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Table of Content

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Full Length Research Paper

Modelling inter-urban trip flow pattern of selected cities in Niger State, Nigeria

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Inter-urban travel forms one of the main spatial and economic features of any nation's economic landscape. Understanding and forecasting inter-urban movement is a crucial input for urban and regional transportation planning. This study therefore was carried out to develop trip generation model of selected cities in Niger State. Questionnaire survey was carried in three main urban centres in the state namely; Minna, Bida and Suleja. Four (400) copies of questionnaires were administered at the three major public motor parks where travelers usually board vehicles for inter-city travels Niger state. Using multiple stepwise regression model analysis, six independent variables namely; travel distance (TD), travel time (TT), population (PP), public institution (PI) and fare charged (FC) were regressed against the dependent variable (Y) which is inter urban travel flow (ITF). However, only 2 independent variables; that is population (PP) and fare charged (FC) were good and significant for explaining the variation in the flow of inter urban trips in the state. Two variables record R^2 of 1.00 which implies 100% contribution to explanation of the variation in the inter-urban travel in Niger State. The study also discovered that Minna-Suleja route constitutes the heaviest traffic corridors in the state. In view of these findings, it was recommended that adequate public transport provision should be made to meet inter urban travel needs within the state by NSTA and a more comprehensive regional transportation planning for the entire state is recommended to cover other important towns that could not be covered in this study.

Key words: Inter urban, travel, pattern, flow, generation, attraction.

INTRODUCTION

Transport has been an important component of man's activities in space. Man's ability to move himself and his materials from one point to another on the earth significantly influences his life and his environment (Ahmed, 2013). Transportation therefore bridges the gap between people and resources in both space and time. One of the ways by which man organizes the space around him is through formation of settlement and the use of transportation as a tool to bringing orderliness into the settlement. Ogunsanya (2002) emphasized on the inevitability of transportation in the city and related basic necessities of life, and stressed that man's basic need of food, clothing and shelter could be hardly achieved without transportation. In most countries, including

developing countries, cities are the major source of economic growth. The transport sector is therefore an important component of the economy and a common tool used for development even at a global level where economic opportunities have been increasingly related to the mobility of people and freight, including information and communication technologies (Rodrigue, 2020).

At regional level, transport also promotes spatial, social and economic interaction between one settlement and the others. The provision of efficient and effective transport system is a precondition for spatial and economic integration among various communities (Ogunsanya, 2002; Ojekunle, 2014). It has also been established that the pattern of urban movements is influenced by the size and density of settlement, topography, length of journey, income and household characteristics. It is also emphasized that demand for transport and travel intensity tend to increase sharply with the size of a city especially when the center or major areas of activity increase correspondingly in term of both area and employment (Ojekunle and Owoeye, 2018; Ojekunle et al., 2019).

The problems of inter urban travel in Niger state are not only many but are also very complex; which include poor road infrastructure, high cost of transportation, poor environmental condition, insufficient right of way, security challenges, inadequate terminal facilities to cope with the demand and poor condition of vehicles. The problem of inter-urban linkages within Niger state has existed for a long time and so Niger state has been known for its bad road network (Ojekunle et al., 2019).

The knowledge of travel demand for public transport service in Niger state therefore, is key to a successful transport system transformation. The efforts of the government to expand road capacity to accommodate the growing traffic are usually hindered by lack of sufficient and reliable data as well as inadequate planning tools and inputs. The lack of adequate information has severally led to over or underestimating future traffic and over or underinvestment in the provision of transport facilities and infrastructure (Ojekunle, 2014). A better understanding of inter urban travel demand will no doubt help the planners and policy makers to make effective policy decision on transport planning, investment and operation.

The lack of reliable information on inters urban travel in Niger state makes effective and efficient inter-urban transportation planning difficult. A study of inter-urban travel demand pattern in addition to providing specific information on the relative importance of causal factors (such as, trip frequency, route distance, journey time, and fare) in determining demand travel in Niger state, will therefore serve as a basis for estimating future inter-urban trip generation in Niger State.

Furthermore, these factors are expected to be quantified and their level of contribution to our understanding of inter urban travel demand will be determined. Inter- urban travel demand models in Nigeria have shortcomings in terms of quantification of their variables which this research seeks to address, in so doing we contribute to both fundamental understanding of travel demand especially in Niger state and the practical need to predict how demand will respond to a range of future scenarios. It is in the light of this, that this study attempts to model inter urban trip generation in Niger State in order to be able to establish a basis for estimating the future inter-urban trip generation.

LITERATURE REVIEW

Travel demand modeling

Intercity travel behavior is different from urban travel behavior in certain aspects, such as travel frequency. However, it still follows the general four-step model for urban travel behavior: trip generation, trip distribution, mode choice, and trip assignment. Intercity travel decision making is typically assumed to consist of trip generation, destination choice, mode choice, and route choice (Chatterjee and Venigalla, 2004)

When used for intercity travel, the model consists of two sequential steps that predict intercity travel by mode. The first step forecasts the total intercity travel volume for city pairs. The second step distributes the volume via a logit model. Typically, the number of trips is formulated as a function of the socio-economic characteristics of city pairs and composite measures of the level of service. Today these models are still in applications such as forecasting high-speed rail ridership (Brand et al., 1992). Conventional travel demand models separate the demand functions into four steps.

Trip generation models

Trip generation is defined as the number of individual trips generated in a given period of time. Traditionally, in travel demand modeling, trip generation is the first component that provides the possibility for the next steps, such as destination choice and mode choice. In the context of urban travel, a trip can be home-based or non-home-based. In practice, according to de Dios and Willumse (2011), it is also classified by purpose, such as trips to work, trips to school or college, shopping trips, social and recreational trips and other trips. Alternatively, the trips can be classified by person type based on income level, car ownership, household size and structure, which is often used as the model segmentation base. In an intercity travel context, a trip is usually categorized as a business trip or nonbusiness trip. It also can be further classified as business, combined business/pleasure, convention, conference or seminar, visiting relative or friends, rest or relaxation (the 1995 American Travel Survey). Trip generation analysis

requires identification of the factors that affect trip generation. Often, the variables taken into account are characteristics of the traveler, and personal trip attraction (de Dios and Willumse, 2011), as well as the attributes of alternatives. The characteristics of travelers include household income, car ownership, household structure, and household size. The personal trip attraction factors include the destination's socioeconomic, industrial, or residential context.

Spatial factors of inter-urban trip generation

There are many empirical studies that have examined the spatial factors on inter urban trip generation. According to Kain and Fauth (1977) inter urban travel demand is affected by spatial factors. They had considered urban development as measured by the population density in each zone and the socioeconomic characteristics of the households and the location of their jobs and residences as strong factors to explain household modal choice. Dargay and Hanly (2002) have also highlighted the need to consider the relationship between transport and the use of space. According to Ojekunle and Owoeye (2018), travel decisions are influenced by the density of buildings and the type of activity. Button et al. (1993) have demonstrated that there is a positive relationship between car ownership rates and the level of urbanization. But this relationship applies only up to a point. Beyond this point, the infrastructure becomes so saturated that the higher the urban density the more car use, car ownership rates, number of trips and energy consumption are reduced (Camagni et al., 2002). This would lead to congestion and its attendant adverse effects. Paulley et al. (2006) have shown that demand for bus transport depends on the residential zone. Individuals who live in rural zones with low population densities tend to be more dependent on car relying less on public transport, than those living in urban zones.

As Crane (2000) has reported, it remains difficult to identify how the use of urban space impacts on travel practices. Furthermore, Handy (1996) has shown that the urban activities mix has a negative effect on car use, while emphasizing the complexity of this finding. This complexity is also apparent when we consider the form of the city, even if a polycentric structure seems to result in lower energy consumption by traffic. This scholar shows, for example, that the larger the city the longer individuals' journeys, but the size of the city does not seem to have a direct effect on modal choice.

From the above review, there has have been numerous studies on modelling inter urban trip generation and attraction particularly in developed countries. However, the need for continuous studies on the travel behaviors and search for explanation on the observable inter-urban travel generation and pattern existing in many developing countries still requires further research especially in Nigeria. This is therefore an attempt to contribute to knowledge and underlying factors influencing inter-urban travel pattern and trip generation in Nigeria using Niger state as a case study.

Study area

Niger State is a state in Central Nigeria and is the state with the largest landmass in the country with total of 76,363 km^2. The state capital is Minna, and other major urban centres are Bida, Kontagora, and Suleja. It was created in 1976 along with Sokoto State, when it was carved out of the then North-Western State.

The State is named after the River Niger. Two of Nigeria's major hydroelectric power stations, the Kainji Dam and the Shiroro Dam, are located in Niger State. The famous Gurara Falls is in Niger State, and Gurara Local Government Area is named after the Gurara River, on whose course the fall is situated. Also situated the state is Kanji National Park, the largest National Park of Nigeria, which contains Kanji Lake, the Borgu Game Reserve and the Zugurma Game Reserve. Figure 1 shows the map of Niger State with locations of major urban centres.

The study towns in Niger state

Minna

Minna is the administrative Capital of Niger State, it has an estimated population of 350,000 as at 2006 (NPC, 2006). Minna is one of the fast developing urban centres in the north central Nigeria. Three homogenous residential densities of low, medium and high were recognized in Minna. These residential areas are characterized by social, economic and physical patterns. Being the administrative capital of Niger State, it attracts a lot of social and economic interactions from other major urban centres within the State and from other neighboring states in the country. Apart from being the administrative headquarters of Niger State, the City houses a Federal University of Technology, an Army formation, a College of Education, the administrative headquarters of National Examination Council (NECO) and Nigerian Airforce base. All these institutions are trip generating land uses which attract and generate trips within and outside the city.

Bida

Bida is the third largest city in Niger State with an estimated population of 171,656 people at 2006 (NPC, 2006). Its location is peculiar because it lies on the A124 highway connecting the south and the north of Nigeria, thus making it a major transit hub. Two major Federal

Institutions: The Federal Polytechnic and the Federal Medical Centre (FMC) are situated there, and Bida is home to the only Nursing School in Niger. The Town has an area of 512 km^2 and it is equally bounded by Gbako local government to the North, Lavun local government to the south, and Katcha local government to the west.

Suleja

Suleja is a city in Niger State with a population of 216,578 as at 2006 (NPC, 2006). It is sometimes confused with the nearby city of Abuja, due to its proximity, and the fact that it was originally called Abuja before the Nigerian government adopted the name from the then Emir Sulayman Barau for its new Federal Capital in 1976. It was established in the early 19th century by Mohammed Makau, the last Hausa emir of Zaria and his followers who were fleeing the Fulani jihadists engaged in the conquest of northern Nigeria.

METHODOLOGY

The cross-sectional survey research design was adopted for the purpose of data collection. Questionnaire was designed to collect data on inter urban travel behaviour and characteristics of public transport passengers. The information collected covered the conventional distance of the trip, the frequency of the trips, the estimated journey time, the fares paid, the purpose of the trip, and the type of vehicles used. To determine the sample size, the 2006 population census figures of each of three urban centres were obtained from the National Population Commission (NPC). The population figures are: Minna has 350,000, Suleja has 215,075 and Bida has 185,000 making a total of 745, 075 (NPC 2006). For the purpose of this study, these population figures were therefore projected into 2019 at growth rate of 3.2% which gave the following figures: Minna 492,100, Suleja 302,000 and Bida 260,700 making a total of 1,054800.
   Based on the above population, Yamane's (1967) formula for determining the sample size was applied to arrive at a total sample size of 400. Four hundred questionnaires were distributed to passengers at the public motor parks in Minna, Suleja and Bida to elicit the required information. A total of 186, 115 and 99 questionnaires were administered in Minna, Suleja and Bida respectively. To show spatial pattern of inter urban trip flow, a digital map of Niger State was produced with the aid of ArcGIS environment.   Regression analysis model was adopted for estimating inter urban trip generation of the study area.

RESULTS AND DISCUSSION

Inter urban travel pattern

Attempt is made here to analyze the flow pattern of inter urban trip generation in Niger State particularly among the three major urban centres studied. Table 1 and Figure 2 show the weekly inter urban flow of trip generation and attraction among the three towns.
   From Table 1, the largest trips are generated between Minna and Suleja. More people travel from Minna to

Suleja than any other towns in Niger State. The number of trips attracted to Minna from Suleja is also higher than ones from Bida. This indicates that the level of economic and social interactions between Minna and Suleja is far higher than what is existing between Minna and Bida. Figure 2 and 3 show the spatial pattern of trip generation and attraction between the three studied towns. The flow pattern shows a heavy inter urban trips between Minna and Suleja. It also shows that more trips generated from Minna to Suleja than trips generated from Suleja to Minna. This is not unconnected with higher population concentration in Minna and Suleja. Moreover, the proximity of Suleja Town to Abuja; the Federal Capital City could be a contributing factor to the level of inter urban travel noticed between Minna and Abuja.

Modelling inter urban trip flow determinants

Here, the study attempt to model the determinants of inters urban travel in Niger State; six independent variables were identified as probable determinants of the observable inter urban trip flow pattern in the State. The multiple regression analysis was used here for the purpose of modelling. The multiple regression models have been used severally in the literature to estimate degree of fitness and also forecast and determine the relationship between dependent variable and a number of independent variables. It can therefore be conceptualized that there is a set of variables x_1, x_2, x_3-----x_n which can be used to explain the inter urban trip flow among the urban centres in Niger State.
   This can be expressed mathematically as:

$$Y = f (X_1, X_2, X_3\text{-------}Xn) \tag{1}$$

As a result, the equation can be written using multiple regression equation thus;

$$Y = a + b_1x_1 + b_2x_{2} + b_3x_3 + bnxn + e \tag{2}$$

Where the dependent variable; a = constant; b1, b2, b3------bn = the intercept; x1, x2, x3, ------- xn = the dependent variables, and e = error term (unexplained variables)
   In this study, Y which is the dependent variable is the inter urban trip flow among the three major towns of study in Niger State denoted as (ITF). The following have been identified as independent variables:

X_1 is the travel distance measured in kilometre denoted as (TD).
X_2 Travel time is measured in minutesdenoted as (TT).
X_3 Population measured in number of people living in each town denoted as (PP)
X_4 Public Institution measured by the number of establishments of higher educational institutions found in each town denoted as (PI)
X_5 Fare charged is measured in naira (Nigerian national
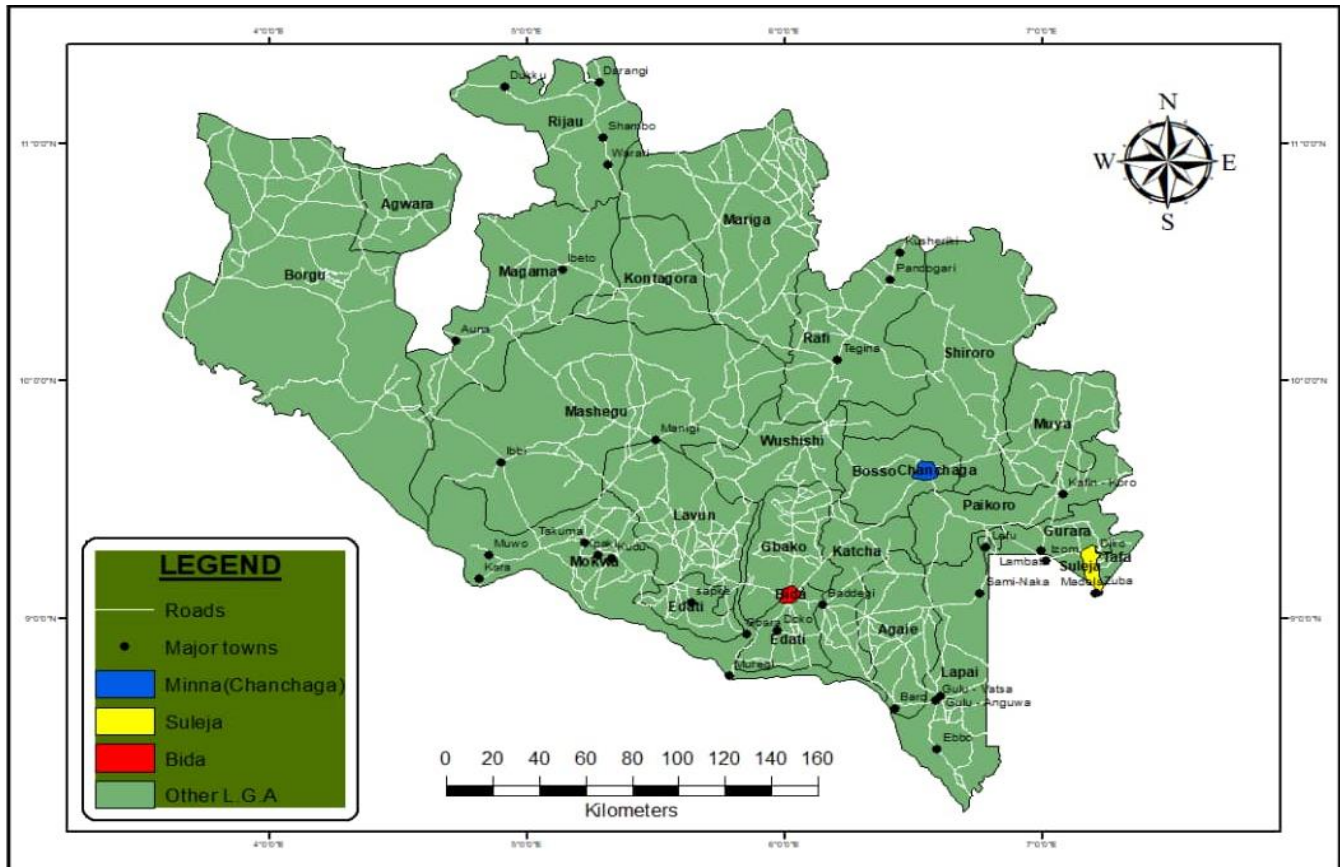
Figure 1. Map showing selected towns in the context of Niger State.
Source: Adapted from administrative map of Niger State (2019).

Table 1. Inter-urban travel generation and attraction in Niger State.

Towns	Route	Weekly inter-urban trip flow	Percentage
Minna	Minna - Suleja	5388	48.31
Suleja	Suleja - Minna	3183	28.54
Bida	Bida- Minna	2583	23.16
Total		**11154**	**100**

Source: Ojekunle et al. (2019)

currency) denoted as (FC)

The above variables are hereby operationalized as;

$$ITF = a + b_1TD_1 + B2TT_2 + b_3PP_3 + B_4PI_4 + b_5FC_5 + e \quad (3)$$

However, the first step taken in modelling inters urban trip generation and attraction is to carry out correlation analysis of both dependent and independent variables. Table 2 shows the correlation matrix of both dependent and independent variables. It is revealed that all the independent variables are highly correlated with dependent variables; none of them has less than 65%

correlation coefficient. The population of each town (PP) has the highest correlation with inter urban trip flow (ITF) which implies that interactions between settlements is a function of population size., while the travel distance has the least of 66.5% correlation coefficient. The table also reveals that there is high level of multi collinearity among independent variables. The least correlation coefficient is recorded between fare charged (FC) and public institution (PI). However, in modelling trip flow and generation multi-collinearity is not considered as a problem as long as the scenario continues into the future.

Another remarkable thing one could notice from Table
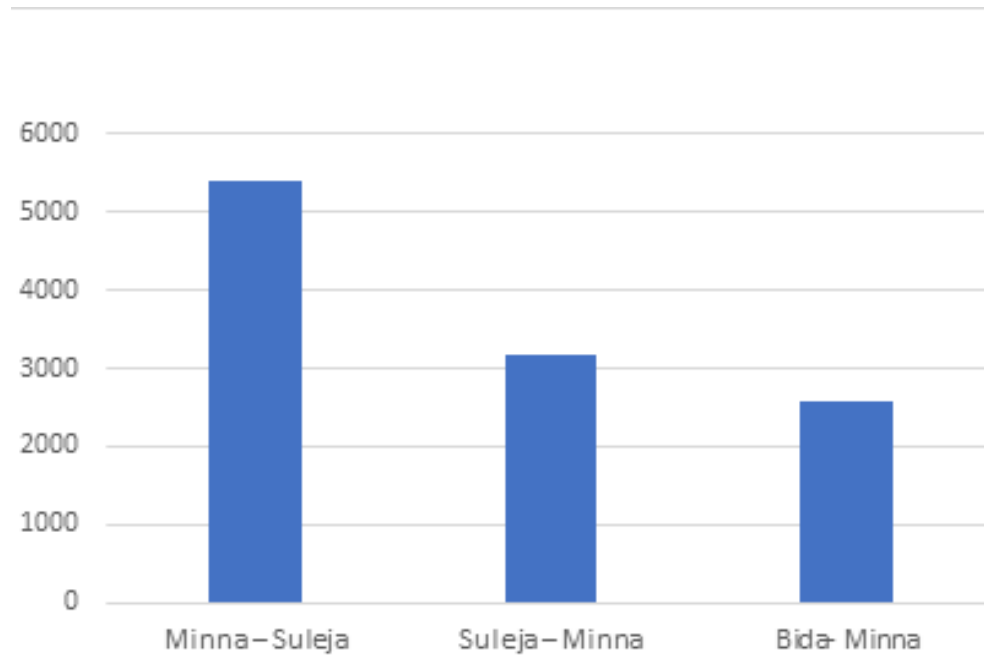
Figure 2. Inter-urban travel between towns in Niger State.
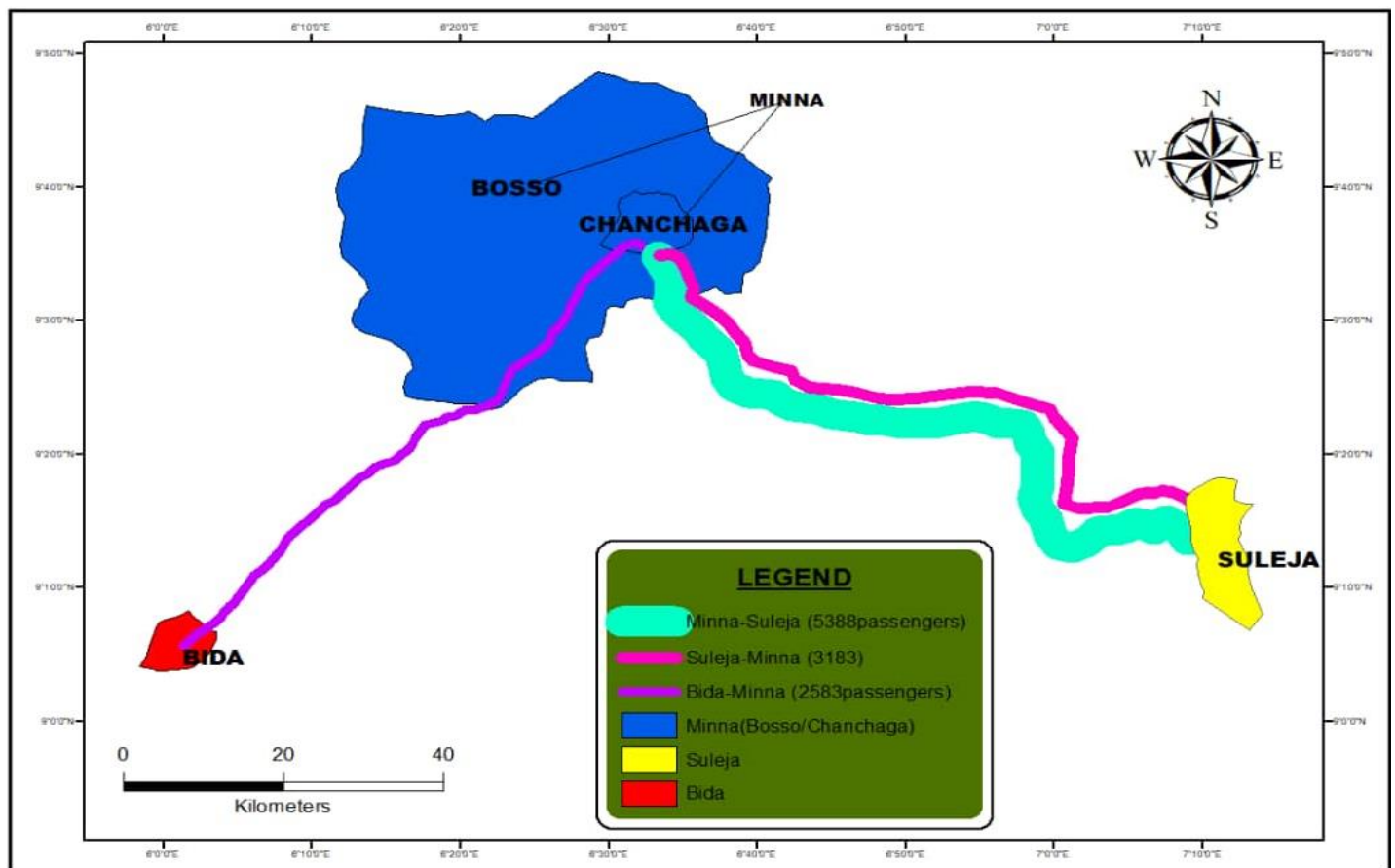
Figure 3. Inter urban trip flow pattern in Niger State.
Source: Ojekunle et al. (2019)

Table 2. Correlation analysis of dependent and independent variables.

Variable	1TF	TD	TT	PP	PI	FC
ITF	1					.
TD	.665	1				
TT	.730	.996	1			
PP	.999[*]	.638	.706	1		
PI	.979	.500	.577	.986	1	
FC	.695	.999[*]	.999[*]	.669	.535	1

ITF= Inter Urban Trip Flow, TD =Travel Distance, TT =Travel Time, PP =Population and PI =Public Institution and FC = Fare Charged.
Source; Computer Output from SPSS (2019).

Table 3. Regression coefficients[a].

Model		Unstandardized coefficients		Standardized coefficients	t	Sig.
		B	**Std. error**	**Beta**		
1	(Constant)	-488.441	156.182		-3.127	.197
	Population	0.017	0.001	0.999	28.017	.023
2	(Constant)	-793.803	0.000		.	.
	Population	0.016	0.000	0.967	.	.
	Foco	0.717	0.000	0.048	.	.

[a]Dependent Variable Source: Computer Output from SPSS (2019).

Table 4. Model summary.

Model	R	R Square	Adjusted R square	Std. error of the estimate
1	0.999[a]	0.999	0.997	74.510
2	1.000[b]	1.000	.	.

[a]Predictors: (Constant), population (PP); [b]Predictors: (Constant), population (FC).
Source: Computer Output from SPSS

2 is that all the independent variables are positively related to dependent variable, which implies that as dependent variable increases the independent variables also increase. Also, all independent variables are positively related to one another, which imply that they all increase or decrease together at the same time.

Regression output and interpretation

A multiple stepwise regression model was adopted for identifying the key determinant of inter urban trip flow in the study area. The stepwise regression is useful because it helps to eliminate redundant variables especially when it was discovered there was a high level of multi collinearity among the six variables. Table 3 only two variables actually entered the stepwise regression model namely; Population of each town (PP) and the

Fare charged (FC). The table shows the regression coefficient of two independent variables and their level of significance. It shows the regression coefficient for the independent variables and the constant term in the second column labelled "B". The column shows a constant term (a) of-793.803, PP is.016 and FC is.717.

The least squares equation for predicting inter urban travel flow pattern among the towns in Niger State = -488441+ .016 (Population) + 717 (Fare Charged).

Table 4 shows the model summary, the computation of the coefficient of determination (R-square) shows that the strength of the relationship (R-square) for model 'a' is .999. This implies that population alone accounts for 99.9% of the variation in the flow of inter urban trips between and among the urban centres in the State.

The second model 'b' shows that two variables, that is, population (PP) and fare charged (FC) account for 100% of the inter urban trip generation and attraction among
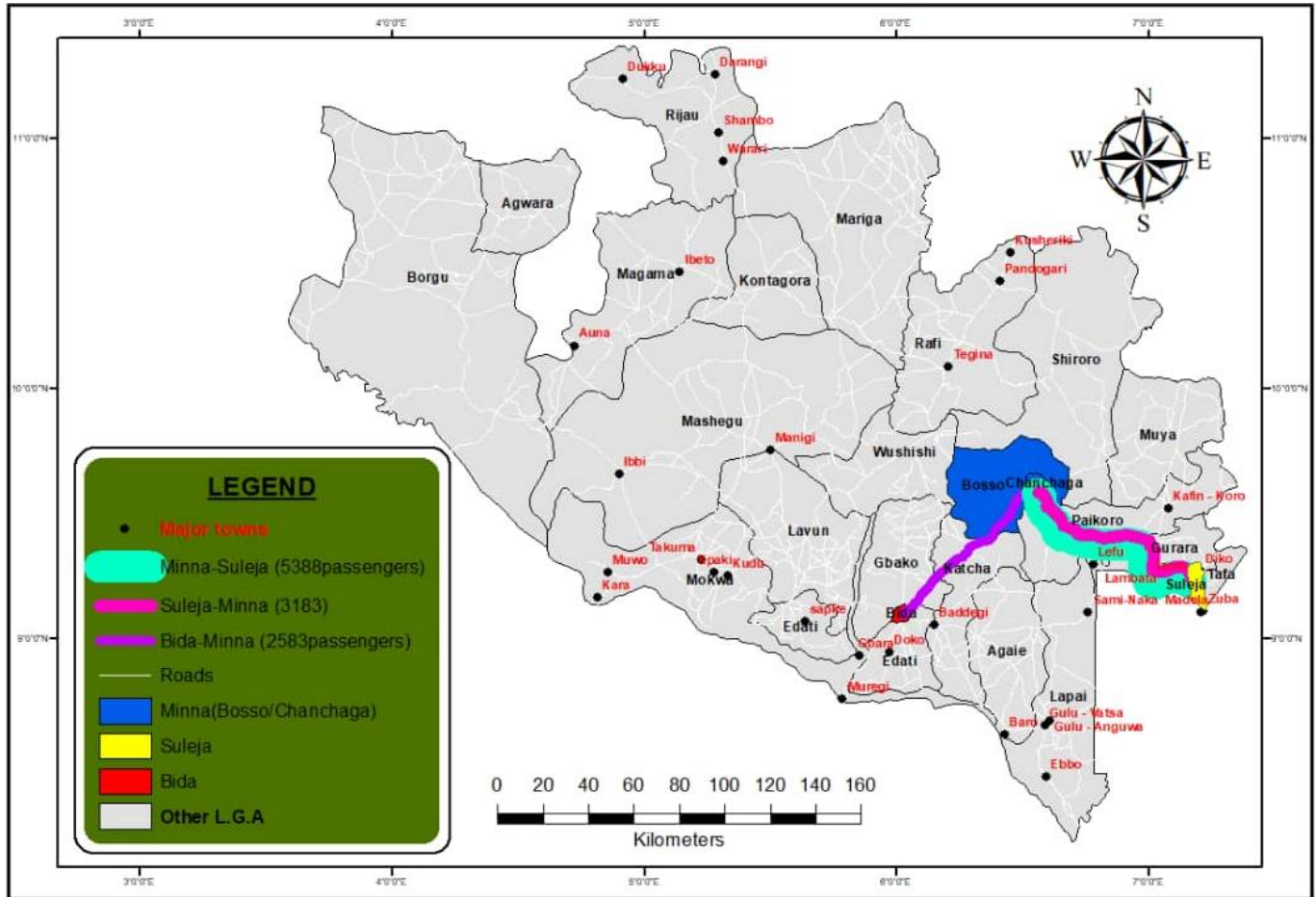
Figure 4. Spatial pattern of inter urban travel flow in Niger State
Source: Ojekunle et al. (2019)

the three towns in the State. One can therefore conclude that population and cost of transportation are the key determinants for the flow of inter urban trips generated and attracted in Niger State Figure 4.

Conclusion

The study attempts to find explanations for the pattern of inter urban trip flow in Niger State and develop a model that can be useful in estimating inter urban travels in the State. From the results of analyses, it is discovered that population of each town and cost of travel are the key determinants for estimating trips generation and attraction among major towns in Niger State and Minna and Suleja is the most trip generating and attracting urban centres in the State. The above findings therefore no doubt have implications for regional transportation planning of Niger State. The study covered only three towns due to limited financial resources, it is hoped the future research efforts will be expanded to cover other towns in the State and country.

Recommendations

Based on the above findings and conclusion, the following recommendations are hereby made;

1. Provision of adequate and efficient public transport system for inter-city travelers should be made by Niger State government through Niger State Transport Authority (NSTA) directly or indirectly with strong alliance with other public transport operators. Furthermore, the Niger State Transport Authority (NSTA) needs to redirect its services to inter-urban routes within Niger State instead of focusing only on inter-state services.
2. A special attention should be given to Minna-Suleja route, since the route has the highest inter-urban travel in the State. The public transport services along the route should be improved upon both in term of quality and quantity to meet the growing demand.
3. It is equally important to keep the fare (that is, cost of travel) as low as possible because it is discovered that travel cost plays a key role in inter-urban travel in the State.

4. Furthermore, it is important that the State Government should embark on more comprehensive regional transportation planning in the state so that future inter urban mobility need of the people can be guaranteed.

5. Finally, a further search is necessary to cover other towns like: Kontagora, Mokwa, Borgu and Kainji in the state in order to further establish the reliability and validity of the model.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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The impact of Rural Enterprise Development Hub (RED Hub) project on beneficiaries maize yield in Mqanduli, South Africa

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The study analysed the impact of Rural Enterprise Development Hub (RED Hub) Project on maize yield of beneficiaries. Out of a total of 398 beneficiaries, 200 maize farmers were sampled using the Cochran sample size formula followed by convenience sampling at the second stage. With the use of a 'before' and 'after' approach, a survey was conducted using structured questionnaires which were administered on the beneficiaries of the project in Mquanduli community within the 9 villages of the community. Descriptive and inferential statistics were used to analyze the data. It was established that, a P-value of less than 0.05 was statistically significant. The study revealed a significant average annual yield increase of maize farmers who benefitted in the project from 1,003 to 1,891 kg with an increase of 88.53% on hectare basis (t = 100.3 and p <0.05). Also, there was an average increase in annual yield from 1,976 to 4,351 kg which was significant with an increase of 120.19% per maize farm (t = 32.7 and p<0.05 p-value). Determinants of increase in maize productivity were identified using regression analytical technique; They were fertilizer (t = -4.46 and p <0.05), seedling (t = 4.47 and p<0.05) and capital (t = 4.35 and p<0.05). The study recommends sustained subsidy and direct delivery of productive inputs to beneficiary farmers and additional provision to accommodate more maize farmers in Mqanduli.

Key words: Rural, yield, beneficiaries, farmers, community.

INTRODUCTION

Maize production in South Africa mostly subsistence-oriented was carried out using several farming systems. Most of these maize farmers are emerging medium/large scale commercial farmers. One of the characteristics of maize farming in South Africa is low yields regardless of the size of the farm. These account for high unit costs which lead to low returns (Iortyom et al., 2019, 2018; Trefry et al., 2014).

According to Matlou et al. (2017), the largest locally produced field crop and the most important source of

carbohydrates in the Southern African Community (SADC) region which is widely consumed by both animals and human beings is maize. It is also a major diet for both urban and rural areas in South Africa (ARC-LNR, 2016). Maize occupies a central position in the country's strategy for food security with other food options like potatoes and sugarcane. Commodity value chain agents earn income through maize; the chain includes farmers' households, produce buyers, processors, exporters and transporters. From the view point of food security and income generation, the importance of maize cannot be over emphasized (Smit, 2016).

Over the years, the South African Government has launched and implemented programs to boost agricultural productivity and to address the cycle of hunger and poverty. These programs were initiated by the national government and stepped down by provincial governments to suit the specific needs of the rural populace at the grass-root level (Obadire et al., 2014). One of these programs, the Comprehensive Rural Development Programme (CRDP) was launched in 2009 at Muyexe village, in Limpopo Province by the President of South Africa, Jacob Zuma.

In 2012, two years after the launch of CRDP the government of Eastern Cape Provincial in South Africa launched the Rural Enterprise Development Hub Project shortened as RED Hub Project aimed at increasing primary production activities, processing and marketing those products within the rural communities (Iortyom et al., 2019). The RED Hub project model makes it possible for rural economic activities to thrive through the facilitation of basic grains like maize, sorghum and soyabean resulting in increased rural incomes (Iortyom et al., 2019; Qongyo, 2015). The sum of R91 million over three years was allocated to ECRDA and ECDC for the implementation of the project by the Development Bank of Southern Africa (DBSA) (Inkqubela, 2015). The cost of the primary production is jointly funded with 75 and 25% from ECRDA and farmer contributions, respectively. The Development Bank of Southern Africa (DBSA) through its Jobs Fund agro-processing initiative, the RED Hub Project supported the financing and implementation of maize production, processing and marketing all within a community to generate income for beneficiaries and improve their livelihood (ECRDA, 2013/2014). The project was initially to be implemented for three years, from 2013 to 2015 but the funding has been extended to 2016.

The strategy of the RED Hub project is hinged on Community-Driven Development (CDD) which gives ownership of the project and decision making to the beneficiaries. CDD alludes more to the way a strategy or an undertaking is planned and executed than to the substance of an approach or to the parts of a venture task or program (International Fund for Agricultural Development-IFAD, 2009). CDD took the stage as a response to the failures of earlier programs in South Africa which were aimed at alleviating poverty. These include lending to agricultural institutions and integrated development programs for a geographical area. CDD is a strategy that encourages community groups to be incharge of their development in terms of decisions making and implementation (Iortyom et al., 2019).

Reviews of some extant aforementioned research studies (Baird et al., 2009; Binswanger et al., 2012; Dongier et al., 2003; Kwadwo and Peter, 2012; World Bank, 2013; Obadire et al., 2014; Iortyom et al., 2019) show that the evaluation of any Community-Driven Developmental (CDD) program is relevant, whether it is funded by internationally donor organizations, national or provincial governments. Similarly, the study fills a gap that is important in the body of existing literature by critically assessing the effectiveness of the government of the Eastern Cape Province designed Rural Enterprise Development Hub project in the attainment of improvement in maize production, processing and marketing. This study also provided understanding on how significant and impactful the project has affected maize production on the achievement of poverty reduction among subsistence farmers in the study area.

MATERIALS AND METHODS

This study was carried out in Mqanduli Community. The community is located 30 km South of Mthatha and 22 km North of Elliotadle with the Eastern Cape Province, South Africa (Iortyom et al., 2018; Iortyom et al., 2019). Mqanduli was created in 1876 and is located between latitudes 31°49'9'' South and longitude 28°46'42'' East (Figure 1). It is 752 m above sea level. The settlements in the area have large uneven and low levels of services. However, some settlements, especially in the heart of Mqanduli, along the major route from Vigesville to Coffee Bay, have rural service nodes with community facilities as a result of recent development within the area. The population density is 268.05/km^2 with a percentage increase of +1.15% per year (DRLR, 2015; StatsSA, 2017).

The data used to compare the economic status of beneficiaries before and after the intervention of Rural Enterprise Development Hub Project included; increase in income and profit of maize farmers. This was determined by the means, averages, and percentage changes before and after the project intervention. Comparison between yields of beneficiaries before and after the intervention of the RED Project was analysed using SPSS Version 21. Descriptive statistics, graphs, mean, standard deviation, confidence level, paired wise t-statistics and percentages were used to show the variance in farmers' income before and after the project intervention. All the beneficiaries of the Rural Enterprise Development Hub Project in the nine participating villages at Mqanduli were part of the survey. The economy of Mqanduli is driven by mainly agricultural enterprise comprising maize farming (Statistics South Africa, 2017).

Multistage sampling technique was used to select respondents used for the study. To statistically get the required sample, Cochran sample size formula (Cochran, 1977) was used to get the sample of 200 respondents from 398 farmers who benefitted from the project at a confidence level of 95% with 5% margin of error in the first stage (Iortyom et al., 2018). This sampling formula was used in corresponding studies by Assenga and Kayunze (2016), Pindiriri et al. (2016), Sharoni et al. (2016), Shoja and Choolandimi (2016), Tesfahunegn et al. (2016), Israr et al. (2017) and Iortyom et al. (2019). The Cochran sample size formula is shown below:
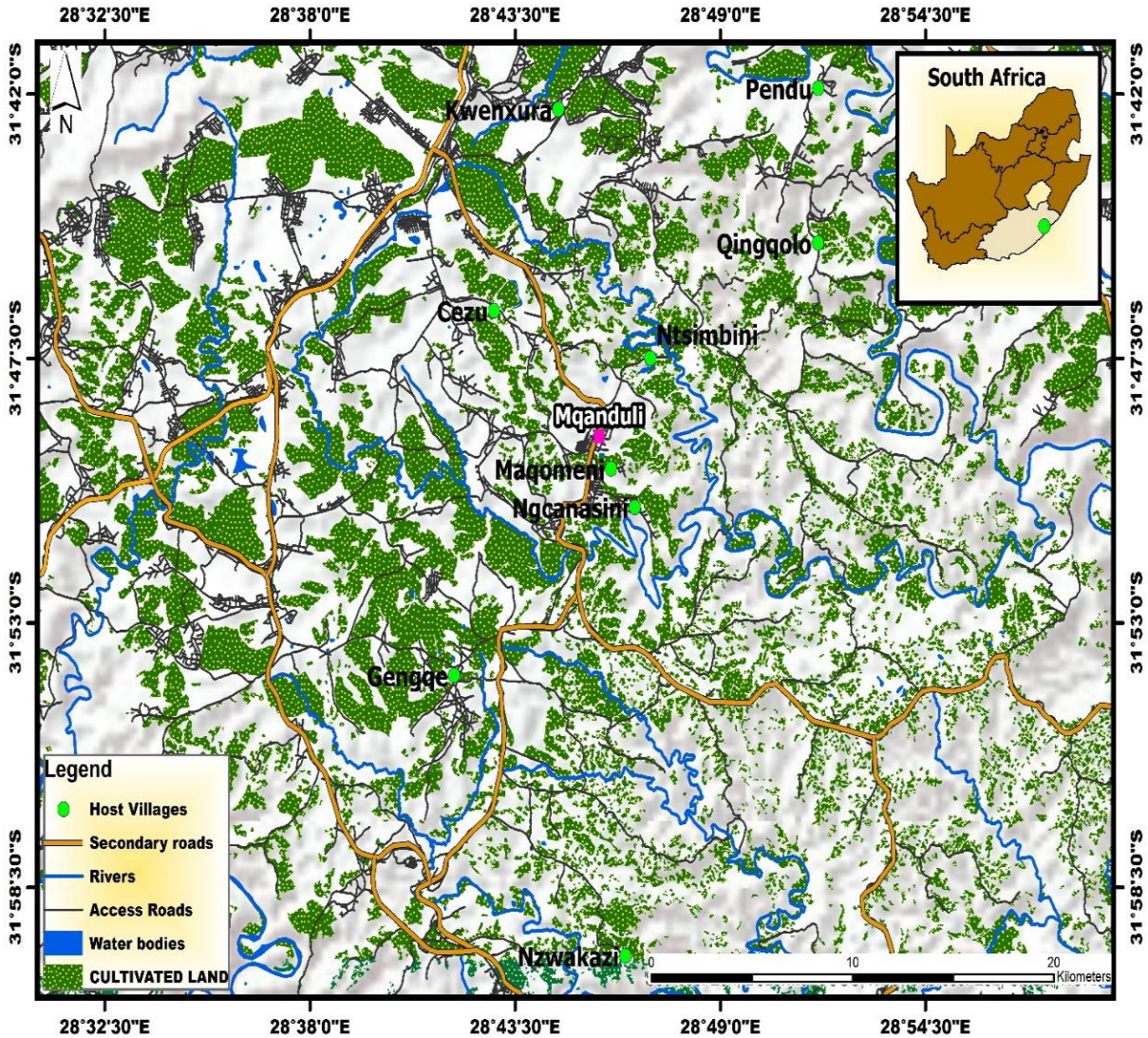
Figure 1. Map of Mqanduli showing RED Hub Project benefitting villages.

$$\text{Sample size} = \frac{\frac{z^2 \times p(1-p)}{e^2}}{1 + (\frac{z^2 \times p(1-p)}{e^2 N})}$$

Where Population = N; Q = the complement of p (proportion); Margin of error = e; Z-Score (Standard Score) = Z; Convenience sampling was done at the second stage to determine the number of maize farmers in various villages who benefitted from RED Hub Project (Iortyom et al., 2018; Iortyom et al., 2019). Convenience sampling is a type of non-probability or non-random sampling where members of the target population that meet certain practical criteria, such as easy accessibility, geographical proximity, availability at a given time, or the willingness to participate are included for the purpose of a study (Etikan et al., 2016).

These villages and the number of respondents were; Ntsimbini-21; Khwenxura-26; Qhingqolo-21; Phendu-16; Cezu-21; Ngcanasini-36; Magomeni-16; Gengqe-22; and Nzwakazi-21. There is variance in the number of respondents as a result of more beneficiaries of

RED Hub Project in some villages than others and also the number of participants was based on the response of beneficiaries to the invitation for the exercise. Correspondingly, Oladoja and Adeokun (2009) used the same approach to get the required sample for their study on the performance of the National Fadama Development Project in Ogun State. A pre-tested structured interview questionnaire was tested for reliability, to ascertain if the content of the questionnaire is not above the level of the respondents before it was finally administered on the sampled population. Data collected were analysed with SPSS Statistics version 21. Mean ($\bar{x}$), Averages, Frequency Counts and Simple Percentages, Chi-square (x^2), p-value based on paired wise t-test, and regression statistics were used to discuss the results from the analysis. Based on the adopted impact evaluation model of the Before and After project intervention, the t-test was used to compare the levels of availability of benefits before and after the project. Where there was a significant difference in the p-value of less than 0.05 of the availability of benefits after the project, the benefits were interpreted as the positive impact of the project. Where there was a p-value greater than 0.05 of availability of benefit after the project, it was

interpreted as a negative impact.

RESULTS AND DISCUSSION

Socio-demographic and economic characteristics of respondents

The socio-economic and demographic variables for this study are presented in Table 1. In all, the majority of the beneficiaries out of 200 respondents are females (67%), while 33% are males. Gender analysis and its importance in this study have been classified by Oladoja and Adeokun (2009). It was also observed that beneficiaries between 36-60 years dominate the project as they constitute 83% of the entire respondents. The implication of this finding is in agreement with Osondu et al. (2015) who reported that most of the respondents are judged to be responsible and in their active and productive ages characterized with strength and commitment. The low number of those below 35 years (7%) indicates that the young adults are not intensively involved in the project; this also includes those who are 60 years (10%) and above. This is also observed in a study carried out by Olaolu et al. (2015).

The marital status of the sampled respondents indicates that about 134 (67%) of them are married and living together as a family. This result validates the view which upholds that marriage institution is still appreciated and an indication of financial responsibility of caring for dependent relatives by the respondents (Oladoja and Adeokun, 2009). This is contrary to the claim by Babatope (2016) that adults in the Eastern Cape Province avoid marriage to avoid marital responsibilities. Forty-eight (24%) are widowed and separated, while 18 (9%) are single with an insignificant number of respondents participating in the project. This implies that, apart from the large number of adults benefitting from the project, the youths are not well represented in RED Hub project.

Majority of the beneficiaries (96) representing 48% had no formal education. This has great implications on the implementation of the RED Hub project in the area as most of the illiterates perceived the project as being more of an embodiment of paperwork. According to Ogwumike (2000), and Iortyom et al. (2020), lower levels of education are associated with higher rates of poverty. The study also revealed that most of the households are headed by women and 159 (79.5%) households' family size range between 4-6 persons. Household income of beneficiaries is also derived from other sources. The average income of the beneficiaries before the project intervention is R1, 411.9.

These additional incomes are from other sources like social grants, loans and dividends from other investments. This implies that the beneficiary maize farmers are not depending on RED Hub project to meet their daily needs. This finding supports the claim by Ahmad and Abubakar (2016), Olaolu et al. (2015) and

Oladoja and Adeokun (2009) that most farmers engage in other farm and non-farm enterprises to supplement incomes they get from their primary farm enterprises. Although the average household income for Eastern Cape is R6, 400 as reported in Statistics South Africa 2012, it is believed that this figure is a true estimate of the household monthly income when interpreted alongside the major sources of income where a substantial percentage of the population live on social grants which fall within the income range.

On farming experience, a good number of farmers have more than 15 years of farming experience. This implies that most of the maize farmers have been into farming long before the intervention of RED Hub project. Nwalieji (2016) stated that seasoned experience in farming is very important and essential in farm productivity because it is a factor for fast adaptability of farm innovations. The number of years a farmer has spent in farming is a pointer to the fact that he/she has gained practical knowledge on how to manage their production activities since well-experienced farmers are better risk managers than the inexperienced ones (Onyekuru, 2008). When properly channelled, the experience can lead to higher efficiency, higher productivity, higher incomes and a higher standard of living for the farmer, her family, community and the nation. Adebayo (2014) also observed that the longer a person stays on a particular job, the better the job performance tends to be. However, the experience can sometimes become a limiting factor to production improvement as farmers become set in their ways and refuse to change and take advantage of new ideas on production. In conclusion, while the experience is a necessary condition for productivity improvement, it is however not a sufficient condition. Farmers with years of experience in farming should also watch out for innovations that can improve their productivity (Atagher, 2013).

Impact of RED Hub project on maize yield per hectare and farm

The study revealed that the project had impacted positively on the yield of the maize farmers beneficiaries as shown in Tables 2 and 3, respectively. This further explains that the intervention of the project has resulted in an increase in yield of maize farmers per hectare, per farm (Tables 2 and 3).

Table 2 shows that the mean yield/ha for Ntsimbini village before the project was 951 and 1,883.5kg after RED hub project intervention with a percentage of 98.05%. Khwenxura village was 1,023.5 and 1,933.5 per hectare before and after the project respectively with 85.83% percent change. Qhingqolo village was 1,018.5 and 1,902.5 kg before and after the project having 86.79% change. Phendu village was 969 and 1,863 kg before and after the project with 92.78% change. For Cezu village, it was 966 and 1,885 kg before and after

Table 1. Socio-demographic characteristics of respondents.

Variables	All beneficiaries (n=200)	Male (n=66)	Female (n=134)
Age (Years)			
35 and below	14 (7.0)	12 (85.7)	2 (14.3)
36-60	166 (83.0)	43 (25.9)	123 (74.1)
Above 60	20 (10.0)	11 (55.0)	9 (45.0)
Education			
No formal education	96 (48.0)	26 (39.4)	70 (52.2)
Primary	101(50.5)	37 (56.1)	64 (47.8)
Matric	2 (1.0)	2 (3.0)	0 (0.0)
Higher education	1 (0.5)	1 (1.5)	0 (0.0)
Village			
Ntsimbini	21(10.5)	6 (9.1)	15 (11.2)
Khwenxura	26 (13.0)	8 (12.1)	18 (13.4)
Qhingqolo	21 (10.5)	7 (10.6)	14 (10.4)
Phendu	16 (8.0)	6 (9.1)	10 (7.5)
Cezu	21 (10.5)	7 (10.6)	14 (10.4)
Ngcanasini	36 (18.0)	14 (21.2)	22 (16.4)
Maqomeni	16 (8.0)	6 (9.1)	10 (7.5)
Gengqe	22 (11.0)	6 (9.1)	16 (11.9)
Nzwakazi	21 (9.1)	6 (9.1)	15 (11.2)
Marital status			
Single	18 (9.0)	12 (18.2)	6 (4.5)
Married	134 (67.0)	53 (80.3)	81 (60.4)
Widowed/separated	48 (24.0)	1 (1.5)	47 (35.1)
Household head	200 (100)	66 (33.0)	134 (67.0)
Number of dependents			
0-2	12 (6.0)	4 (6.0)	8 (6.0)
3-5	159 (79.5)	55 (83.4)	104 (77.7)
6-10	29 (14.5)	7 (10.6)	22 (16.3)
Family size			
0-3	11 (5.5)	4 (6.0)	7 (5.2)
4-6	159 (79.5)	55 (83.4)	104 (77.7)
7-10	30 (15)	7 (10.6)	23 (17.1)
Household income (R)			
1000 and below	24 (12.0)	11 (45.8)	13 (54.2)
1001-2000	173 (86.5)	54 (31.2)	119 (68.8)
2001-3000	3 (1.5)	1 (33.3)	2 (66.7)
Housing type			
Owned	200	66 (33.0)	134 (67.0)
Years of farming			
15 years and below	24 (12.0)	17 (70.8)	7 (29.2)
16-35	135 (72.5)	33 (24.4)	102 (75.6)
36-55	41 (20.5)	16 (39.0)	25 (61.0)

Source: Field survey.

Table 2. Changes in annual yield/Ha (kg).

Village	Annual yield (kg/ha) before x̄ (SD)	Annual yield (kg/ha) after x̄ (SD)	Mean difference (CI)	T statistics	P-value	Percentage change in yield/ha (kg)
Ntsimbini	951(2.39)	1,833.5 (0.83)	882.5(17.53-19.77)	34.85	0.000	98.05
Khwenxura	1,023.5 (1.95)	1,902(0.20)	878.5 (16.76-18.37)	44.81	0.000	85.83
Qhingqolo	1,018.5 (3.18)	1,902.5 (0.22)	134.5 (16.23-19.13)	25.48	0.000	86.79
Phendu	969 (1.30)	1,868(0.45)	899(17.3-18.6)	58.1	0.000	92.78
Cezu	966 (1.67)	1,885 (0.74)	919(17.6-19.2)	49.1	0.000	95.13
Ngcanasini	975.5 (1.56)	1863(0.22)	905 (17.2-18.2)	72.0	0.000	90.98
Maqomeni	908.5 (0.43)	1,910 (0.68)	1,001.5(19.6-20.6)	88.2	0.000	110.46
Gengqe	1,116 (3.44)	1,916.5(0.62)	800(14.4-17.6)	21.0	0.000	71.73
Nzwakazi	1,078.5 (2.89)	1,900 (0.60)	820 (15.1-17.7)	26.0	0.000	76.17
All Villages	1,003 (2.53)	1,891(0.61)	890(17.4-18.1)	100.3	0.000	88.53

t-test statistics. P value <0.05; 0.000 = Significant.
Source: Field survey.

Table 3. Changes in annual yield per farm (kg).

Village	Annual yield per farm in kg before x̄ (SD)	Annual yield per farm in kg after x̄ (SD)	Mean difference (CI)	T statistics	p-value	Percentage change of yield per farm in kg
Ntsimbini	2,252.5(10.12)	5,335.5(23.55)	3,083(52.7-70.6)	14.3	0.000	136.87
Khwenxura	2,213.5 (5.70)	5,923 (12.11)	3,709.5 (68.6-79.8)	27.3	0.000	167.45
Qhingqolo	1,274(9.82)	2,357 (11.67)	1,083(19.3-24.1)	18.8	0.000	85.01
Phendu	2,225 (2.00)	4,703 (5.56)	2,478(46.8-52.4)	37.6	0.000	111.37
Cezu	2,445.5 (7.96)	5,474 (16.50)	3,028.5(53.9-67.3)	18.9	0.000	123.80
Ngcanasini	2,197(2.60)	4,708.5 (2.89)	2,511.5(48.8-51.6)	72.8	0.000	114.31
Maqomeni	2,056.5 (5.24)	4,669(8.18)	2,612.5 (48.0-56.5)	25.9	0.000	127.04
Gengqe	1,580(9.81)	3,047.5 (9.29)	1,467.5(24.5-34.2)	12.6	0.000	92.88
Nzwakazi	1,421.5 (8.96)	2,533.5(9.18)	1,112(19.8-24.7)	18.7	0.000	78.23
All Villages	1,976(10.68)	4,351 (27.64)	2,375(44.6-50.4)	32.7	0.000	120.19

t-test statistics. P value <0.05; 0.000 = Significant.
Source: Field survey.

the project with 95.13% change; for Ngcanasini village, it was 975.5 and 1,863 kg before and after the project intervention, respectively with 90.98% change. Maqomeni village had 908.5 kg before and 1,910 kg after the project with 110.46% change. Gengqe village had 1,116 kg and 1,916.5 kg before and after the project with 71.73% change, while Nzwakazi village had 1, 7078.5 and 1,900 kg before and after the project intervention, respectively with a percentage change of 76.17%. The mean for all the villages shows that 1,003 and 1,891 kg are for before and after the project intervention with a percentage change of 88.53% per hectare. All the villages had a statistical p<0.05 which indicates that the change in annual yield of maize yield per hectare was significant.

It was observed that the level of farm yield of maize farmers before the project intervention was low. After the project intervention, their farm yield on maize production

was high. The mean annual yield per farm from Table 3 indicates that Ntsimbini village was 2,252.5 and 5,335.5 kg with 136.87% change before and after RED hub project intervention. Khwenxura village was 2,213.5 and 5,923 kg before and after the project with a percentage change of 167.45%. Qhingqolo village was 1,274 and 2,357 kg with 85.01% change before and after the project intervention. Phendu village was 2,225 and 4,703 kg respectively with 111.37% before and after the project intervention. Ngcanasini and Maqomeni villages had 2,197, 4,708.5, 2,056.5 and 4,669kg with percentage changes of 114.31 and 127.04%, respectively. Gengqe village was 1,580and 3,047.5 kg before and after the project with 92.88% change and Nzwakazi was 1,421.5 and 2,533.5 kg with 78.23% change, while the percentage change of annual yield in the entire study area is 120.19% with the mean annual yield of 1,976 and 4,351

Table 4. Determinants of maize yield.

Model parameter	Unstandardized coefficients		Standard coefficient	t Statistics	P-value
	B	Standard error	Beta		
Fertilizer X_1	-1.41	0.32	-11.80	-4.46	0.000
Pesticide X^2	-	-	-	-	-
Herbicide X^3	-	-	-	-	-
Insecticide X^4	-	-	-	-	-
Labour X^5	-	-	-	-	-
Capital X_6	0.02	0.005	11.52	4.35	0.000
Seedling X^7	9.516	2.18	11.56	4.47	0.000
Constant	38.63	0.14		269.10	0.000

t-test statistics. P value <0.05; 0.000 = Significant.
Source: Field survey (2017).

kg, respectively. The change in annual yield per farm for all the villages is statistically significant at p<0.05.

Determinants of maize farmers' productivity in the study area

Multiple regression analysis was used to ascertain the efficient use of inputs provided by beneficiaries. Regression analysis is a statistical technique for estimating the relationship among variables which have reason and result relation. The main focus of univariate regression is to analyze the relationship between a dependent variable/s and one independent variable and formulate the linear relation equation between dependent and independent variable/s (Uyanik and Guler, 2013). A P-value of less than 0.05 was considered to be statistically significant. Tables were used to present the results. The productivity of maize farming by beneficiaries of RED Hub Project in the study area is determined using a regression analytical technique.
The standard formula for multiple regression analysis is stated thus;

$$Y = a + b_1 x_1 + b_2 x_2 + b_3 x_3 + b_4 x_4 + b_5 x_5 + b_6 x_6 + e$$

Where: Y = Dependent variable (Yield); a = constant; b = constant coefficient for X; X_1 = Fertilizer (Kg); X_2 = Pesticide (Litre); X_3 = Herbicide (Litre); X_4 = Insecticide (Litre); X_5 = Labour (hours/ha); X_6 = Capital (Rand); X_7 = Seeds (kg); e = Standard error of coefficient

The centrality of efficiency in agricultural input/output has been widely recognised by researchers and policymakers alike (Shabu, 2013). It is established by the reports of Awoyemi et al. (2003) and Shabu (2013) that when farmers and agricultural processors do not make use of existing technology, their efforts at improving efficiency would be more cost-effective as compared to introducing technology as a means of ensuring production efficiency. On the other hand, Shehu and Mshella (2007)'s findings indicated that, since an increase in productivity is directly linked to production efficiency, it becomes necessary to raise the productivity of the farmers by supporting them to reduce inefficiencies in technology. According to the authors, such support could be rendered by investigating the farmers' status of resource productivity and efficiency.

Table 4 shows the factors that determine the productivity level achieved by the benefitting maize farmers in the study area after RED Hub intervention. Seven independent variables were entered into a regression model namely; fertilizer, the quantity of herbicides and pesticides, seeds, labour, and capital against the dependent variable (Maize yield). However, the result of this study as presented in Table 4 indicates that the major determinants that significantly contributed to the increase in maize yield are fertilizer seedling and capital with t-statistics and p-values of -4.46 and <0.05 for fertilizer, 4.47 and <0.05 for seedling and 4.35 and <0.05 for capital. This agrees with the postulation of Okechukwu (2015), Shabu (2013) and Awoyemi et al. (2003) that improved technologies have been central in raising yields. Such technologies could be high varieties of seed, chemical fertilizers, and modern farming techniques. These variables can therefore be exploited to improve the productivity level of beneficiaries of the project to further boost their economic status in the area. There is a need to encourage maize farmers to adopt the use of fertilizer, improved seedling and also make capital accessible to farmers which have the tendency of propelling maize production in the study area.

Conclusion

Rural Enterprise Development Hub is an applaudable intervention project which has adopted the direct input delivery to the beneficiaries to improve on their maize

production in Mqanduli as evidenced by the significant increase in maize yield. This has satisfied an aspect of the project of ensuring a sustainable increase of maize yield through the provision of productive inputs to the beneficiary maize farmers to boost maize production. This also reflects the ability of the project to encourage the communities to participate in the project for sustainable maize production. The study recommends sustained subsidy and direct delivery of productive inputs to beneficiary farmers and additional provision to accommodate more maize farmers in Mqanduli.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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Soil carbon dynamics in a humid tropical zone in SE Nigeria: Environmental influences and conservation prioritization

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Tropical landscapes are generally known to store much carbon in its varied ecosystems, but information required to prioritize and conserve areas with much soil carbon concentration is scanty. This study provides insight on the patterns of carbon storage and its dynamics in an extensive humid zone in SE Nigeria. Soil carbon data was downloaded from soil grids of 250 m carbon stocks for the first 30 cm of the soil profile and compared with the land use/cover, geology and digital elevation model of the region. Carbon estimates varied over the four epochs used and ranged from 29-177, 29-172, 12-172 and 4-177 tons/ha in 1992, 2001, 2010 and 2018, respectively. Even though land cover variation was quite distinct in the zone (between the northern zone with much cover and the southern zone with less), it was not seen as the major factor that influenced soil carbon in the zone. Much of the explanations on carbon concentration and variability were mainly from the geology of the zone which is categorized into six major classes. But three out of the categories were seen to dominate the carbon store: Ajali formation, Mamu formation and Nsukka formation. This exogenous factor (geology), which is not uniform, was seen as the major variable to consider in deciding areas that will be prioritized for carbon conservation in the zone. Proper land use strategies and policy frameworks that would help to maintain proper baselines and further enhance adequate carbon conservation were equally recommended.

Key words: Carbon management, conservation, land use change, modified ecosystems, prioritization, tropical.

INTRODUCTION

Preserving ecosystems across the globe especially in the current Anthropocene era are rife with environmental challenges and are imminent concern. This need is increasingly urgent as much of the world's landscapes have progressively been altered in various ways by human activities, with consequences such as habitat destruction, species extinction and modified biological communities (Pardo et al., 2018). This trend seems

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exacerbated by a growing human population whose demands and rising consumption demands lead to much pressure on ecosystems and furthermore contribute to the consequent degradation across the landscapes (Foley et al., 2005; Drescher et al., 2016). Though variable across spatial scales and biomes, this process of degradation has collectively affected much of the global land area (up to approximately 25%; FAO, 2011) and an undocumented array of their services and functions. Associated effects of such losses in ecosystem services especially carbon storage is really affected by the wide ranges of land use and its changes, since both the biodiversity and the soil of such zones (which act as carbon stores) become degraded.

Issues about carbon storage and its role in climate change mitigation are widely acknowledged and are of international concern (Sasaki and Putz, 2009; Mackey et al., 2013). Much of such efforts and inquiry on regulating climatic processes involving biogeochemical cycling and carbon storage have targeted tropical ecosystems due to their known capacity in achieving this (Saatchi et al., 2011; Lewis et al., 2013). Though tropical landscapes are at the epicentre of carbon sequestration, much of the strides on preserving and maximizing its carbon stores have been challenged by the ever-changing dynamics and modifications of the ecosystem. Indeed, tropical forest loss and degradation have grown in scale and magnitude over time and are considered a greater peril for global biodiversity than any other contemporary phenomenon (Pimm and Raven, 2000; Bradshaw et al., 2009). Such threats to tropical forest ecosystems have mainly emanated from activities in the region: agriculture and mining (Abood et al., 2015; Tyukavina et al., 2018), urbanization and other associated demands of increasing population in the region such as the need for more housing units and infrastructural developments. Though varied across scale within the region, these have contributed to altering the ecosystem such that as much as 500 million hectares of tropical forests are estimated to have been degraded as of 2009 (Asner et al., 2009). With an increase in degradation of landscape, ecosystem, habitat and land scales, tropical ecosystem services become more threatened and hence require concerted attention and management.

Efforts to conserve ecosystems have emphasized the use of protected areas and as much as about 15% of the earth's land surface areas are set aside as protected areas to protect endemic species and facilitate ecological functions (Watson et al., 2014; Liu et al., 2020). Across the tropics, protected areas were established to promote ecosystem conservation (IUCN, 1994; Ezebilo, 2013) and in many parts of the tropical landscape such as in Nigeria, this has focused on the preservation of the biodiversity of the ecosystem, with little or no attention on soil conservation. Omitting such a vital segment in carbon sequestration initiatives is not ideal and should be redressed. This need for adjustment in conservation is

deemed necessary since soil contains the largest pool of carbon in terrestrial ecosystems (Jobbagy and Jackson, 2000; Batjes, 2014); hence, by promoting its conservation and efficient use, more carbon could be sequestered. With such in mind, this work is focused on showing the soil carbon capacity of a wetland zone and the probable environmental factor or activity that defines its carbon concentration. Such initiative should help in achieving targeted carbon storage for the zone and the bulk of tropical landscapes where pressures and degradation that emanates from human encroachment and modifications are continually becoming a challenge.

## MATERIALS AND METHODS

Study area

The study region Anambra River drainage basin- is a vast wetland zone in south eastern Nigeria (Figure 1). It lies within a weakly cretaceous tertiary and quaternary sedimentary rock formation that is found mostly on lowlands and a crest that is dominantly made up of false bedded sandstone. The region is located within the humid tropics where mean annual rainfall varies between 1500 to 22500 mm. Temperature condition of the area is high with mean annual temperature range of 27 to 28°C and a peak of about 35°C between February and April (Monuanu, 1975).

The south eastern zone where the study area is located is a dense population zone with a small land area compared to other parts of Nigeria where land is much more abundant. As a result, the zone is put to much use and become degraded; though with variations between the urban and rural areas. Much of the rural landscape is suitably used for agricultural activities over the years and is seen as the main cause of degradation. The zone is a river basin with a dendritic drainage pattern and is characterized by many tributaries that flow in a south eastern direction that drains into the River Niger. Within the river channels in the zone, artisanal fishing activities are practiced and form a major source of livelihood for many households. Forest cover loss and degradation in the zone are driven by underlying and proximate drivers of forest loss as seen in tropical landscapes and no known conventional conservation is practiced.

Data acquisition, analysis and processing

The Landsat data were acquired from the National Aeronautics and Space Administration https://earthexplorer.usgs.gov/ while landuse/land cover image with a spatial resolution of 300 meters was obtained from the European Space Agency (https://www.esa-landcover-cci.org/). The soil carbon data were downloaded from https://www.soilgrids.org/ for four epochs: 1992, 2001, 2010 and 2018. This was used to verify the patterns of change or dynamics of carbon storage over the region under review. Landuse data obtained from https://www.esa-landcover-cci.org/ were subset for the study area with 2018 being the base year. Dynamics of land use/cover for the four epochs: 1992, 2001, 2010 and 2018 were equally provided to ascertain the patterns of change and the contribution of land use in carbon store. The dataset was reclassified using the ArcGIS Reclassify tool. Digital elevation model (DEM) was equally downloaded from https://earthexplorer.usgs.gov/ while the geology map of the study area was developed from the geology map of the region.

Soil grid of 250 m carbon stocks for the first 30 cm of the soil profile as the reference values for calculation was used. First 30cm
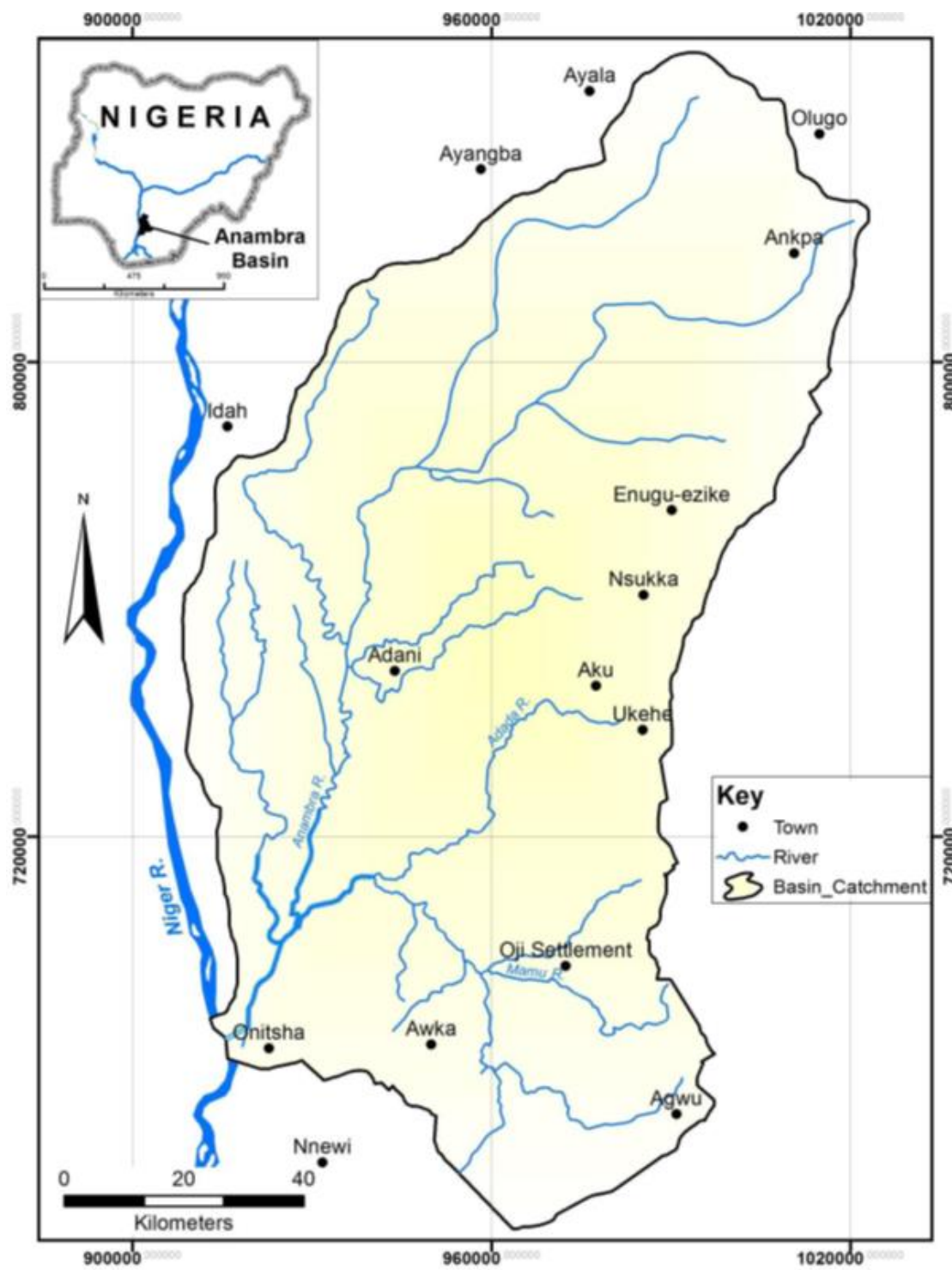
Figure 1. Anambra river drainage basin map with the map of Nigeria inset.

was used since it is where much carbon accumulation is found; hence it is a basic standard when assessing the changes in soil organic carbon in a location, a standard measurement in soil sampling for edaphic variables and is used extensively for such investigations (Marshall et al., 2012; Smith, 2014). To estimate the changes in land use, management and inputs as recommended by the carbon stocks, the carbon conversion coefficient for changes in Intergovernmental Panel Climate Change (IPCC) and the United Nations Convention to Combat Desertification (UNCCD) was adopted. However, spatially explicit information on management and carbon inputs is not available for most regions. As such, only land-use conversion coefficients were applied for estimating
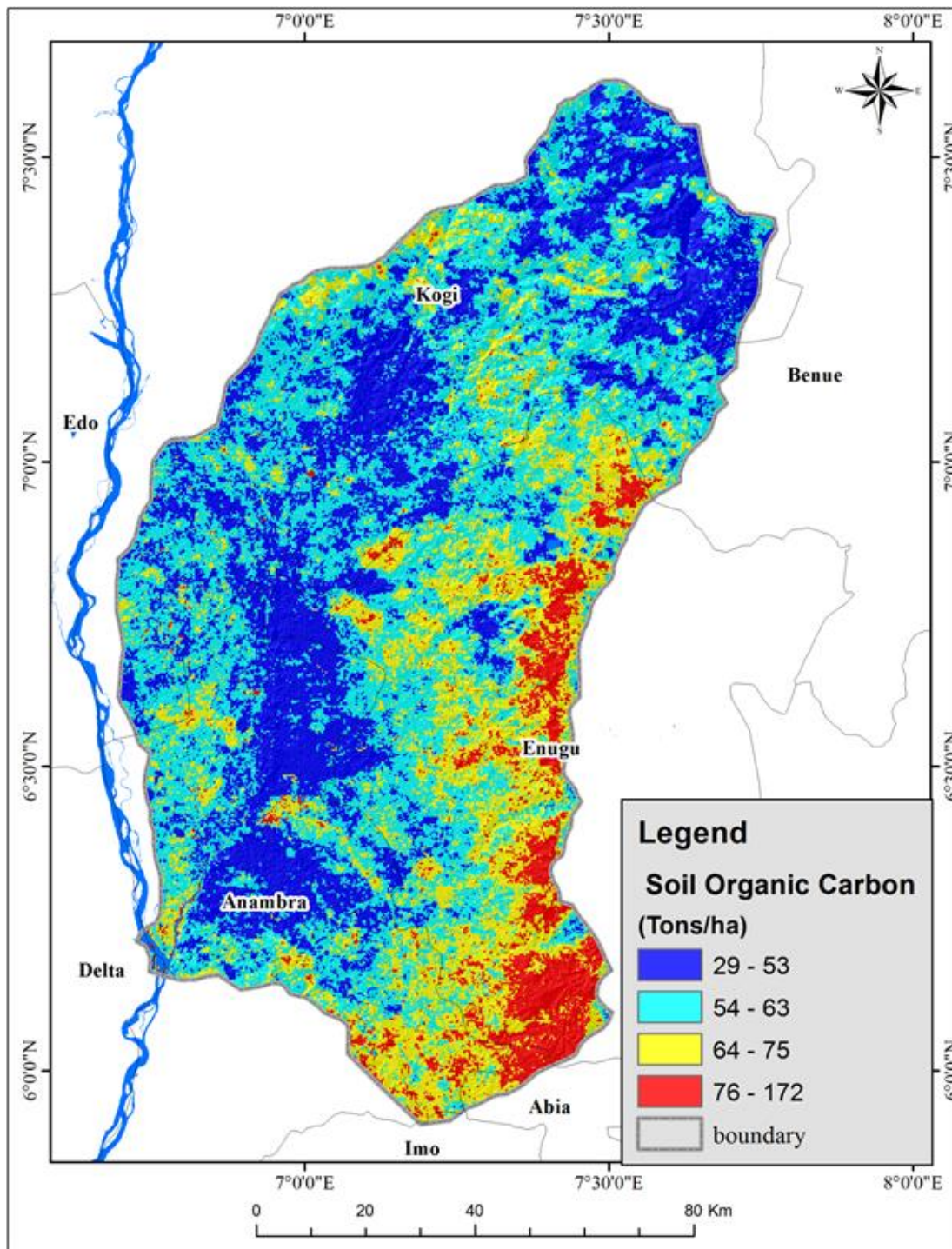
Figure 2. Carbon store in the area of study for the year 1992.

changes in carbon stocks (using land cover as a proxy for land use).

RESULTS AND DISCUSSION

The area under study experienced modifications and changes over time, especially in its carbon storage (Figures 2 to 5) and then in land cover (Table 1). Soil carbon was found to vary in the area under study: 29-177, 29-172, 12-172 and 4-177 tons/ha in 1992, 2001, 2010 and 2018, respectively (Figures 2 to 5). Some part of the region had more carbon and others less, while in
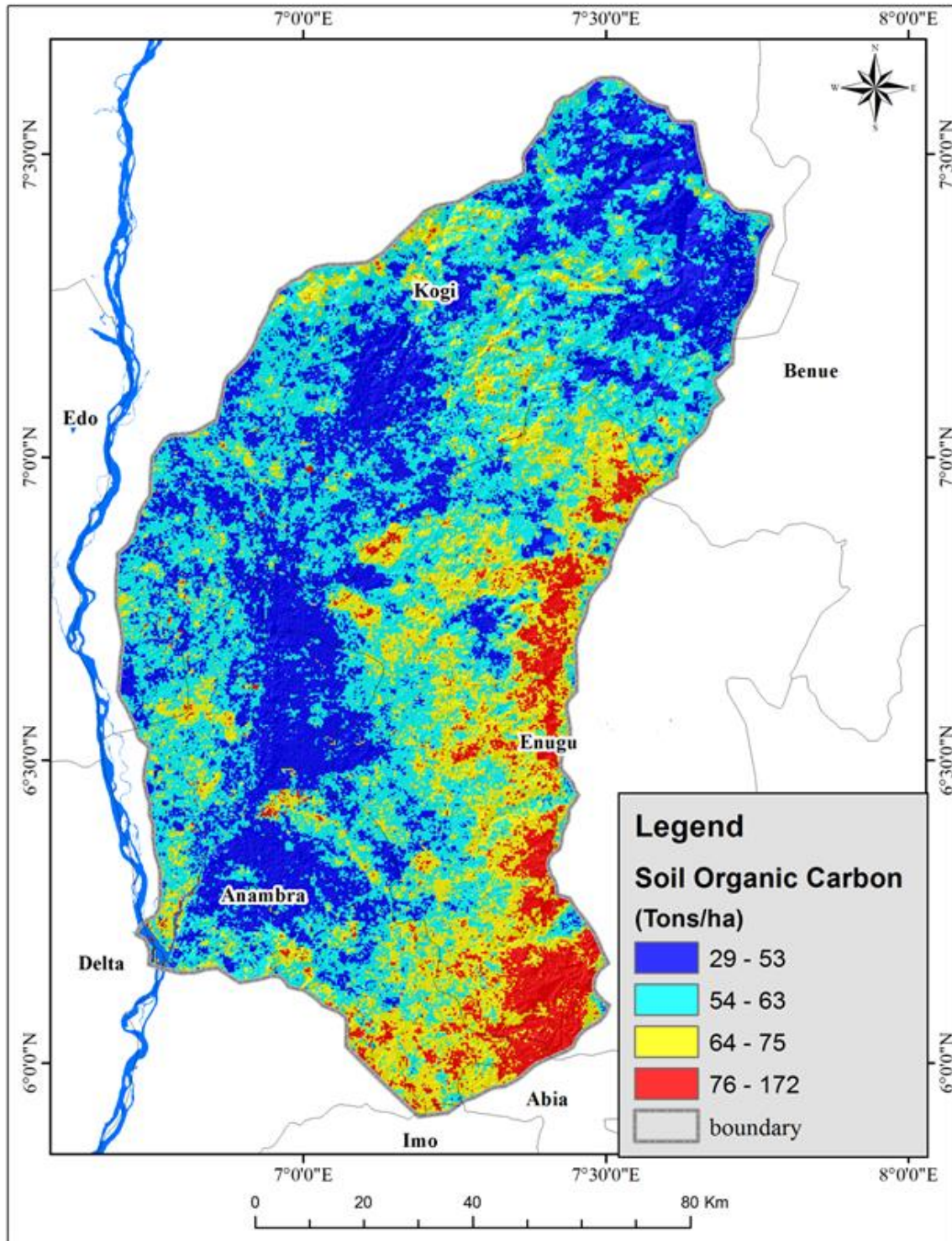
Figure 3. Carbon store in the area of study for the year 2001.

other cases, the variation was mostly from a temporal perspective in which case, it varied over the years. Total accumulated carbon over the zone reduced steadily from the initial year (1992) until 2004 and then increased afterwards (from 2005) until 2013; the remaining years (2014-2018) fluctuated in the accumulation (Figure 6). Though accumulated carbon varied across the years, the difference in the amount of carbon (tons) was quite
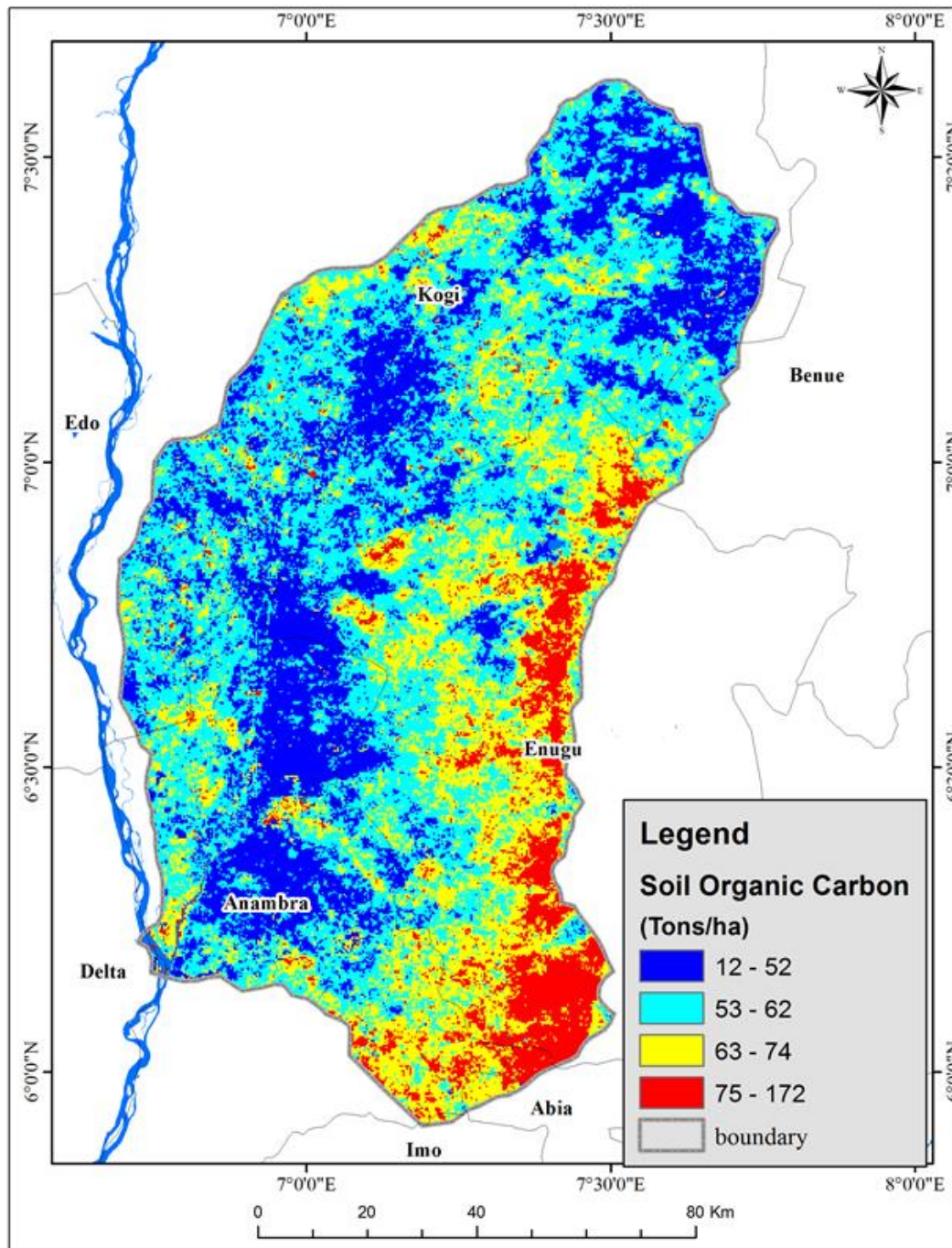
Figure 4. Carbon store in the area of study for the year 2010

minimal (Table 2); as the highest variation of 0.048 tons of carbon was seen between the 58.242 tons and 58.290 tons for 2004 and 2012/2013, respectively (Table 2). Such variations in carbon though slight, could be attributed to changes which would normally be seen in land use. Since dynamics in land use change easily impacts ecosystem services over short time scales (Li et al., 2013) and can directly lead to overall changes at

regional scale (Vidal-Legaz et al., 2013) for ecosystem services such as carbon storage, guided use of ecosystems to prevent intense impacts are advocated. Carbon storage is indeed an ecosystem service that ecosystem degradation- through forest loss, disturbance and modification affects greatly (Igu and Marchant, 2016); however, such impacts have direct effects on the above ground carbon (AGC) (through biomass removal
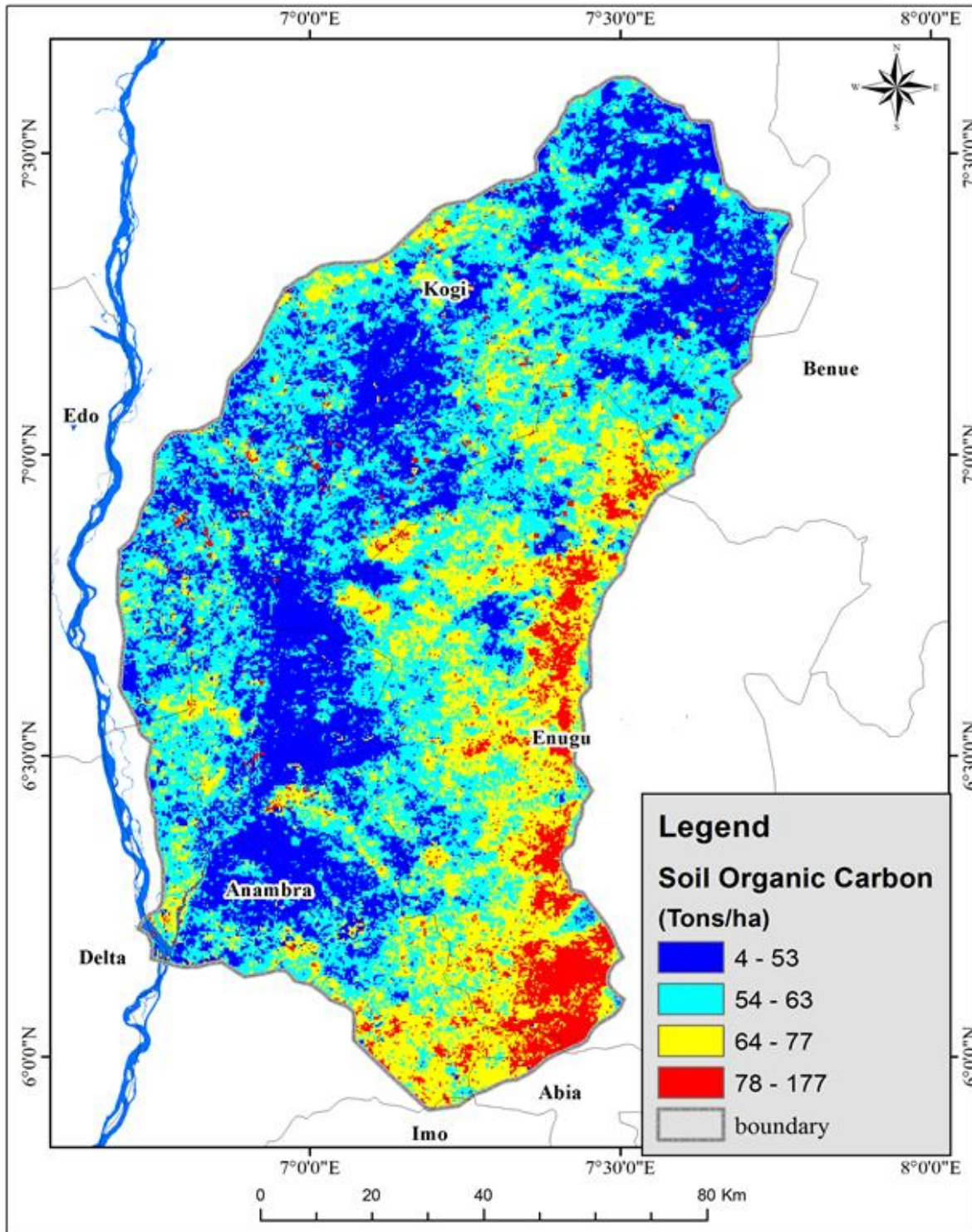
Figure 5. Carbon store in the area of study for the year 2018.

or reduction) than the soil carbon store (in comparison with the AGC) that are not easily discernible. Variations in decomposition rate of the litter (depending on land use and ecosystem) can equally contribute to the time lag involved in soil carbon store changes even when ecosystems become modified.

Land-use generally affects carbon storage in ecosystems but varies in its impacts according to the

Table 1. Land use and cover of the area in Square kilometre.

Legend	Year 1992 area (Km^2)	Year 2001 area (Km^2)	Year 2009 area (Km^2)	Year 2018 area (Km^2)
Cropland	1324.17	1350.61	1250.09	1230.50
Grassland	5546.42	5264.73	3582.23	3499.11
Treecover	6303.42	6548.20	8299.18	8361.38
Wetland	17.02	17.02	19.02	19.02
Builtup	11.70	20.45	50.12	90.73
Waterbody	30.91	32.62	33.00	32.90

Figure 6. Inter-annual variability of soil organic carbon.

various categories of the land use or cover in each zone. Major categories as seen in the study region includes: tree cover, grassland, cropland, wetland, built up and water body (Figure 7). The extent of land area each 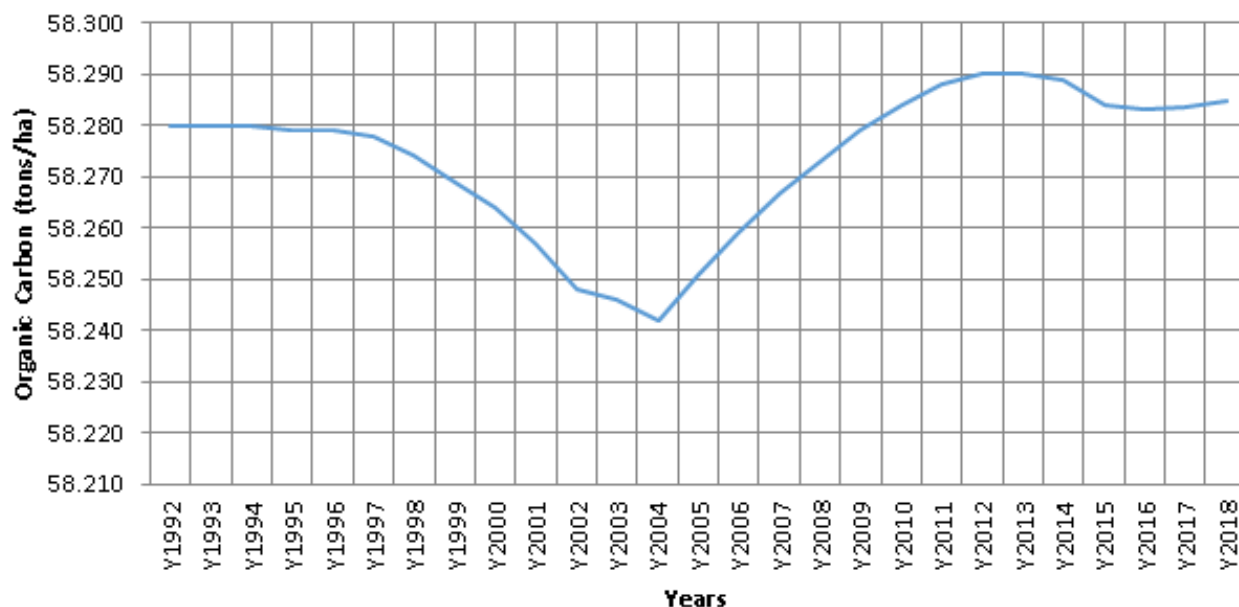of the land uses covered differed accordingly (Table 1). Areas categorized as natural landscapes: grassland, tree cover, wetland and water body, had higher extents of land in comparison with those that were already modified (cropland and built up zones). The later (modified zones) are expected to have lesser carbon stores than the former (natural zones) and since they are conversions from forest areas, they contribute to carbon emission for the area (Houghton et al., 2012; De Sy et al., 2019). While built up areas could be seen as an already transformed environment, agricultural landscapes on the other hand still retain ecological functions and are expected to store more carbon, depending on its intensity and system adopted. However, their contributions to soil carbon are minimal when compared to the natural landscapes that are the least modified and most likely to

store carbon. Natural landscapes are less exposed and more likely to retain its carbon, especially the areas under tree cover and grassland which are characterized by biological activities and facilitating interactions.

Areas under natural landscapes, especially tree cover zones were not evenly distributed (Figure 7); thus showing the variations in land-use and human impact in the region. Vegetal covers were much concentrated in the northern than the southern zones which had much modified landscapes and were characterized by patches of forest covers. This pattern of forest cover distribution (less forest cover in the south and more in the northern part of the region) would be expected to dictate the soil carbon pool of the region, but it seemed minimal (comparing Figures 5 and 7). While forest cover amount and extent would no doubt affect the total soil carbon of the zone, the amount, rate and scale at which it happens are not easily discernible. Land cover in ecosystems is generally made up of varied species compositions with differing functional types, decomposing rates, soil fauna

Table 2. Total soil organic carbon of the ecosystem from 1992-2018.

Years	Soil organic carbon (tons/ha)
1992	58.280
1993	58.280
1994	58.280
1995	58.279
1996	58.279
1997	58.278
1998	58.274
1999	58.269
2000	58.264
2001	58.257
2002	58.248
2003	58.246
2004	58.242
2005	58.251
2006	58.259
2007	58.267
2008	58.273
2009	58.279
2010	58.284
2011	58.288
2012	58.290
2013	58.290
2014	58.289
2015	58.284
2016	58.283
2017	58.284
2018	58.285

and microbes (De Deyn et al., 2008). These differing mechanisms which influence their carbon pools and dynamics do not easily change at very short time scales; hence, soil-carbon-environment interactions require more extensive, longer-term carbon studies and will form the basis for future studies for the region.

Much of the carbon was concentrated in particular areas of the study region, unlike in some other zones where it was more dispersed (Figures 2 to 5). Though affected by land cover and its dynamics, its concentration is however viewed to be determined by other exogenous factor(s); since such zones do not necessarily coincide with zones with much vegetal cover. Further comparisons of the geology (Figure 8) and digital elevation model (Figure 9) with the carbon map showed that carbon concentration of the region had more links with the geology of the area. Hence, though the geology of the area is broadly categorized into six (Figure 8), three geologic areas: Ajali formation, Mamu formation and Nsukka formation were where the carbon concentrated. Since the carbon was localized in such zones, efforts in promoting soil carbon storage for the region should be targeted there. Initial steps at achieving conservation across the Nigerian state were focused on biodiversity and to an extent, their soils. Areas that were mainly considered for such conservation efforts were mainly zones with much biodiversity and available land (Usman and Adefalu, 2010; Igu et al., 2017) and there were no records of conservation across geologic or soil zones for ensuring maximum enhancement of soil carbon storage. It has become imperative that such initiatives be prioritized following such guidelines especially as much land that would be ordinarily set aside for such purposes is shrinking in size and currently has competing interests. There is equally the need to continually conserve the carbon stores from going below the established baseline by engaging in proper land management schemes so that this important ecosystem service (carbon) will become better preserved and its benefits maximized across the region.

Managing ecosystems are essential for achieving prolonged ecosystem service use and efficiency. This is however confronted with a host of challenges in tropical landscapes such as Nigeria where land ownership and
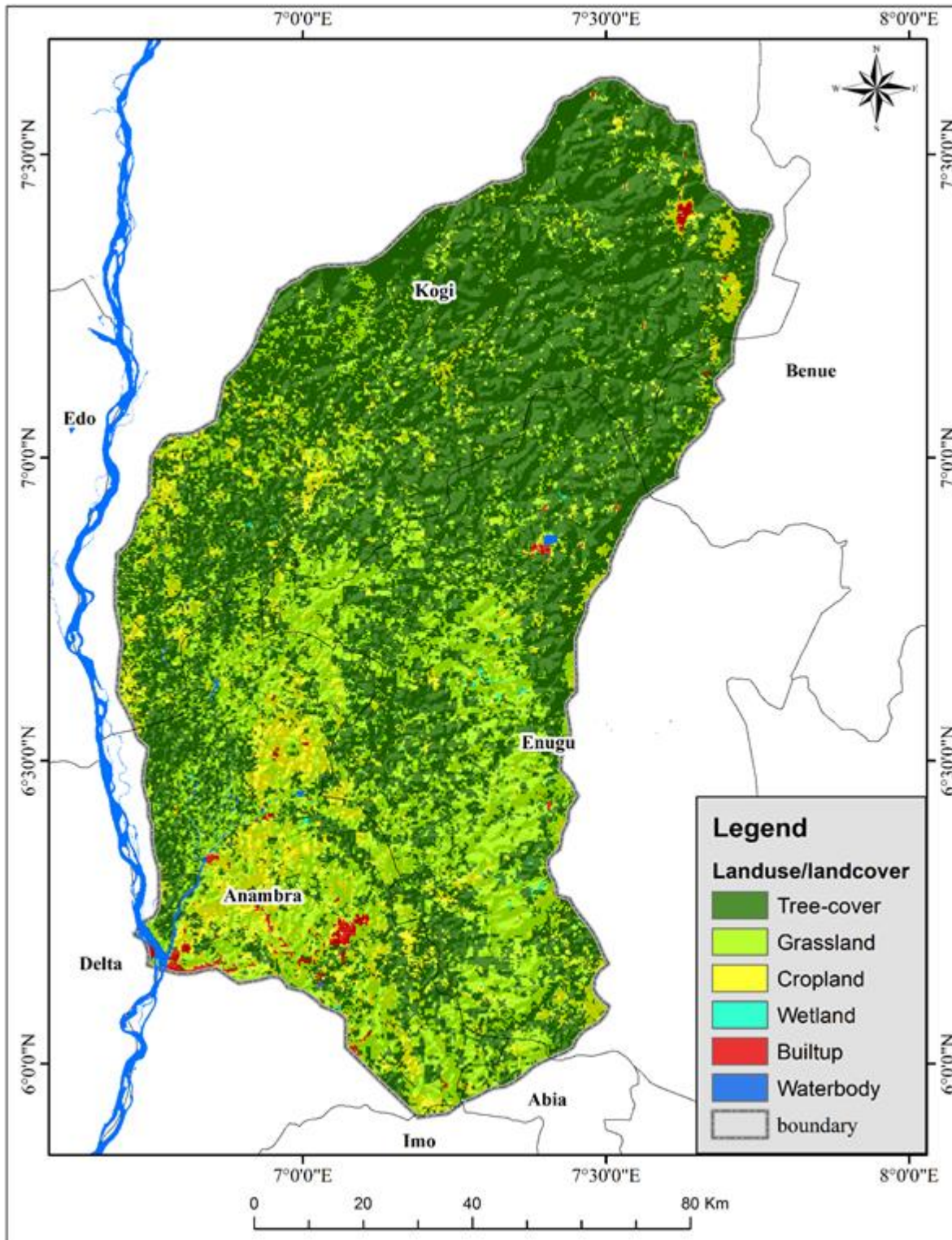
Figure 7. Land use/cover of the study area.

tenure issues are major points of concerns. Since much land is fragmented due to the multiple ownership structures and inheritance over the years, setting land aside for forest and soil conservation initiatives becomes more challenging; hence the need to equally maximize already existing reserves for such measures. Though
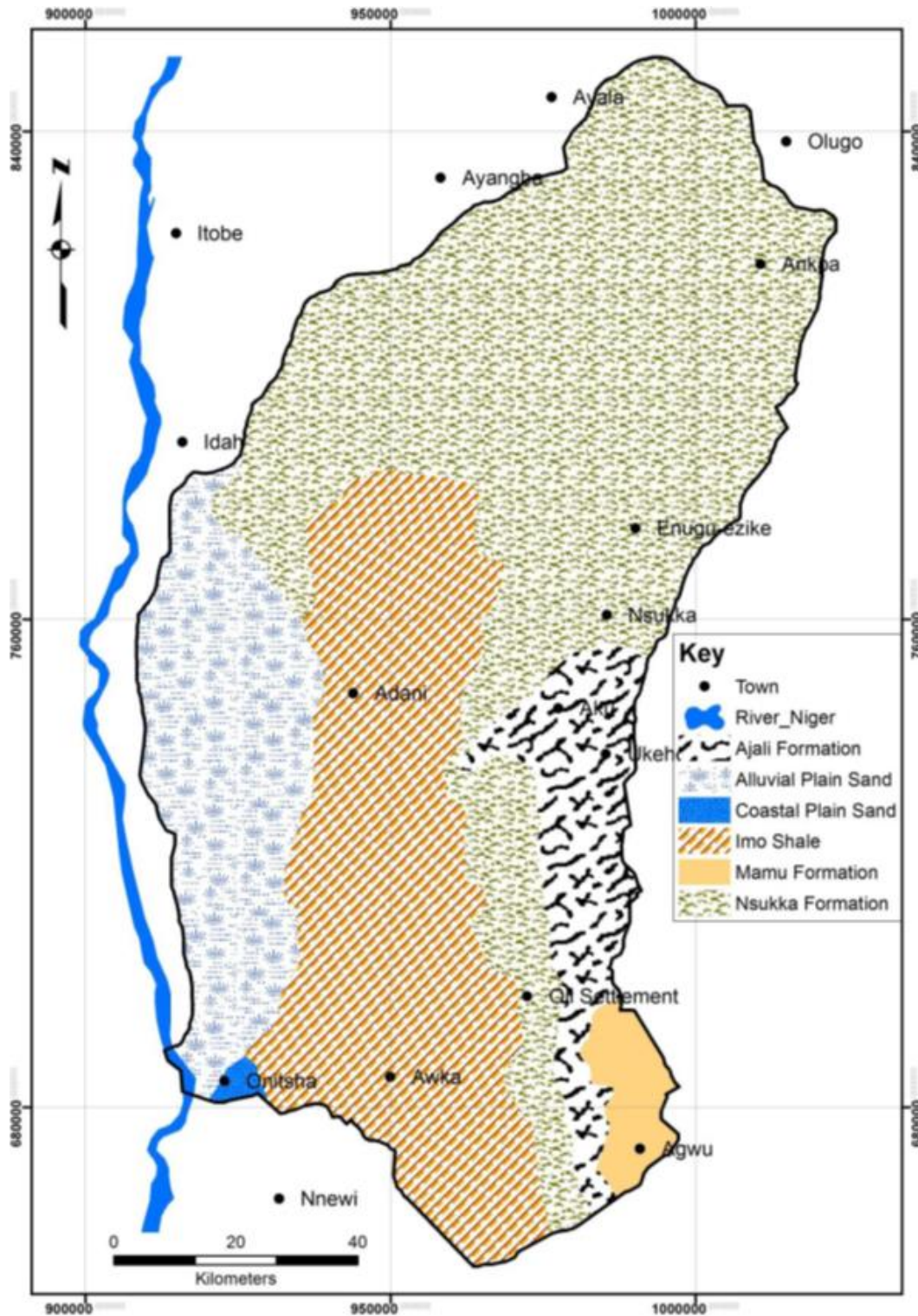
Figure 8. Geology map of the study area.
Source: Modified after Umeji (2002).

available land seems to be dwindling due to the increasing pressures emanating from population growth such as development, need for more housing units (increased built up zones) and agriculture, governments should consider long term concerns of climate change and the need to sequester carbon in the ecosystems as
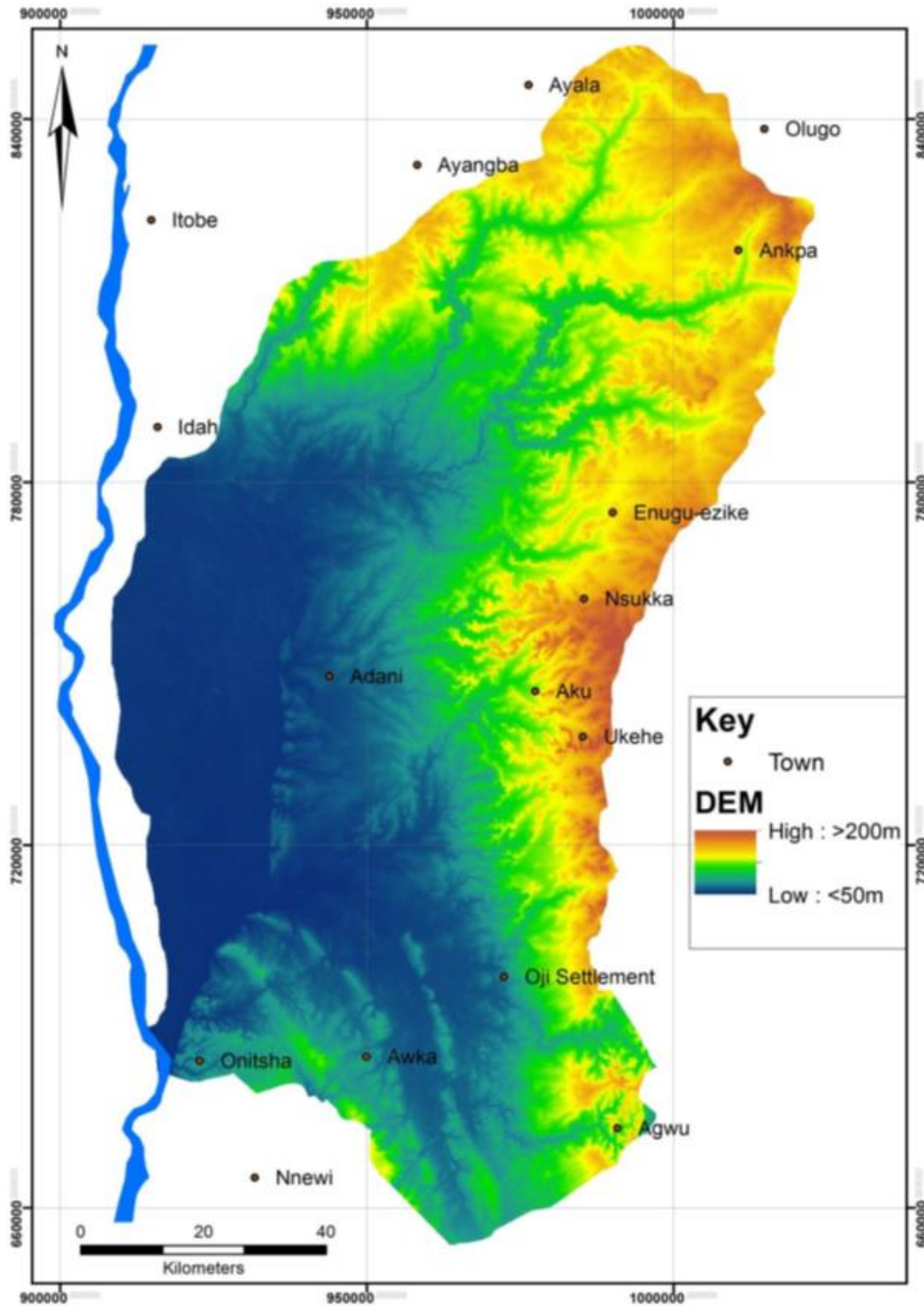
Figure 9. Digital elevation model of the study area.

pressing issues that need concerted attention. This may require making policies that would adjust how open and green spaces are gazetted, used and conserved to accommodate soil carbon storage initiatives. Particularly, this would require revisiting the land use act to enable

government to set aside land that has higher carbon capacities (following environmental assessments) to be reserved. To make such strides to be feasible and effective, such reservations of land should not target extensive land areas in one location (as was the case in

earlier days when much land were available), but instead sizeable portions of land should be gazetted in different locations. This will reduce the resistance by host communities as the parcels of land set aside in each location could be managed or absorbed in each zone. More so, adequate compensation should be given to communities or individuals whose land were taken over and where possible, involve them in the management of the land.

Conclusion

Ecosystems vary in their carbon store across spatial scales as seen in the Anambra drainage river basin. There is need to prioritize the zones with more stored carbon and conserve it through suitable ecosystem management strategies. Suitable policy frameworks that target land-use and cover changes are very desirable so that both the above ground carbon and its soil component will be better preserved and harnessed.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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Informal land use and environmental pollution in Ogbomoso

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Against the background of the contribution of the informal sector and/or land use to the urbanization process of the developing economies, especially in Africa, this paper examines the spatial distribution and environmental pollution implications of automobile workshops, as an important informal land use in Ogbomoso, Nigeria. Inventory of the locations of the workshops was done, and air, water and soil samples were taken from six of the workshops selected from different density areas of the town for tests on the presence and concentrations of pollutants, and the results compared with appropriate standards. The spatial distribution of the workshops was observably non-random, but have some environmental implications, noted especially in water samples (with concentrations of heavy metals such as lead and zinc higher than permissible levels) and air samples (with gaseous pollutants such as CO and CO_2, among others, beyond permissible levels). The paper, however observes that the operators of the informal activity are responsible household heads with an average income higher than the national minimum wage, capable of contributing meaningfully to the urban and national economy. It is therefore recommended that the land use activity be integrated into the formal economy and land use planning by easing the required processes of establishing, registering, and operating the business outfits through implementation of relevant people-friendly policies. This, the paper argues, would also necessitate further studies on different other dimensions of formalizing the land use.

Key words: Informal land use, integration, urban planning.

INTRODUCTION

The issue of informality in the urbanization process of African communities, which has not been adequately understood or appreciated, is a clog in the wheel of progress, particularly with respect to sustainable development. While this informality question may not be peculiar to the developing nations, real development in all its ramifications, may elude African economies, whose informal component engages higher proportions of workforce than the formal one, and whose urbanization processes are much driven by different dimensions of informality. The spatial manifestation of this is in land use, which is a challenge to land use planning and urban land use planners, who find their plans always distorted by the less recognized and unregulated human activities.

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Of particular concern is the fact that the informal activities are major sources of environmental pollution, which need be analyzed for effective control and physical planning purposes. A particular and highly visible category of the land use type is informal automobile workshops. Such issues as distribution, types, reasons for their location (where they are), specific impacts, and effective frameworks for the control and/or planning of informal workshops in a medium term town (like Ogbomoso, before it gets out of hand as witnessed in larger cities) are the questions agitating the mind of the land use planner.

The problem

The increasing urbanization level in Africa is an established phenomenon which shall continue into at least the foreseeable future (Jelili, 2012). As a particular characteristic of urbanization process in Africa, informality, expressed in all forms of less regulated urban land use activities and housing, among others, is a serious issue. A major category of this is informal automobile workshops, with their pollution potentials. As observed by Adewoyin et al. (2013), informal automobile workshops are associated with deliberate releases or discharge of petrol, diesel, solvents, grease, and lubricants on the land and in the atmosphere. These are substances that are toxic to humans and animals, and can as well pollute waterways directly or indirectly. More so, Bassuer (1987) observes that chemicals such as refrigerator gases used in vehicle air conditioners, and often released during maintenance work at these workshops, are made up of chlorofluoro-carbon, which is capable of depleting the ozone layer and causing a greenhouse effect. This is in line with the conclusion of Pollutionfree (2010) that automobile workshops emit large quantities of CO_2, Co, PM and substances known as mobile source air toxics (MSATs) such as benzene, formaldehyde, acetaldehyde, 1-3 butadiene, and lead, among others.

In view of the above, research attempts have been directed at unveiling the impact of this phenomenon on specific aspects of the environment. For example, Nwachukwu et al. (2010), Faronbi (2013), Adewoyin et al. (2013), Eludoyin et al. (2013) and Utang et al. (2013), among others establish the impact of informal automobile workshops on soil, surface and underground water. In the same vein, Wong and Lau (1985), Iwegbue (2007), Ipeaiyeda and Dawodu (2008), and Ekong (2012), among others, identify the link between informal automobile workshops' activities and atmospheric and environmental pollution generally.

The above, among others, provide an insight into the physicochemical properties of the substances released or discharged within or around the automobile workshops due to their maintenance and repair work, and the pollution impact of the same. Those attempts, no doubt, raise concern and consciousness about the likely health implications of the activities of the complex land use. It is, however, saying little or nothing about the reason why such land use activities are located where they are, their spatial distribution in relation to land use pattern or density, and socioeconomic factor that may be responsible for same. These are important variables that are necessary for effective planning and control towards reducing the negative impacts of the activities.

Research attempts at unveiling such relevant variables of physical planning importance are inadequate. While the works of Onyebueke and Geyer (2011), among others, provide the conceptual clarification and basic characteristics of the informal sector activities, those of Onyebueke (2000) and Okeke (2000) unveil the general characteristics and spatial distribution of informal sector activities, especially within residential areas, and establish the relationship between the phenomenon and density. Jelili and Adedibu (2006), in their attempt to give it a more spatial perspective, link the incidence of informal sector activities with road hierarchy and land use type, and observe that the activities are more along higher order roads than lower order ones, and more concentrated in and/or around commercial land use than within other land use types. The research efforts here, though from physical planning perspective, represent spatial dimension of informal sector activities in general, and not specifically on informal automobile workshops, which are the major informal sources of urban pollution. This is a challenge taken up by Jelili et al. (2017) in their analysis of spatial distribution and planning implication of informal automobile workshops in Osogbo, the capital of Osun State, Nigeria. The study observes a spatial distribution pattern that encourages springing up of the land use within and around any form of land use if left uncontrolled by effective planning and development control, and recommends establishment of workshop complex, called 'mechanic village'.

It is important to observe, however, that the situation observed in one town or city may not be the same in others, depending on the factor of spatial extent or human population size, urbanization level, being a state capital city or not, and socioeconomic and cultural factors, among others. In this study, the situation in a non-capital city, Ogbomoso, with perhaps different socioeconomic and urbanization level is examined. The study essentially provides answers to such questions as: (1) what is the spatial distribution of informal automobile workshops in the town?; (2) what are the specific pollution types that are associated with the informal automobile workshops?; and more importantly, (3) how can land use planning solutions be provided for effective integration of the land use into formal land use planning and control of the same towards safeguarding the health

and well-being of the people?

Purpose of the study

The main aim is to examine the spatial distribution of informal automobile workshops (IAWs) and their environmental pollution impacts. This is with a view to identifying effective framework for the planning and control of the informal land use. The specific objectives are to: (1) examine the spatial distribution of IAWs; (2) evaluate the environmental impacts; (3) determine the socioeconomic implications of the activities of the IAWs; and (4) suggest land use planning framework and/or measures for integrating the land use into formal spatial planning.

CONCEPTUAL FRAMEWORK: ENVIRONMENTAL MANAGEMENT, INFORMAL LAND USE AND PLANNING

Environmental management refers to all procedures that are involved in the protection and improvement of human environment, basically for safeguarding the air, water and land, as well as the forest and wildlife, with the main goal of protecting and improving quality of human life. According to Uchegbu (1998), it is the process of putting together those items of environmental nature where man exists so that man's penetration and exploitation do not have adverse effects on the environment. It involves management of all components of the bio-physical environment (Juhasz and Szollosi, 2008) as well as the built or cultural environment, including the control of all human activities, which is of great concern here.

Human activities are spatially expressed as land use, which Essaghah (1997) simply puts as the use to which land is put. Land use is an expression of the complex interrelationships among different human activities and how they are distributed in space. However, one of the most disturbing problems of land use in urban areas is its classification (Jelili and Adedibu, 2006). This arises from the flexibility in the factors which produce land use pattern, and more importantly, due to the emerging dichotomy of formal and informal dimensions of land use.

Ordinarily, there should not be informal category (or informal land use) where land use planning and control is effective. Land use planning, which deals with the spatial ordering of human activities in a way to achieve harmony, economy and beauty, is expected to have resolved the conflict to be brought about by the emergence of informal land use, which in most, if not all, cases are non-conforming land use. This is because the process (of land use planning) ought to have classified all human activities into different primary (residential, commercial, industrial, etc) and secondary (residential density areas,

classes of commercial use, types of industries, etc) uses before distributing them accordingly in space. This implies that the so called informal land use is a complex land use terminology, which refers to all forms of land use not recognized by the existing formal plan or other legal documents. Interestingly, however, many human activities in developing countries, especially in Nigeria, fall under this category of land use. They are described, according to UNDP (1986) as activities that "thrive in their thousands in the cities of the less developed countries, transforming them into beehives of minuscule enterprises all of which are pitched in stiff competition for dwindling space and patronage". Of much importance to environmental management, land use planning, and this study in particular, is IAWs' category, which constitute a significant proportion of informal land use in Ogbomoso and other towns and cities in Nigeria.

Automobile workshops or auto-workshops are repair shops where automobiles are repaired or maintenance work takes place by automobile artisans, technicians and/or engineers. The workshops specialize in certain areas such as break, muffler and exhaust systems, automobile electrification, air-conditioner and glass and general engine repairs and reinstallation, wheel alignment, painting, panel beating and vulcanizing, among others (Kayemuddin and Kayum, 2013). Because most of them, particularly in Nigeria, are located at undesignated places, unregistered and pay nothing as company tax, make use mostly of artisans and technicians (who are in most cases, sole proprietors of the IWAs) and unstable apprentice, and are described as informal automobile workshops. They, however, constitute a significant component of the urban economy in most towns and cities in the developing economies. Therefore, rather than make them continue aggravating the problem of distortion of land use plan (where any) and consequently aggravating the problem of environmental management, there is need for effective ways of integrating them into formal land use planning and environmental management system. This may continue to be a mirage, unless their spatial distribution pattern and environmental impacts of their activities are understood. This is the object of this study.

METHODOLOGY

Study area

The study area is Ogbomoso Township, covering Ogbomoso North and South Local Government Areas. Ogbomoso is a major town and second largest urban centre in Oyo State after Ibadan, the state capital. It lies approximately around 8° 8' N of the Equator and 4° 15' E of the Greenwich Meridian. As a gateway to the northern part of the country, it lies within the derived savanna region. The city has tropical wet and dry seasons, with the wet season starting from March to late October or early November, while the dry season, characterized with dry harmattan, starting from late

November to February. The climate is characterized with a fairly high uniform temperature, high relative humidity and moderate to heavy seasonal rainfall.

As one of the fast growing cities in the Southwest of Nigeria, the spatial extent and human population of the town increased tremendously over time. The town, which started as a coalescence of huts/hamlets in the 17th century, increased in size over the centuries to a small town in the 18th century, a relatively big town in the 19th century, and assumed a city status in the 20th century, though with a weak economic base due to its predominantly agrarian economy. But with establishment of educational and other institutions in the latter half of the 20th century, and more importantly, establishment of the Ladoke Akintola University of Technology (LAUTECH), in 1990, it has developed in all fronts – spatially, socially, economically and otherwise – particularly in the wake of the 21st century to assume a major urban centre status (though with a relatively weak industrial base). The temporal urban growth was not unaccompanied by population increase. The population of the town, which was adapted from various sources and population censuses, was put as 25,000 in 1850; 80,000 in 1911; 139500 in 1952; 166,034 in 1991; 253,282 in 2006; and projected (using 3.2% growth rate) to 325,869 for 2014 (NPC, 2006). No doubt, the population has increased the more in the last three years.

Of particular interest is the increasing human and/or land use activities that have accompanied the spatial and demographic growth of the town. As observed by Jelili and Adedibu (2006), and characteristic of most Nigerian towns and cities, there has been little and highly inadequate physical planning and development control activity exhibited in the town, leaving most land use activities uncontrolled and unregulated. The resultant effect of this is the increasing growth of informal activities, especially IAWs whose pollution impacts may portend dangers to the health and well-being of the populace.

Data types and sources

Apart from the secondary data on population obtained from the NPC, and street and other maps adapted from relevant Ministries and Google earth, the study was based mainly on primary data which were obtained on three major aspects, including: (1) spatial distribution of IAWs obtained through physical identification and taking of their rough coordinates for fixing of their locations and mapping; (2) possible effects of the activities of the IAWs on water, soil and air properties as a way of determining the impacts of the activities on the health and well-being of the people; and (3) socioeconomic characteristics of the operators (artisans/technicians).

Data collection and analysis framework

Ogbomoso is a pre-colonial urban centre with a vast spatial extent that is predominantly residential and that could be divided into different density areas. Each of these density areas exhibits certain features in terms of the type, structure, housing layout and condition, occupancy ratio, and nativity of the residents, thereby reflecting social, economic and cultural attributes (Adeboyejo and Onyenuoru, 2002; Afon, 2007).

In all, three density areas were identified with urban localities in each spreading non-contiguously across different parts of the town. Obtained data (on the effects of the activities on the environment) were aggregated for each of the density areas for inter-density analysis. The inter-density analysis is important to bring about physical planning and policy issues necessary for effective

framework for the control of the informal land use.

For the purpose of this study and that of data collection, workshops of the categories below were covered in the survey: (1) fixing of mechanical faults, services and related activities; (2) panel beating; (3) battery charging; (4) car painting, and (5) car rewiring. All the major roads were surveyed for the IAWs in any of these categories and their locations were noted on maps, while their socioeconomic characteristics and other issues were obtained via questionnaire administration to most senior adult identified at the workshops.

For possible air pollution effect, in situ measurements of air samples taken at points where there is uniform flow of gases (that is, during burning, welding points, engine riving, and air-conditioner refilling) at each location using hand held metres, taken at every hour for six hours. Few hours were considered relevant because exposure at short duration affects humans adversely..

Soil samples were collected from 1 to 15 cm depth, while water samples were collected with plastic containers (4 L each) from well found within a radius of not more than 100 m from the centre of each of the selected workshops.

In all, six (two from each density area) fully established IAWs were selected for analysis. A fully established IAW is that, which has three or more units of different automobile repair/maintenance services. This is because they usually exist in groups to benefit from agglomeration economies of land rent, security service, and other reduced costs.

Data analysis

The methods of data analysis used were of two categories. The first one had to do with the physico-chemical properties of air, water, and soil samples, while the second aspect was about the statistical analysis used in summarizing/describing the data and inferential tools used in analyzing the spatial distribution of IAWs and in testing the variation of the physico-chemical properties across density areas.

For ambient air, samples were collected from selected locations and analyzed using hard held air metres to test for the presence and concentrations of Co, Co_2, H_2o and O_2. These are some of the substances described as "criteria air pollutants" (European Environment Agency - EEA, 2012).

For soil samples, bio-chemical properties like conductivity, nitrate, chloride, sulphate, lead, iron, pH, organic carbon, zinc and cadium were tested for, using standard methods as specified by AOAC (1978) and the laboratory of the Department of Agronomy, University of Ibadan. This is to discover which elements exceed the standard soil quality as given by FEPA and WHO.

To test for water quality or extent of pollution in water, it is necessary to examine the presence of trace and heavy metals and its organic content through physico-chemical analysis of water samples for pH, conductivity, total dissolved solids (TSS), dissolved oxygen (DO), total suspended solids (TSS), lead (Pb), cadmium (Cd), iron (Fe), zinc (Zn), sulphate, nitrate and chloride, using standard laboratory procedures as prescribed by the APHA (1998).

The inferential statistical tools used were: (1) nearest neighbour analysis for the IAWs' spatial distribution analysis, and (2) ANOVA for testing the inter-density variations of the air, soil and water samples.

RESULTS AND DISCUSSION

The results of the study are presented under different headings to provide answers to such questions as (1)

how are the IAWs distributed in space; (2) what are the environmental implications of the activities of IAWs; (3) who are the operators (artisans/technicians) of the IAWs?

Spatial distribution of IAWs

Two things are observable from the results of the spatial distribution (Figure 1). The first one has to do with the fact that nearly all the identified IAWs are directly along major roads, while more are found to be landlocked, for an obvious reason of easy access of the clients – motorists. The second thing is about the fact that, with the Nearest Neighbor Index, R, of 0.8654 (that is, less than 1), the distribution is in between clustering and orderliness, whose extreme values are 0 and 1 respectively. With this, and the z-score of 34.23 (which is far greater than +1.96) the hypothesis that "the spatial distribution of IAWs in Ogbomoso is random" is rejected at 95% confidence level. This is at variance with the observed pattern for Osogbo, a state capital (Jelili, et al., 2017) though of the same geopolitical zone (southwest) of the country. The observed tendency for clustering is not unconnected with the fact that many of the workshops, with different services, co-exist within a large space to benefit from agglomeration economies, and to make use, as squatters in most cases, of the available 'abandoned' properties, the spatial pattern of which can also be observed not to be random in the city. The tendency for orderliness is not unconnected with the quest for maximized market/service radius, which necessitates maintaining a relative distance from another group of IAWs.

Environmental and health implications of IAWs' activities

The results here are presented on three components of the environment – air, water, and soil. For the soil samples, it is observed that the results for pH and organic carbon are within permissible levels. For example, while that of pH in all the localities from different density areas ranges between 6.21 and 7.09 (that is, within the permissible range of 6.0 to 7.5), that of organic carbon lies within a range of 1.53 and 11.02 g/kg, which is still within a permissible level and could support urban agriculture and soft landscaping. The same permissible conditions are noted for soil's nitrate, chloride, and sulphate, as revealed in Table 1 that the concentrations of nitrate, chloride and sulphate in the soils are 0.10 to 0.2%, 3.38 to 52.50% and 7.60 to 9.28% respectively. The situation may be regularly examined and kept under constant check, as it is warned that nitrate contaminated drinking water could have an impact on the size and functionality of thyroid gland in school children (AFAR,

2000).

For heavy metals like lead (Pb) (with values ranging between 14.9 and 830.5 mg/kg, and zinc (Zn) (ranging from 108 to 1 337.5 mg/kg), however, permissible levels (of 100 and 400 mg/kg for lead and zinc respectively) have been far exceeded in one of the two places each of the high and medium density areas, except for cadmium (with a score range of 0.35 to 4.0 mg/kg); even then, the score range for cadmium is touching the permissible border. Exceeding or touching permissible border like this is a sign of health danger for the people around the place, as toxic heavy metals can accumulate in human tissues for a long time (Kumar, 2007; FEPA, 1991).

Results on water samples (Table 2) indicate varying concentration levels of pollutants. For heavy metals, it is observed that all (lead, cadmium, and zinc) but one (iron) exceed their permissible levels, with lead (Pb), cadmium (Cd), and zinc (Zn) having concentration values ranging between 0.481 to 0.773 mg/l, 0.014 to 0.058 mg/l and 0.003 to 0.01 mg/l respectively, while iron (Fe) has a concentration level ranging between 0.002 and 0.012. It is important to mention that the situation of high concentration levels of some of these heavy metals raises a health concern. For example, cadmium is highly toxic, and many cadmium compounds are also believed to be carcinogenic, the adverse physiological effect of much consumption of it include depressed growth rate, anemia, hypertension, damage to renal tubules and poor mineralization of bones (Lundset et al., 2003).

A similar pattern of exceeding their permissible levels (as prescribed by FEPA and WHO) is also observed from the results on concentration levels of total suspended solids (TSS) and total dissolved solids (TDS), with concentration values ranging between 181.1 to 513.9 mg/l, and 212.3 to 602.3 respectively. It is important to note that, though, high values of TDS in ground water are generally not harmful to humans, it may affect persons suffering from kidney and heart diseases, while continuous consumption of water with high TDS values may cause gastro-intestinal irritation (Kumaraswamy, 1999; Geetha et al, 2008).

More so, it is observed that while nitrate and sulphate with concentration levels of 1.12 to 2.74 mg/l and 0.05 to 8.88 mg/l respectively, are within the permissible level of 250 mg/l (WHO), chloride with a high concentration level ranging between 90.00 and 918.00 mg/l exceeds the permissible level. The health implication of this is the tendency of the residents to be disposed to eye irritation, and stomach discomfort, among others.

As an essential determinant of corrosive nature of water (Guptaa, 2009), the pH values of water samples are observed to range between 7.1 and 8.1 which fall within the FEPA permissible level. This may be put under constant check, as however, abnormal water pH may cause bitter taste, corrosion, affect mucous membrane and aquatic life.
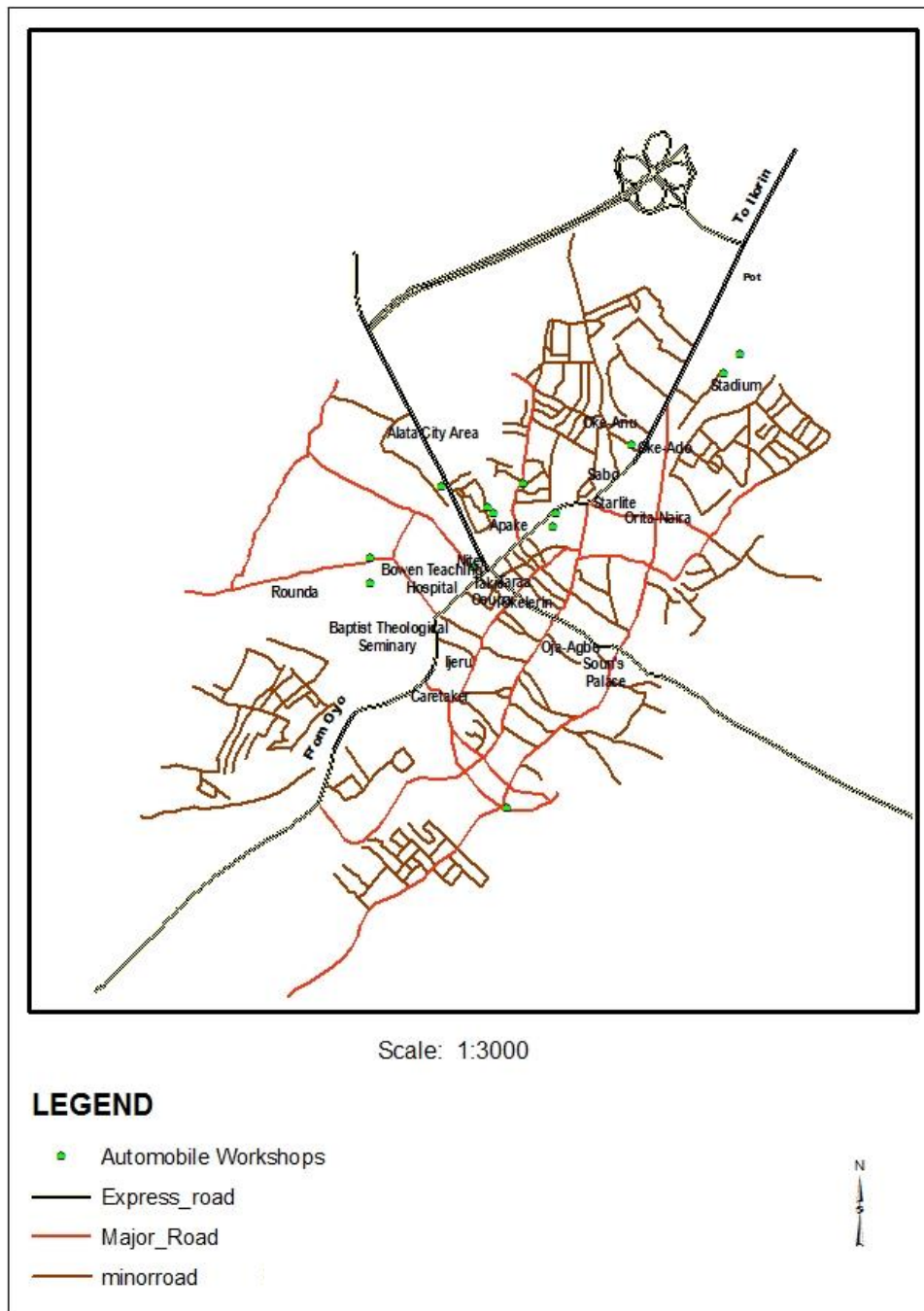
Figure 1. Map of the study area showing recognizable informal automobile workshops.
Source: Google Earth and Author's Compilation (2014).

Next in this research are the results on air samples, which indicate the averages of the recorded concentration levels of air pollutants in different density areas and localities. It is observed that Table 3 above shows the results on five gaseous pollutants, with all observed to be relatively high and above the permissible levels of air quality standards. For example, carbon monoxide (CO) is among the major air pollutants in an informal automobile workshop's environment and contributes largely to air pollution in the study area. CO is a good example of a chronically toxic gas. When it bonds to the hemoglobin molecules in red blood cells, the latter

Table 1. Physicochemical properties of soil samples within/around IAWs in the study area.

Density	Locality	Conductivity (µs/cm)	Nitrate %	Chloride %	Sulphate %	pH of H₂o	Organic Carbon (g/kg)	Pb (mg/kg)	Cd (mg/kg)	Fe (mg/kg)	Zn (mg/kg)
Low	Randa 1	253	0.13	3.38	9.28	6.80	8.39	55.6	3.05	71000	1320
	Randa 2	383	0.10	31.25	9.14	6.21	9.50	14.9	1.60	26500	108
Medium	Stadium	373	0.18	12.00	8.63	7.01	5.61	24.1	4.00	9775	118.5
	Arowo-mole	653	0.10	13.75	8.81	6.90	5.54	460.0	0.35	21625	241.0
High	Kara	443	0.16	52.50	8.23	6.25	1.53	24.2	2.10	24225	137.0
	Ijeru	513	0.20	16.25	7.60	7.09	11.02	830.5	2.85	78500	1337.5
*Permissible level						6 - 7.5		100			400

Source: Authors' Fieldwork (2016); and *permissible levels adapted from FEPA (1991, 1999), AFAR (2000) and Kumar (2007).

Table 2. Physicochemical properties of water samples within/around IAWs in the study area.

Density	Locality	Cond. (us/cm)	TDS (mg/l)	TSS (mg/l)	Nitrate (mg/l)	Chloride (mg/l)	Sulphate (mg/l)	pH of H₂O	Pb (mg/l)	Cd (mg/l)	Fe (mg/l)	Zn (mg/l)
Low	Randa 1	363	277.3	232.3	2.74	234.0	0.05	8.1	0.574	0.057	0.02	0.008
	Randa 2	333	249.8	213.2	1.28	198.0	0.91	7.8	0.520	0.058	0.07	0.010
Medium	Stadium	283	212.3	181.1	1.12	90.0	0.83	7.6	0.481	0.036	0.03	0.006
	Arowo-mole	803	602.3	513.9	2.26	918.0	8.88	7.8	0.496	0.014	0.04	0.004
High	Kara	553	410.3	353.9	2.18	522.0	3.65	7.1	0.773	0.019	0.12	0.003
	Ijeru	553	414.8	353.9	2.39	540.0	4.07	7.3	0.586	0.030	0.03	0.004
*Permissible level								6 to 7.5		0.01	1.0	

Source: Authors' Fieldwork (2016); and *permissible levels adapted from FEPA (1991, 1999), AFAR (2000) and Kumar (2007).

get contaminated and are unable to transport oxygen, the acute condition of which may lead to respiratory arrest or death.

As observed from Table 4, of all the gaseous pollutants tested, only CO_2 and H_2S, with p-values of 0.001 and 0.01 respectively showing a statistically significant variation in the concentration of each pollutant across density area. As attested to from Table 3 for example, while the concentration of CO_2 at an average activity source in low density area is as relatively low as 0.024 mg/m^3, it is as high as 0.058 mg/m^3 for a similar activity source in high density area, which is significantly above the overall average of 0.041 mg/m^3. Similarly, the observed average values for H_2S in low, medium and high density areas are 2.802, 3.570 and 1.61 mg/m^3 respectively, as against the overall average of 2.661 mg/m^3. It is, however, important to take caution in generalizing the situation based on these average values.

This is because the relatively high standard deviation value for virtually every gaseous pollutant suggests that a relatively low or high average concentration value may not necessarily mean a high or low concentration of a pollutant for specific activity areas. It rather suggests that each activity area is to be treated based on the type, magnitude, and duration of pollutant-generating activities.

Who are the informal automobile workshops (IAWs)' operators

The question of who are the IAWs' operators in the study area is attempted here. As noted from Table 5, it is observed that IAWs' operators possess certain socioeconomic characteristics which make it necessary to study their activities, as a land use with implications for urban environment and economy.

Table 3. Physicochemical properties of air samples within/around IAWs in the study area.

Density	Locality	CH$_4$ (ppb)	CO (mg/m^3)	CO$_2$ (mg/m^3)	O$_2$ (mg/m^3)	H$_2$S (mg/m^3)
	Randa 1	3.12	68.0	0.02	20.0	2.69
Low	Randa 2	2.45	89.8	0.03	21.26	2.91
	Mean	2.78	78.9	0.024	20.74	2.802
	Stadium	2.70	47.6	0.04	20.66	4.16
Medium	Arowomole	1.98	73.8	0.05	20.84	2.98
	Mean	2.34	60.70	0.042	20.75	3.570
	Kraa	3.22	90.0	0.05	20.82	0.70
High	Ijeru	2.14	114.6	0.07	21.02	2.52
	Mean	2.68	102.30	0.058	20.92	1.610
Total	Mean	2.60	80.63	0.041	20.80	2.661
	Stand. Dev.	1.37	49.04	0.022	0.620	1.529

Source: Authors' Field Work (2016).

Table 4. Results of inter-density variation analysis (ANOVA) in the gaseous pollutants.

		Sum of Squares	Df	Mean Square	F	Sig.
	Between Groups	1.064	2	0.532	0.269	0.766
CH$_4$	Within Groups	53.356	27	1.976		
	Total	54.420	29			
	Between Groups	8697.867	2	4348.933	1.924	0.166
CO	Within Groups	61031.100	27	2260.411		
	Total	69728.967	29			
	Between Groups	0.006	2	0.003	10.067	0.001
CO$_2$	Within Groups	0.008	27	0.000		
	Total	0.014	29			
	Between Groups	0.205	2	0.102	.252	0.779
O$_2$	Within Groups	10.945	27	0.405		
	Total	11.150	29			
	Between Groups	19.508	2	9.754	5.453	0.010
H$_2$S	Within Groups	48.293	27	1.789		
	Total	67.801	29			

Source: Authors' Analysis (2016).

Table 5 shows that all (100%) IAWs' operators in Ogbomoso are male and married, majority of whom (70.9%) are youths in their thirties, including 37.5 and 33.4%, aged between 31 to 35 and 36 to 40 respectively. Most (70.8%) of them secondary school leavers, with majority (70.8%, that is, 33.3 + 37.5%) of them earning between N50,000 and N6,0000, which is far above the national minimum of N18,000. This has perhaps enabled them to maintain a household size ranging between 4 and 8, with most (91.6, that is, 25 + 45.8 + 20.8%) of them having a household size of 4 to 6. With the highlighted socioeconomic variables, it becomes crystal

Table 5. Socioeconomic characteristics of IAWs' operators.

Socioeconomic variable	Category	%
Gender	Male	100
	Female	0.00
Marital Status	Single	0.00
	Married	100.00
Age Group	18 - 30	0.00
	31 - 35	37.5
	36 - 40	33.4
	41 - 45	12.5
	46 - 50	08.2
	51 - 55	08.4
	56 and above	00.0
Educational Level	Less than Secondary	00.00
	Secondary	70.80
	Tertiary education	29.20
Income	Less than 20,000	00.00
	21,000 - 30,000	08.30
	31,000 - 40,000	20.80
	41,000 - 50,000	33.3
	51,000 - 60,000	37.50
	Above 60,000	00.00
Household Size	Less than 3	00.00
	3 - 4	25.00
	5 - 6	66.60
	7 - 8	08.30
	Above 8	00.00

Source: Authors' Fieldwork (2016).

clear that the IAWs' operators are mostly heads of households, bread winners, service providers, and thereby, constitute an important urban and/or socioeconomic subpopulation, which need be properly accommodated in the urban economy and land use planning, rather than discriminated against.

CONCLUSION AND RECOMMENDATIONS

Informal automobile workshops are an important category of urban land use in most Nigerian towns and cities, exemplified in Ogbomoso, and as such cannot be left out in the scheme of things – urban land use and economic planning. The unregulated nature of the land use has, however, been of concern for long, and has made the

impact (both positive and negative) to be less studied and understood compared to other categories of urban land use especially those in the formal economy. This has necessitated the need for more attention on the land use category, particularly the acclaimed associated impacts with and on the urban environment.

This study has been able to establish the fact that the spatial distribution of the land use is not random, but concentration along major roads and at certain intervals which may not be quite regular, because spaces/buildings occupied are usually not pre-allocated for IAWs, but usually spring up as squatter land use, which has a lot of negative impacts for the environment. Such impacts, though varying in magnitude with type of pollution (air, water, soil) and density area where an IAW is found, depends on the nature and duration of activity of

specific informal workshops.

Given the importance of the services they render for the populace, and the fact that the operators are responsible household heads who also contribute significantly to the urban economy, the land use category ought to be accommodated in the urban economy. The health implication may however portend danger if it is not formally integrated into land use planning.

It is the view of this paper that the process of formalizing business outfits including registration, land acquisition, development permit, among others shall be made simpler for such category of land use to remove the bottlenecks and other hindrances which may prevent the relatively less economically buoyant operators of the IAWs, among similar categories of land use activities. This may include a policy or policies encouraging waivers in some development control and registration processes in favour of IAWs as a land use, and informal land use activities in general.

It is equally suggested that further studies be geared towards addressing different dimensions of the complexity that such process of integration may entail. From such studies, there should be, among others, evolvement of a classification scheme that would recognize different categories of informal land use activities.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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Home Building and demands of the population in Ramshar New Town

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This paper studies the housing and town building policies. It analyzes reasons that new towns failed to achieve their strategic goals. This paper addresses the question of why the new towns are not functional. The research methods are classic linear programming, a benchmarking technique, and a case study strategy. The benchmarking procedure compares the existing urban development pattern to optimal building models. This study explores fundamental theories concerning housing and urban development, proportional to the inhabitants' requirements, lifestyles, and livelihoods. The purpose of this study is to emphasize the natural and social characteristics of each region, as well as the livelihood needs of indigenous peoples in housing and urban policies. The case study of this research uses a market analysis procedure to discover rational and optimal housing policies. Finally, this paper suggests a feasible programming model that changes the present unsuccessful ways toward improved methods of housing policies. The model predicts required urban spaces in the new towns. It recommends design procedures based on the real needs of local people. The presented model of this research has a local application, but it is also helpful for other new urban development projects everywhere.

Key words: Housing, new towns, urban planning and design, market analysis, linear programming.

INTRODUCTION

The substantial new construction projects took place everywhere after the Second World War. The enactment of housing is important for national economies as it causes major impacts in the housing market and other economic sectors. There are variations and similarities between housing markets in different countries. European countries have got rent regulations and Latin American countries, China and Russia might have some shortages in the housing policies. On the other side,

recently, many countries have developed new housing policies. As a sample Iran has planned and built new towns, but unsuccessfully! Even, the last housing policy called for Mehr (=affection) project failed dramatically. This paper studies the housing policies to see how many of the local features and requirements of the inhabitants are respected.

This study is necessary since the houses were not built based on the real needs of the inhabitants and cannot

absorb newcomers. Further, this paper studies the reasons for the ongoing failed housing and town building plans. Our research methods are theoretical studies, a case study strategy, a market analysis, a mathematical linear programming and a benchmarking technique. Both primary and secondary sources of data have been used. All the research methods are problem-oriented. The theories related to the problem have been studied and the observation and field studies have been performed with the help of a case study. The major planning problems of the newly built environments have been examined. The case study explores the local particular features to understand the preferences of the people. The case study includes also a market analysis to project the building productions according to the market.

Our presumption is that the current housing rule does not respect the favourites of the customers and the recommendation suggested by the experts and scholars. Therefore, every new town project shall meet local requirements such as regional market demands, the regional climate condition, inhabitants' lifestyle, the culture of the community and local economic needs.

The target of this research is to suggest a practical model for the production of new homes, according to the livelihood and lifestyle of the local people. After understanding the inhabitants' priorities and preferences, a programming model will be made. The way to achieve the mentioned goal is a crucial change in the ongoing housing and town building policies. The revision is possible with the help of the knowledge-based development ideas, experiences of skilled engineers and international financial support.

The outcome of this research will be a building production model. With the help of a mathematical linear programming our model stands on particular features of the Ramshar new town. The method of benchmarking (BM) will compare the current housing activities to successful suggestions. This article is in five parts. After this introduction, theoretical studies are carried out. The third part will present the case studies. Part four is programming and results and part five will give the conclusions.

Theories on new housing and town building policies

A review of housing policies, urban spaces, and the infrastructure needed by the people of the world shows that various decisions have been made. For example, the Nordic countries have strong support programs, other advanced countries have lending policies, some developing countries have announced regulations and housing programs and in some countries, the government has no responsibility for providing housing (Heinig et al., 2016; Xu and Han, 2018; Kaplan, 2016; Quiggin, 2018; Justo and Santarcángelo, 2016; Kocaarslan et al., 2018). The review shows also that

the housing policies are under revisions, that is, Norway and Finland have abandoned the rent controls (Holmqvist and Turner, 2014). Grace reported that Canadian Federal Government's spending on infrastructure projects is expected to be more than C$180 billion over 10 years (Grace, 2013). During the 1960s-2000s, Iran's housing policy has been the implementation of big projects such as new town buildings and affordable mass apartment buildings (Seelig, 2011; Riazi and Emami, 2018). At present, Iran has no CDSs for the Iranian built environments, housing and urban infrastructure (Tilaki and Hedayati, 2015; Shahraki, 2019b). It is therefore wise for managers in each district and city to plan and design development projects based on the specific circumstances and needs of the people. The earliest modern housing and town building projects in the world have been planned and built-in countries such as the UK and the USA (Dear and Scott (2018). The new town building policy has been a key component of urban planning and management everywhere. The housing construction is made by the government, private and cooperative sectors. Meanwhile, the share of the public sector has decreased during the past decades (Raco, 2018). Like many scholars, we support the idea of the distribution of population in the new towns to provide the necessarily built environments proportional to the existing local natural resources. From a socioeconomic point of view, we consider particularly the quality of urban life. It is why people need new homes and towns with adequate water volume, urban infrastructures and services. (Omrani et al. (2019) and Sun et al. (2018) suggested the following major indicators in detail to progress the quality of life: Rich natural environments, vibrant social life, progressive urban economy, qualified homes, adequate urban services, accessible transport infrastructure networks and qualified built and natural environments. The mentioned scholars also suggested that the housing policies shall include urban life quality. Therefore, In the process of housing and urban infrastructure development, some certain indicators shall be improved. New homes, buildings and towns shall be attractive enough so that the investors will invest in the development projects. Therefore, the problem-oriented method shall be applied during the development processes. The problem-oriented method introduces the obstacles on the way of the qualified urban development. The problem-oriented method is a systematic planning way that explores the major problems in the provision of the required infrastructures and services in new housing projects. Shahraki (2017) applied the problem-oriented method to explore the difficulties related to housing and town building policies. You also agree with us that a major problem is building water shortages in new homes and cities. This deficiency is particularly acute in developing countries and regions involved in regional conflicts. Many scholars have suggested that a major problem in the new housing projects is the shortage of

natural resources, particularly water resources (Tilahun, 2019; Maurya et al., 2020; Chitsaz and Azarnivand, 2017; Shahraki, 2019a). From an engineering point of view, we focus on fair urban-land use policies and design of the buildings considering the inhabitants. The purpose shall be the standard design of adequate urban spaces for education, health care, work, sport and leisure. Our theoretical studies and field experiments show that new development methods and strategic planning for sustainable new houses and towns shall be based on the following principles:

(i) Allocation of enough space in the streets and an effective street network. Adequate areas of urban lands shall be considered for the urban and surrounding transportation (Næss et al., 2020; Austin, 2020).

(ii) A mixed use of urban lands in the sense that a considerable area of the lands, for example, up to 40% of every residential neighborhood should be measured for economic activities, education and other urban services. Many scholars have suggested the distributional planning of the urban spaces (Wu et al., 2018; Gil and Vilhelmson, 2019).

(iii) Social integration shall be a major target in the housing policies. Citizens with different socioeconomic situations and with different cultures and races shall live alongside each other. In order to realize this aim new homes and towns must be planned, designed and built in various models and sizes. Some scholars and experts such as Säumel and co-authors used this principle in the new housing and town building projects. They suggested a strategic model for the development of sustainable, liveable, and healthy cities. They introduced a conceptual framework, which included diverse forms of urban spaces (Säumel et al., 2019).

(iv) Restrictions on the use of urban lands for special groups or uses as much as possible. Hence, lands for a single function or special use should not occupy a significant percentage of the city's land when it is necessary. To fulfil this principle, see Kotulla et al. that made the city with wider groups in the urban neighborhoods (Kotulla et al., 2019).

(v) Allocating some urban land to build homes for the needy and the homeless.

(vi) Use of indigenous climate architecture, compliance with all civil engineering standards and codes for building resilient buildings and towns.

Sinha also suggested the result of improvements in the indicators of quality of life and the progress in the engineering principles outlined above give sustainable new built environments (Sinha, 2019). The planning and building of sustainable new homes and towns play a significant role in human communities and economic activities. One of the characteristics of new housing and town building should be a consumer attraction and marketing success. For this reason, indicators of quality of

life promotion and technical and engineering standards contribute to sustainable development. Thus, sustainable development is also of economic importance (Chapman and Larkham, 1999; Pardo-Bosch et al., 2019). Maurya et al. (2020) suggested that the social and ecological health of the cities aggregates the economic values of the properties too. Obviously, the sustainable development means that every city ought to be able to supply essential services for its citizens. The short required urban infrastructure stops the provision of urban services. The urban infrastructure is the physically interrelated component of a city's system, which supplies essential commodities to enhance the quality of urban life. Sullivan and Sheffrin described the importance of urban infrastructure. *"Urban infrastructure works with the efficient planning, designing, placement, building, financing, managing, and maintaining of the required structure across an individual neighborhood, settlement district of a city, town, city or the whole of a region"* (Sullivan and Sheffrin, 2003). There are also suggestions that a successful housing policy requires adequate urban infrastructures (Shahraki, 2017).

Usually urban landowners try to spend all the land on construction rather than urban infrastructure. They only think about the economic value of land and buildings by not respecting the technical standards of urban planning. Lijesen and Shestalova found the funding limitations a big problem in the urban infrastructure developments (Lijesen and Shestalova, 2007). Scholars like Borer believe that the culture and the regional tradition are other factors, which influence the attractiveness of the new towns. Therefore, when locating new sites for housing projects, paying attention to cultural attractions can encourage people to live in those homes (Borer, 2006). Although every country has a lot of cultural places and heritages, the current development policies conflict with the architectural culture. Dumouchelle learned that the built environments are duplicated and lack national and international standards and codes. The building projections do not respect the needs of the local communities. The result of such development has been the decline of the green areas versus the climate architecture principles (Dumouchelle, 2017). In fact the current development programs are declining the natural resources. As people leave the nature-based lifestyle, they damage the natural environmental components. Their buildings do not have any associations with nature (Angen, 2013). That is why a revision in the current housing and town building polices is necessary. Worse, the built environments are not resistant against natural hazards either, because they usually are built without strategic economic programs. Unfortunately, the majority of people are unemployed and the cities are usually dormitories. Several scholars suggest that the need for a multidisciplinary planning method has been voiced to resolve the mentioned problems in the new housing and town projects (Kovacic et al., 2011). Scholars like

Governa and Sampieri suggested that new towns have been built in various functional purposes such as a country's capital, industrial center, new suburb district or a residential neighborhood (Governa and Sampieri, 2020). The new towns have usually been planned to the home surplus population of the metropolitans. Therefore, the new housing and town building projects shall fulfil the socioeconomic, engineering, environmental, urban infrastructures and aesthetic requirements to attract inhabitants.

CASE STUDIES

Problems of Iran's housing policies

Major Iranian engineers, planners and scholars reported that the housing and new town building policies in Iran have not been successful (Atash and Beheshtiha, 1998; Arefian and Moeini, 2016; Annamoradnejad and Zarabi, 2011; Ghafourian and Hesari, 2018). The new housing and town building project has been unsuccessful in several perspectives such as planning, physical designing, the building of infrastructures, functionality, environmental protection and natural resources' saving (Hosseinali et al., 2015). Worse the involvement of the dominant corruption in the process of planning, building and use has been yet another fundamental problematic (Rasoolimanesh et al., 2013; Khaki and Sadat, 2015). The unplanned building, short urban infrastructure and public urban spaces, non-resistant building, lack of knowledge and technology, and incompetence management are some problems in Iran. As Ghasemi et al stated, Iran's national strategic policy had been the distribution of the increasing inhabitants in the new towns (Ghasemi et al., 2019).

Although Iran has built 23 new towns, many believe that it needs yet homes, public spaces, and infrastructures. Therefore, the 23 projects do not satisfy the classic standards and services and cannot attract the customers. Recently, the government has stated that it will only have a supervisory role in housing construction projects. Of course, this monitoring is done by assigning projects to corrupt government agents. Recently, the government has stated that it will only have a supervisory role in housing construction projects. Of course, this monitoring is done by assigning projects to corrupt government agents (Sun et al., 2019). The latest huge housing project in Iran called for the Mehr housing project, which had been loosed out and canceled due to several claimed failures (Arefian and Moeini, 2016). The Mehr housing policy was in the framework of the duty of the Islamic government constitution to provide homes for the citizens. But after removing this policy, there is no plan to provide homes in Iran. Therefore, now, the housing sector is wandering and locked.

Persistent poverty in the majority of the ordinary Iranian people hinders them to build, buy or rent suitable homes (Hosseini, 2018). Provincial segregation is another hindering factor that makes the housing policy in Iran unsuccessful. The segregation within Iran's cities influences negatively neither. The latter segregation is observable in the form of special protected housing zones belonging to the government official staff, loyal professors of universities, the staff of the judiciary and etc. while the ordinary people live in eroded, dispersed and marginal urban districts of the cities (Shirazi, 2018). That is why the new towns have not been successful to attract the people (Hatami and Siahooei, 2013). The above-mentioned challenges suggest that Iranian housing and new town building trends are in an incorrect direction. The development shall be shifted to new knowledge-based and environmental-friendly planning and design methods (Maurya et al., 2020). Therefore, the need for new housing policy and professional urban development exists.

The present unsuccessful housing policy and building g production shall be stopped. That is why the debates on the methods and results of the national housing policies and the situation of the new towns are still continuing. The question of the current discussions concerning the housing policy is whether the earlier housing projects and the latter Mehr project have met their goals? Therefore, the preferences and needs of the local people shall be known as bulks of the new developments. This case study gathered the ideas of local people concerning the following questions:

(i) How many buildings in different applications are wanted for the future population in the place?
(ii) How shall we plan and build to meet the real needs of the inhabitants?

The survey was done in the new town of Ramshar with the help of a questionnaire.

Field studies in the new town of Ramshar

The field studies were done in Ramshar new town. Ramshar is approximately 40 km South of Zabol City, next to Zabol-Zahedan Road and the border of Iran and Afghanistan. Therefore, it has an international position (Figure 1). This case study analyzes the impacts of Ramshar on the housing market and compares the results to the standard, well-planned, functional and successful new towns suggested by the principles and suggestions presented by the scholars. Many apartments had been built in Ramshar. Unfortunately, the Ramshar project has failed dramatically. The New town of Ramshar failed in terms of respecting the classic indicators of engineering standards, land-use policies, climate and, natural resource considerations and including the local lifestyle and livelihood needs.
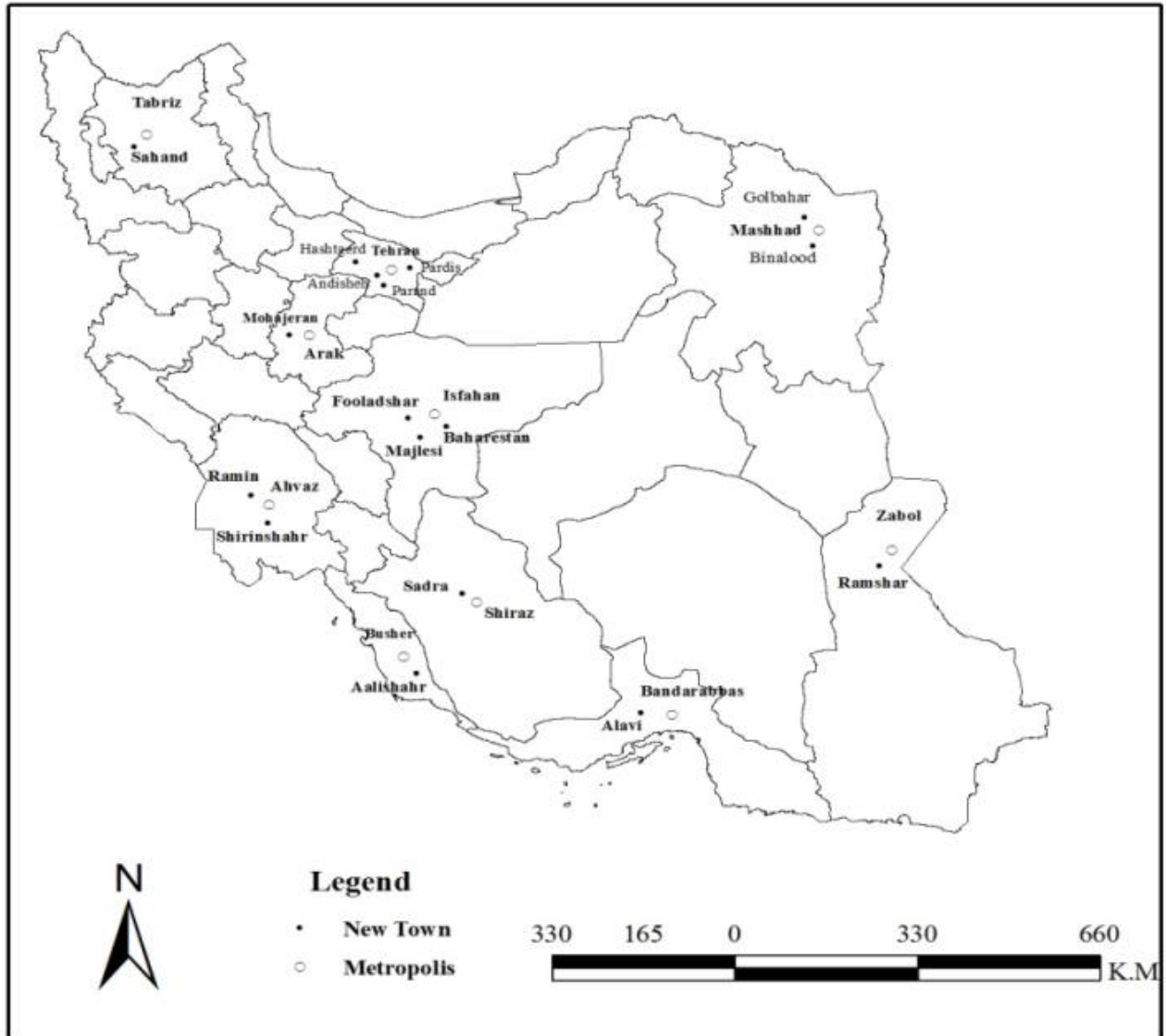
Figure 1. Location of Ramshar new town.
Source: Varesi and Ghanbari (2012).

The failure has its roots in none feasibility studies before starting the building process. The corrupted managerial authority, which is responsible for the New town project is weak regarding the required knowledge, technology, and skills. Our observation in Ranshar shows that the project had not been in line with the regional lifestyle and livelihoods. We analyzed the market to correct the production line of buildings in the future. We tried to find answers to the following important questions:

(i) What types of homes, buildings and urban services shall be planned to attract likely customers?
(ii) Will there be users to rent or buy the buildings regarding the economic ability of the people of the region?

The gathered data and information determine the future demand and supply of building numbers, structural types, architectural models, applied building materials, etc. The demand analysis includes demographic features, purchasing ability of local people, the number of likely immigrants and overall expected customers. The gathered data assist to survey the quantities and qualities of the existing houses, flats, offices, public spaces, water supply network, sewage system, and urban internal and external transportation infrastructures. We applied a questionnaire technique to foster public consultation and participation. The questions focused on the demographic and economic features of the region. Further, we asked about the preferences, interests and expectations of local people.

Table 1. Number of jobs in different economic sectors.

Type of job	Number	Percent
Unemployed	56	20
Other jobs	30	11
IT and computer	4	1
Military	120	43
Education	30	11
Care and hygiene	20	7
Private sectors	20	7
Total	280	100

Table 2. Income distribution in the sample population per $.

Income/month	Number	Percent
>270	0	0
180-270	40	14
100-180	100	36
50-100	110	39
<50	30	11
Total	280	100

We have tried to make a statistical population, which represents all the people in the study area to get reliable results. We distributed 500 questionnaires and two hundred and eighty equal to 56% of those were returned with responses. We collected and grouped their data. Finally, we analyzed and interpreted the outcomes to outline some qualitative conceptual suggestions. The suggestions predict more likely future trends of the needs, expectations and priorities of the local people related to the housing and town building policies.

We learned that 86% of the responders were males and 14% females. The major shares of the respondents are the local people. The age distribution of the respondents is such that 11% of them are younger than 30 years, 75% between 30 and 50 and 14% are more than 50 years old. The main fact is that 75% of the respondents are between 30 and 50 years old. The fact that respondents are people, who are more involved in economic activities, ensures the validity of the answers. The result suggests that every family has four members on average. 57% of the total family members are males and 42% of them are females. The sample population states that 68% of family members are within the labor force and 32% of family members are less than 18 years old. It could be said that during the first phase of the Ramshar development, the building of educational, hygienic, sport and other urban spaces in the group of 7-18 years old are very much needed. The target of Ramshar was to lodge 5000 people during its first

development plan. It means that Ramshar had to give facilities for 1135 persons equal to 24% of the Ramshar population during the phase. The obtained data show that 20% of the respondents are unemployed. Approximately 80% of the employed people work at governmental organizations and only 20% of them work in private sectors. This study recognized that people in the state sectors have special powers and advantages, which will have caused widespread inborn corruption. Table 1 shows the different economic sectors in the region. As Table 2 states, regional people have got various incomes. Almost 50% of respondents were paid less than 100 $ monthly. Only 14% of them receive 180- 270 $. Table 2, that except for some particular individuals, the majority of the people are poor indeed. Therefore, the incomes are not at all in proportion to the high prices of the buildings.

We examined the socioeconomic impacts of Ramshar's new town project in the region too. We inquired whether the building of Ramshar will improve the quality of life in the region. We asked as an example if the project will increase investments in the region or not. The various ideas of regional people have been collected and categorized (Figure 2). Figure 2 exhibits that some 10% of the regional populations believe that the Ramshar project will not improve regional development while a higher percentage of people expect positive regional impact for Ramshar. Some 31% are sceptical. It seems that most regional people have positive outlooks about Ramsar's impacts on the region. We also asked about the regional impacts of the Ramshar project. The opinions of respondents are summarized in Figure 3.

As you see in Figure 3, the share of respondents who do not believe the positive impact of Ramshar, particularly in terms of improvement of quality of life is 21%. On the other hand, 16% of the respondents believe that the project will cause advantages for the region. 14% do not expect that the project will increase cooperation in the region. Approximately 49% of the respondents believe that Ramshar's new town will create positive development outcomes. This study also explored the regional opinions if the building of Ramshar is a correct decision. Table 3 shows the average grade, which people gave for the idea of building Ramshar.

As seen in Table 3, the lowest grade is zero and the maximum grade is 20, an interval between 0 and 20. Thus, people gave the grade 9.3 from 20 to the decision of building the new town of Ramshar. In fact, some people have many doubts about the future of Ramshar and they are not optimists. This grade proves that people fear failures in terms of planning, design, constructing, using building materials, required infrastructure, natural and water resources, management and none real regulations. It indicates that the current architectural models and types of houses, homes and urban spaces in Ramshar may not be suitable to the lifestyle and livelihood requirements of the regional people.
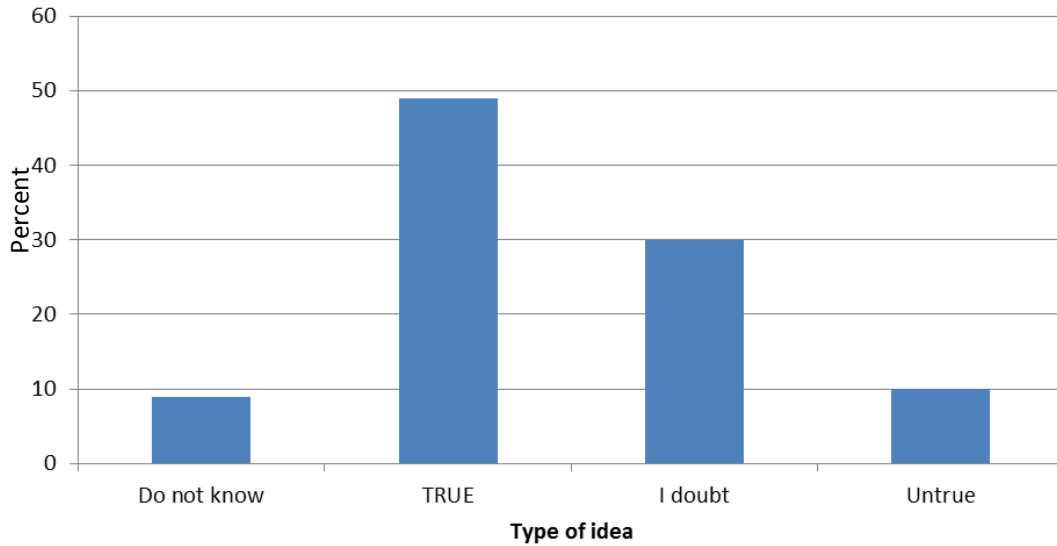
Figure 2. Ideas about impacts of the Ramshar project in the region.

Figure 3 data table:

	Idea- I do not know	I doubt	TRUE	Untrue
Increases cooperation	8	42	37.5	13
Creates an advantage	10.2	39.8	34	17.5
Increases investment	9.3	28.2	59	7.5
Increases life quality	7.5	29.5	42	20
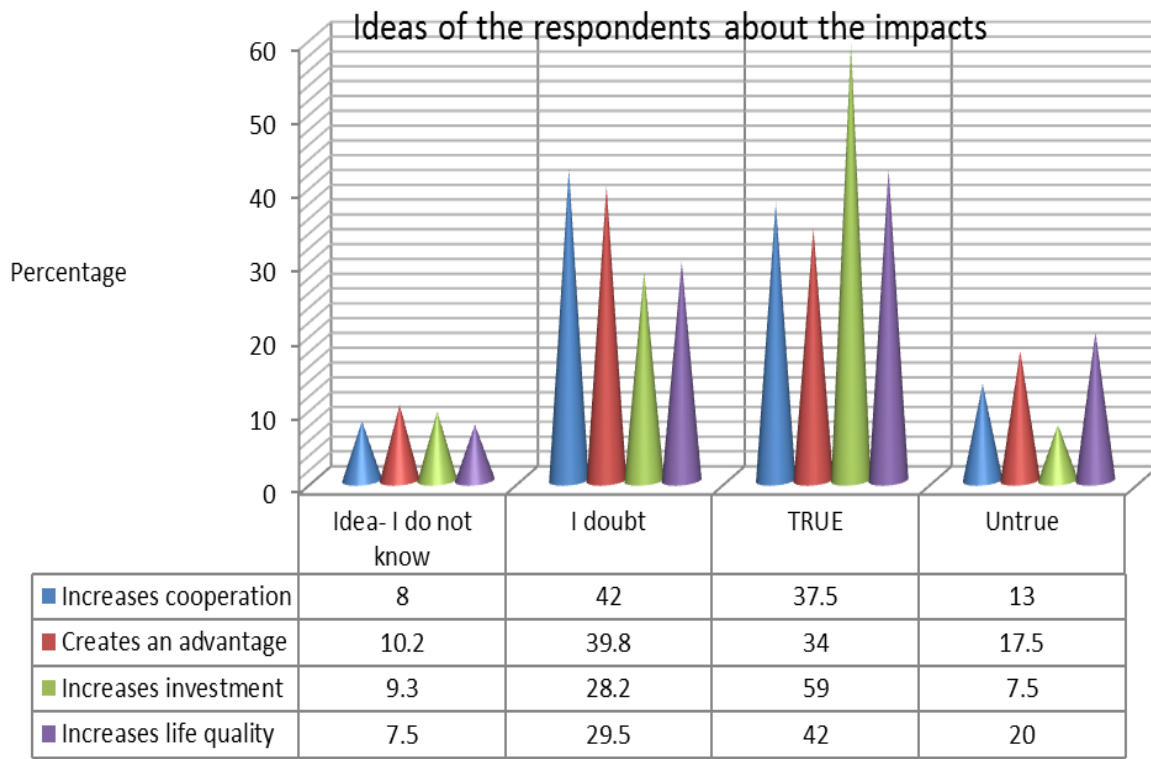
Figure 3. Ideas of the local people about different types of the new town project in the region.

We studied the impact of the Ramshar project on the labor market. We would like to see if Ramshar will influence on the labor market positively. This study selected six significant indicators related to the impact of Ramshar on the labor market (Table 4). The data state that a majority of respondents do not believe that Ramshar will affect the labor market positively. You see, in the table that 92% of the respondents believe that Ramshar will not supply job opportunities. If you look at other indicators in the table you do not generally see a

Table 3. Grades of positive impacts of the Ramshar project.

Description	Grade range	Average	Respondents
To build Ramshar is a right action	From 14 to 20	17	99
I have my doubts on the project	From 7 to 13	10.5	40
To build Ramshar is totally wrong	From 0 to 6	3.5	141

Table 4. Ideas about impact of the Ramshar project on the labor market.

Type of impact	Not true	Having doubt	True	No idea
Growth of job opportunities during the next 10 years	28	42	26	4
Shortage of workforce will appear	46	15	30	9
The demand for educated personnel will increase	72	17	7	4
The demand for unskilled and uneducated personnel will decline	36	32	25	7
Illegal economic activities and smuggling still will increase	14	35	44	7
Ramshar will be more attractive as a workplace	78	14	4	4

Table 5. Percentage of the demanded various architectural types of buildings.

Architectural characteristics	Respondents	Interest/percent
Firm and modern architectural structures, anti-earthquake	156	56
Firm and traditional structures, anti-earthquake	124	44

Table 6. Measuring demand for various types of homes.

Types of houses	Respondents	Percent
Villa of more than 500 square meters land	26	9
Villa of 200-500 m^2 land	100	36
Villa of 200 m^2 land	120	43
A 2-4 room flat	3	1
A 2 room flat	31	11

positive outlook about the impact of Ramshar on the regional labor market. On the other hand, since Ramshar is a border town the problem of smuggling can have an impact on the responses. Almost 48% think that the building of Ramshar without uncorrupted urban management; modern traffic infrastructure networks will encourage the illegal economy and smuggling.

Finally, we explored the housing market in the region of Ramshar. We should understand why Ramshar has failed to attract people and whether the failure depends on the structural systems of the houses, architecture of building products or the applied building materials. Table 5 reports the results.

According to Table 5, 56% of people prefer modern architectural styles. A large percentage of people would like traditional architectural types as well. However, both groups insist on firmness and resistance to the buildings against earthquakes and natural hazards. Another significant factor in the housing market is the prices of the homes. Therefore, the Ramshar project should decline the costs of building productions. This study also asked people if they would prefer flats or villas. Table 6 reports what the respondents wish.

Table 6 states that overall people prefer villas. This is understandable since people produce agricultural commodities and they cannot live in flats. 88% of the respondents prefer villas sitting on $200 m^2$ land compared to flat alternatives that are preferred by only 12%. The observation proves that the flat building in Ramshar has been a basic error. The field observation further contributed to the understanding of the regional market demands to the building production and urban infrastructures. People would simply like to see detached

houses in Ramshar rather than apartments. The next section of this paper presents a model to program the building productions or with other words the housing policy optimally.

PROGRAMMING AND RESULTS

Programming for required buildings

There is always an association between optimal housing and new town planning and its determinant variables. One important variable is the growing regional population. This study checked the regional preferences and recognized the ideas of regional people about types, sizes and qualitative features of the needed future building productions in Ramshar. This study got a real understanding of likely demands for different types of buildings. Now, let us apply linear programming to build a working model mathematically in the sake of future housing policy in Ramshar. We call the model programming types of needed buildings, PTNB. The model programs the types of needed buildings and assists in the development of Ramshar scientifically and successfully. We start setting up the PTNB model with the following general equation:

$$Y = mX + b \tag{1}$$

$$Y = m_1 X_1 + m_2 X_2 + ... + b \tag{2}$$

when a multiple ranges of variables exist.

We have got four variables as follow:

X_1 = the number of demanding villas,

X_2 = the number of demanding flats,

X_3 = the number of modern buildings and

X_4 = the number of buildings with respect to the inhabitants' lifestyle and livelihood requirements.

The PTNB model supposes that the new town of Ramshar will plan and build villas and flats upon the marketing analyses. The new town of Ramshar uses linear regression analysis to estimate the areas of land used in different types of building productions. Table 7 introduces the variables used in our linear programming.

In Table 7 you see the names of variables and their largest, least and average sizes. You see the diversification from the average called for Std Dev as well. It assumes that a direct linear correlation exists between the independent variables $(X_1, X_2, X_3 and X_4)$ and the dependent variable (Y) and the total land area occupied). Therefore, we write the Equation 3 as:

$$Z = 34 X_1 + 246 X_2 + 39 X_3 + 31 X_4 \tag{3}$$

Call Equation 3 as a target function Z. Z is the maximum number of households that will be settled in Ramshar during the first phase of the development plan. Z is an association between the households interested in various flats and those interested in different villas. It also specifies the rate of applied modern and traditional architectural styles of buildings. To develop the model, assume the followings:

1-The total lands allocated for homes are **20** ha in the first phase and
$$X_1 \geq 0, X_2 \geq 0, X_3 \geq 0 and X_4 \geq 0$$
2- X_1 is the number of households interested in different types of flats and $X_1 \geq 34$

3- X_2 is the number of households interested in villas and $X_2 \geq 246$

4- X_3 is the number of modern homes needed.

5- X_4 is the number of buildings, which respect the inhabitants' lifestyle and livelihood.

Consider also the following limitation equations.

$$17 X_1 + 123 X_2 \leq 200000 \tag{4}$$

$$17 X_1 - 123 X_2 = 0 \tag{5}$$

$$39 X_3 + 31 X_4 = 280 \tag{6}$$

Thus, see the following system of equations:

$$\begin{cases} Y = 17 X_1 + 123 X_2 + 39 X_3 + 31 X_4 \\ Y = 17 X_1 + 123 X_2 = 200000............. \\ Y = 17 X_1 - 123 X_2 = 0...... \\ Y = 39 X_3 + 31 X_4 = 280.................... \end{cases} \tag{7}$$

The problem is solvable both algebraically and geometrically. The variables have been found at the following:

$$X_1 = 5882, X_2 = 813, X_3 = 28 and X_4 = 37.$$

In fact, to find the number of homes for **Z** number of households in Ramshar we have:

$$123 X_2 = 17 X_1$$

The upper equality means that while Ramshar builds one flat it shall build seven villas. In practice, the villas are suitable homes for Sistan's people and pertinent to their economic activities and lifestyle. The size of the Z will be specified by the Equation 3. The total area of land needed for homes is equal to 20 hectares as it has been

Table 7. Descriptive statistics.

Variable code	Variable description	Mean	Std. Dev.	Minimum	Maximum
Y	The total land area occupied/square meter	100000	141421.35624	0	200000
X_1	Number of demanding villas	2941	4159.20209	0	5882
X_2	Number of demanding flats	406.5	574.87781	0	813
X_3	Number of Modern buildings.	2	2.82843	0	4
X_4	Number buildings which respect the inhabitants' livelihood	1.50	2.12132	0	3
Z	Total number of households	140	197.98990	0	280

decided already. Thus, the land area for every type of building will be decided by solving the equation system 7 in every exact situation.

Outcomes of the case study

The purpose of this case study was to understand the reason for the housing policy failures in Iran.
The problems of the housing and town building policies were explored by the Iranian scholars' publications, the author's academic and workshop experiences and ideas of the local people. We found the problems as follow:

(i) The housing and new town building policies in Iran are unsuccessful in various perspectives
(ii) The dominant and structural corruption in the process of the developments
(iii) The expansion of unplanned and unauthorized built environments
(iv) None existence of the required urban infrastructures
(v) The vulnerability of the built environments against risks and hazards
(vi) Incompetent, unscientific and ideological urban management
(vii) Lack of engineering, materials and structural building codes and standards
(viii) The none existence of a rational macro, regional and local published housing policies
(ix) Persistent poverty amongst the ordinary people in Iran
(x) Segregation in support and funding between different provinces and cities
(xi) None sustainable housing activities
(xii) Housing projects do not respect the requirements of local people

We performed a case study to examine the details of Iranian housing and town building policies. We learned that the place of Ramshar's new town had been selected wrongly considering the site planning techniques. The locating is not appropriate because it is alongside the two countries, Pakistan and Afghanistan with regional conflicts. The place is not an optimal one since it is not resistant against various climatic tensions like ever-

existing sand dune storms. In addition, the soil of the place is not suitable for planting and vegetation. Our observation proved that Ramshar has not got competent management and a knowledge-based strategic plan. The Ramshar project has not included public participation in the process of the development. We observed that there are no clear regulations to use the urban lands fairly and to hand over the flats, villas, and other productions of the new town to the needy people.

Our marketing studies for the building productions showed that the Ramshar project had been planned regardless of the livelihoods of indigenous people. People gave a score of 9.3 from a total of 20 that means a noteworthy disappointment. Surveying people's opinions showed that they like resilient homes and towns against risks and natural hazards. We learned that the most significant obstacle to develop Ramshar is the lack of water resources. Ramshar depends on the Hirmand River, which originally comes from Afghanistan. The analysis made in the new town of Ramshar voiced a need for a new urban planning and design model aiming at building suitable to the inhabitants' preferences while there are many new demands for homes. The outcome of our case studies is the model of Programming Types of Needed Buildings, PTNB. The model of PTNB forecasts different types of wanted buildings. The model can program the housing and town building policies, according to our understanding of the characteristics of the region and the needs of the local people. The model says that the ratio of production of an apartment to a villa is $\frac{1}{7}$, that is, one apartment, but 7 houses with yards or villas. Such a production line would have customers. In addition, there is an imbalance between the public urban spaces and residential spaces in the new towns. That is why the new towns became only dormitories. The PTNB model, of course recommends including urban infrastructure and essential services in the process of development.

Conclusions

This paper explored major problems in the current

housing and town building policies of Iran. The theoretical framework introduced some indicators and standards for optimal housing planning and development. The case studied introduced the failures of the new town project and Mehr housing project in Iran. It analyzed the process of planning and building the Ramshar new town in detail. We discovered that the new town of Ramshar had had shortages in feasibility studies, locating studies, planning procedures, design standards, environmental and climate codes and socioeconomic indicators. The result of this study proved our hypothesis on the necessity of changing the current failed housing policy. Our marketing analysis could program the required building productions for the future in the new town.

As the population number increases in the metropolises many critical urban difficulties are arising. The findings of this research verify that the planners and decision-makers in the global housing market need to build new built environments based on the preferences of the inhabitants. The presented PTNB model assists the regional planners and decision-makers to program optimal housing and town building strategic policies with sustainable outcomes. The method of analysis performed and finally, the PTNB model presented in this article can be a helpful guide for urban planners, engineers, investors, and decision-makers everywhere because this model anticipates market needs.

CONFLICT OF INTERESTS

The author has not declared any conflict of interests.

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