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Physical Planning Inputs in Managing Desertification: A Case Study of Jibia Local Government Area in Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. Author HTA designed the study, carried out the field survey, analyzed the results and wrote the first draft of the manuscript. Author MI wrote the protocol, managed the literature searches and carried out the general review of the paper. Author MAF contributed in the discussion and recommendations of the paper. All authors read and approved the final manuscript.

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ABSTRACT

Jibia Local Government Area falls within the arid zones of the desert. This region is characterized by low amount of rainfall, high temperature, low humidity which has caused frequent drought in the area thereby making the area vulnerable to desertification. This has adversely affected the socioeconomic activities of the inhabitants of the area. This study utilized climatic data to examine prevailing physical environmental conditions in Jibia, also field survey data was acquired to understand the present desertification adaptation strategies in the area with a view to making physical planning proposals. Since Jibia falls within the arid zone, it is therefore proposed that in planning a settlement in the area, emphasis should be based on centralizing the residential areas; this should then be followed by an open space for future expansion. Trees should be provided

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round the residential area to serve as buffer against the winds and sunrays. Moreover, there should be an expanse of farmland for cultivation by the inhabitants at the outskirts of the residential area. Narrow routes should also be provided, shaded with trees.

Keywords: Desertification; physical planning; desertification control.

1. INTRODUCTION

The United Nations Convention to Combat Desertification defines desertification as "land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors including climatic variations and human activities" [1]. Drylands include those land areas of the earth receiving under 600 mm/year of precipitation and for which the ratio of average annual precipitation of potential evapotranspiration is between 0.05 and 0.65 [2].

Desertification is often caused by the interplay of environmental and socioeconomic factors such as poor irrigation methods, deforestation, and overgrazing resulting to reduced vegetation cover and soil organic matter, decreased infiltration, increased runoff, and increased wind and water erosion. Desertification of drylands is matter of serious concern as it eventually leads to declining capability of land for crop production, livestock grazing, and thus supporting human populations [3].

The social consequences of desertification are manifested in the increasing migration of rural populace and shepherds to the cities resulting into increasing pressure on the urban amenities and utilities. Other environmental consequences of desertification include the formation of sand dunes and sand encroachment on urban areas, farmlands, roads and railways [4].

Schreiber [3] highlighted how geospatial technologies (including global positioning systems (GPS), satellite imagery, aerial photography, and geographic information systems (GIS)) can be used in monitoring and management of land areas vulnerable to desertification. Likewise, Petta et al. [5] tested the usefulness of spatial analysis methodologies to capture spatiotemporal heterogeneity from environmental gradients, for the assessment of desertification process at Remote Sensing data. They provided spatial and georeferenced information related to the susceptibility to desertification of several areas of the Northeast of Brazil. In addition, they integrated the georeferenced data with other environmental indicators to identify five different levels of susceptibility to desertification (very high, high, moderate, low and very low), and the geographic domain of each class in the area of study.

Haijiang et al. [6] employed remote sensing, GIS and field survey to build a dataset for monitoring and analysis of sandy desertification of Otindag Sandy Land in China. Results showed that the land has been suffering sandy desertification since 1987 with 2 different desertified stages. The first stage from 1987 to 2000 was a severe sandy desertification period, characterized by the fixed sand dunes decreasing at a high speed, and the semi-fixed and active sand dunes increasing remarkably. The second stage spanned from 2000 to 2006 and the sandy desertification was weakened greatly [6]. Also, Gad and Shalaby [7] integrated remote sensing data (SPOT, Egypt Sat, and SRTM images) with geologic and soil maps in a GIS environment for calculating the Environmental Sensitivity Areas Index (ESAI) for desertification in the inland Sinai and Eastern Desert of Egypt. They found the area is characterized by varying degrees of sensitivity to desertification, ranging from high, moderate to low.

Similarly, Kheiry et al. [8] applied remote sensing and GIS techniques in relation to socioeconomic and human factors to assess the impacts of desertification process within the agrosilvopastoral system in North Kordofan of Sudan. Their study found a strong link between the process of desertification and landuse/landcover change within the agrosilvopastoral system in the area. Likewise, Edris et al. [9] employed remote sensing and GIS in assessing and monitoring sand encroachment and vegetation degradation as desertification indicators in Al-Butana area of Sudan (a semi-arid environment). They discovered that most of the study area experienced a significant change due to sand movement and sand encroachment from northerly direction to the southern part of the study area.

Jibia Local Government Area falls within the arid zones of the desert. This region is characterized of low amount of rainfall, high temperature, low humidity which has caused frequent drought in the area. Over time this has affected the socio-economic lives of the inhabitants. The aim of this study is to examine the problems of desertification in Jibia Local Government with a view of making physical planning proposals.

1.1 Area of Study

Jibia Local Government Area was created in May 1989 in Katsina State of Nigeria. It lies on latitude $11^{o}05'$N and longitude $7^{o}04'$E. It is bordered to the North by Niger Republic, to the South by Batsari Local Government, to the East by Katsina Local Government and the West by Sokoto State. It occupies a total land area of about 32177km^2 and has a total population of 169748 according to 2006 census. It consists of some important towns and villages with the main Jibia town serving as administrative headquarter (See Fig. 1).

Jibia lies within the Sudan Savannah composed of short grasses and variety of trees scattered over an expanse of grassland. These trees are characterized with broad canopies and are hardly taller than 20 meters. This area is characterized with sandy soil constituting about three quarter of the soil type while clay and loamy soil constitutes the rest of the one-quarter of the soil type. This area falls within the Chad formation of sedimentary rocks of cretaceous origin. The area suffers from strong and direct sun rays radiation during the day. Absence of cloud cover permits the easy release of the heat stored during the daytime to a form of long wave radiation towards the cold night sky. The annual mean maximum monthly screen temperature in Jibia is between 37.6^{o}C to 39.3^{o}C especially during the hot season (between March and April). The mean minimum temperature in this period is usually 19.6^{o}C to 24.2^{o}C. But during cold season (November to February) maximum mean temperature in the period falls down to about 17.5^{o}C and 10.5^{o}C.

The main occupation of a greater percentage of the people in the area is agriculture, which is estimated to have taken about 85% of the total population. This 85% engage in various agricultural practices from farming, livestock, poultry and fish farming. The rest of the population (15%) is engaged in other occupations such as trading, carpentry, blacksmithing, etc.

Settlements in the area are dispersed over space with the Jibia administrative town towards the North-Western of the area showing that the administrative town is decentralized. There are also some villages located on the boundary of the Local Government and most settlements are located closer to the boundary.

There are four types of linkages between the settlements in the area:

i. Major or main road which runs from Jibia administrative town North-West down to Gusau of Zamfara State linking with some villages, and this same road runs from Jibia town North-East to Katsina Local Government.
ii. Minor roads linking important villages/hamlets, villages and district headquarters as well.
iii. Footpaths mostly linking villages and hamlets
iv. Rivers and streams linking some of the villages at the South-Western part of the Local Government and serving a purpose of fishing.

2. MATERIALS AND METHODS

The data for this study was obtained through the following methods:

2.1 Field Survey

This involves trip to the study area where observations were made on the physical environment, spatial organization of activities and the socioeconomic condition of the affected area. This was achieved through discussion with traditional rulers, environment professionals and non-governmental organizations.

2.2 Interviews

Interviews were conducted to obtain information on the factors responsible for desertification, the impact of the encroachment on the physical environment and the lives of the people, as well as adaptation strategies to desertification in the area. A total of 100 respondents were selected which comprises of 80 residents and government officials. A combination of stratified and systematic sampling methods was employed

across the various wards in Jibia to obtain a representative sample of the whole population. The respondents included 20 officials from Ministries of Land and Survey, Agriculture, Environment, as well as the Environmental Protection Agency. These respondents were selected through purposive sampling technique.

2.3 Secondary Data

This was obtained from Annual Reports of Katsina State planning board, Bulletin of Katsina Afforestation Project Unit and other relevant agencies. Other sources include maps, theses, dissertations and literatures on the area of study.

3. RESULTS AND DISCUSSION

3.1 Physical and Environmental Characteristics of Jibia Area

3.1.1 Temperature

The annual mean maximum monthly screen temperature in Jibia Local Government falls between 37.6°C to 39.3°C especially during the hot season (between March and April). The mean minimum temperature in this period is usually 19.6°C to 24.2°C. But during cold season (November to February), maximum mean temperature in the period falls down to about 17.5°C and 10.5°C as shown in Table 1.

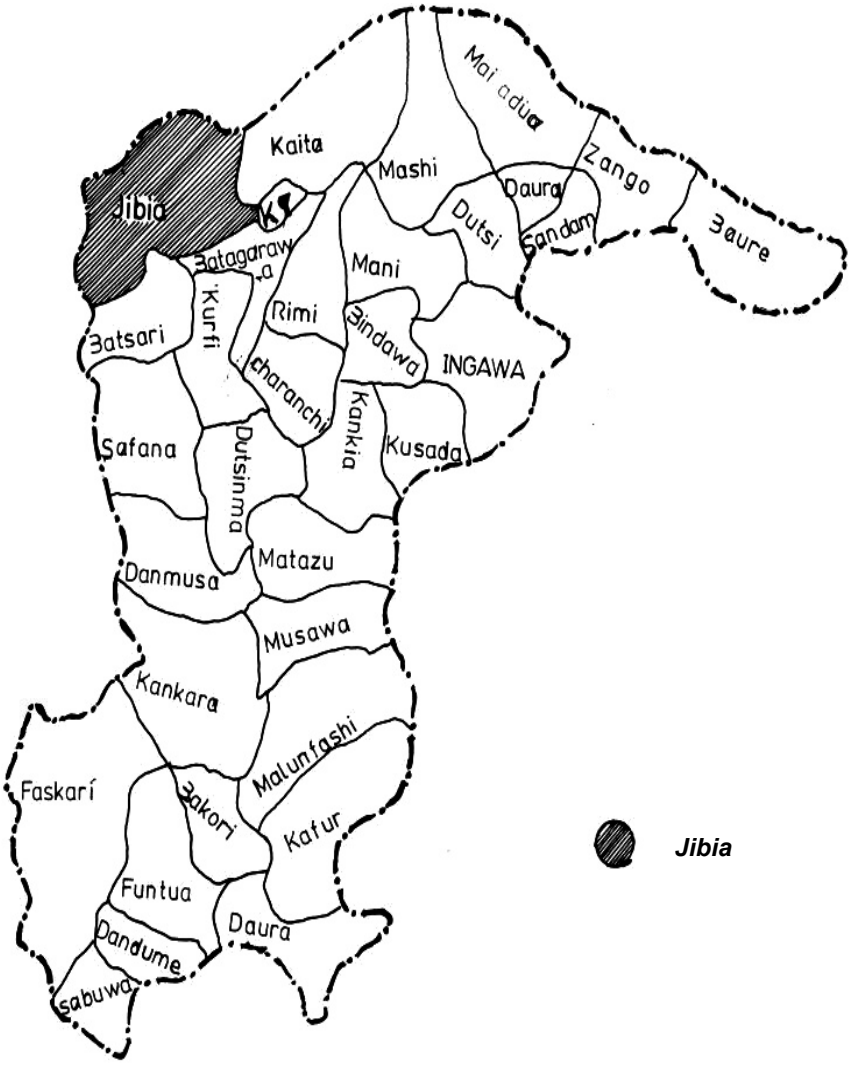

Fig. 1. Map of Katsins State showing Jibia Local Government Area
Source: Jibia Local Government Area, 2006

The highest maximum mean monthly temperature is in the month of April of the year 1996 where temperature rises up to 39.3^{o}C signaling intensive heating of the ground surface. Variation in the mean monthly maximum temperature between the years 1994 and 1996 shows that almost all of the minimum mean temperatures of 1994 rises in 1996, thus indicating increase in heating condition of the ground surface which is an indicator of the advancement of desert like condition in the study area.

3.1.2 Relative humidity

Relative humidity is rather low during the hot season and the dry season as well with a monthly variation of 36.0% and 7.3%, and a seasonal distribution of about 29.5% up to 75.6% during the rainy season as illustrated in Table 2.

Variation in the monthly relative humidity between the years 1992, 1993 and 1994 shows that there is a drastic fall between the 1992 and 1993 periods especially in the months of January, February and March signaling that the air is dry and dusty. But in the years 1993 and 1994, there were rises in some months and fall in January. In February, there was a drastic fall as much as in March but in the months of October, August and April there was a high rise in the moisture content signaling the arrival of the rainy season. Decrease in the amount of moisture content in the air shows the arrival of desert-like conditions associated with intense heating of the atmosphere.

3.1.3 Rainfall

Rainfall in Jibia usually starts in the month of May lasting to September, covering a period of five (5) months. Annual rainfall in this area is about 600mm per annum as indicated in Table 3. The Table also indicated that Jibia experienced low amount of rainfall especially in the year 1964 when mean annual rainfall of 247.09 mm was recorded. In addition, it can be observed from Table 3 that Jibia experienced low amount of annual rainfall between 1934 and 2004. This is one of factors causing desertification in the area as reported by [4] who observed that the low and irregular annual rainfall has increased the severity of the desertification in Arab countries. There was a sudden rise of rainfall in the year 2004 where 506.49mm was recorded. Also, rainfall is associated with strong wind that often affects crop yield in the area.

3.1.4 Wind

Symeonakis and Drake [11] identified four important indicators of desertification which are vegetation cover, rain use efficiency, surface run-off and soil erosion, at a regional scale. He however suggested the need to examine other important desertification indicators such as wind at longer time-scales.

Jibia Local Government Area is under the influence of two types of local winds: the North-Eastern trade winds, or the Hamattan wind, which originates from its neighboring border country i.e. Niger Republic's Sahara desert. The wind brings along with it hot and dry weather with dust storms, which usually occurs in the late afternoon when conventional wind stir-up the dry surface of the ground. The second wind is the South-West wind that originates from the Atlantic Ocean bringing cool and warm weather. This wind usually blows during the wet season. Heating of air over the hot ground causes temperature inversion and as the lower warm airmass breaks through the higher cooler air and the Local whirl wind are often created. The average wind speed in the area is shown in Table 4.

In the month of March throughout the period of 1992 to 1994, the wind-speed was so high that a maximum of 241.28 km/hr was recorded in the year 1993. Also in the month of June in the same year, wind-speed rises up to 251.12 km/hr bringing in very hot and dry dusty air. In the month of October of the year 1992, there was a drastic fall in wind-speed to a maximum speed of 92.24 km/hr which rises to 102.42 km/hr in the year 1994. We can infer from Table 4 that the wind speed in Jibia is generally high. Hence influences the desertification in the area. This is in line with finding of [3] that discovered that degradation process can be aggravated by reduced vegetation cover, increased runoff, and increased wind.

3.2 Present Traditional Adaptation Techniques to Desertification in Jibia

Based on their experience, the residents of Jibia have developed traditional skills in mitigating and adapting to desertification in the area. These are presented in the sections that follow:

3.2.1 Wind consideration

1. Town form – Though the settlements of Jibia are dispersed over space, the form of

its traditional towns are usually compacted. This compaction of houses is necessary in this area so as to reduce the effect of wind. Consequently, narrow passages which are often shaded with trees are provided so as to reduce the easy facilitation of hot and dry wind of the Sahara.

2. Layout of road networks – Roads in Jibia usually run North-West and South-East and shaded with shelter belts. This is necessary so as to reduce the effect of dusty winds on the eyes of motorists.
3. Green belts – Trees are usually provided within the settlements and along routes so as to check the flow of the dusty wind and serve as a shading device.

3.2.2 Solar consideration

1. Town form – The compact form of the traditional towns help reduce walking distances within the villages under the hot sun and intensive solar radiation. It also helps to enhance the provision of shades in the villages.
2. Layout of road networks – Location of roads on the North West and South East direction help ease the effect of sun glare on the eyes of motorists.
3. Building materials – Most houses in the study area are usually built with local building materials such as the walls made up of mud and sometimes a combination of both mud and reed grasses, while the roofs are made up of reed grasses but in some cases corrugated sheet is used. Mud and reed grasses are best known as bad conductors of heat while the corrugated roofing sheet is a good conductor of heat. These houses are often designed with courtyards located centrally within the houses. It provides shades and also serves as a resting place.

3.2.3 Rainfall consideration

Rainfall plays a vital role in the socio-economic activities of the people of Jibia Local Government. Agriculture is the major occupation of over 80% of the inhabitants of the area. Though the annual rainfall in the area varies and is still below the average, but with the help of the Jibia dam, farmers are able to cultivate their farms. Apart from the dam, farmers are only opportuned to cultivate their farm deep in the rainy season. Besides, farmers in this area practice a form of shifting cultivation due to low fertility of the soil and are only able to grow grains.

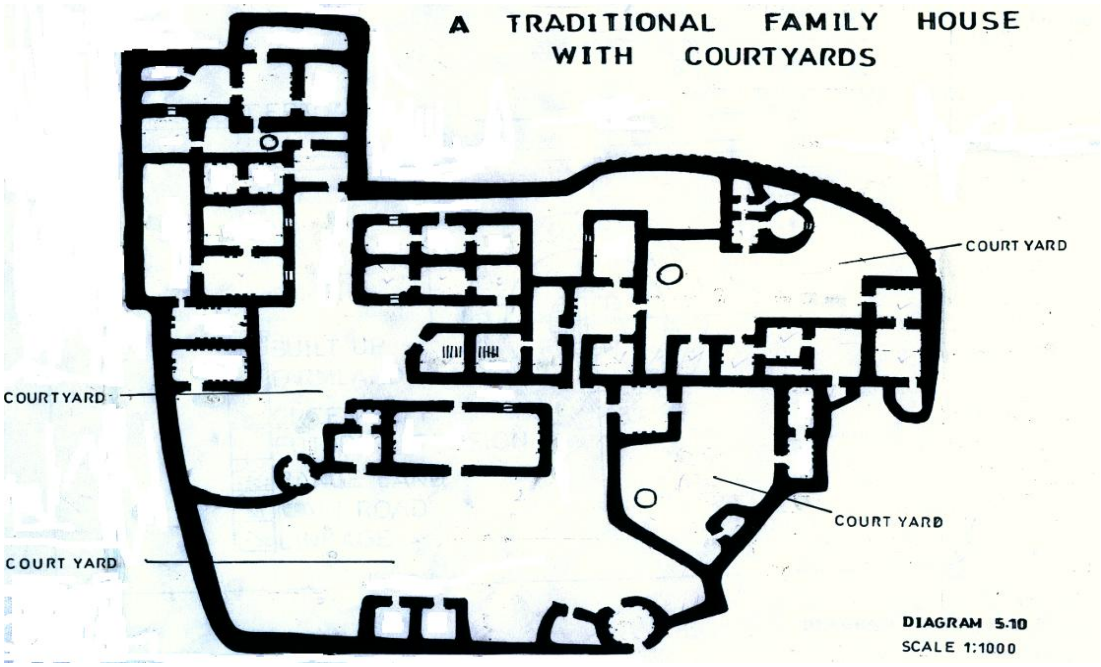

Fig. 2. A traditional house with courtyards
Source: Author's work, 2006

Table 1. Variation of the Mean Monthly Temperatures in Jibia between 1994 and 1996

	°C	J	F	M	A	M	J	J	A	S	O	N	D	(T)
1994	Max.	30.2	31.5	38.2	38.6	39.0	35.5	31.8	29.7	31.3	34.1	32.7	27.3	399.90
	Min.	12.8	13.6	19.6	22.9	24.2	29.2	20.0	19.1	19.8	20.7	13.5	10.5	206.99
1996	Max.	25.0	35.8	37.6	39.3	39.0	34.5	33.1	31.8	32.3	31.9	31.2	31.8	403.3
	Min.	12.1	15.4	18.5	21.8	24.8	30.2	22.0	20.8	21.8	20.6	15.4	14.7	238.1

Source: Agricultural Development Projects, Katsina State (2006) [10]

Table 2. Seasonal Variations in Relative Humidity of Jibia in 1992, 1993 and 1994

%	J	F	M	A	M	J	J	A	S	O	N	D	(T)
1992	20.6	21.9	36.0	40.0	52.2	51.0	72.6	75.6	69.3	35.5	21.6	16.0	512.3
1993	19.7	17.1	12.7	20	38.5	49.4	66.0	72.0	66.5	29.5	16.0	17.0	424.4
1994	18.0	8.1	7.3	32.9	39.2	55.7	69.9	78.5	73.8	59.3	20.8	12.6	476.1

Source: Agricultural Development Project, Katsina State (2006).

Table 3. Mean Annual Rainfall in Jibia Area between 1934 and 2004

Year	Rainfall in (mm)
1934	492.13
1944	484.18
1954	467.68
1964	247.09
1974	394.17
1984	341.48
1994	440.00
2004	506.49

Source: Agricultural Development Projects, Katsina State (2006)

Table 4. Wind Speed in Jibia over the period of 1992 to 1994

Wind (Km/hr)	J	F	M	A	M	J	J	A	S	O	N	D	Totals
1992	-	-	-	-	225.39	-	166.31	204.70	121.39	92.24	151.75	145.0	1106.78
1993	-	-	175.95	212.69	241.28	251.12	235.56	187.12	169.56	113.68	95.78	96.4	1179.14
1994	169.65	202.6	173.74	203.47	222.48	231.49	206.98	146.0	97.37	102.42	100.73	186.93	2043.86

Source: Agricultural Development Project, Katsina State (2006)

3.3 Physical Planning Approach to Desertification in Jibia

Intensive heat condition in Jibia Local Government Area is associated with the high rate of the mean monthly temperature of the area. Also variation in the amount of the annual rainfall in this area leads to fall in agricultural produce in the area. Furthermore, the high wind speed and fall in moisture content of the air symbolizes the blowing of heavy dust particles in the area and wearing away of the fertile sub-soil which also reduces the rate of cultivation in this area. All of these climate conditions symbolize the advance of desert-like condition in the area. It was found that climate plays a significant role in the environmental conditions of Jibia. This can be seen in the form of its traditional towns, layout of roads, socio-economic activities of its inhabitants and materials used for building. The following planning inputs are viable in combating desertification in the area:

1. It is hereby proposed that courtyards should be included in the building design of houses and construction in modern quarters such as those of the traditional houses, for its importance as a shading device. Provision of trees in the courtyards will help enhance ventilation. A typical traditional house with courtyard is shown in Fig. 2.
2. Heat transfer can be reduced in the study area by constructing houses with thick walls especially in modern quarters. But the traditional houses should maintain the existing situation.
3. Dense clustered pattern of settlements should be adopted for future layout in the study area. Roads should be relatively narrow and shaded with trees to reduce the effect imposed by direct sun rays and wind.
4. Most inhabitants of the arid zones like Jibia are farmers and animal rearers. Therefore, in planning a settlement an arid zone, emphasis should be based on centralizing the residential areas; it should then be followed by an open space for future expansion. Trees should be provided round the residential area to serve as buffer against the winds and sunrays. Also, there should be an expanse of farmland for cultivation by the inhabitants at the outskirts of the residential area. Narrow routes should also be provided, shaded with trees.

4. CONCLUSION

Jibia Local Government Area falls within the arid zones of the desert. This region is characterized by low amount of rainfall, high temperature, low humidity which has caused frequent drought in the area thereby making the area vulnerable to desertification. This has adversely affected the socioeconomic activities of the inhabitants of the area. This study utilized climatic data to examine prevailing physical environmental conditions in Jibia, also field survey data was acquired to understand the present desertification adaptation strategies in the area with a view to making physical planning proposals. Findings revealed that some of the traditional techniques in adapting to desertification in the area are viable and could be maintained. For instance, the general compact nature of houses in the study area and nature of building materials used as a result of desert encroachment has affected the layout of infrastructures in the area. This can be maintained in the present settlements but redesigned in new settlements or layouts. Since Jibia falls within the arid zone, it is therefore proposed that in planning a settlement in the area, emphasis should be based on centralizing the residential areas; this should then be followed by an open space for future expansion. Trees should be provided round the residential area to serve as buffer against the winds and sunrays. There should be an expanse of farmland for cultivation by the inhabitants at the outskirts of the residential area. Narrow routes should also be provided, shaded with trees.

It is anticipated that if these proposals are implemented and management structures are well organized, desertification in Jibia Local Government shall be reduced to a minimum. Future studies should review the government desertification control measures in the area.

In addition, a study of long term climatic data of the area should be carried out to show if climate change has an impact on the physical and environmental characteristics as well as the severity of desertification in Jibia Local Government Area.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. UNCED. Earth Summit Agenda 21: Programme of Action for Sustainable Development. United Nations Department of Public Information; 1992.
2. UNEP. Status of Desertification and Implementation of the United Nations Plan of Action to Combat Desertification. Report of the Executive Director. Nairobi: United Nations Environment Programme; 1992.
3. Schreiber KV. An approach to monitoring and assessment of desertification using Integrated Geospatial Technologies, Millersville University of Pennsylvania, Millersville, Pennsylvania.
4. Saad AMA, Shariff NM. Estimating desertification in the Arab World using GIS approach Middle-East. Journal of Scientific Research. 2011;8(6):1046-1053.
5. Petta RA, Ohara T, Medeiros CN. Desertification studies in the Brazilian Northeastern Areas with GIS Database Anais XII Simpósio Brasileiro de Sensoriamento Remoto, Goiânia, Brasil, 16-21 Abril, INPE. 2005;1053-1061.
6. Haijiang L, Chenghu Z, Weiming C, En L, Rui L. Monitoring sandy desertification of Otindag sandy land based on multi-date remote sensing images. Acta Ecologica Sinica. 2008;28(2):627−635.
7. Gad A, Shalaby A. Assessment and mapping of desertification sensitivity using Remote Sensing and GIS, Case study: Inland Sinai and Eastern Desert Wadies. US-Egypt Workshop on Space Technology and Geo-information for Sustainable Development, Cairo, Egypt; 14-17 June, 2010.
8. Kheiry MA, Mahmoud TE, Mofadel HIA. Applying remote sensing tools for assessing desertification process within the agrosilvopastoral system, North Kordofan- Sudan. Tropentag 2012: Conference on International Research on Food Security, Natural Resource Management and Rural Development organised by: Georg-August Universität Göttingen and University of Kassel-Witzenhausen, Göttingen, Germany; September 19-21, 2012.
9. Edris OHA, Dafalla MS, Ibrahim MMM, Elhag AMH. Desertification monitoring and assessment in Al-Butana Area, Sudan, using remote sensing and GIS techniques. International Journal of Scientific & Technology Research. 2013;2:3.
10. Agricultural Development Projects. Katsina State; 2006.
11. Symeonakis E, Drake N. Monitoring desertification and land degradation over sub-Saharan Africa. Int. J. Remote Sensing. 2004;25(3):573–592.

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