between 1986 and 2000 cultivated lands decreased by 5,927.22 ha (28.70%) and by 2,843.32 ha (19.25%) between 2000 and 2016. Although between 1986 and 2000 other land use categories such as open space, shrub and light forest decreased by 4,299.52 ha (16.28%), 6,736.48 ha (23.52%) and 6,104.66 ha (25.46%) respectively, the rate of decline of cultivation was the highest. However, between 2000 and 2016 the rate of decrease of cultivated lands has slowed down to 2,843.32ha (19.25%), while other categories of land use such as water body, open space, shrub and light forest decreased by 6,354.68 ha (18.43%) 8,733.23 ha (39.44%), 15,964.37 ha (72.90%) and 11,396.32 ha (63.64%) respectively. On the other hand, built up increased by as much as 40,068.2 ha (103.29%), while wetland increased by 5,031.01 ha (37.11%).

It should also be noted that between 1986 and 2000 cultivation had the highest annual rate of decrease of 2.05% compared to open space, shrub and light forest which had 1.16%, 1.68% and 1.82% annual rates of decrease. Also, within this period water body, built up and wetland increased at the average rates of 0.78%, 2.58% and 16.24% per annum. On the other hand between 2000 and 2016 (table 3) the decline in cultivation had slowed down to an average rate of 1.20% per annum, while water body, open space, shrub and light forest decreased at the average rates of 1.15%, 2.47%, 4.56% and 3.98% respectively. However, between 2000 and 2016 built up and wetland increased at the average rates of 6.46%, and 2.32% per annum. Perhaps, the slowdown in the decline of cultivated lands may be attributed to the nascent result of the urban greening programme of the Lagos State Government which had begun to yield results, as it encourages horticulture and landscaping. A journey through the stretch of Agege-Aiport-Oshodi road and Oshodi-Oworonsoki road enroute Third Mainland confirms these findings.

Furthermore, the above spatial configuration of cultivated lands in the Lagos metropolis between 1986 and 2016 tends to support the findings by Adereti et al. (2010), in their study of urban agriculture in Ojo Local Government where it was reported that 12 % of urban farmers in the study area had frequent displacement. Urban agriculture is therefore increasingly under pressure from other competing urban land uses, especially urban built up area which has continued to consume more and more lands at the expense of other land uses.

Table 2. Spatial extent and rate of change in land use/land cover from 1986 to 2000
(Data source: Author's image analysis, 2018)

	1986		2000		Change between 1986 & 2000		Average Rate of Change	
LULC	Area (ha)	Area (%)	Area (ha)	Area (%)	Area (ha)	Area (%)	Area (ha)	Area (%)
Water body	31,041.06	19.00	34,418.79	21.07	3377.73	10.88	241.27	0.78
Built up	28,495.25	17.45	38,782.77	23.74	10,287.52	36.10	734.82	2.58
Cultivation	20,654.40	12.64	14,727.18	9.02	-5,927.22	-28.70	-423.37	-2.05
Open space	26,404.54	16.17	22,105.02	13.53	-4,299.52	-16.28	-307.11	-1.16
Shrub	28,637.36	17.53	21,900.88	13.41	-6,736.48	-23.52	-481.18	-1.68
Light forest	23,972.98	14.68	17,868.32	10.94	-6,104.66	-25.46	-436.05	-1.82
Wetland	4,138.09	2.53	13,546.77	8.29	9,408.68	227.37	672.05	16.24
Total	163,343.68	100	163,349.73	100	-	-	-	-

*LULC- Land use/Land cover

Table 3. Spatial extent and rate of change in land use/land cover from 2000 to 2016
(Data source: Author's image analysis, 2018)

	2000		2016		Change between 2000 & 2016		Average Rate of Change	
LULC	Area	Area	Area	Area	Area	Area	Area	Area
	(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)	(%)
Waterbody	34,418.79	21.07	28,120.06	17.22	-6,354.68	-18.43	-397.17	-1.15
Built up	38,782.77	23.74	78,860.46	48.28	40,068.2	103.29	2,504.26	6.46
Cultivation	14,727.18	9.02	11,924.56	7.30	-2,843.32	-19.25	177.71	1.20
Open Space	22,105.02	13.53	13,410.41	8.21	-8,733.23	-39.44	-545.83	-2.47
Shrub	21,900.88	13.41	5,933.96	3.63	-15,964.37	-72.90	-997.77	-4.56
Light forest	17,868.32	10.94	6,511.58	3.99	-11,396.32	-63.64	-712.27	-3.98
Wetland	13,546.77	8.29	18,588.68	11.37	5,031.01	37.11	314.44	2.32
Total	163,349.72	100	163,349.71	100	-	-	-	-

*LULC- Land use/Land cover

Persistence, Gain and Loses in Agricultural Land use in Lagos Metropolis (1986-2016)

Table 4 revealed that between 1986 and 2000 while only 14.75% of cultivated lands remained unchanged, as much as 89.48% of cultivated lands have been converted to other land uses such as water body, built up, light forest and wetland which has net gains of 9.81%, 26.53%, 34.17% and 69.45% respectively. Whereas, within this same period even though cultivated lands had a gain of 85.25%, it suffered a net loss of 40.25%.

Also, between 2000 and 2016 (table 5) while 30.09% of cultivated lands remained unchanged as much as 75.64% have been lost to other land uses. Within this period although cultivated lands had a gain of 69.91% it suffered a net loss of 23.50%. In comparison to cultivated lands, between 2000 and 2016, 96.31% of water body, 40.35% of built up, 20.19% of open space, 33.65% of shrub, 53.76% of light forest and 35.07% of wetland remained unchanged, while within these same period water body, built up, and wetland had a net gain of 22.40%, 50.82% and 27.12% respectively, open space, shrub and light forest had a net loss of 64.84%, 269.08% and 174.41% respectively. The inference that may be drawn from the preceding findings is the fact that while urban agriculture is being practiced consistently in Lagos metropolis, urban farmers are either being displaced by land speculators or by perennial flooding, and are being forced to abandon their farmlands, which are often on marginal lands.

The pattern of distribution and fragmentation of cultivated lands between 1986 and 2016 is presented in figures 3a-c. More farmlands were present in 1986 compared with that of 2000 and 2016. However, while urban farmlands appeared extensive in 1986, they appeared more fragmented in 2000 and by 2016 they have been completely engulfed by built up and reduced to small patches. This observed spatial pattern of cultivated lands is an indication of the fact that the land available to urban farmers in Lagos Metropolitan area for the practice of urban agriculture has continue to shrink over the years, thereby hampering large scale production of crops and hence promoting only subsistence farming. The result presented above further revealed the dynamic and migratory nature of urban agriculture as has been noted by some researchers (Mougeout, 2000; Drechsel & Dongus, 2010; Addo, 2010; Islam & Siwar, 2012).

Veenhuizen & Danso (2007) observed that the city is in a constant process of building and decay. Open spaces get built on and their formal or informal temporary users become evicted (as is regularly happening to many urban farmers); they are forced to find an alternative location or give up farming. Meanwhile, degenerated residential, office or industrial areas are demolished, creating new open spaces that may stay vacant for a long time until given a new use and the required investments become available. New roads and power lines are built, creating new vacant open spaces. Often, such newly created open spaces are gradually occupied by urban producers (informal occupation or temporary leases).

Table 4. Proportion of Agricultural Land use Gained and/or Lost between 1986 and 2000
(Data source: Author's image analysis, 2018)

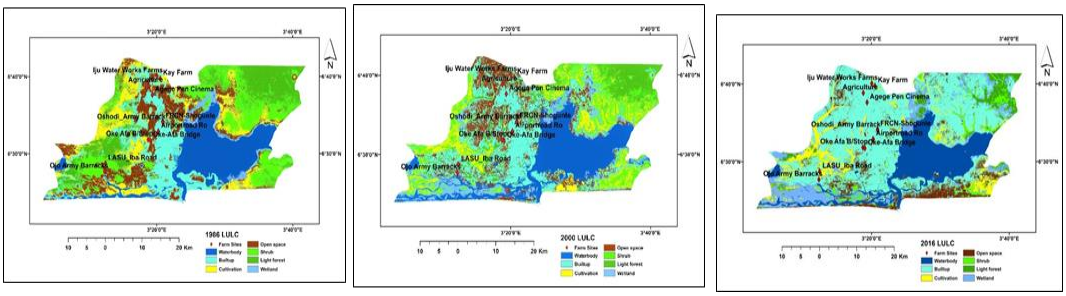
LULC	LULC in 1986 and Unchanged in 2000		LULC in 1986 lost to other LULC by 2000		LULC in 1986 gained from other LULC type by 2000		LULC in 2000 (unchanged + gained)		Difference of (1986-2000) LULC gained-lost	
	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%
Water body	26,557.35	77.16	4,483.71	14.44	7,861.44	22.84	34,418.79	100	+3,377.73	+9.81
Build up	14,942.99	38.53	13,552.26	47.56	23,839.78	61.47	38,782.77	100	+10,287.52	+26.53
Cultivation	2,172.24	14.75	18,482.16	89.48	12,554.94	85.25	14,727.18	100	-5927.22	-40.25
Open space	7,224.22	32.68	19,180.32	72.64	14,880.8	67.32	22,105.02	100	-4299.52	-19.45
Shrub	9,780.19	44.66	18857.17	65.85	12,120.69	55.34	21,900.88	100	-6736.48	-30.76
Light forest	10,261.99	57.43	13,710.99	57.19	7,606.33	42.57	17,868.32	100	-6104.66	+34.17
Wetland	1,565.13	11.55	2,572.96	62.18	11,981.64	88.45	13,546.77	100	+9408.68	+69.45
Total	72,504.11	44.39	90,839.57	55.61	90,845.62	55.61	163,349.73	100	-	-

*LULC- Land use/Land cover

Table 5. Proportion of Agricultural Land use Gained and/or Lost between 2000 and 2016
(Data source: Author's image analysis, 2018)

LULC	LULC in 2000 and Unchanged in 2016		LULC in 2000 lost to other LULC by 2016		LULC in 2000 gained from other LULC type by 2016		LULC in 2016 (unchanged + gained)		Difference of (2000-2016) LULC gained-lost	
	ha	%	ha	%	ha	%	ha	%	Ha	%
Water body	27,081.22	96.31	7,337.57	21.32	1,038.84	3.69	28,120.06	100	-6298.73	+22.40
Build up	31,816.87	40.35	6,965.90	17.96	47,043.57	59.65	78,860.46	100	+40077.67	+50.82
Cultivation	3,587.52	30.09	11,139.66	75.64	8,337.04	69.91	11,924.56	100	-2802.62	-23.50
Open space	2,707.79	20.19	19,397.23	87.75	10,702.62	79.81	13,410.41	100	--8694.61	- 64.84
Shrub	1,996.60	33.65	19,904.28	90.88	3,937.36	66.35	5,933.96	100	-15966.92	-269.08
Light forest	3500.78	53.76	14,367.54	80.41	3,010.8	46.24	6,511.58	100	-11356.74	-174.41
Wetland	6,518.51	35.07	7,028.26	51.88	12,070.17	64.93	18,588.68	100	+5041.91	+27.12
Total	77,209.29	47.27	86,140.44	52.73	86,140.4	52.73	163,349.71	100	-	-

*LULC- Land use/Land cover



a. b. c.

Figure 3. Land use/land cover Map of Metropolitan Lagos 1986, 2000 and 2016
(Source: Author's image analysis, 2018)

Conversion Pattern of Cultivated Lands between 1986 and 2016

Although urban agriculture is a permanent element of the urban system, its locations within the city may vary over time. Field survey has revealed a form of lease agreement between private and institutional owners of vacant lands with organized farmers group allowing temporary use for longer periods. They may also provide alternative lands (often also on a temporary basis) when these sites are needed for other purposes before the lease ends. The Lagos State Water Corporation at Iju, the Broadcasting Organisation of Nigeria (BON) at Shogunle and Kay Farms at Obawole areas of Lagos state are good field examples of such dynamic urban farms (Awoniran, 2017).

Planning controls have been known to influence farm sizes through the encouragement of development in areas that were once used for farming. Where physical development has been slow and there is less enforcement of controls over development, farm sizes are not affected and agriculture prevails. This situation becomes reversed where development is fast and where controls upon it are strictly enforced. In such cases, sizes of farms tend to be drastically reduced (Nsangu and Redwood, 2009).

Further analysis of agricultural land use change as presented in table 6 and 7 indicated that between 1986 and 2000, 1115.33 ha (5.40%) of cultivated lands have reverted to water body, 5651.63 ha (27.36%) have been converted to built-up, 4,607.35 ha (22.31%) to open space, 3,094.16 ha (14.98%) to shrub, 1444.45 ha (6.99%) to light forest and 2569.22 ha (12.44 %) to wetland. So also between 2000 and 2016, 7.10 ha (0.05%) of cultivated lands had reverted to water body, 5856.03 ha (39.76%) have been converted to built-up, 1839.74 ha (12.49%) to open space, 746.07 ha (5.07%) to shrub, 788.23 ha (5.35%) to light forest and 1902.48 ha (12.92%) to wetland.

Table 6. Conversion Pattern of Cultivated Lands between 1986 and 2000
(Source: Author's image analysis, 2018)

Land use/Land cover classes of 2000 (ha)									
Land use/Land cover classes of 1986 (ha)	LULC	Waterbody	Built-up	Cultivation	Open space	Shrub	Light Forest	Wetland	TOTAL
	Waterbody	26,557.35 85.56%	1624.76 5.23%	388.14 1.25	1092.43 3.52	160.59 0.52%	21.31 0.07%	1196.48 3.85%	31,041.06 100
	Built up	3159.43 11.09%	14942.99 52.44%	1170.34 4.11%	6114.36 21.46%	705.24 2.48%	1217.53 4.27%	1185.36 4.16%	28,495.25 100
	Cultivation	1115.33 5.40%	5651.63 27.36%	2,172.24 10.52%	4607.35 22.31%	3094.16 14.98%	1444.45 6.99%	2569.22 12.44 %	20,654.40 100
	Open space	1754.34 6.64%	9367.87 35.48%	1209.67 4.58%	7,224.22 27.36%	2144.58 8.12%	1432.68 5.43%	3271.09 12.39%	26,404.54 100
	Shrubs	566.36 1.98%	4218.88 14.73%	6117.45 21.36%	1618.56 5.65%	9,780.19 34.15%	3416.31 11.93%	2919.61 10.19%	28,637.36 100
	Light forest	94.86 0.4%	2560.22 10.68%	3564.49 14.87%	912.72 3.81%	5738.42 23.94%	10261.99 42.81%	840.28 3.51%	23,972.98 100
	Wetland	1170.20 28.28%	414.96 10.03%	103.54 2.5%	534.83 12.92%	276.11 6.67%	73.34 1.77%	1,565.13 37.82%	4,138.09 100
	TOTAL	34,418.79	38,782.77	14,727.21	22,105.02	21,900.88	17,868.32	13,546.77	163343.68

*LULC- Land use/Land cover

Drescher (2003) argued that conversion of agricultural land to urban uses is a particular concern, as rapid growth and escalating land values threaten farming on prime soils. Existing farmland

conversion patterns often discourage farmers from adopting sustainable practices and a long-term perspective on the value of land. At the same time, the close proximity of newly developed residential areas to farms increases public demand for environmentally safe farming practices. Comprehensive new policies to protect prime soils and regulate development are needed. By helping farmers to adopt practices that reduce use of chemicals and conserve scarce resources, sustainable agriculture research and education can play a key role in building public support for agricultural land preservation.

Table 7. Conversion Pattern of Cultivated Lands between 2000 and 2016
(Source: Author's image analysis, 2018)

Land use/Land cover classes of 2000(ha)	Land use/Land cover classes of 2016 (ha)								
	LULC	Water body	Built-up	Cultivation	Open space	Shrub	Light Forest	Wetland	TOTAL
	Water body	27,081.22 78.68%	3056.29 8.88%	126.29 0.37%	1150.03 3.34%	143.73 0.42%	83.69 0.24%	2777.54 8.07%	34418.79 100
	Built up	431.82 1.11%	31,816.87 82.04%	1447.11 3.73%	4345.46 11.21%	381.04 0.98%	2.07 0.01%	358.38 0.92%	38,782.77 100
	Cultivation	7.10 0.05%	5856.03 39.76%	3,587.52 24.36%	1839.74 12.49%	746.07 5.07%	788.23 5.35%	1902.48 12.92%	14,727.18 100
	Open space	88.45 0.4%	18326.48 82.91%	317.58 1.44%	2,707.79 12.25%	278.56 1.26%	1.89 0.01%	384.27 1.74%	22,105.02 100
	Shrubs	19.77 0.09%	8696.50 39.71%	4077.59 18.62%	1351.92 6.17%	1,996.60 9.12%	1496.19 6.83%	4262.31 19.46%	21,900.88 100
	Light forest	2.25 0.01%	7356.08 41.17%	1723.69 9.65%	1164.32 6.52%	1736.01 9.72%	3500.78 19.59%	2385.18 13.35%	17,868.32 100
	Wetland	489.44 3.61%	3752.20 27.70%	644.77 4.76%	851.15 6.28%	651.96 4.81%	638.75 4.72	6,518.51 48.12%	13,546.77 100
	TOTAL	28120.05	78860.45	11924.55	13410.41	5933.97	6511.6	18588.67	163349.71

*LULC- Land use/Land cover

Implications of the Practice of Urban Agriculture for Urban Planning

Threatened Food Security

Sustained conversion of farmland to real estate development in Lagos Metropolis threatens the long-term viability of urban agriculture and by extension food security. Much of the present urban growth in the metropolis is occurring at the expense of urban farmland. As this pattern of growth is likely to continue the land available for urban agriculture in the metropolis may be drastically reduced. Sy et al., (2014) reporting from the city of Dakar, Senegal submited that the present condition of urban agriculture is the outcome of ambiguous land and urban planning policies on the part of authorities. Despite the enormous benefits for individuals and communities, urban agriculture is largely ignored in urban and regional planning (Lovell, 2010). Instead of considering opportunities to preserve farmland or to integrate new production functions into urban environments, agricultural landscapes are often considered by land use planners as areas for future development. Because planners and policy makers are not typically engaged in the production activities of agriculture, they often overlook problems and opportunities within the entire food system. As a result, we see a growing disconnect between urban residents and the agricultural landscapes that sustain them (Pothukuchi, 2004). A community dependent on food resources from distant locations is vulnerable to any unforeseen disasters (natural or otherwise) or disruptions at different levels of the food systems chain from production through processing and transport to distribution centers (Lovell, 2010).

Decreasing Access to Land by Urban Farmers

One of the greatest constraints to the widespread adoption of urban agriculture is the limited access to land for those who would like to grow food, and the lack of secure of tenure on that land, particularly where the production functions are competing with other uses (such as commercial development) that provide greater profit for the landowner (Redwood, 2009). For example, studies have revealed that many urban farms are established on vacant lots or other underutilized spaces, but without the direct permission or long-term commitment of the land owner or manager. Marginalized groups and minority populations are particularly vulnerable to the problem of land access and security, since they often do not have the means to purchase land (Redwood, 2009; Poor and Brule 2007). Thus urban agriculture as practiced in most cities of developing countries, remain a survivalist enterprise, undertaken by people unable to secure a regular wage employment or access to an

economic sector of their choice. Consequently, poverty and a desperate attempt to survive are the prime defining features of urban agriculture enterprise (Adeyinka et al., 2006).

CONCLUSION AND RECOMMENDATIONS

The results of this study has shown that the practice of urban agriculture cut across both male and female gender and is a spatial phenomenon that is prone to change. However, in view of the facts that the land available for urban farming is shrinking deliberate efforts should be made to attenuate this potential threat to food security and sustainable urban growth. This can be done by zoning designated agricultural areas along streams, roads or power lines (buffer zones). This would be a milestone towards official support and more sustainability of this interesting farming system.

Urban agriculture provides an important research opportunity in assessing the suitability of urban land for agricultural functions, based on factors such as soil type, solar access, and proximities to necessary markets and resources. Spatial analysis in Geographic Information Systems (GIS), which has been used to map green infrastructure and extend green networks could offer useful applications for assessing and expanding urban agriculture. Asset mapping, which is a multi-stakeholder process for action planning and policy design, can be used to describe the physical characteristics of a study site using GIS data including land use land cover Using the results of suitability analysis, land use inventories can be developed to map the suitable land to help increase institutional awareness and political support for urban agriculture.

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COCOA PRODUCTION PATTERN IN NIGERIA: THE MISSING LINK IN REGIONAL AGRO-ECONOMIC DEVELOPMENT

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Abstract: Pre-independent in Nigeria, cocoa was one of the main source of revenue but lost its glory to the discovery, exploration and exploitation of crude oil, especially from the 70s onwards. Despite the rapid growth in its production and positive impact in the nation's economy, cocoa production has been witnessing drastic reduction when compared with percentage of population involving in agriculture since the discovery of crude oil in commercial quantity in Nigeria. This paper reviews the trend pattern of cocoa production and its place in Nigerian economy from pre-1970 up to 2012. It was discovered that most of the cocoa plantations were old and majority of proposed cocoa processing factories were not functioning. The study recommends equilibrium practice of cocoa production and internal processing, establishment of cocoa processing factories through public-private partnership in cocoa producing states.

Key words: Cocoa, export, production, processing, trend

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INTRODUCTION

Cocoa is produced by comparatively few countries; all of them tropical, but the product is processed and consumed mainly in temperate countries (Asiedu, 1989). Eclipsed these days by oil as the country's major export, Nigeria still produces 300-350 metric tons of cocoa a year, most destined for consumption abroad – the country exports about 96% of its cocoa crop. Cocoa (Theobroma cacao) is a major economic tree crop in Nigeria because it provides jobs and income to the farmers, raw materials for industries and foreign exchange for the country. Between 1950 and 1960, cocoa was the highest source of foreign exchange in the country. The discovery of oil in 1970, coupled with other socio-economic factors led to the relegation of cocoa to the second position in terms of foreign exchange earnings for the country. Since then, the oil sector has been at the centre of the Nigerian economy with attendant poverty, unemployment and a weak industrial base.

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Nigeria is the fourth-largest producer of cocoa beans in the world behind Côte d'Ivoire, Ghana and Indonesia. After petroleum, cocoa is the country's most important agricultural export product. Fourteen of Nigeria's 36 states grow cocoa of which more than 80% are from southwest geopolitical zone. Inability of the Nigerian farmers to produce cocoa like Ghana and Côte d'Ivoire are attributed mainly to loss of soil fertility, world price fluctuation, aging plantation, and negligence of agriculture in favour of crude oil by government. Since 70s, crude oil has remained the highest source of foreign exchange earnings while cocoa, a versatile, renewable and sustainable source of revenue is yet to reclaim its lost glory. Also, cocoa production in Nigeria is retarded by declining productivity of the existing old cocoa trees. Cocoa production in Nigeria is undertaken mostly by poor, small scale and low technical farmers that neither use fertilizer nor manure for soil fertility improvement. These farmers therefore face difficulties in setting up new cocoa farms and rehabilitation of old ones. This paper aims at examine cocoa production trend within the period of twenty (25) and factors militating against the production fluctuation over the years.

COCOA PRODUCTION AND NIGERIA ECONOMY

In the 1960s, the agricultural sector was the most important in terms of contributions to domestic production, employment and foreign exchange earnings. The situation remained almost the same three decades later with the exception that it is no longer the principal foreign exchange earners, a role now being played by oil. Before the discovery of crude oil in Nigeria, major agricultural products such as palm oil, rubber and cocoa (from the South, West and East); groundnut and cotton (from the North) played prominent roles in the growth, development and stability of the nation's economy. Even, Nigeria was once the second leading producer of cocoa in West Africa and palm oil globally. During this period, cocoa ranked the first Nigeria foreign exchange commodity. The issue of unemployment is the product born out of the negligence of the agricultural sector for crude oil exploration and exploitation. In pre-1960s, agriculture was the most important sector of the economy, and accounted for more than 50% of GDP and 75% of export earnings. Consequently, with the rapid expansion of the petroleum industry, agricultural development was neglected, and the sector entered a relative decline (Akinwumi, 2013).

Declined agricultural productivity due to oil discovery in Nigeria has drastically reduced the volume of agricultural products and revenue from cash crops over the years. Nigeria's dependence on oil is a disaster to the country's economic growth due to the negligence of non-oil products such as cocoa, cassava, palm oil, among others, that made Nigeria great in the first Republic (Akinwumi, 2013). Thus, between the mid-sixties and the mid-eighties, Nigeria moved from a position of self-sufficiency in basic foodstuffs to one of heavy dependence on imports. Under-investment, a steady drift away from the rural to urban areas, increased consumer preferences for imported foodstuffs (particularly rice and wheat) and outdated farming techniques have kept the level of food production well behind the rate of population growth.

Of non-oil exports, cocoa has been dominant. It accounted for over 50% of the total export in 1970s, and over 60% in 1980. However, since the 1970s, its share steadily declined from 49% in 1989 to 22% in 1998 (Aigbokhan, 2001). Cocoa was the most important agricultural export crop during 1960-1970, contributing significantly to foreign exchange earning of the country. According to Osuntogun et al., (2007), prior to the 1970s, the policy of government towards agricultural development in general and to cocoa production in particular in Nigeria was one of minimum government interventions. The production increased gradually to 308, 000 metric tonnes in 1970/71. The Structural Adjustment Programme (SAP) policy period introduced liberalization which resulted in improved cocoa pricing at the farm gate and increased output in the short run. Also, Osuntogun et al., (2007) attributed the consistency in economic down turn and decline aggregate cocoa output in Nigeria to the introduction of SAP programme in 1986. In addition, Awe (2013) blames the reduction in cocoa production on military intervention in Nigeria politics in 1986. This negatively affects the cooperatives which

virtually collapsed after the abolition of the commodity boards. By 1999, the production level had declined to 170,000 metric tonnes.

In terms of export earning according to Aigbokhan (2001), agricultural export accounted for 81% of total export in 1955-59, 80% in 1960-64 and 57% in 1965-69. In terms of contribution to GDP, agriculture was the leading sector in the 1950s and 1960s, agricultural output accounted for 63 percent of GDP, and in 1965-69 for 54 percent (Aigbokhan, 2001). In 1970-74, it declined to 33 percent, a period which marked the watershed in Nigeria's economic history through the 1973/74 crude oil price shocks. However, from 1970, the decline became very dramatic and this coincided with the prominence of crude oil as the country's main export commodity. In 1970-74, agriculture accounted for 26% of the total exports, thereafter it accounted for less than 10%, being 5.7% in 1975-79, 2.7 and 5.6% in 1980-84 respectively. In 1990-93, it's nose-dived to its lowest at 1.8%, before some recovery in 1994-98 (Aigbokhan, 2001). International Cocoa Organization (2010) reported that, of the global production, Africa production of cocoa beans has declined from 71.8% in 2007/2008 to 68% in 2009/2010 while Americas, Asia and Oceania have increased from 12.5% and 15.8% to 14.4% and 17.5% respectively. The maximum values of cocoa beans exported from Nigeria increased over the period covered from $309,781,000 in pre-1970 to $503,666,000 in 2000-2009 (FAO, 2011). Though, production and exportation might varied and fluctuated over the years but exchange earning ($) increased (table 1). Also, the ministry of trade and industry reported that Nigeria made 1.3billion from cocoa export (Agribusiness, 2017).

Table 1. Cocoa Beans Net Production Value (1970-2009)
Source: Food and Agricultural Organization (2011)

Year	Value	Change (%)
Pre-1970	$309,781,000	
1979-1983	$161,744,000	-47.78
1984-1999	$259,608,560	37.69
2000-2009	$503,666,000	48.45

Despite the absolute paradigm shift by the government from agriculture into the crude oil, cocoa still remain the second foreign exchange earning in Nigeria. In Nigeria, cocoa is a major export crop with revenue of at least 34 billion derived annually from the export of cocoa beans alone, besides revenue from cocoa by-products like butter, cake, liquor and powder (Akinwale, 2006; Ibiremo et al., 2011).

HISTORY OF COCOA PRODUCTION IN NIGERIA

Since its discovery in the 18th century at the Amazon basin, cocoa cultivation has spread to other tropical areas of south and central, and indeed West Africa, which became the major producer from the mid-1960s (Opeke, 1978). According to Eduardo and Philippe (2013), dominance in world cocoa production shifted from America to Africa in the second half of the nineteenth century and remains so to date. Cocoa was introduced to West Africa from Brazil (South America) precisely from Fernando Po into Nigeria in 1874 and Ghana in 1879 by one Squiss Bamengo, a chief of the Niger Delta (Adegeye, 1996). West Africa has been the centre of cocoa cultivation for many decades, as two-thirds of the world's cocoa is produced in West Africa (Hartemink, 2005). West Africa is a major producer accounting of approximately 70% of global production which fluctuates annually with climatic variations (Abayomi, 2017). Currently, according to International Cocoa Organization (2012) the main producers of cocoa are Cote D'Ivoire, Ghana, Indonesia and Nigeria. Nigeria remains the third largest producer of cocoa and sixth globally. Before the emergence of black gold (crude oil) in Nigeria, cocoa was the major leading cash and export crop in Nigeria especially in southern part of Nigeria. Cocoa was first planted in the Delta region and then spread northward to its suitable cocoa belt of

Western Nigeria. Cocoa was first planted in the Western Region in 1890 (Oyekale et al., 2009). It rapidly gained prominence in Nigeria to the extent that Nigeria happened to be the second largest producer globally by 1965. Before the emergence of black gold (crude oil) in Nigeria, cocoa was the major leading cash and export crop especially in the southern part of Nigeria. Nearly all Southwest States in Nigeria except Lagos involve in cocoa production. The top growing States Ondo, Ogun, Osun Oyo and Ekiti account for about 60% of the cocoa production and make up at least 30% of the total cocoa export in Nigeria. Others are Cross River, Edo, Abia, Kwara, Kogi, Adamawa, and Akwa Ibom. But Nigerian Bureau of Statistic (2013) identified eighteen cocoa producing States in Nigeria. Therefore in addition to the aforementioned State, others are Taraba, Delta, Lagos, Bayelsa, River and Imo States (table 2).

Table 2. Estimated Area (000) and Production (000 mt) of cocoa in Nigeria
Source: National Bureau of Statistics, 2013

		2011/12		2010/11	
S/N	State	Area	Production	Area	Production
1	Ondo	321.97	92.22	320.19	91.99
2	Cross River	327.91	69.42	310.99	71.45
3	Osun	251.3	74.1	237.06	71.1
4	Ekiti	98.15	36.46	97.07	37.97
5	Oyo	109.03	36.06	107.75	33.57
6	Edo	104.77	23.68	105.28	27.36
7	Ogun	92.76	19.9	89.84	19.88
8	Taraba	10.53	4.89	9.78	4.32
9	Delta	11.52	3.93	10.69	3.81
10	Abia	14.49	3.34	13.46	3.3
11	Akwa-Ibom	5.35	1.25	6.82	2.25
12	Adamawa	5.34	1.65	5.33	1.66
13	Kwara	5.14	1.43	4.77	1.41
14	Kogi	3.84	1.06	3.56	1.05
15	Lagos	0.97	0.2	0.9	0.2
16	Bayelsa	0.32	0.09	0.3	0.09
17	Rivers	0.18	0.3	0.16	0.05
18	Imo	0.04	0.01	0.04	0.01
	National	1,363.60	370.01	1,324.00	371.47

Table 2 show that cocoa is cultivated in 18 States on a total land area of 1,363.60 hectares in Nigeria. Cross River State cultivated the largest land area with 327.91 hectares followed by Ondo State with 321.97 hectares. The least cultivated land areas were 0.04 and 0.18 hectares by Imo and Rivers State respectively. The total production by the 18 States were 370.01 metric tonnes, with Ondo State contributing the highest with 92.22 metric tonnes, equivalent to 25% of the total production followed by Osun State with 74.10 metric tonnes per annum. The least production was 0.01 metric tonnes by Imo State. Adegeye (1996) states that over 50% of the total quantity of cocoa produced for export or utilized locally per annum are from Ondo State. Even within Ondo State, cocoa production is not equally produced among the existing district (North, Central and South). In Ondo State, Idanre, Ondo West and Akure South Local Governments are leading producers from 2005-2007.

Soils in South-Western Nigeria had been classified according to their suitability for cocoa into four categories, namely: good cocoa soils, fairly good cocoa soils, poor cocoa soils and very poor cocoa soils (Ibiremo et al., 2010). A previous survey of cocoa soils of Southwest Nigeria also indicated that 62% cocoa in the area was planted on good and fairly good soils while 38% of the cocoa were planted on poor and very poor soils categories. Cocoa production is geographically restricted mainly to the southern, western and eastern parts of the

country (figure 1). All South Western States in Nigeria except Lagos involved in cocoa production in commercial quantity. Other cocoa producing states in Nigeria apart from southwestern states are, Cross River, Edo, Delta, Taraba, Abia, Kwara, Kogi, Adamawa, and Akwa Ibom States. In Ondo State which is the major producer, production varies. Idanre, Ondo West and Akure South Local Governments are the leading producers of cocoa over the years. According to National Cocoa Survey (2005), Ondo State ranked first among the fourteen cocoa producing States in Nigeria (Aikpokpodion, 2010). Over 50% of the total quantity of cocoa produced for export or utilized locally per annum always comes from Ondo State (Ajayi et al., 2010). About four major tree crops (cocoa, rubber, palm tree and cashew) produced in Ondo State, cocoa alone accounts for 80.69% with annual increases of 6.44% over twelve years (2000-2011) of observation (Afolayan and Ajibade, 2012).

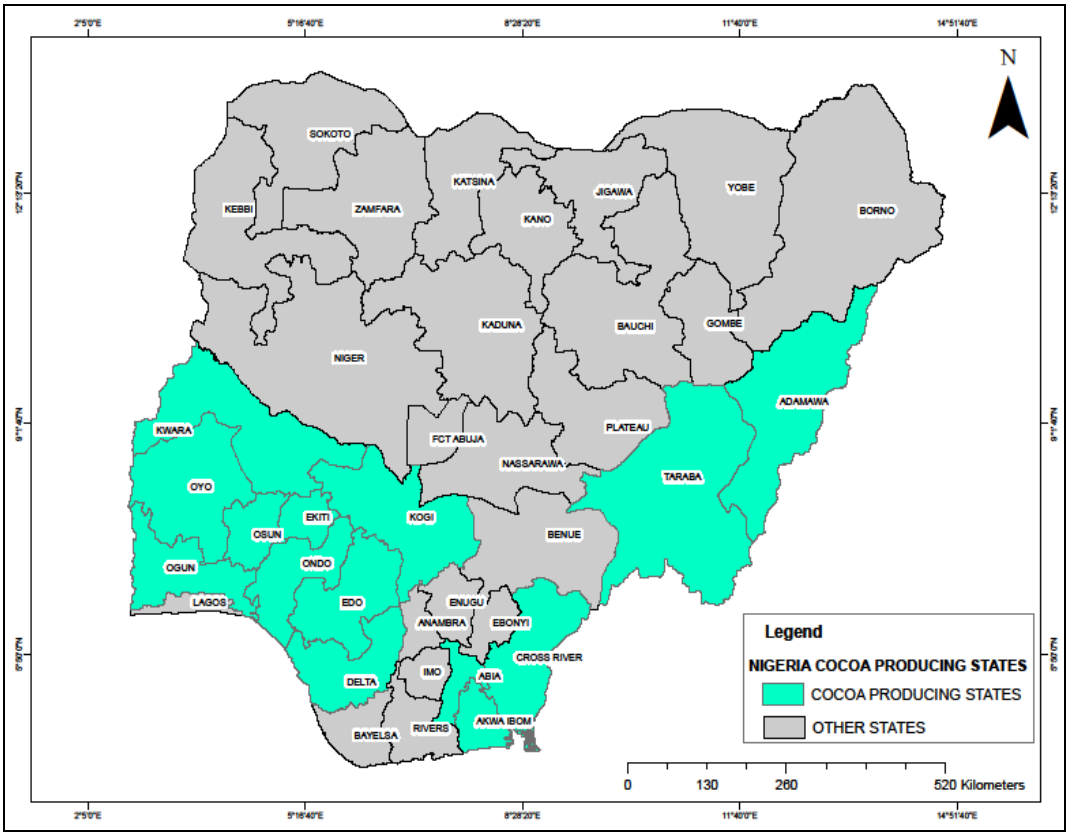

Figure 1. Cocoa Producing States in Nigeria
Source: NCDC (2010) and Afolayan (2016)

Observation on cocoa production data from table 3 calls for serious attention. In summary, it indicates that a remarkable change above 50% of cocoa production occurred from 1971 to 2010. Also in 1988, cocoa output increased from 100,000 metric tonnes in 1986 to 230,000 tonnes, 203, 000 tonnes to 323,000 tonnes from1994 to 1995 and 225,000 tonnes (1999) to 338,000 tonnes (2000). The percentage for the three years was approximately 130%, 59.1% and 50.2% positive change above the previous years (figure 1). The situation of cocoa production and exportation in Nigeria is calling for attention due to the increase in the rate of importation. Production and exportation pattern were decreased at the same rate from 1970–1980.

Table 3. Cocoa Production and Exportation in Nigeria
Source: Modified from NBS (2013), Taiwo et al. (2016), www.statista.com (2019)

Production and Export in Tonnes				Production and Export in Tonnes		
Year	Output	Export		Year	Output	Export
1970	305,000	302,000		1994	203,000	147,897
1971	257,000	254,000		1995	323,000	138,981
1972	241,000	241,000		1996	325,000	182,065
1973	215,000	212,000		1997	318,000	147,075
1974	214,000	212,000		1998	370,000	135,041
1975	216,000	215,000		1999	225,000	208,617
1976	181,000	179,000		2000	338,000	144,821
1977	193,000	192,000		2001	340,000	184,122
1978	157,000	152,000		2002	362,000	191,992
1979	151,000	150,000		2003	385,000	385,000
1980	153,000	150,788		2004	412,000	412,000
1981	174,000	213,551		2005	441,000	441,000
1982	156,000	154,577		2006	485,000	485,000
1983	140,000	228,220		2007	500,000	500,000
1984	140,000	151,183		2008	502,000	502,000
1985	160,000	116,161		2009	513,000	513,000
1986	148,000	174,600		2010	525,000	525,000
1987	100,000	117,070		2011	370,010	N/A
1988	230,000	220,322		2012	371,470	N/A
1989	256,000	148,982		2013	238,000	N/A
1990	244,000	153,520		2014	248,000	N/A
1991	268,000	160,395		2015	200,000	N/A
1992	292,000	110,749		2016	230,000	N/A
1993	306,000	160,420		2017	240,000	N/A

Table 3 shows that from 2003 to 2010, 100% of the nation cocoa output ended up in the foreign country. This implies that cocoa production in Nigeria servicing the processing and other companies in developed countries at the detriment of Nigeria economy. This laid the foundation for the unemployment in Nigeria and setback in agro-economy sector. A living example is Multi-trex Integrated Food Plc. in Ogun State, Nigeria. Today, most of the processing industries are folding-up like Multi-trex while existing ones are not functioning and new ones are not coming on board due to government policies on agricultural products and trade agreement with foreign countries. Declining in cocoa production pattern may be attributed to the absence of cocoa processing industries while the wide gap between 1980-1989 could be the impact of the local cocoa processing industries establishment like Cocoa Industries Limited, Ikeja, Lagos, Cocoa Products (Ile-Oluji) Limited and Stanmark Cocoa Processing Co. Ltd., Ondo State, Multi Trex Integrated Food Plc., Ogun States and others (figure 2).

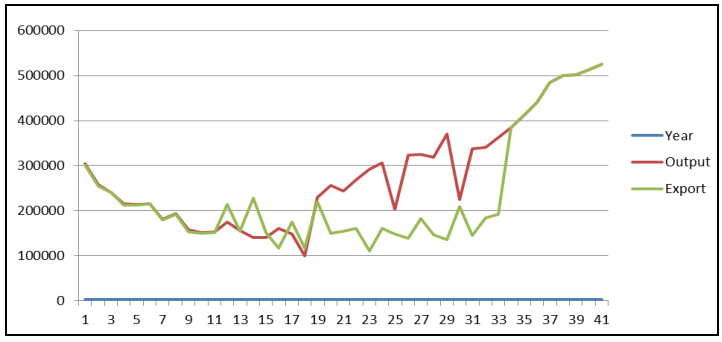

Figure 2. Cocoa Production Trend Pattern in Nigeria
Source: Author's Analysis (2018)

Impart of research institutes such as Cocoa Research Institute of Nigeria, Ibadan established in 1964 as well as the output of the introduced hybrid cocoa species reflects on annual production from 1988 onward.

MISSING LINK IN NIGERIA LOCAL COCOA PROCESSING INDUSTRIES

Varying opinions are put forward for the problems militating against the rapid drop in the quantity of cash crop production in Nigeria. Economy survival of Africa countries, particularly Nigeria had been on cash crop production dated pre-colonial era till the first decade after independence. Agriculture used to be the mainstay of Nigerian economy, providing 65% of Gross Domestic Product (GDP) in the 1960s (Kayode, 2010). But according to Oduwole (2001), its contribution has dropped in recent times to about 26%. Problems militating against cocoa production in Nigeria are climate change, aging of plantation, soil nutrient degradation (natural) and negligence of agricultural sector in favour of oil exploitation, internal and external price fluctuation, and excess exportation due to shortage of cocoa processing factories in Nigeria (human). Apart from these, production and marketing of cocoa has witnessed series of difficulties since 1970s. The price of agricultural products in developing countries is not always stable. Even the government of the country does not has capacity to determine price because of weakness in the area of insufficient local processing industries, absence of cocoa boards, government policy on agricultural products, bi-lateral agreement with the foreign nations and other. Apart from the external factors, cocoa price differs seasonally among the cocoa producing states in Nigeria.

According to Afolayan and Ajibade (2012), Nigeria exports about 86% of raw cocoa bean into the countries of the north on annual basis due to incapability of the available factories to meet up with the global demand. Similarly, Proshare Economy (2017) emphasized that in Nigeria; about 80% cocoa produced is exported as cocoa beans while the other 20% is processed into powder, butter, cake and liquor before being exported. Nigeria is yet to fully capitalize on cocoa production, as most of the beans are sold unprocessed. The study also identified eight cocoa processing factories in Nigeria with combined installed capacity of 150,000 metric tons but only four of them are functional with a combined total volume of 50,000 metric tons per annum. Shortage of cocoa processing factories also added to the problem of cocoa production and marketing in Nigeria. According to experts' statistics, presently, there are about 17 cocoa processing companies in Nigeria; only 9 are functional (Akinfolarin et al., 2012). The rest have either not been completed, closed down or did not come on board at all. Functional cocoa processing factories in Ondo State, the leading producer of cocoa in Nigeria process about 63,000 metric tonnes annually. The newly resuscitated Osun State Cocoa Processing Industry in Ede, Osun State, Nigeria was inaugurated on October 17, 1982, had stopped production in 2001 due to obsolete equipment and management issues (This Day, 2017).

Table 4. Nigeria Cocoa Processing Industrial Capacity
Source: Author Data Analysis (2018)

S/N	Industry	Location	Year	Capacity
1	Cocoa Products Ltd	Ile-Oluji, Ondo State	1984	30,000
2	Cooperative Cocoa Products Ltd	Akure, Ondo State	1992	18,000
3	Stanmark Cocoa Processing Company Ltd	Ondo, Ondo State	1992	15,000
4	Cocoa Industries Ltd	Ikeja, Lagos State	1964	30,000
5	Multi-Trex Ltd	Warawa, Ogun State	2006	12,000
6	Osun State Cocoa Processing Industry	Ede, Osun State	1982	n.a
7	FTN Cocoa Processor Plc	Ibadan, Oyo State	1991	n.a
8	Cadbury Nigeria Plc Cocoa Processing	Akure, Ondo State		
				105,000

Summary of local cocoa processing capacity in Nigeria is approximately 105,000 metric tonnes while the annual production above 370,000 metric tonnes (table 2). In 2011 and 2012, Nigeria production of cocoa in amounts to 370,000/371,000 metric tonnes respectively (Afolayan, 2016). Reports on annual production of cocoa for Nigeria are conflicting. Annual cocoa yields for Nigeria are generally estimated at an average of between 300 to 350,000 metric tons. With regards to their processing capacity Stanmack Cocoa Processing Company Limited, Ondo (15,000), Cocoa Product, Ile-Oluji (30,000) and Cooperative Cocoa Products Ltd, Akure (10,000) (table 4). Effective and efficient functioning of the aforementioned factories would definitely generate thousands of employment either directly or indirectly via multiplier effect. The erstwhile foremost cocoa factory in Nigeria rated as the first in Africa-Cocoa Industries Limited; Ikeja had about 19,000 workers when it was at the peak of production. The processing companies also have many challenges such as irregular power supply, high cost of cocoa bean, inefficient, inadequate working capital as well as obstructive government policies.

CONCLUSIONS

The trend pattern of cocoa production and exportation in Nigeria has been fluctuating since 1970 while generated revenue has been increasing. Exportation is geometrically increasing while local processing is gradually dwindling; the basis for more attention on local processing industries as agro-economy instrument of regional development. To drastically diversify the country economy from mono-economy, the country policies on export agricultural produces needs to be reviewed in favour of local processing. That is equilibrium on cocoa production, internal processing and exportation of semi-finished or finished product should be the main focus of the country rather than absolute concentration on the rate of production alone. Emphases should be laid on the local processing industries in all cocoa producing State across the countries through Public Private Partnership in order to strengthen the stability of the industries rather than one man business. Also, the processes for the revitalization of the liquidated Cocoa Board need to be reviewed. The study also recommends the use of cocoa production as a mean of regional economic development because of its multiplier effect in anticipation of unemployment rate reduction and nation gross domestic product improvement.

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DETERMINANTS OF THE ADOPTION OF FARM MANAGEMENT PRACTICES FOR SUSTAINABLE CROP PRODUCTION AMONG FARMERS IN SOUTHERN PART OF KADUNA STATE, NIGERIA

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Abstract: This study examines the determinants of farmers' adoption of farm management practices (FMPs) that enhances sustainable crop production and ultimately facilitates food security in Southern Kaduna, Nigeria. A total of 1137 registered members of Fertilizer Farmers Association (FFA) during the 2016/2017 farming season were identified in which 286 farmers were purposively sampled for the study. Data were elicited through questionnaire administration. Descriptive statistics and logit regression were adopted in the analyses of the data. The results of the study showed that crop rotations, mixed cropping, use of inorganic/organic fertilizer, traditional tillage system, and minimum tillage/mulching were the common FMPs used by farmers. However, intermittent fallow system and surface irrigation practice were not popular because of poor infrastructural facilities. Similarly, the most common FMPs adopted in Katugal was minimum tillage/mulching, surface irrigation system in Madakiya, mixed cropping was very common in Mailafiya and Zankam, while intermittent short fallow in Kurmin Sara. Age, family size, land tenure, farm size and distance of plot from homestead had influenced significantly on the choice of FMPs. Also, the major determinants of farmers' adoption for FMPs were farming experience (75.9%) and soil fertility status of the farmlands (68.9%). The study therefore, recommends the revitalization of abandoned irrigation infrastructures in Kagoro and Madakiya, and improves the popularity of traditional tillage and soil mulching among the Southern Kaduna farmers to achieve sustainable crop production and food security.

Key words: land, management practices, food security, sustainability, agro-ecological zone

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INTRODUCTION

Pressure on land resources and demand for food throughout the world has resulted for increase of agricultural land use and intensive agricultural purposes. In Nigeria, there is fast growing human population as well demanding the natural resources couple with agricultural activities. Geissen et al. (2009) observed that intensive land use may cause an important change in soil characteristics that can affect fertility, increase erosion and compaction as well as food security. Similarly under this circumstance, significant soil deterioration and depletion of soil nutrient fertility can lead to reduction in land productivity. However, Ersado et al. (2004) observed that adoption of technical efficiency and productive farming practices can enhance agricultural productivity and improve environmental sustainability that remains the most practical agricultural option for achieving economic growth, food security, and poverty alleviation in Sub-Saharan African Countries. Thus, Terr Africa Partnership (TAP, 2006) explain clearly that farm management practices is the adoption of land use systems that enable land users to maximize the economic and social benefits of the land, while at the same time maintaining or enhancing the ecological functions of the land resources for support of the continued use of the land resources.

Land sustainability is very vital to farmers' means of sustenance that any constraint to land use is affecting subsistence farmers in many ways as observed by Adekoya (1997) cited in Raufu and Adetunji (2012) that subsistent farmers are faced with a lot of constraints for integrating different farm management practices as well, this has affected the sustainability of crop yields. Kong (2014) and Global Environmental Facility (GEF, 2016) however, attributed these constraint to many factors which include insufficient capital, poverty, lack of knowledge or confidence to make a change, lack of financial incentives, land tenure dichotomy, labour constraint and poor infrastructures, low educational level of farmers, limited knowledge of inputs, poor fertility status of soil and unsustainability of some practices. The understanding of these constraints farmers' can use sustainable management practices that would boost farmers' morale to involve in applying different farm management practices in areas of inadequacy that need improvement in order to sustain crop productions.

Furthermore, in a bid to sustain crop production and improve soil fertility status in Nigeria, farming communities adopts different farm management practices such as conventional and conservation tillage system, organic fertilization, inorganic fertilizer application, irrigation agriculture, mono-cropping, mixed cropping and crop rotation among others. Some of these farm management practices may produce high yield while some may instead lead to degradation and depletion of soil nutrient fertility of the agricultural lands. Lal (2015) stressed that adoption of appropriate site-specific techniques, restoring soil quality, conservation agriculture, integrated nutrient management, and continuous vegetative cover such as residue mulch, cover cropping and controlled grazing at appropriate stocking rates among others improve high crop yields and sustains the soil fertility status.

Thus, to achieve sustainable crop production and future food security in Southern Kaduna in particular, a good knowledge of farmers' participation and adoption of different farm management practices is necessary. Therefore, this study examines determinants of farmers adoption of farm management practices in Southern Kaduna located in the vicinity of Nigerian Guinea Savannah Agro-ecological Zone with a view to establish the factors influencing the farmers choice of different farm management practices that facilitate sustainable crop production in the study area.

THE STUDY AREA

Southern Kaduna lies within the Guinea Savanna Agro-ecological Zone of Nigeria, covering approximately 24,536 km² and lies between latitudes 9°00'00''and 10°45'00''North of the Equator and longitudes 7°l0'00''and 8°45'00'' East of the Greenwich Meridian. The study area shares boundaries with Niger State in the West, Federal Capital Territory (FCT) and Plateau State to the South and South-East, Bauchi States in the East and Kano in the North (figure 1).

The climate of the study area is classified as Koppen's Aw with two distinct seasons, a wet season and a dry season. Rainfall occurs between the months of April and October with a peak in August, while the dry season extends from the end of October of one calendar year to April of the next. The mean annual rainfall is about 1733 mm in Kafanchan-Kagoro areas in the Southern part of the study area (Abaje et al., 2010) this is due to the influence of the Jos Plateau with orographic effect. The rainfall in the central part of Kaduna reached about 1203 mm. The mean monthly temperature is 28 ºC, while the mean relative humidity is about 63% (Abaje et al., 2016).

The vegetation of the study area is the Guinea Savanna type influencing the formation organic matter of the main type of soil known as Ferruginous tropical soil. According to Abaje et al. (2010) the soil is affected by the climate, vegetation, lithology and the topography of the area. The soils are well drained and shallow, with texture consisting of loamy sand to sandy loam top soils (0-20 cm) and supports wide variety of annual, perennial and tree crops respectively (Aregheore, 2005). The relief according to Abaje et al. (2009) is relatively flat and undulating influences the formation of the drainage pattern of the study area.

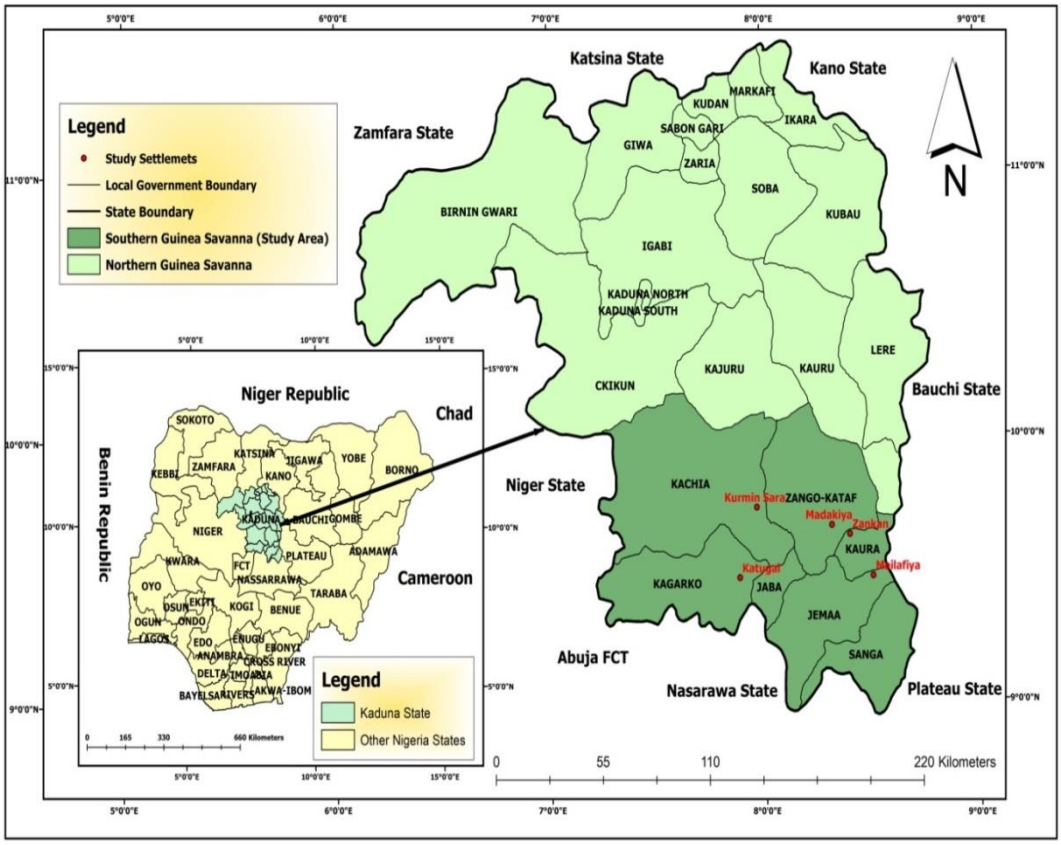

Figure 1. Location of the study Area
(Source: Ministry of Land Survey Kaduna State, 2017)

MATERIALS AND METHODS

Data Required and Sampling Techniques

The data required for this paper include: demographic characteristics of the farmers, land tenure (ownership of farm plot), types of crop grown, distance of farm plot from farmers' houses, factors influencing farmers' choice of farm management practice.

Purposive sampling technique was used to select five local government areas (LGAs) (Kaura, Kagarko, Kachia, Zango Kata and Jema'a) from the seven LGAs of Southern Kaduna. The same sampling technique was used to pick five villages from each LGAs identified located in Guinea Savanna Agro-ecological Zone. Using Cohen et al. (2011) table of sample size determination, at 95% confidence level, 286 sample size was decided and picked from 1137 registered members cultivated lands in 2016/2017 cropping season. The total number of respondents was selected in each settlement as follows: Zankam (55), Katugal (60), Madakiya (35), Mailafiya (70) and Kurmin Sara (61).

Copies of structured questionnaire were administered to 286 registered farmers' selected using table of random numbers in the five sampled villages, then 281 copies of the questionnaire were completed correctly and found useful for the research analysis.

Analytical Technique

The data collected were subjected to descriptive method and inferential statistical technique that included percentage and logit regression analysis and presented in bar graph.

RESULTS AND DISCUSSION

Farmers' Adoption of the Common FMPs for the Sustainability of Crop Production

The result of multiple responses on the different farm management practices commonly used by farmers in Southern Kaduna is presented in table 1.

Table 1. Multiple Response on all Adoptable Farm Management Practices
Source: Field Survey, 2017

S/No.	Farm management practices	Responses	
		Frequency	Percentage
1	Intermittent long fallow	20	1.3
2	Intermittent short fallow	64	4.1
3	Minimum tillage/mulching	156	10.1
4	Zero tillage	40	2.6
5	Conventional tillage	210	13.5
6	Contour bund	9	.6
7	Construction of ridges across the slope	79	5.1
8	Organic farming (animal manure)	169	10.9
9	Use of inorganic fertilizer	227	14.6
10	Organic Compost	61	3.9
11	Mixed cropping	235	15.1
12	Crop Rotation	252	16.2
13	Surface irrigation	30	1.9
14	Total [mr]	1552	100.0

mr = Multiple Responses

The use of farm management practices varied in proportion with 13.5% farmers engaged in the conventional tillage and 12.7% engaged in minimum tillage/mulching and zero tillage. The result also revealed that 14.6% of the respondents used inorganic fertilizer only as soil conditioner while 10.9% of them engaged in the used of organic farming (use of animal dung) and in most cases farmers mixed with inorganic fertilizer for those farmers who could afford the two soil conditioners. Crop rotation (16.2%) and mixed cropping (15.1%) were also the predominant farming practices. The used of organic compost (3.9%) was not common in the rural communities. Due to the high growth in population and the subsequent pressure on agricultural lands, only 5.4%

of farmers practiced intermittent short fallow in rural communities with more than enough farmlands to cultivate. Irrigation agriculture was not too commonly practice, about 1.9% of the respondents only engaged in surface irrigation using the available water channels, water locked and marshy areas. The result is agreed with Oriola (2009) assertion that shows the unreliable supply and distribution of irrigation water leaves many farmers dissatisfied and unwilling to participate in irrigation practice. This also conform to Junge et al. (2008) observation that has widespread acknowledgement with low usage of irrigation because some of the farming system practices declined and degraded soil and water quality (table 1).

Furthermore, the five bolded farm management practices shown in Table 1 indicated the focus areas of this research and cumulatively formed 42.1% of the adoptive farm management practices. The study has also revealed that, crop rotation, conventional tillage, the use of inorganic fertilizer were also the common management practices adopted in the study area and constituted 44.3% cumulatively, this was greater than 42.1% of the focus area used for this study and subsequently the analyses were based on these selected land management practices vis-à-vis the other variables of interest.

Adoption Rate of Farm Management Practices among the Study Settlements

Figure 2 shows the farm management practices adoption among the five sampled settlements. The result revealed that mixed cropping (22.6%) was the most common farm management practices adopted in Zankam settlement. Then followed by surface irrigation practice cited by 13.3% of the respondents. The least practice was intermittent short fallow and minimum tillage/mulching. In Katugal, minimum tillage/mulching (30.8%) was the most farm management practice adopted and the least was mixed cropping (17.9%). In Madakiya farm settlement, surface irrigation was the major practice (46.7%) and intermittent short fallow practice (9.4%) is the least form of management practice. In Mailafiya, farmers practice mixed cropping (27.2%) more and the least practice was minimum tillage/mulching (19.2%). The result also reveals that farmers in Kurmin Sara settlement adopted intermittent short fallow (42.2%) followed by minimum tillage/mulching (34.26%), whereas, none of the farmers in this settlement adopted surface irrigation system as a form of farm management practice.

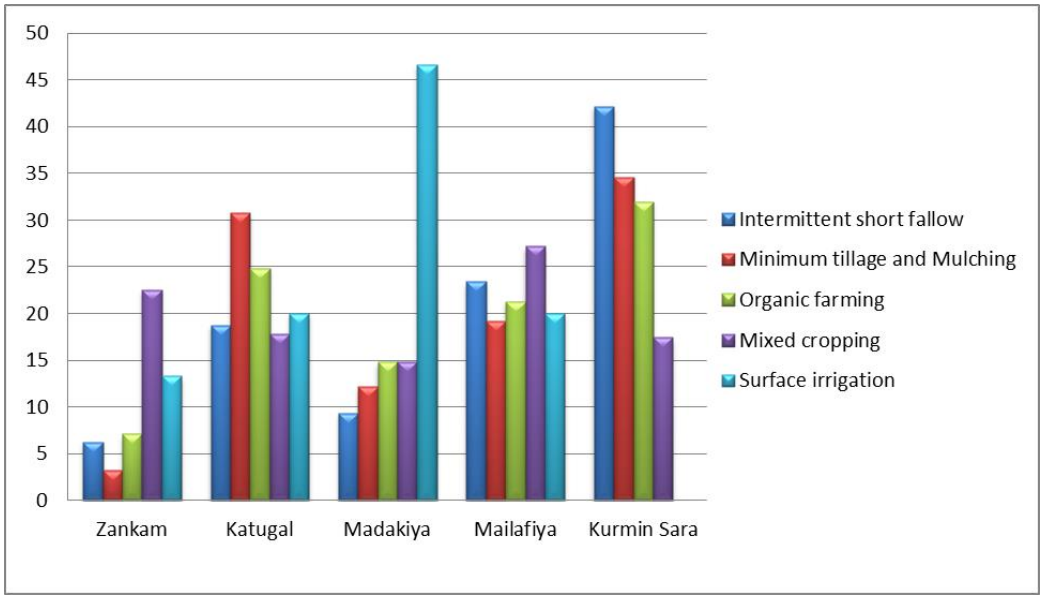

Figure 2. Farm Practices Adoption among the Study Settlements
(Source: Field Analysis 2017)

Generally, the results reveal that, there was no uniform adoption of the farm management practices in all the five sampled settlements. However, while minimum tillage/mulching (32%) was being the largest adopted farm management practices in Katugal sampled settlement, surface irrigation system in Madakiya (35.35%), mixed cropping in Mailafiya (42.38%) and Zankam (67.95), then intermittent short fallow (30.68%) in Kurmin Sara were the most popularly adopted farm management practices. Babalola and Olayemi (2013) reported similar study that revealed high adoption of mixed cropping and minimum tillage/mulching in Ogun State, Nigeria. The high adoption rate of these practices were attributed to simplicity, moderate cost and effective stabilization of soil fertility.

Demographic / Socio-Economic Attributes and Farm Structural Factors Influencing the Adoption of Farm Management Practices in the Sampled Settlements

Logit regression model was used to examine the influence of attributes for demographic / socio-economic characteristics for the adoption of farm management practices. Table 2 revealed the result of the model for adoption of farm management practices that influenced by several demographic variables. Age of farmer has influenced positively and significantly to the adoption of intermittent short fallow, surface irrigation and mixed cropping practice at $P<0.05$. This implies that both young and old farmers have higher probability for adopting the farm management practices in the region, this is probably due to the benefits accrued from these management practices. Muhammad et al. (2014) observed that there were both positive and negative correlation between age of farmers and adoption of conservation farming practices. Families are veritable sources of labour for farm operations and adopted for farm management practices that are labour intensive and are often of great advantage to farm productivity. Household size was positive significantly influenced the adoption of minimum tillage/mulching, organic fertilizer and mixed cropping but influenced negative for intermittent short fallow and surface irrigation. This indicates that households that utilize family labour tend to adopt labour intensive farm management practices. This was concurrent with the findings of Kassie et al. (2009) cited in Miheretu and Yimer (2017) reported that the probability of adopting conservation tillage in Ethiopia was increased with the number of household members. In contrast, Holden and Yohannes (2002) revealed zero relationship between family size and some farm management practices.

Farmers' educational attainment of farmers influenced positively and significantly with mixed cropping practice and not significantly related to the adoption of intermittent short fallow, minimum tillage/mulching and organic fertilizer probably these practices do not need higher educational and technological know-how in the farm management practices. This was conformity with the study of Muhammad et al. (2014) that revealed there was both positive and negative correlation between educational attainment and adoption of farm conservation practices.

According to Bewket (2007) land tenure security is an important factor affecting farmers farming decisions and ownership of land is a major guaranty to changing cropping patterns and management practices. The result indicated that ownership of lands has both positive and negative influence for the adoption of intermittent short fallow, organic fertilizer, mixed farming practice and minimum tillage/mulching. This implies that land owner can secure with courage the provisions of financial incentives required for farming investments in farm management practices affecting significantly farmers decision for choosing a farm management practice. The study of Akpoko's (2004) informed that land tenure influenced significantly positive adoption of farming conservation practices. In the same vain, types of crop grown have positive and significant influence for mixed cropping, intermittent short fallow and organic farming at $P<0.05$. Similarly, distance from homestead influenced significantly both positive and negative for the adoption of minimum tillage/mulching, organic farming and surface irrigation practice. This implies that any unit increase in distance from homestead resulted for 19%, 96% and 26% probability of adopting minimum tillage/mulching, organic fertilizer and surface irrigation respectively. The implication

of these results enhanced through targeting of both younger and older families where both spouses work on the farm for full-time basis. Specific farm management practices show positive relationship and significantly influenced by variables such as age, family size, land tenure, farms distance from homestead and farm size but has no significant relationship with educational attainment and types of crop grown as shown by 5% of farmers. It is imperative to recognize that that education to a certain extent in this study area does not influence adoptive behavior of choice of farm management practices because farmers with many farming experience and knowledge obtained through extension services have made them actually aware of the type of farming that provide high crop yields with necessary and right able inputs appropriate under each soil good condition for conservation measure at the same time.

Table 2. Factors Influencing Farmers' Choice of Farm Management Practices
Source: Computed from Field Survey Data, 2017

Model	Variables	Intermittent short fallow	Minimum tillage and mulching	Organic farming	Mixed cropping	Surface irrigation
X_1	Age of farmer (years)	0.04(0.02)**	-0.04(0.01)**	0.01(0.01)	0.03 (0.02)**	0.02(3.41)**
X_2	Household size	-0.20(0.06)**	0.06(0.03)**	0.07(0.03)**	0.13 (0.08)**	-0.11(0.05)**
X_3	Education of the farmer	-0.37(1.30)ns	1.40(1.25)ns	1.73(1.24)	2.31 (1.67)**	-0.42(1.34)
X_4	ownership of plot	-1.59(0.34)**	-0.47(0.27)**	-1.46(0.30)**	2.49 (0.48)**	-0.13(0.46)
X_5	Type of crops grown on plot	-0.62(0.55)ns	-0.32(0.54)ns	-1.22(0.68)	1.55 (0.63)**	0.50(1.09)
X_6	Distance of plot from homestead	-0.15(0.12)ns	0.19(0.10)**	0.15(0.10)	0.96 (0.18)**	-0.26(0.17)**
X_7	plot location	1.35(0.65)**	0.45(0.65)ns	1.95(0.88)**	-0.39 (0.86)	-0.45(1.10)
	Constant	0.20(1.55)	0.48(1.53)	-0.91(1.59)	-70.52 (20.10)	-5.26(2.23)
	Log Likelihood	**-126.09834**	**-183.90675**	**-169.9232**	**-82.920377**	**-86.834117**
	chi2(10)	**50.89**	**23.86**	**44.29**	**101.55**	**17.91**
	Prob>chi2	**0.0000**	**0.0012**	**0.0000**	**0.0000**	**0.0124**

Key: **significant at 0.05%, ns= not significant

Determinants of Farmers' Adoption of Farm Management Practices in Southern Kaduna

Table 3 shows that majority of the respondents about 29.3% opined farming experience an determinant factor for adoption of farm management practice, 26.6% of them cited nature of the farmlands, 15.8% recognize ownership of many farmlands afford alternative farm management practices and 15.2% mention large farm size enable the farmer to divide the land into different management practices per season. These four different farm management practices were the major determinants for the adoption of the common farm management practices in the study area. Farmers disagreed that topography as reveal by 4.5% of them, some 8.6% also recognize that land and knowledge obtained from participating in government agricultural programme may have not been determinant for adoption of farm management practice. Absence of any government agricultural programme and rugged terrain has hampered agricultural practices in some places of the study area.

Table 3. Determinants of Farmers' Adoption of Farm Management Practices
Source: Field Survey, 2017

Determinant factors	Responses	
	Frequency	Percentage
The experience gotten from many years of farming business	217	29.3
The ownership of many farmlands to afford alternative practices	117	15.8
Farm sizes that enable the farmers share for different management practices per season	113	15.2
Due to the topography of the land(s)	33	4.5
Knowledge obtained from participating in Government agricultural programme	64	8.6
Nature of the farmlands (soil fertility status)	197	26.6
Total responses mr	741	100.0

mr = Multiple response

Adoption of Farm Management Practices in the Sampled Settlements

The determinants for the adoption of farm management practices among farmers in the five selected settlements have been presented in table 4. The result shows that 100.0% of the respondents cited farming experience, 96.4% of them mention nature of the farmlands were the major determinants for adopting FMPs in Zankam. In Katugal also farming experience account for the view of 70.0%, 40.0% recognize nature of the farmlands as the major determinants for adopting different farm management practices. The result for Madakiya shows that 100% of the respondents mention nature of the farmlands as a major determinant for adoption of farm management practices, then 85.71% of them indicate farming experience and 85.71% of them again agree that knowledge obtained in participation in Government agricultural programme contributed to the adoption of farm management practices. Furthermore, 74.2% of farmers considered ownership of many farmlands afford alternative farm management practices and 60.0% opined large farm sizes enable the farmers to divide the farmlands for different management practices per season. Land topography was not considerable for adoption of farm management practices in Madakiya because proximity to Kaduna Agricultural Development Project office at Samaru Kataf has made farmers to benefit enormously from the Government agricultural programme.

Similarly, in Mailafiya some farmers 72.9% of them identify nature of the farmlands as the major determinant then followed by farming experience with 61.4% respondents. Furthermore, 60.0% of them indicate the ownership of many farmlands affords alternative practices and large farm sizes enable them divide the farm for different management practices per season. In Kurmin sara, the common determinant was the farming experience as reveal by 77.1%, then 57.4% indicated ownership of many farmlands afford alternative practices and then 55.7% cited nature of the farmlands and 45.9% opted large farm sizes enable them to divide the farm land for different management practices per season. Whereas knowledge obtained from participating in Government agricultural programme (22.9%) and topography (9.8%) were least considered as determinant for the adoption of farm management practice.

Table 4. Multiple Responses on the Determinant of the Adoption of Farm Practice in the Selected Settlements
Source: Field Survey, 2017

Determinants of Farm Management Practices	Location					
	Zankam	**Katugal**	**Madakiya**	**Mailafiya**	**Kurmin Sara**	**Total [mr]**
The experience gotten from many years of farming	55 (100.0)	42 (70.0)	30 (85.71)	43 (61.43)	47 (77.05)	217 (77.22)
The ownership of many farmlands to afford alternative practices	8 (14.55)	6 (10)	26 (74.29)	42 (60)	35 (57.38)	117 (41.64)
Large farm sizes that enable the farmer share for different management practices per season	4 (7.27)	18 (30)	21 (60)	42 (60)	28 (45.9)	113 (40.21)
Due to the topography of the land(s)	2 (3.64)	12 (20)	0 (0)	13 (18.57)	6 (9.84)	33 (11.74)
Knowledge obtained from participating in Government agricultural programme	2 (3.64)	12 (20)	30 (85.71)	6 (8.57)	14 (22.95)	64 (22.78)
Nature of the farmlands (soil fertility status)	53 (96.36)	24 (40)	35 (100)	51 (72.86)	34 (55.74)	197 (70.11)
Total[mr]	**124**	**114**	**142**	**197**	**164**	**741**
No.	**55**	**60**	**35**	**70**	**61**	**281**
Missing	**0**	**0**	**5**	**0**	**0**	**5**

Percentages and totals are based on respondents, [mr] = Multiple response

Thus, first of all farmers about 77.24% considered the farming experience acquired in many years of farming, then some 70.11% recognized nature of the farmlands before adopting any farm management practice. The other factors considered were the ownership of many farmlands afford alternative practices as well as large farm sizes which enabled them divide the farm land for different management practices per season (41.%). However, knowledge obtained from participating in Government agricultural programme (22.78%) was less concerned and virtually all

the farmers did not consider it together with topography of the land (11.74%) as a determinant due to the relatively flat to gentle terrain of the regions.

CONCLUSION AND RECOMMENDATIONS

The study establishes different farm management practices adopted by farmers under indigenous and modern techniques of farming. Farming experience and nature of soil fertility status of the farmlands were the major determinants for the adoption of the common farm management practices. While age, household size, land tenure, farm size and distance of farm plot from homestead were influenced significantly for farmers' choice of land management practices. The study recommends the revitalization of abandoned irrigation infrastructures in Kagoro and Madakiya to take the full potential of the availability of fadamas, including the marshy areas and streams with alluvial banks deposits. This would encourage farmers to participate fully in irrigation agriculture. It is necessary to help the farmers in order to improve the management of their agricultural farm lands in the study area at two levels. First, those practices that are common in each settlement should be targeted for improvement. Second, farm land management practices that are not currently being used by farmers in each settlement but have the potential to improve crop production should be identified and promoted in the respective settlements.

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MAPPING SOUTH CHINA SEA REGION BY GMT FOR MARINE GEOLOGICAL ANALYSIS AND VISUALIZATION

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Abstract: The study details geological analysis of the South China Sea region. South China Sea is a marginal sea located in unique geographical region of west Pacific Ocean. It has a complex tectonics history being developed at subduction zone of three tectonic plates: Eurasian, Pacific and Indian. Geologically, South China Sea is rich in mineral resources and has high geological prospects. Within the scope of the study, the review of the general settings of the study area (bathymetry, geology, tectonics and sedimentation) is accomplished by the report on the current activities, methods and research clusters. Current directions in the marine geological research in the South China Sea area are presented. Research methods of the seafloor surveying and mapping currently undertaken in the South China Sea region are described: systematic measurement by multi-beam echo-sounders, altimetric measurements, GPS positioning, application of the unmanned underwater vehicles, GIS mapping, data analysis, dredging and drilling. The results include maps visualized by means of Generic Mapping Tools (GMT) showing geological and geophysical settings in the South China Sea region, bathymetry and model of the marine free-air gravity. Research development and recent progress in marine geologic investigations are reported with focus on current activities in the coastal area of the South China Sea region.

Key words: South China Sea, marine geology, Pacific Ocean, research policy

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INTRODUCTION

Systematic ocean exploration in the 20th century started on ships, naval or merchant navies in different countries. However, the diversity of the scientific tasks and the need to study different research objects in the ocean resulted in the diversification of the research branches, as well as specialized geological and geophysical vessels, equipment and tools. Generally, ocean research fleet consists of vessels of various state and departmental affiliation. They are designed for specialized study of the seafloor relief, marine biological and geological resources, geophysics, multilateral study

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of the ocean water properties, atmosphere layers. Special units of the scientific fleet include drilling vessels and drilling platforms, as well as underwater manned vehicles.

A variety of factors determine the importance of the marine research for China: large territory, dense population, location surrounded by seas on the south and east, vast ocean resources and long coastline. Therefore, the development of the marine geology program on the governmental level is highly actual. The organization of the geological research at the international level is one of the most important problems of the marine geology discussed at international geological congresses. Multi-dimensional aspects of the marine geology program around South China Sea region are maintained and being developed (Jin, 1989). Cross-institutional arrangement impacts ocean governance in various ways. Interdisciplinary science has links between the geology and oceanography, including exploitation and protection of the marine environment and resources, marine economy, ocean policy, regulation of ocean management, application and resources of the marine science and technologies, development of harbour facilities and coastal engineering (Cai, 1989).

Coastal and marine geology expertise contributes to the environmental mission, providing impartial information on the health of marine ecosystems and environment around Hainan and Taiwan Islands (Lin and Kangming, 1983), natural hazards (tsunami), natural resources, impacts of the climate change, core science systems enabling timely forecasting, relevant and usable information. Institutional arrangement is both critical and essential element in ocean governance. Through cross-institutional arrangement in China, marine geology research and survey laboratories began to make efforts for the establishment of integrated ocean policy such as introduction of new legal actions, policy strategy, or comprehensive planning systems.

METHODS

Various methods have been developed for successful application at the depths of the ocean seafloor of the continental margins using underwater photography, acoustic, GIS and remote sensing methods. These methods were applied towards studies of the South China Sea region. Eastern tropical part of the Pacific Ocean was recently surveyed in the scope of a program aimed at understanding distribution of the ferromanganese clusters located at the seafloor basement, carried at depths from 4400 to 5100 m with the use of a 1-5 m above the seafloor of installed underwater cameras. Survey technical means and equipment at South China Sea Institute of Oceanology include modern facilities, remote sensing devices, GIS, drilling equipment that increased significantly since 1960s (Wyrtki, 1961). Applied methods include high-resolution airborne geophysical surveying, land magnetic and resistivity surveying, natural electrical field methods, induced polarization and transient electromagnetic techniques, gravity surveying. It conducts integrated mapping of the coastal environment and marine geology to define offshore hazards and sediment processes, support habitat and resource management, monitor changes.

Multi-beam echo sounder measurements are a basic method to measure the seafloor depth, with an example of the Hydrosweep DS (Caress and Chayes, 1996). It is the basis for all subsequent geological, geophysical research works and theoretical developments. Application of the multi-sounder devices for bathymetric mapping (echo-sounder recorders) is closely related to the accuracy of bathymetric maps. Echo-sounder devices increase the number of measurements, improve their accuracy and expand research scope. The multi-beam sonar echo-sounder was invented in late 1970s. It opened new opportunities for detailed study and mapping of the submarine topography. Special feature of the multi-beam echo sounders consists in the hundreds sound beam sent to the seafloor. The fan beams diverge from the emitter along the axis of the vessel, and enable bathymetric survey with a wide band (from 70% of the depth to three or more depths, at depth of 5000 m, a band of 15,000 m can be mapped). Currently, multi-beam echo sounders of various designs (181-rays and more) are installed worldwide on ca. 1,000 vessels. Technical parameters of all modern echo sounders installed on Chinese research vessels include radiating and receiving antennas, subsystems radiation intake, control of onboard pitching and rolling sweeps, special blocks for digital processing to visualize bathymetry in real-time.

Precise surveying of multi-beam echo-sounder enabled complex detailed geological and geophysical surveys of the seafloor. For decades, study of the seafloor was conducted along the ship by route measurements. Large distances between the ticks did not allow data to correlate with a high degree of reliability. Along with recent technical progress, all types of oceanic morphostructures of the Ocean are detected and discovered. Discovered submarine relief forms include large forms (mid-oceanic ridges, uplands, plateaus, gutters, fault zones) and small forms (separate mountains, underwater canals). The details of the study significantly improved after the organization of work on landfills – limited areas within which parallel tracks are located at the distances of 2-5 miles.

Seafloor survey by multi-beam echo sounders includes a set of the equipment, profiler, magnetometer, gravimeter, side-scan sonar and continuous seismic profiling. Studies of the landforms are accompanied by the station research collecting various geophysical data. As the ship follows straight line, the transducers sends multiple sound pulses to the seafloor sent in many directions simultaneously. When the pulses hit the seafloor, they reflect back to the ship to be detected by the receiver. The multi-beam system then calculates the angle, the time it took for the pulses to travel, the ship's orientation to the water to determine the depth of the seafloor at that spot. Once the data pulses return and are analysed by a computer, the topography of the seafloor is mapped. To "ground-truth" mapping data divers or remotely operated vehicles are used to verify the data collected onboard of the ship. Navigation is important goal for safety of the marine survey, geological and geophysical research. Main method determining the location of the vessel is a GPS system of satellite navigation. A large number of satellites enable to locate vessels, including submarines, up to meters away, regardless of the location of the work area.

Seismic methods of the seafloor mapping are the most important ones to study structure and sedimentary cover of ocean (structure, velocity characteristics): (Lisitsyn et al., 1990; Morgan, 1974; Pushcharovsky and Neprochnov, 1984; Heuret and Lallemand, 2005). Depending on the radiation frequency, the depth of the penetration energy into the sedimentary cover or deeper horizons may change. High-frequency single-channel (continuous seismic profiling) multi-channel methods, as well as deep seismic sounding can be distinguished by the frequency of radiation. The principle of the seismic method of seafloor survey is based on the energy penetration issued by the compressed air, electric discharge, into the water column and then into the rock. After reflection of the signal from the sedimental horizons, the reflected signal goes back to the ship and is received by the antenna (a seismic streamer). The received data is accumulated digitally on a seismic station. Further processing is completed on the computer stations by software that filters out the acoustic noise and store information on the structure of the Earth's crust. There are many modifications of the equipment, such as bottom stations, radio beacons. A set of the equipment designed to study gravimetric, magnetic fields, together with lateral-view sonar, profiling and other geological and geophysical equipment. Example of the gravimetric map is given on figure 3. Special immersible robot is mixed over the ocean floor at an altitude of 300-400 m. The side-scan sonars are designed to study the morphology of the bottom, identify faults in the oil pipelines, and search for sunken objects (ships) of any size with a high degree of resolution. The principle of their operation is based on irradiation of the bottom surface with a frequency of about 6.5 kHz.

The study of the seafloor is possible not only through vessels, but by means of satellites from space. Systematic measurement of the surface height (altimetry) of the world ocean water level by the satellite radar at an altitude of ca. 800 km with accuracy of several meters proved that water level depends on the topography of the seafloor and density of the underlying rocks. Positive relief forms attract water body increasing the height of its surface and vice versa. Figurative concept of the "world ocean level" is not permanent, and differences in the height of the water surface can be more than a hundred meters. Analysis of the ocean altimetric data enabled to create a mathematical model of the relief of the entire oceans, the so-called predicted topography with a high degree of reliability. Satellite data were compared with real echo sounder measurements and extrapolated to unexplored regions.

Among other research techniques currently used by Chinese researchers for the seafloor surveying and mapping is the Unmanned Underwater Vehicles (UUV). The UUV are any vehicles able to operate underwater without humans. The UUV are used to solve both theoretical and practical problems (inspection of underwater parts of engineering structures, pipelines). In the deep-sea trenches, UUV are used to test the rocks of the seafloor, direct observations of the geological structure, collection of information about the pelagic world, benthos or the properties of the aquatic environment. A breakdown of the oceanic crust on the transverse ridge in the Atlantic Ocean was discovered by UUV apparatus. UUV are widely used to study active and inactive hydrothermal fields that may cause ore formation (Butuzova, 2003). The UUV may be divided into two categories: remotely operated underwater vehicles, controlled by a remote human operator, and autonomous underwater vehicles operating independently, a kind of robot. The accuracy of the predicted topography enabled to plan marine expedition paths (choose areas, tracks), to make major theoretical generalizations. However, it should be stressed that it cannot completely replace the echo-sounder in-situ surveying.

Dredging and drilling are other methods to study the seafloor. Testing bottom rocks through rocks extraction from the seafloor is used by various tools: tubes, dredges, pipes, trawls, scoops. Tube testing is primarily intended to study the upper layers (<50 m) of the sedimentary cover pressed by its own weight. The tube penetrates at a high speed to the ocean bottom and takes a column of the seafloor sediments into the hollow part of the instrument. In some cases even the bedrock may be taken. Although a complete section of oceanic crust has not yet been drilled, it helps understand the seafloor. Some of them are the samples recovered from the seafloor by drilling or dredging (an underwater rock excavation). Dredging is one of the main methods that allow taking samples of the bedrock from any depths at depths 20 to 6000 m. The most important and evident trend in the recent development of the marine geology policy is advanced made in research on ocean resources and related applications and commercialization of resources for the development of marine science, technology and industry. This included following activities:

1. supported research on ocean resources and related applications;
2. commercialization of the research on ocean resources;
3. development of science and technologies in the marine industry;
4. supported research on ocean and polar science and technology policies and institutions;
5. fostering professionals in the marine sector and public services;
6. development, inspection, repair of marine-related equipment, machinery and technology;
7. establishment and operation of the infrastructure, marine science research stations.

Funded research and technology partnerships with domestic and overseas universities focused on marine geology resulted in a variety of publications on China South Sea geology (Ren et al., 1980). Ocean governance includes essential elements: ocean policy, institutional arrangement, implementation of ocean policy, coordination and cooperation between the sectors and policy constituency.

RESULTS

Current study is based on cartographic mapping by Generic Mapping Tools (GMT), successfully tested in previous studies. The advantages of the GMT lie in its advanced cartographic solutions, shell scripting approach, open source availability and compatibility with both UNIX and MacOS environment. All maps presented below are made by author using various GMT modules using described methods (Lemenkova, 2019b, 2019c, 2019d). General methods of the marine research described above are cost-expensive and require organization and cooperation, while mapping and spatial analysis and data visualization by GMT are available for anybody which is valuable for researchers. The test study area presented below is South China Sea area.

South China Sea is a unique geographical region, a marginal sea located in the west Pacific Ocean, at the junction of 3 tectonic plates: Eurasian, Pacific and Indian. Geographical location of the South China Sea is between 2°30´E 23°30´N and 99°10´ – 121°50´E (figure 1). South China

Sea is surrounded by China mainland, Indo-China Peninsula, greater Sunda Islands, and the Philippines Islands having length from south to north of ca. 3100 km, width from east to west of ca. 1200 km, area of 350*104 km^2 (Xu et al., 1997).

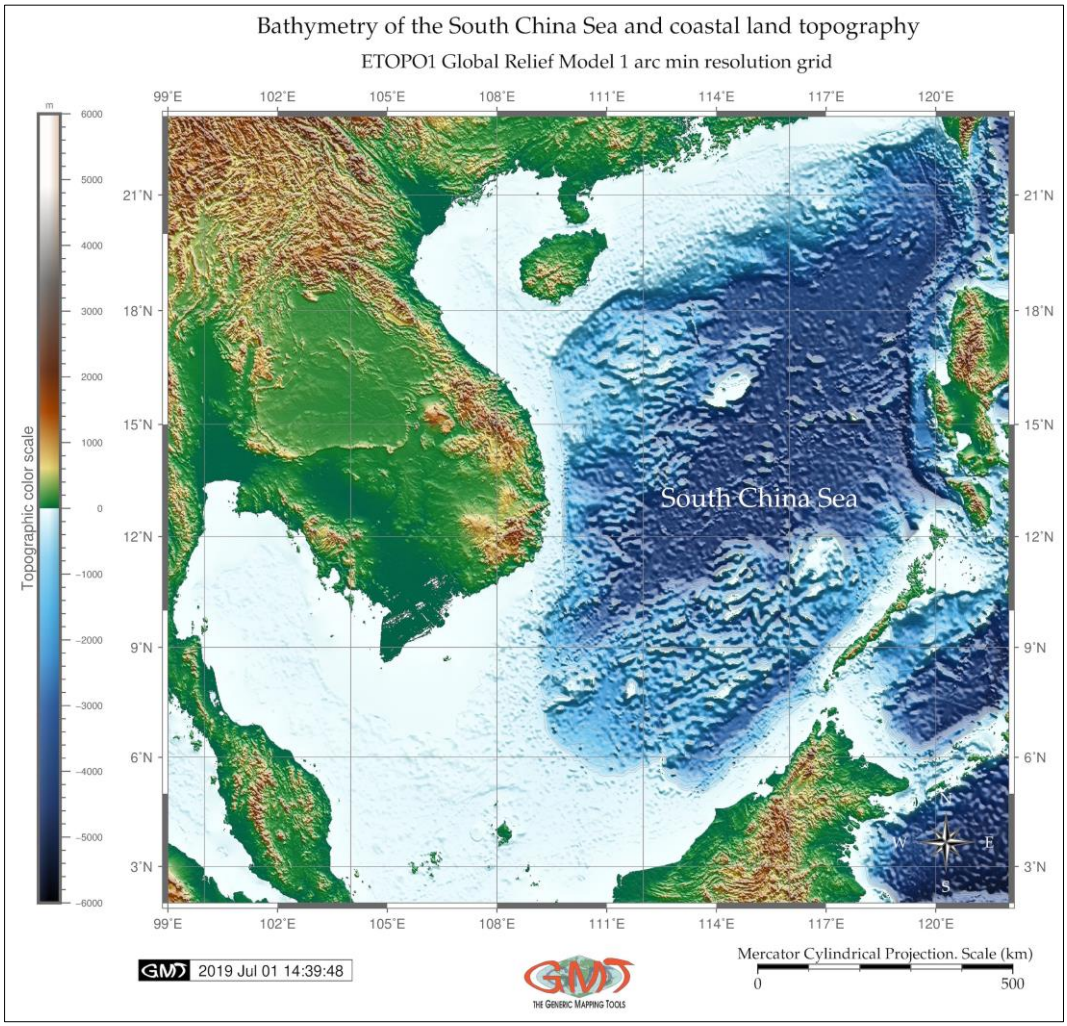

Figure 1. Bathymetric general map of the South China Sea
(Source: Author)

South China Sea is one of the marginal seas in western Pacific adjacent to the Southeast Asia, consisting of a deep-sea basin and a terrain system (Jin and Ke, 1990). The special geological and geographical features of the South China Sea results in abundant mineral resources, natural gas and oil which naturally attracts policy makers, environmentalists, governmental authorities and geoscientists. South China Sea belongs to the type of marginal seas adjacent to the continents. The main part of the transition zones (continental and oceanic margins) is located on the western periphery of the Pacific Ocean.

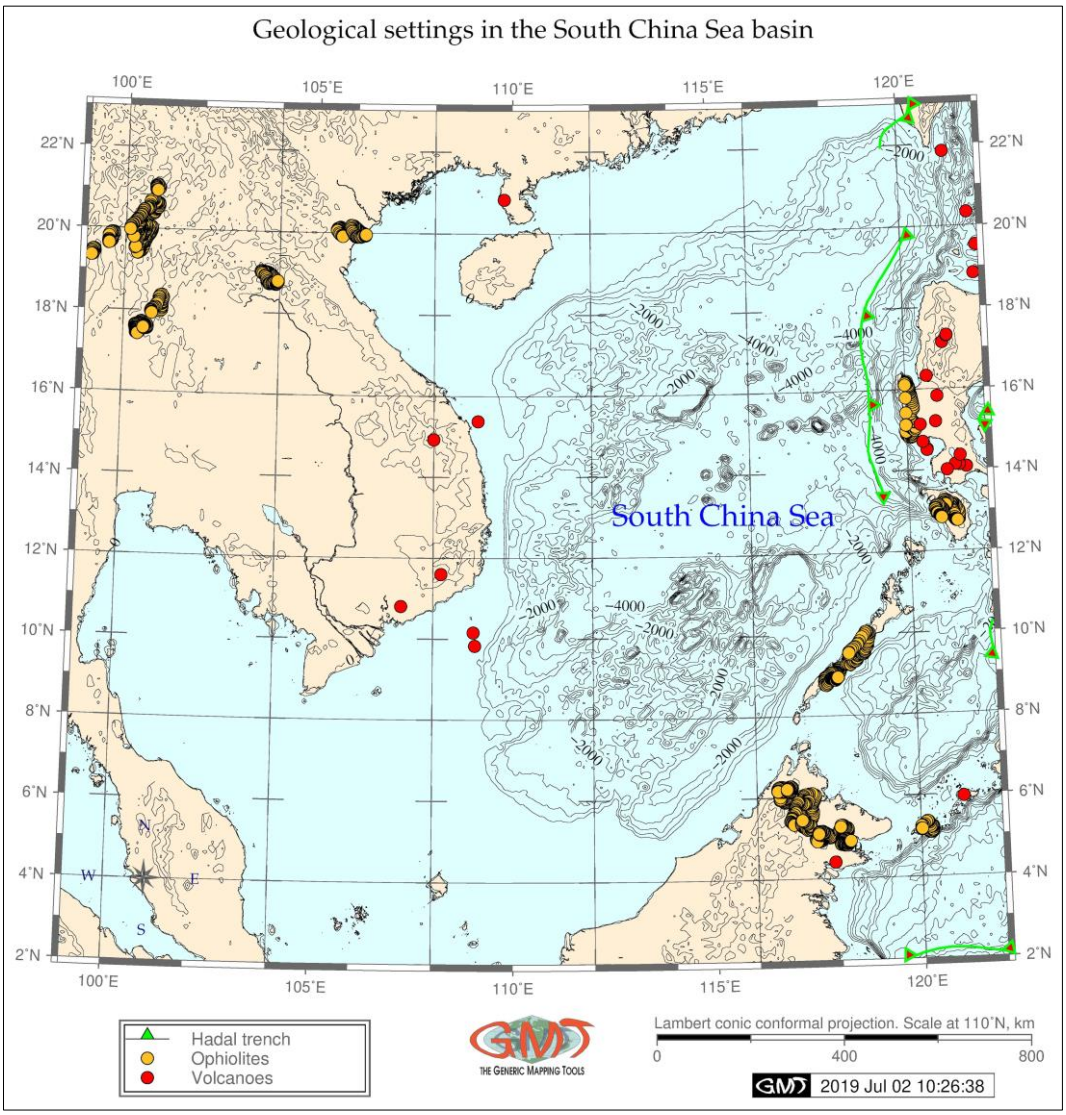

Figure 2. Geologic map of the South China Sea: location of the volcanoes, ophiolites and hadal trenches (Source: Author)

There are several morphological types of crust that differ in the position of the basins of the seas. Besides South China, examples of other marginal seas include, for instance, Bering Sea, Sea of Okhotsk, and Sea of Japan. South China Sea belongs to the transitional zones of the western part of the Pacific Ocean. This region is notable for a very complex geomorphology with dissected area of island arcs and massifs, shallow shelves and deep basins, ridges and gutters, located between the Southeast Asia and Australia, including Philippine Islands. The shelf in the South China Sea has a significant width in the northern and southern parts and is noticeably reduced along the coast of Vietnam. The prevailing depths range from 60 to 100 m, and <50 m between the islands. The surface of the shelf is mostly levelled, with exception in the coastal zones and near the small islands where it is complicated by numerous coral reefs.

The shelf area with the continental crust is noticeably larger in South China Sea comparing, for example, to the Sea of Japan. A subcontinental crust with a thickness of more than 30 km lies

under the Philippine Islands. A suboceanic crust with a thickness of about 12–20 km lies under the bottom of the sea basin, and becomes noticeably thicker on the submarine elevations. A complex combination of the subcontinental and suboceanic crust can be seen to the south from the Philippine Archipelago. The crust under the islands and underwater ridges has a thickness of more than 25 km and consists of a relatively thin volcanic layer and two main layers with seismic speeds of 5.7–6.2 and 6.7–6.9 km/s. On the contrary, the thickness of the crust decreases to 10 km in the depressions, such as basins of Sudu, Sulawesi, Banda and others. Its structure is comprised by layers with seismic velocities of about 5.0 and 6.4–6.9 km/s as well as sedimentation layer (Murauchi and Ludwig, 1973).

South China Sea has the enclosed nature of the basin, the geometric shape similar to a rhombus, with long axis in North-East-South-West direction. Its length stretches to ca. 3100 km, width of ca. 1200 km, area of ca. 350,104 km^2 (Becker and Sandwell, 2008). The average bathymetric depth is 1212 m, and the deepest point is located at the southeast end of Manila trench with depth of 5377 m (Lafond, 1966). South China Sea is divided from the periphery to its central part. The continental shelf and island shelf area covers 48.14%, the continental slope while island slope area 36.12%, and sea basin area 15.74%, respectively (Taylor and Hayes, 1983).

The ETOPO1 global relief model was modeled (figure 1) using Generic Mapping Tools (GMT) cartographic scripting toolset using ‘grdimage’ module (Wessel and Smith, 1995). The bathymetry of the South China Sea was visualized using ‘geo’ color palette. The original data is derived from the sea-surface satellite altimetry measurements and ocean soundings provided by numerous global geospatial sources. The ETOPO1 includes existing bathymetry data set with 1 min resolution (Smith, 1993) and uses interpolated gravity values (Smith and Sandwell, 1995). The shoreline was added using coastal vector layer embedded in GMT (Wessel and Smith, 1996).

The continental slope in the South China Sea has a complex stepwise block structure, descending in a staircase-like pattern to the bottom of the basin, which occupies the central part of the South China Sea. In its northern, western and southern parts, the slope is complicated by the marginal plateaus. Notable geomorphological features include the Dongshandao reef, the Paracel islands and Nansha islands with surrounding coral reefs, rise on one of these plateaus. A particularly complicated structure of the submarine relief is observed on the Nansha Plateau, where the straits between the islands and reefs are formed by very steep canyons and troughs with depths reaching up to 1700–2000 m. Seamounts are rising at the seafloor of the South China Sea basin, where the depths are 4200–4400 m (and >5000 m near the Philippine Islands). Seamounts are especially notable in the north-eastern part of the South China Sea with elevations up to 3000-4000 m.

The tectonics of the South China Sea has complex character. This, the crustal type of the South China Sea continental margins is composed of the continental, oceanic and transitional crust (Taylor and Hayes, 1980). The distribution of the continental crust is mainly adjusting the land areas while new oceanic crust appears in the continental crust. The oceanic crust is mainly located near the ocean borders. The transitional crust in continental shelf and continental slope areas encompass 30–32 km, the northern continental shelf region is about 28–24 km, and the north of Dongsha Islands increases to 30–32 km, and southwestern continental shelf crust thickness is 24–26 km (Yincan et al., 2017). The central basin of the South China Sea is presented by the oceanic crust with thickness of 6–8.5 km and with the average thickness of 6.8 km. According to the characteristics of crust, the South China Sea can be divided into blocks: northwest, southeast, central basin and Luzon-Palawan Island arc fold belt. South China Sea is notable for the high seismisity (Dubinin and Ushakov, 2001). The historical development of the tectonics os South China Sea includes several processes: during the Meozoic, the tectonic movement of lithosphere in South China Sea presented the assembly and the accretion of plates or terrains, thereafter the small plates or terrains gradually integrated and merged into a unified plate which formed a part of the Eurasian Plate (Jin, 1992).

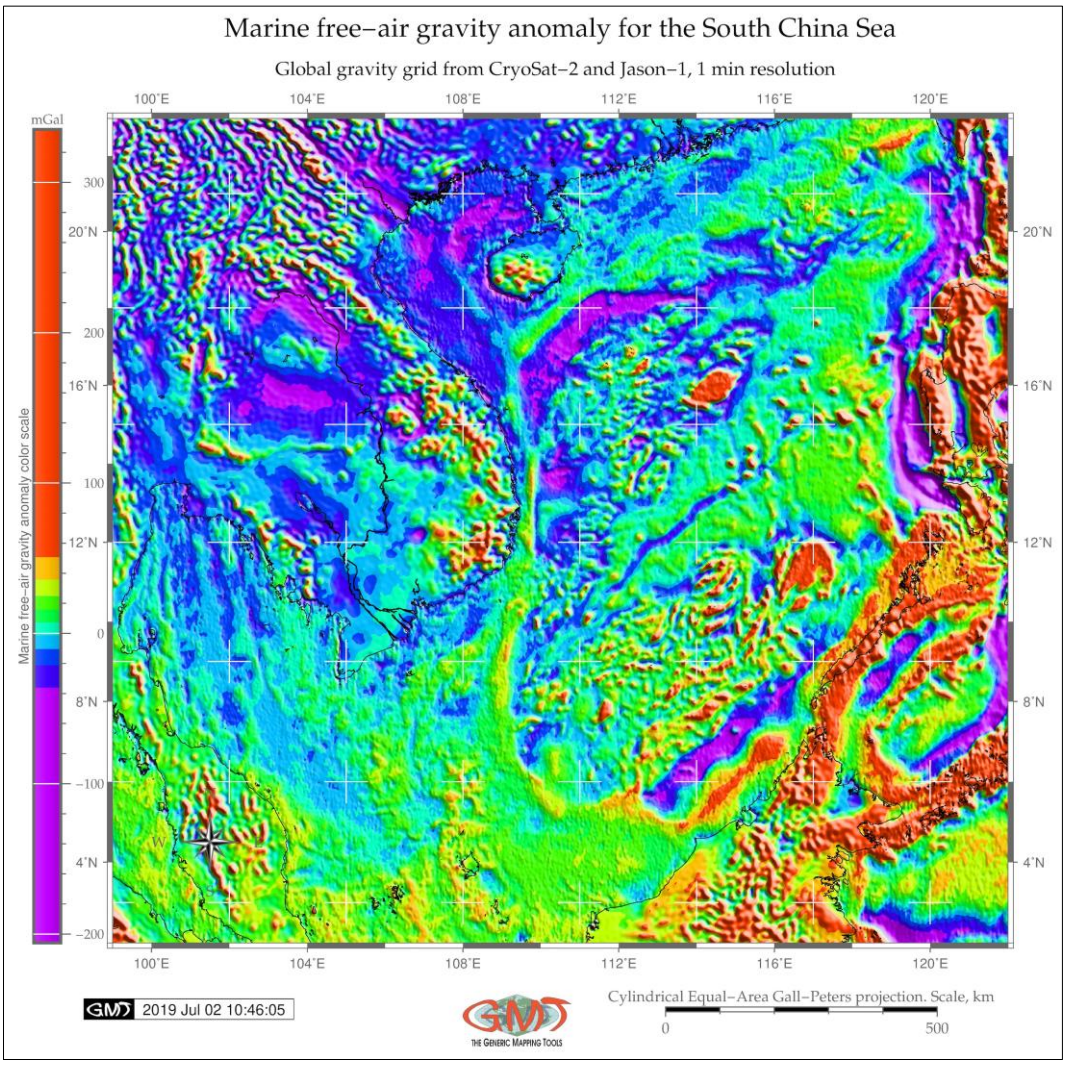

Figure 3. Marine free-air gravity map of the of the South China Sea
(Source: Author)

South China Sea basin was formed as a result of the continental margin rifting and spreading. The continental lithosphere was attenuated to the extent of plate spreading indicated by the geomagnetic pattern with east-west trend. The southern coast of the China is characterized by numerous postglacial embayments and near shore islands. Sedimentation is controlled largely by moderate tidal currents depositing fine-grained sediments (Gurvich, 1998). South Sea is characterized by numerous islands that have been submerged during the last transgression.

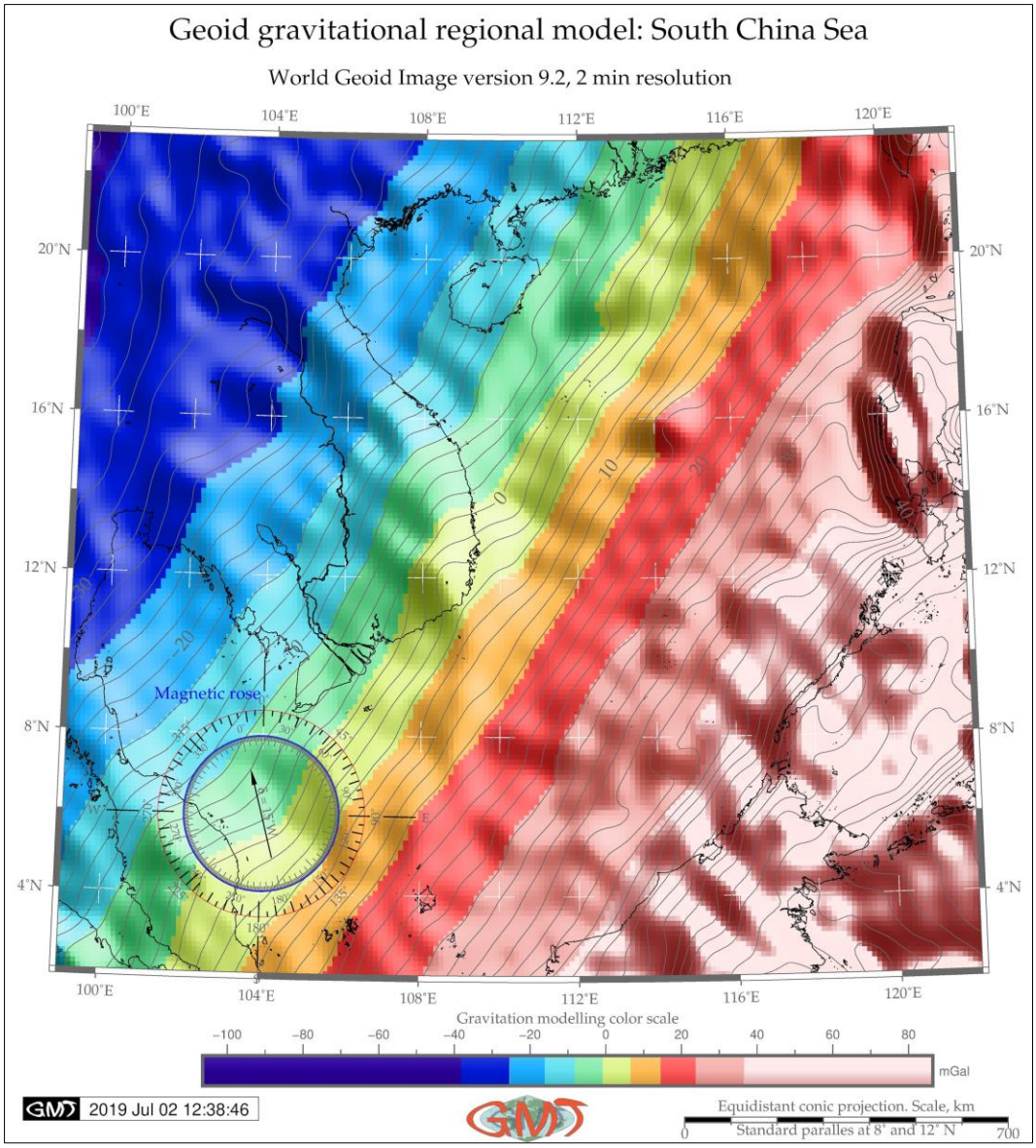

Figure 4. Map model of the geoid on the region of the South China Sea
(Source: Author)

Shallow subsurface mapping using high-resolution seismic profiling has revealed that the sea is characterized by complex incised valley systems and transgressive deposits during the rise in sea level. The notable landform of the South China Sea is the Philippine Trench and the Manila Trench which stretches up to 10 km. Generally, the surface of the basement on the shelf in a South China Sea has a depth of less than 1 km, complicated only by minor local depressions. At the shelf edge, it descends along a complex stepwise block ledge to the bottom of the basin, while the basement surface of the Cenozoic structures of the Philippine Islands descends along a simpler ledge. The surface of the basement at the seafloor of the basin has depths of over 5 km. It is complicated in the southern part of the South China Sea by the raising of the Nansha (Spratly)

Islands, where its depths do not exceed 2 km. The Spratly Islands, one of the major archipelagos in the South China Sea, consist of islands of accumulated biogenic carbonate which lie upon the crests of the submarine ridges, uplifted fault blocks. Geologically, these horsts present part of a series of parallel rotated fault-blocks.

South China Sea has complicated tectonic and sedimentation history. Tectonically, the basin of the South China Sea has developed between the terrains (continental fragments) rifted from Asian continent. Therefore, the sedimentation has also occurred between and on the submerged continental fragments. The unique feature that distinguishes the South China Sea among other Pacific marginal seas is the fact that South China Sea is surrounded by land territories with intense erosion. Therefore, the abyssal deposits are mainly composed of the terrigenous clastic sediments and biogenesis carbonate in various proportions (Kennett, 1982). Hence, the sedimentation rate in the South China Sea is much higher than in the open Pacific. Locally, the sedimentation rate of pelagic sediment lower than 1 cm·ka−1 in the Pacific (Lisitzin, 1972), and the pelagic areas have ca. 10% lower sedimentation rate than in deep South China Sea. Generally, the thickness of the Meso-Cenozoic sedimentary cover in the deepest parts of the basin of the sea >1 km. The thickness of the cover is noticeably reduced at the tops of numerous uplifts of the seafloor of the sea. Here, the sedimentary cover is mainly represented by the Cenozoic coral limestones. A similar situation is observed in the numerous basins of the Malay archipelago. Cenozoic terrigenous sediments with a thickness of up to 1 km or more are predominant here, which are reduced and replaced by coral limestones at the elevations of the bottom.

Geoid gravitational model (figure 4) shows the gradual increase in the gravitation values from the north-west to the south-east directions. The values lies in the interval between -100 to 80 mGal with the lowest values on the continent (coloured blue). On the contrary, the highest values reaching 80 mGal are located in the area near Philippine archipelago that is east and south-east area on the map. The central part of the South China Sea has gravity values in ranges 0-8 (segment coloured light yellow), following by 8012 (coloured orange), than 12-24 (coloured red), as shown on figure 4. On the shelf of the South China Sea, developed linear magnetic anomalies are associated with Precambrian anticlinal base structures. The same situation is observed in the basin near the Philippine Islands, where a sharp change in short-period anomalies by a calm field is clearly visible (figure 3). The linear magnetic anomalies of the basin resemble oceanic ones and may indicate a suboceanic type of the Earth's crust in the region of the South China Sea.

DISCUSSION AND RECOMMENTATIONS

Currently, China has extensive and special interest in the coastal areas and marine geologic investigations. In order to realize these benefits, it has taken many active measures on research on the South China Sea. Continuous efforts have been made by the government of China in the South China Sea region, aimed to explore hydrocarbon in the concession blocks. Thus, attempts were made by the Chinese Institute of Geology projects since early 1960s to obtain data on the geological structure of the shallow portions of the South China Sea. Following questions were of particular attention for research on South China Sea area: the geologic structure and tectonics, general and sequence stratigraphy, sedimentary facies and processes, origin and development of the marginal seas include shelf areas with a narrow continental shelf and deep basins, rocky embayment (Ben-Avraham, 1989; Royal Observatory Hong Kong, 1989; Zhu, 1987). These research problems were recently investigated by the Chinese authorities. Moreover, special research projects studied marine geological structure drilled holes throughout the South China Sea basin. Shallow subsurface mapping using high-frequency profiling and deep cores into the Holocene/Pleistocene boundary have been made to reveal late Quaternary depositional processes and sequence stratigraphy in this unique epicontinental sea (Kudrass et al., 1986; Wan and Zhu, 1989; Wu, 1988).

Research plan of marine geology progress in China includes following tasks in the development of the marine geology program in the South China Sea are:

- to perform applied research in oceanography and marine geology;
- to promote the efficient use of coastal and ocean resources;
- to undertake comprehensive surveys and studies of South China Sea;
- to conduct research in polar and tropical regions: Antarctica and Pacific Ocean;
- to develop technologies related to the coastal and harbour engineering;
- to develop ship engineering, ocean engineering, and maritime safety;
- to support and cooperate with agencies, universities and private industries towards the development of marine resources and the protection of the ocean environment;
- to participate in the international cooperation on oceanographic research projects.

Planning and organization of the geological research and survey is conducted by the Ministry of Geology P.R.C. The regional departments are organized through the territorial geological management and agencies, as well as ministries related to development of mineral resources and construction. Research work in marine geology domain is carried out by multiple research centers, institutes and laboratories and of some other ministries and Chinese Academy of Sciences. A series of periodic scientific geological journals reporting marine expedition results and outcomes published regularly with the most important publishing house in Beijing (Ru, 1987; Zhang, 1989). Since 1960s China is intensively developing the geology of the seafloor investigations in the South China Sea region, with particular focus on the industrial mineral development of the large areas in the continental shelf. The geophysical methods are widely used in the research on geology of the seafloor. Recently, high-latitude drilling is being performed with specially equipped vessels.

Recent achievement in the domain of marine geological research focused on the region of South China Sea includes several levels successfully reached in the Chinese marine geology program:

1. Equipment of the research centers by specific data on the marine geology across the coastal areas of the country (main centers: Qingdao, Hangzhou, Guangzhou, and Xiamen);
2. Adapted and development methodologies of the seafloor survey with updated technologies, devices, sensors, and specialists to achieve high standards;
3. Marine geo-information data systems aimed to perform bathymetric mapping by enriching digital models with data get during ship cruises including examples of numerical data analysis in marine applications;
4. Updated technical assistance by the multi-beam data received during the cruises. Storage of GIS data in data centers enables to support decision making and bathymetric mapping.

Nowadays a great variety of research and investigations in the coastal environments and marine geology of South China Sea region is performed by Chinese research centers. Among recent achievement advanced GIS technologies (Schenke and Lemenkova, 2008; Kuhn et al., 2006; Klaučo et al., 2013, 2014, 2017; Gauger et al., 2007) should be recommended for mapping and data analysis. There are improvements and progress in the development of marine geology program in the South China Sea region. Highlighted recommendations directions specifically for the South China Sea region include:

- systematic high precision and accuracy mapping of the seafloor of the South China Sea;
- regular sea expeditions should acquire geodata, seabed sediments, and data on geomorphology, mineral resources, geochemistry, geophysical parameters, surface and subsurface samples and other geological data around the aquatory of South China Sea;
- detailed documentation of the observation samples collected from the offshore cruises around the South China Sea to be compiled to enable prognosis or evaluations and comparison with existing data (GEBCO, ETOPO1, SRTM);
- combination of the long term multi-spectral satellite images and GIS data in the marine resources prognosis mapping has great application potential for the monitoring process;
- the in-situ data, received from the R/V expeditions is to be processed using advanced analytical tools and algorithms, published in various reports: Python (Lin, 2008; Marta-Almeida et

al., 2011; Oliphant, 2007; Lemenkova, 2019a; Millman and Aivazis, 2011), R (R Development Core Team, 2014; Vermeesch et al., 2016), GMT (Wessel and Smith, 1995) that can generate data on the geological situation of the marine geology in the South China Sea region;

- developing ocean big data center focused on the marine geology around the South China Sea has to be created. The data should be multi-source and actual with regular updates. This will provide useful insight for marine geological management and gain content;
- implementation of the oceans policy integrated as a coordinating agency with sub-ordinated institutions focused on the marine research with transparent coordination;
- establishment of the benefit-cost analysis aimed at systematical assessment of the efficiency of public policies in marine geology. The benefit-cost analysis should be applied before new equipment is ordered, to assess advantages and financial drawbacks;
- organizing regular conferences, meetings, panels, aimed at the multi-disciplinary discussions on specific problems concerned South China Sea at the international level;
- close cooperation with neighboring countries of the basin of the South China Sea, which is beneficial for the development of the South China marine program;
- advanced development of the seafloor mapping in the region of South China Sea aimed at precise bathymetric mapping for navigation and research.

CONCLUSION

In China, as a result of recent scientific development, several ocean research centres were established in China, financed and ruled by the Chinese government. These centres conduct research on the Pacific Ocean and Chinese seas in general and South China Sea in particular (table 1). These centres have driven development of the marine sciences and technology of China for several decades since establishment. Ocean centres and research institutes of China have several branches located within the country, all of which fulfil necessary functions in marine geology research and development. Important marine research centre in the field of maritime geology is located in Hangzhou: the Second Institute of Oceanography SOA. The Chinese CAS approved a bill to establish a research centre to help advance the country's marine geology sector. Research facilities of the South China Sea Institute of Oceanology Hangzhou widely use towed devices above the bottom, e.g. dredging. Remote sensing and GIS methods as well as data analysis by Python and R programming libraries are also widely used. Research interests of CAS, Guangzhou as a major research centre for marine geology in China encompass the area surrounding the South China Sea and the region of the western Pacific Ocean (e.g. Mariana Trench, Philippine Trench). However, it also includes fundamental research in Antarctica. The main areas of interest are geological and geophysical science, the life sciences, and climate science. The CAS owns the research vessels R/V, used to supply the year-round ocean investigations.

Examples of publications with a focus on the marine geology are as follows: China Sea (Chen et al., 1990; Qinhuan et al., 1989; Yulian and Liao, 1983; Zhang and Huang, 1990), Kermadec and Tonga Trenches (Lemenkova, 2019e), Philippine Trench, Mariana Trench, Kuril-Kamchatka Trench (Lemenkova, 2019f), Barents and Pechora Seas (Suetova et al., 2005).

Table 1. Key CAS and research centres with special focus on ocean and marine research
(Data source: Web)

Name of the institution	City	Province
State Key Laboratory of Satellite Ocean Environment Dynamics-SOED	Hangzhou	Zhejiang
Institute of Oceanology, CAS	Qingdao	Shandong
First Institute of Oceanography SOA	Qingdao	Shandong
Second Institute of Oceanography SOA	Hangzhou	Zhejiang
Third Institute of Oceanography SOA	Xiamen	Fujian
South China Sea Institute Of Oceanology	Xiamen	Fujian

China Ocean Development Research centre	Qingdao	Shandong
Ocean University of China	Qingdao	Shandong
Shanghai Ocean University	Shanghai	Shanghai
Shanghai Maritime University	Shanghai	Shanghai
Dalian Maritime University	Dalian	Liaoning
State Key Laboratory of Tropical Oceanology, South China Sea Institute of Oceanology, CAS	Guangzhou	Guangdong

The scope of these and others research encompasses various topics of the marine environment, navigation and mapping. State decisions in the field of maritime activities, such as administrative, legislative reforms, are taken on the basis of the results of operations of this body. A wide range of fisheries research is carried out at the fisheries centres and branches (Mallory, 2016; 2015). The most progressive tool used in marine geology seafloor investigations if multi-bean techniques. As a result of the publication activities, the geology of the South China Sea is well described in numerous reports. This is an area for further detailed studies of high-resolution and high accuracy sequence stratigraphy. A number of offshore exploratory wells have also been drilled by governmental companies, revealing high hydrocarbon potential.

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