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Article

Ratio of Land Consumption Rate to the Population Growth Rate- A Case of Metropolitan Gombe

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Abstract: United Nations Human Settlements Programme recommended equation and tools for reporting SDG indicator 11.3.1. This indicator aim at one ratio between population growth and land consumption rates in order to promote sustainable urban expansion. Because nowadays urban areas rapidly expand, with increasing rate of surface extent that over sweep the rate at which population grows. Trends.Earth was used for the key Impervious Surface Indices (30m resolution) and informed on urban trend, extent and SDG 11.3.1 of metropolitan Gombe for the periods 2000-2005, 2005-2010, and 2010-2015.The research reveals that SDG 11.3.1 for three periods stand at 0.4194, 0.4292, and 0.3041 respectively. The research also indicate that the population growth rate is greater than the land consumption.

Keywords: SDGs; sustainable development goalsl; indicator; sustainable cities

1. Introduction

The sustainable Development Goals are blue print to attain distant better and more sustainable future for all. SDGs were embraced at the end of September 2015, amid UN summit in New York, by all Joined together Countries as all inclusive call to activity to put down poverty, ensure the planet and guarantee that all individuals appreciate peace and success by 2030 [1].

Sets of 17 Sustainable Development Goals and 169 targets came into effect in January 2016 and coordinates in a way they recognize that activity in one area will influence the result of the others. These goals are categorized into three grades based on the branch of

philosophy that analyses the principles, procedures and availability of data at world level. The SDGs are anticipated to direct and adjust the three attributes of sustainable development comprise of economic, social, environmental approach and investments until 2030. [2] United Nations Human Settlements Program recommended equation (LCR:PGR) of SDG indicator 11.3.1 which aim to determine the "ratio of Land utilization rate to Population Growth Rates" [3]

Cities and towns depend on environment services to flourish, they too debilitate the components of the environment through resource-use, contamination that result in land deterioration [4]. In fact, the contemporary urban transformation rate cause changes in environmental state at different scale, which is closely related to land-use, cover, diversity of plant and animal life, climate and other components of environment [5]. Though cities in all their differing nature, appropriate land in different ways and the patterns in these cities are energize by a few essential variables like: changes in populace, economic opportunities and efficiency, good physical and social conditions presence of empowering policies etc. Cities change, adjust, expose to certain variations with rising patterns some of the time grow, or shrivel depending on the size of afore specified variables [6].

The world's settlements are relatively getting to be urban, hence United Nations predicts that by the year 2030, more individuals in every locale of the world will live in urban than in rural areas in country regions, indeed in Asia and Africa, where presently are the slightest urbanized parts of the globe. This urbanization comes almost through the social, political, economic and cultural dynamic and result within the convergence of human activity in all cities regardless of size. This result in competition for land to extend as request for numerous land uses and ecosystem services rises whereas this urban zones still speak to nowadays a little extent of the Earth's surface [7, 8] and their impacts on hydrology, climate, resource, resource request and utilization,

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and emissions, for case, are progressively felt from territorial to mainland, and indeed worldwide scales

It becomes crucial to come up with tools which is ready to precisely measure and monitor urban development and their characteristics and for better understanding of the cause and effect of this changes. This framework 11.3.1 decides to determine how best urban areas consume surface area against the rate at which population increases. With the fore objective to accomplish land use efficiency, nations ought to get it how quick their urban zones are developing, and in which course. This will not only help understand the development patterns and viably address demands for the fundamental services but moreover open door to make approaches that encourage ideal utilize of urban land effectively securing other land uses.

In other words, for accomplishing environmental sustainability, the urban utilization must be coordinated to be in harmony or be underneath what the common environment can give, and the coming about pollutants must not overpower the environment's capacity to supply resources to people and other components of the ecosystem [9].

According to the [10] positions 100 worldwide cities on three metrics of sustainability: people, planet and profit. (They speak to social, environment and economic sustainability). The research appears that cities in and around the world are not balancing these three pillars of sustainability. Instead, many of these cities portray split identities either in people, and planet or profit, but exceptionally few do well in all three, demonstrating the challenge that cities ought to adjust all three needs effectively to guarantee long-term sustainability. As such, analysts and related NGOs, pressure groups emphasize on the role of knowledge of good urban transformation within the setting of urban planning [11].

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The framework 11.3.1 is being categorized as grade II because of its universal set up technique for its calculation, [12] in spite of that, the data for its establishments are not frequently produced by nations. In the fore going, analysts view the numerical equation recommended for computation of the framework 11.3.1 [3] is lacking because it result into uncertain figures. The discourse on the techniques and availability of datasets for the evaluation of the framework has been limited to set of researchers collaborating with the UN for this reason.

In keeping with [12] that this framework aim to evaluate the way and manner urban areas occupies their surface extent in relation to population increase. A few disarray does exist with respect to the classes of land referred by the framework as standard for its definition remain silent. However researchers assume the classes of land tended to by the framework is urban surface area extent which including compacted built up areas and the sparse areas in and around the periphery of the target cities. [3]

The aim of this paper is to measure the relationship between urban surface extend of Metropolitan Gombe and its population growth. It's intended to answer the question of whether the remaining undeveloped urban land is being developed at a rate that is less than, or greater than, the prevailing rate of population growth, in order to achieve optimal urban land use. In conclusion a rate of land consumption lower than or equal to the rate of population growth would be desirable.

2. Materials and Methods

The framework aim to determine the relationship between urban area extent and its rate of population increase. Assessing changes of the metrics over time needs information on area covered by urban center and population count for the time frame. The equation recommended to determine the relation between the metrics of the framework is presented below:

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Stage 1 Establishing factor of population increase:

$$PGrate = \frac{\ln (P_{t2} / P_{t1})}{nY}$$

ln is natural logarithm;

P_{t1} is whole population in Gombe Metropolis initial period;

P_{t2} is whole population in Gombe Metropolis for the final period;

nY is years difference.

Stage 2 Establishing factor of urban area extent:

$$LCrate = \frac{\ln (U_{t2}/U_{t1})}{nY}$$

ln is natural logarithm

U_{t1} is whole surface area extent of Gombe Metropolis for initial period;

U_{t2} is whole surface area extent of Gombe Metropolis for final period;

nY is years difference

Stage 3: computing SDG 11.3.1.

$$LCrate:PGrate = \frac{ALCR}{APGR}$$

LCrate:PGrate is relationship between urban area extent and rate of population increase

ALCR is land consumption Rates.

APGR is Population Growth Rates.

Population Estimate in each year of study

The number of people living within Gombe metropolis is being established for the each analysis year through Gridded population of the World (GPWv4) which estimate the distribution of the population counts and densities on a continuous raster surface. The

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built-up areas (land use pattern) of Gombe Metropolis is been used to determine the population, with the aid of grid cells based method that tracks the population both for the undeveloped land and high density residential areas, where each grid cell has a unique value, depending on location and quantity of the built up area and land use classes.

Land Consumption Estimate

Land consumption rate is estimated using impervious surface dataset at fine spatial resolution for the years 2000, 2005, 2010, and 2015. These data is then converted to binary representation which determine surface area occupied by the buildings within the squares of Metropolitan area.

- **Impervious Surface Index ISI:** In this index 15% is applied to cover both the high and low density of the metropolitan areas
- **Night Time Lights Index NTL:** In this index 15% is applied to cover both the high and low density of the metropolitan areas
- **Water Frequency Index WFI**: In the absence of large water body in and around metropolitan Gombe this is index is being selected as default.

Computation of SDG 11.3.1

Trends.Earth Plugin for Quantum GIS is employed for the analysis. This conservation internationals platform and Google Earth Engine give way to compute multi dated images for key land changes and track the relationship between urban area extent and population increase in the metropolitan Gombe and produced map and tables for interpretation.

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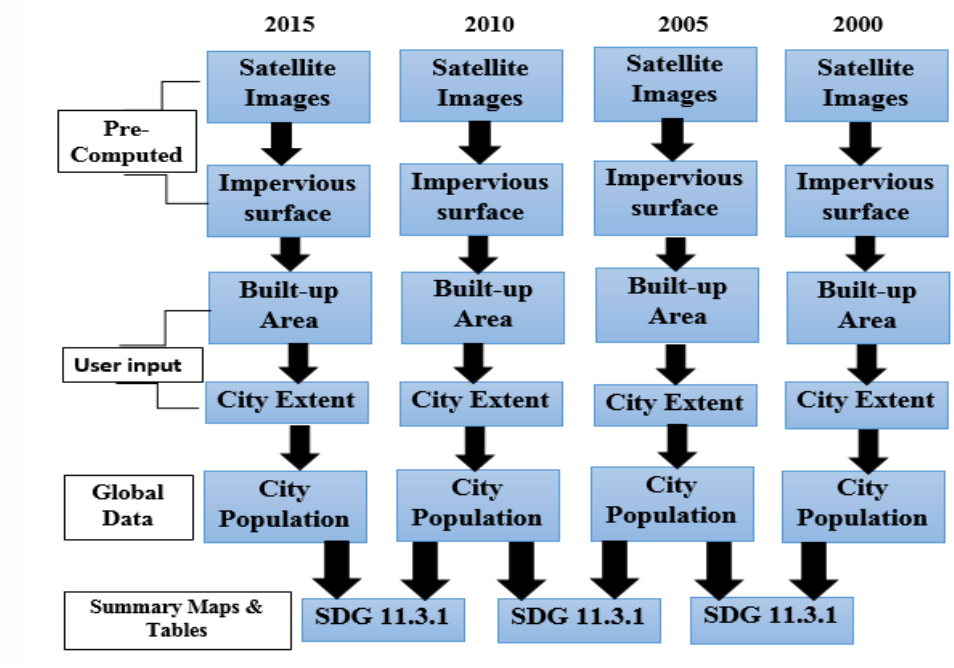

Figure 1: Processing work-flow for computing SDG 11.3.1

With the aid of the work-flow in Figure 1 above, the key required impervious surface dataset with 30m resolution and the required Landsat data are computed in relation with population data to determine urban extent for 2000-2015 (at interval of 5 years) and tables for SDG 11.3.1

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Study Area

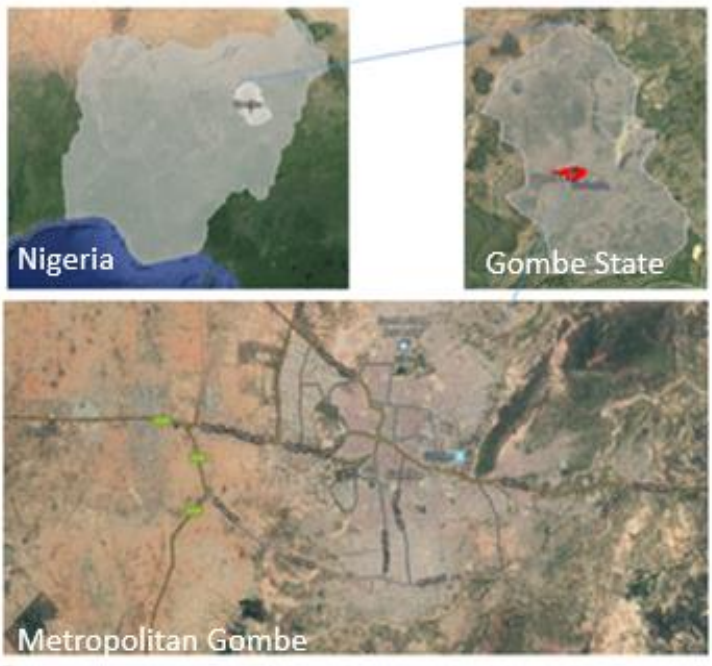

Figure 2: Study Area

3. Result

3.1 Population of Metropolitan Gombe

The population of metropolitan Gombe indicate a progressive increase during the period of this study and is presented in table 1

Table 1: This is a table showing Summary of Population

Years	Population
2000	262226
2005	321278
2010	402885
2015	495000

Source: Lab analysis 2019

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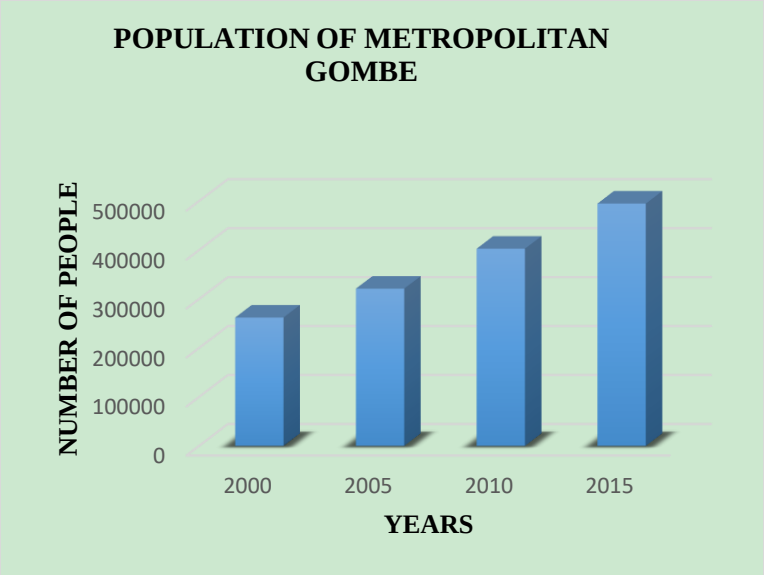

This is figure 1 showing a chart for Population of Metropolitan Gombe

Table 3: This is a table showing Population Changes and Population Growth

	Metropolitan Population Changes
2000-2005	59052
2005-2010	81607
2010-2015	92115

Source: Lab analysis 2019

The period of studies between the year 2000 and 2005 has population changes of 59052 and. The period between the year 2005 and 2010 has population changes of 81607. Then for the year 2010 and 2015 has the changes of 92115.

3.2 Land consumption

The study identified that during the year 2000 the metropolitan Gombe consume 90 sq.km of land area. This surface area increase to 98 sq.km in the year 2005. In 2010 the surface area reach 108 sq.km. In the year 2015 the surface area increase to 115 sq.km. The surface area per year is presented in Figure1 below:

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Table 3: This is a table for land consumption of Metropolitan

Years	Area Extent (sq.km)
2000	90
2005	98
2010	108
2015	115

Source: Lab analysis 2019

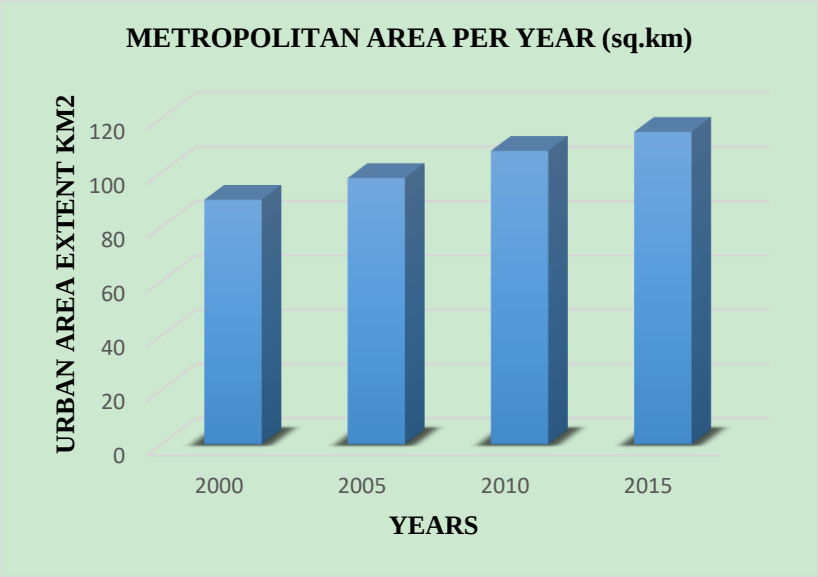

Figure 4: This is a figure presenting Metropolitan land consumption per year**.** The chart reveals a progressive increase in surface area within the time frame of the studies. The surface area of the metropolitan is being occupied the primarily by land use ranging from residential, commercial, office to educational etc.

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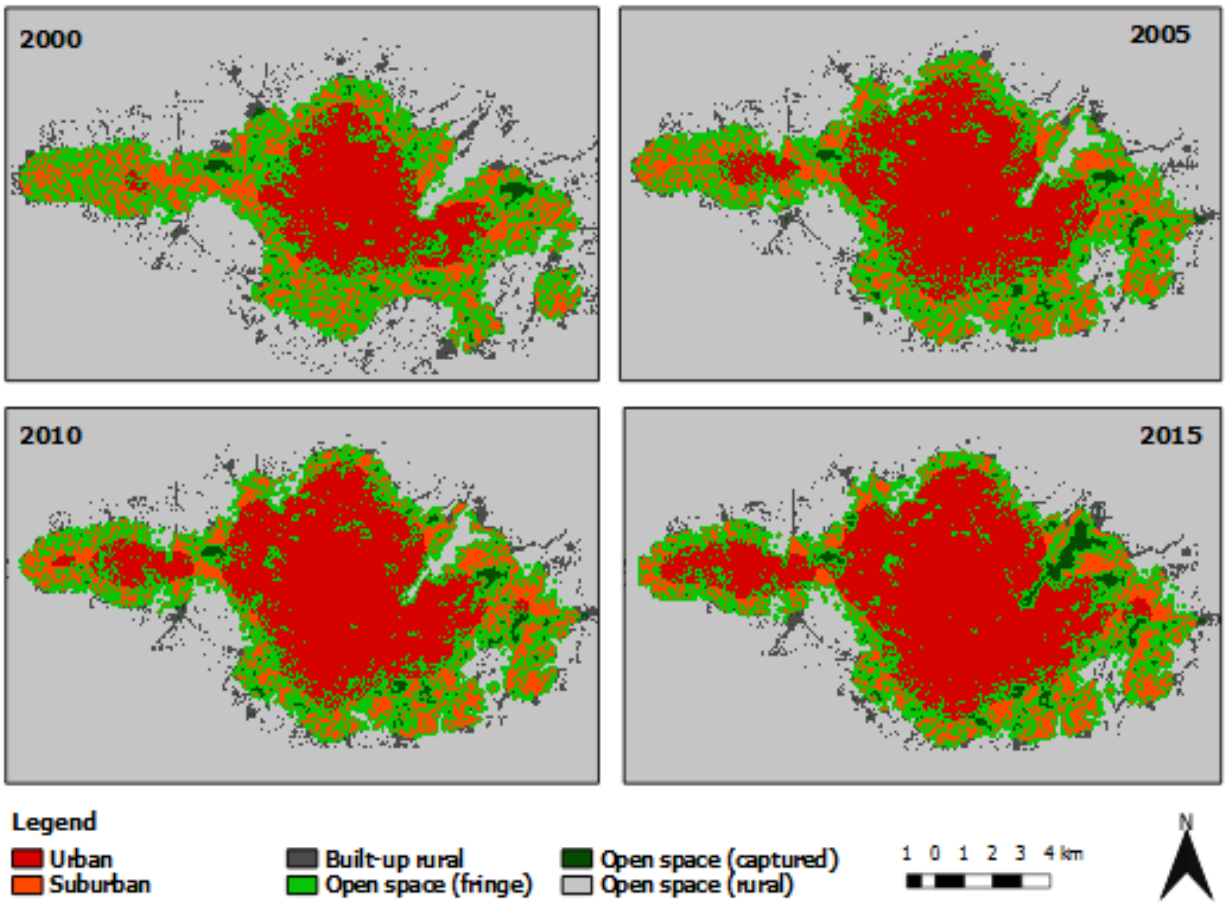

Figure 5: Metropolitan area extent

Figure 5 above reveals the surface area with respect to year of study. This surface area is being classified into six classes for interpretation

- Urban represent areas where the buildings are compacted together with access roads. This area can be seen at the central part of Metropolitan and during 2005, 2010, 2015 show progressive growth of urban area to the western part in and around Tumfure. This class is represented by red color in figure 2 above.
- Suburban represent the area on the edge of the area classified as urban and the buildings are not well compacted with open spaces. This area is represented by orange color in figure 2 above.

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- Open space represent plot of land own by individuals not developed. This class is found in and around suburban areas. This area is represented by light green color figure 2 above
- Built-up Rural represent the rural areas around the metropolitan.

Table 4: This is a table for land consumption Changes

	Land Consumption Changes sq.km
2000-2005	8.00
2005-2010	10.0
2010-2015	7.00

Source: Lab analysis 2019

Table 4 above shows land consumption changes for the period of studies at interval of five years. The land consumption difference between the year 2000 and 2005 stand at 8 sq.km. During 2005 and 2010 surface area differences stand at 10 sq.km, and in the year 2010 and 2015 the area difference stand at 7sq.km.

3.3 Computation of SDG 11.3.1

Table 5 shows Population growth rate of Metropolitan Gombe where during 2000-2005 has growth rate of 0.0406, during 2005-2010 has growth rate of 0.0452 and 2010-2015 has growth rate of 0.0411.

Table 5 indicate the land consumption rate for the three period of the studies, The 2000-2005 period has consumption rates of 0.0170, during 2005-2010 the rate stand at 0.0194 and during 2010-2015 the rate stand at 0.0125.

Table 5: Table showing summary of population growth, land consumption and SDG 11.3.1

	Population Growth	Land Consumption Rate	SDG 11.3.1
2000-2005	0.0406	0.0170	0.4194
2005-2010	0.0452	0.0194	0.4292
2010-2015	0.0411	0.0125	0.3041

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Source: Lab analysis 2019

SDG 11.3.1 of metropolitan Gombe for the three periods of studies is computed using population growth and land consumption rate and presented in the table 5. The period during 2000-2005, has SDG 11.3.1 of 0.4194, during 2005-2010 has 0.4292 and during 2010-2015 has 0.3041.

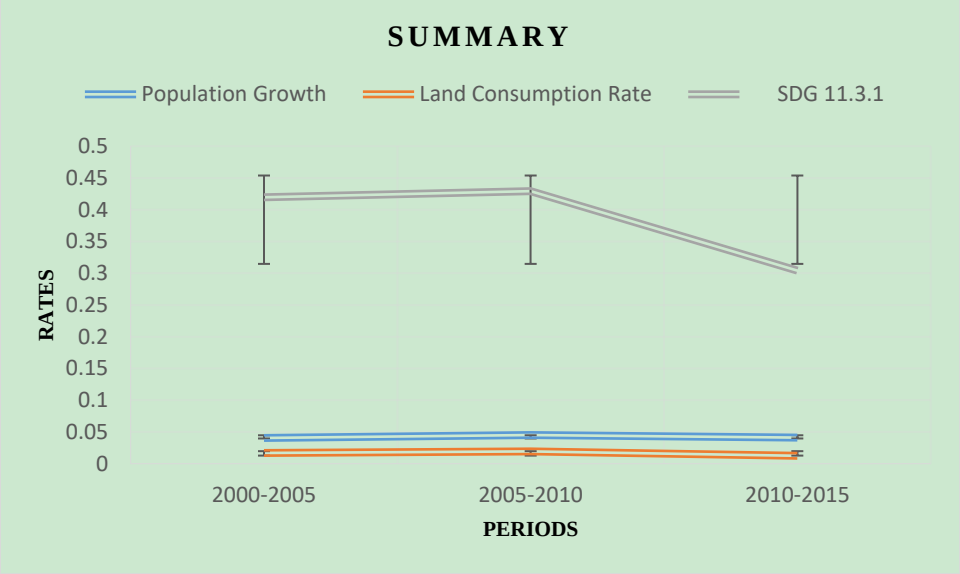

Figure 6: This is a figure presenting the chart for population growth and land consumption rates and SDG 11.3.1

4. Discussion

This research paper uses the recommended equation and Trends.Earth work flow and determine the ratio of surface area occupied by Metropolitan Gombe to the population increase rate for the period of 15years.

Population growth rate is one of the metrics of SDG 11.3.1 reveals (Table 5) that during 2005-2010 experienced the highest growth rate at 0.04526. This rate might be in connection with the influx of IDPs from the neighboring states as a result of insurgency and other economic activities. During 2010-2015 the rate stand at 0.0411 and 2000-2005 stand at 0.04062. This growth uses land resources for various land use to provide for its needs.

Population growth rate is one of the driving agents for urban dynamics and pattern of development. The pattern reveals the way and manner how other prevailing factors encourage the process of land use. The amount of open space and farmlands lost urban areas is related to changes in population especially those areas with greater increase in population losing more space [13]. The losing of open space and farmlands for urban surfaces result into sealing of the soil from the atmosphere and disrupt natural water and biogeochemical cycles

German government presented a strategy for national sustainability in 2002, *Perspektiven für Deutschland* which means outlooks for Germany, which aim to put down the use of urban surface area to 30 ha per day until 2030 and currently Land consumption stand at 66 ha per day [14].

Land consumption in one of the German federal states of North Rhine-Westphalia stand at 10 ha per day in 2011 [15].

In this studies the Land consumption in metropolitan Gombe occur as result of conversion of open space and farmlands to residential, commercial, office, or other developed land uses. Greater percentage of the ground surface of the metropolitan area is sealed with impermeable material like asphalt, concrete etc. Though there are land surfaces that are covered by non-impervious surfaces (areas include: parks, football fields etc.) The study reveal that the land consumption rates for the three periods stand at 0.0170, 0.0194 and 0.0125 respectively.

SDG 11.3.1 defined two metrics (population growth and land consumption rate) for its computation, and give way to monitor and manage urban expansion in an efficient way to promote land use efficiency. The indicator aim to reach one ratio and symbolize harmony between the metrics. In a case where the metrics are maintain in harmony and constant manner, such urban area will become compacted and likely function in way activities and services are within the reach of people. This urban area will tend to appropriate land in a positive manner to the total sum of the external surroundings.

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In a case where land consumption go pass the population growth then urban sprawl is the order of the day and result into uncontrolled physical expansion, physical infrastructure deterioration, CO^2 emissions, Imbalance between growth of labor force and urban population among others. Land consumption needs to be done in an efficient way to ensure sustainable land use and management for all. The indicator coordinates in a way to influence achieving other SDGs, pertaining to health, food security, energy and climate change

In this studies the indicator reveals that the population growth rates of the three periods of research go pass the land consumption, for that factor the ratio stand at less than one. The SDG 11.3.1 of the three periods stand at 0.4194, 0.4292, and 0.3041 respectively. The result reveal that Metropolitan Gombe is an urban setting where the population growth is greater than the land consumption.

5. Conclusion

The indicator defined two metrics (land consumption and population growth rates) and aimed to determine a ratio between the two. In view of that we employed the recommended equation, Trends.Earth tool and tracked the ratio of consumed land in metropolitan Gombe against population growth. The study reveal Metropolitan Gombe reflect an urban area where population growth rate is higher than land consumption which is favorable. In essence this is tool is used for check and balance to ascertain in what direction urban development is going and to inform decision makers where land consumption go pass the population increase rate to checkmate the potential environmental effect may arise in that course. Attaining sustainability require integration of four key factors: environmental management, social growth, economic growth, urban control. Though there are some factors that affect afore mentioned sustainability factors, in what ways can we identify them and inform urban administrators and decision makers. This indicator coordinates in a way to provide means for archiving other SDGs related to

health, education, hey recognize that activity in one area will influence the result of the others

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