EFFECTS OF SPATIO-TEMPORAL CHANGES IN LANDUSE LAND COVER ON THE ENVIRONMENT OF KATSINA STATE, NIGERIA

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Abstract

An increase in infrastructural development to meet the needs of the population size causes a transformation in surface covers. The study assessed the effects of changes in land use on the land cover of Katsina State between 1991 and 2021. Data on specific categories of surface covers and the magnitude of each were generated from Landsat images of 1991 and 2021 using diverse GIS and remote sensing techniques while published materials provide information on the background to the study. The effects of changes in land use on the land covers were determined by comparing the magnitude of the same category between 1991 and 2021 to determine the rate of drift. From the result, land use decreased by 0.72% while land covers increased by 0.71%. Adaption of agro-vegetation in areas distressed by vegetation covered by individual tree species like *Azadirachta indica* (neem) that are ecologically adapted to the semi-arid region, fast-growing and of importance to inhabitants should be intensified.

Keywords: Population size; Human activities; land use and land covers; transformation; environment

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Introduction

Man through his survival activities such as arable farming, wood harvesting, mining and construction alters natural components of the Earth's surface, especially with the increase in population (Ramirez, Gonzalez, & Perez, 2016). Before the interference of man with the Earth's surface, the cover was mainly composed of native vegetation cover, water bodies like rivers, seas, lakes and streams, and bare rock outcrops (Environmental Encyclopedia**,** 2020)**.**

The rising human population is the main driving force directly responsible for land use land and cover change in any region. This is because infrastructures are expanded to the detriment of the initial surface covers (Rahaman, Kumar, Chen, Meadows and Singh, 2020). Since the 20th century, the magnitude of environmental degradation is linked to human population size and resource use. Thus, population growth affects natural resources like fresh water, arable lands, vegetation covers, and wildlife through the increase in consumption (National Academy of Sciences, 2018). Massive clearing, thinning or significantly disturbing of native vegetation cover is recognized as a major factor contributing to a decline in environmental qualities such as loss of biological diversity due to fragmentation, soil erosion due to removal of vegetation cover, siltation of river channels, destruction of wildlife habitat, and changes in land use land cover (New South Wales, 2021).

Land transformation is caused by natural and anthropogenic driving forces; and its impact on the affected environment is a key issue in understanding the relationship between society's economic activities such as arable farming and the environment (Rahaman *et al*., 2020). Studying land use land cover change dynamics of the environment is important in understanding the causes and implications of land use and the changes that occur. This will enhance the understanding of how the land use system, planning and policy function together (Idris, Mahmood, James, Olojo, Isah and Mustapha, 2016).

The study is conceived from the works of literature on the increase in human population manifested by diverse economic activities such as arable farming transforming the natural surface covers

into manmade environments (Ochola, Nyamai, & Owuor, 2019). In Katsina State, structural development such as an increase in tertiary institutions, primary and secondary schools, the adaption of 34 local government areas, and the expansion of road networks and settlements have transformed the natural land cover into a manmade environment (Katsina State Government, 2016). Activities of the population that increased from 3,753,133 to 7,961,820 which led to an increase in density from 150 to 319 persons per km^2 between 1991 and 2021 have transformed the natural surface covers (National Population Commission of Nigeria, 2020; Nigeria: Administrative Division, 2020).

The study aims to identify the specific types of land use land covers and the magnitude of each with a focus on determining the effects of land use on land cover. The objectives include: isolating land use land cover and the magnitude of each, and deducing the effects of the changes in land use on the natural land cover. The study is limited to land-use land cover of Katsina State in 1991 and 2021. The land use include all areas transformed into manmade environment such as built-up area, agricultural lands, reservoirs, and woodlots or orchards while land cover is restricted to all areas under natural vegetation covers, water bodies and bare land surfaces.

An Overview of Katsina State

The state is located between latitudes 11007'49 and13022'57 north of the Equator and longitude 6052'03 and 9002'40 east of the Prime Meridian. It shares a common boundary with Zamfara and Sokoto States to the west, Jigawa and Kano States to the east, Kaduna State to the south, and Niger Republic to the north. It has a landmass of about 24,971 km2.

Rainfall is seasonal with a dry season from November to May while June to October is the wet season. The cumulative annual rainfall amount in 2021 was 500 to 1000 mm. August is the wettest month with rainfall amounts between 250 to 400mm. The mean annual maximum temperature per day is 34 to 37^0C. The hot season is between March and May with a temperature of about 37^0C while the cold season is between December and January with a temperature of 13^0C due to the occurrence of harmattan (Nigerian Meteorological Agency, 2022).

The soils of the state are generally loose, sandy, and well-drained with low water retention, low organic matter content due to low vegetation cover, and less resistance to erosion. The soils are highly erodible by wind and water (El-ladan, Yaro, & Daura, 2018). The relief ranges from about 450 to 650m above mean sea level with isolated hills of about 750m. The most important rivers include Gagare, Turami, and Bunsuru which flow into Zamfara State while rivers Gada, Tagwai, and Safke flow into Niger Republic. Rivers Chalawa, Gari, and Kaganya are tributaries to the Kano River basin. Minor streams like Marigo, Damari, Maikategi, Magajin Dutse and Kara in the southern part of the state are drained into river Kaduna (Ibrahim and Aliyu, 2018).

The Vegetation cover of Katsina State falls within the Sudan Savanna, a semi-arid region of northern Nigeria. It is dominated by scrubland which occurs under relatively harsh conditions such as human activity like arable farming and pastoralism, and drought stress. The predominant woody plant species include *Butyrospermum parkii, Vitex doniana, Khaya senegalensis* and *Celtis integrifolia* while the rare species are *Sclerocarya birrea, Lannea schimperi* and *Adenium obesum* (Katsina State Government, Nigeria, 2020).

Between 1991 and 2021, the population increased by 16.60% invariably the density increased by 169 persons per km^2 while land per capita decreased by 3154.51m^2. Table 1 presents Katsina State population trends and land per capita for 1991 and 2021.

Table 1: Katsina State Population Trends and Land per capita

Year	Population	Percentage increase	Landmass (km^2)	Density (km^2)	Land per capita (m^2)
1991	3,753,133	14.81	24,971	150	6666.67
2006	5,801,584	22.89		232	4310.35
2016	7,831,300	30.89		314	3184.71
2021	7,961,820	31.41		319	3134.80
Total		**100.00**			

Source: National Population Commission of Nigeria (2020); Nigeria: Administrative Division (2020).

The Infrastructural developments in the state include:- New Local Government Areas and District Councils, institutions of higher learning, numerous secondary and primary schools, ministries and parastatals. More importantly, structural developments embarked upon include the expansion of settlements and road networks, markets, dams, and hospitals that were constructed and upgraded (Katsina State Government, 2016). The predominant economic activities of the people include arable farming on crops such as groundnuts, cotton, millet and sorghum, and vegetables like onion, tomatoes, garden eggs and pepper. Some people keep animals like cattle, sheep, goats, horses and donkeys (Encyclopedia Britannica, 2015).

Materials and Methods

The data required are specific land use land cover types and the magnitude of each that are used to determine the effects of the changes in land use on the environment (land cover). The sets of data were generated from Landsat imageries of 1991 and 2021. ArcGIS (version

9.3) ETM 15m resolution was adopted to analyse both the imageries. The images were both geo-referenced to UTM projection bands 4 and 3 that were subjected to clustering that produced 13 classes which were labelled using the topographical map of Katsina State.

From the scenes, sub-setting was done to demarcate Katsina State. Simultaneously, mosaicking was adopted to merge the scenes. Accordingly, a base map of the state was imposed on the Landsat imageries of 1991 and 2021 separately to produce land use land cover maps. Likewise, to isolate the areas and to determine the magnitude of changes in land use land cover types, signature files were developed using 13 colour bands to represent similar surface covers that were extracted from the images. These were run on a supervised classification model by ERDAS that generated statistics for the 13 signature files created. The emphasis is to isolate and determine the magnitude of the adopted land use land cover of the classes.

To quantify the influence of changes in land use on the environment (land cover), the magnitude of the land uses was equated to the magnitude of the land cover. The effects were based on whether the 2021 land covers decreased or increased from the base year (1991). When the land cover decreased, effects on the environment were deduced from observations of the decline in area cover. The environment is synonymously used as a land cover that is considered as the initial surface covers like vegetation covers, natural water bodies and rock outcrops while the land use includes woodlot/orchards, built-up area, intensive small-holder rain fed agricultural land, extensive small holder rain fed agricultural land, floodplain agriculture, woodlot/orchard and reservoir which are human transformed surfaces.

For meaningful explanation, the 13 types of adapted land use land covers are first categorized into four (4) similar surface covers such as (1). Vegetation cover includes all areas under natural plant cover such as riparian vegetation covers, grassland and scrubland. (2). Water bodies consist of natural surface water such as rivers, streams and lakes. (3). Land use includes all areas transformed by men such as built-up areas, intensive small-holder rain fed agricultural land, extensive small-holder rain fed agricultural land, floodplain agriculture,

woodlot/orchard, agricultural tree crop plantation and reservoir. (4). Bare lands include gully and rock outcrops devoid of vegetation covers that are not transformed for significant economic use. Secondly, the four (4) categories of land use land cover are further classified into two (2) to differentiate land use from land cover, and to foster comparison between magnitudes of land use land cover.

Literature Review

The result of the study indicates that an increase in land use like arable farming affects vegetation covers adversely. The massive vegetation removal, clean weeding and ploughing convert the natural surface of native vegetation covers to agricultural lands. Thus, the vegetation reserves are increasingly deserved for arable farming. Also, the cultivation of woodlots on exotic tree species like *Mangifera indica*, *Citrus reticulata* and *Psidium guayava* convert native vegetation into agro-vegetation cover (Gandapa, 2014). Agriculture which is the active production of useful plants and animals transforms the natural environment into altered surfaces, especially in semi-arid regions (Encyclopedia Britannica, 2015). Ochola *et al*. (2019), stated that apart from human activities like arable farming and infrastructural development which are the major causes of changes in land use land cover; natural processes like volcanic eruptions, erosion, change in river channels and climatic variations are some of the causes while the drivers include environmental conditions like landform, plant succession, drainage patterns, geomorphic and soil processes.

According to (Ochola *et al.* (2019), landuse is the meaningful utility of land for arable farming, grazing, mining, settlements and roads construction while land cover is the biophysical state (vegetation cover, water body, bare rock outcrop) of the Earth's surface. Likewise, land cover change is the conversion or modification in form, function, and change in areal extent of a given type of land use or land cover. Conversion is the change or replacement of one cover type to another while modification implies alteration of structure, function or composition without changing its overall classification or the type. The

linkage between land use and land cover changes is that both affect the environment.

Study on the impact of population size on the environment indicates that the combined effects of population growth, consumption and misuse of resources, and adaption of technologies to supply energy, food, and extract minerals have stressed the environment. More population means more land is required to produce food, more space to construct houses and roads, and more vegetation removal for various purposes. Likewise, the increase in population size leads to the diversification of economic activities like arable farming which affects the land cover of the local environment (Mittal and Mittal, 2013). The development of social infrastructures such as schools, houses, hospitals, clinics; and economic infrastructures such as roads, airports, railways, bridges, dams, national power grid and electrical power lines and mobile phone towers have resulted in the conversion of the natural surface covers to transformed surfaces (Gandapa, 2014).

Results of studies especially those of Gandapa (2014); Ochola *et al*. (2019); Mittal and Mittal (2013) are important in identifying the causes of changes in land use and land cover. However, none of the studies assessed the effects of changes in land use on land cover neither compared to 1991 to 2021 nor restricted their studies to Katsina State. In Katsina State, many areas have been converted from riparian vegetation covers, grassland and shrubland to farmlands and built-up areas a destructive form of land use that substantially alters the initial surface cove. This is because the increase in population exerts more pressure on the environment such as vegetation covers and water bodies to meet the needs of the population (Encyclopedia Britannica, 2015).

Results and Discussions

1991 and 2021Landuse Land Cover Types of Katsina State

From Figure I, intensive small-holder rain fed agricultural land dominated the area in the years under study. Extensive small-holder rain fed agricultural land is concentrated in the North West around Kusada and Kastina, and in the centre around Dutsima. In 1991 the extensive-small holder rain fed agricultural land around Baure in the

northeast was taken over by intensive small-holder rainfed agricultural land in 2021. From the pictorial data in Figure I, there are insignificant observable changes in land use land cover types between 1991 and 2021.

Figure I presents categories of land use land cover types of Katsina State in 1991 and 2021.

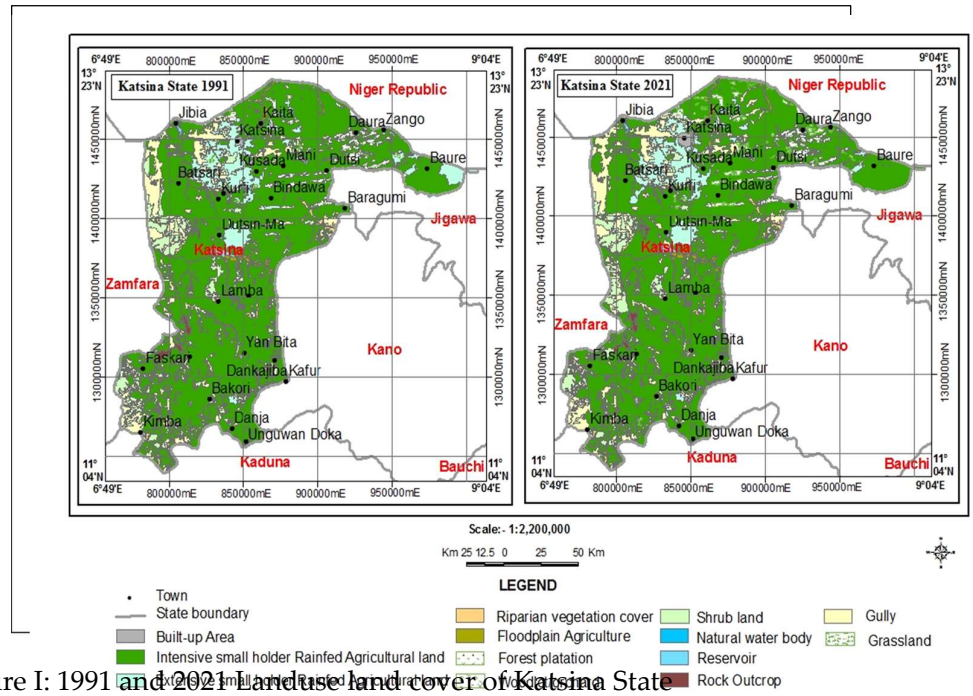


Figure I: 1991 and 2021 Landuse land cover of Katsina State

Amongst the land use land cover categories compared, gully has the largest land cover while woodlot or orchard has the least land use. Shrubland and grassland vegetation covers decreased by 0.27% together while riparian vegetation cover increased by 0.01%. Natural water bodies decreased by 0.02%. Bare surfaces such as gully increased by 1.00%. Among the four (4) categories of land use land covers compared, vegetation covers, natural water bodies and lands decreased by 0.26%, 0.02% and 0.72% respectively while bare surfaces increased by 1.00%. The magnitude of all categories of land use decreased by 0.72% while land covers increased by 0.71%.

Detected Trends in Land use Land Cover and Magnitude of Each

Table 2 presents a summary of land use land cover types, magnitude and rate of changes that are generated from Figure I.

Table 2: Types of Land use Land Cover and Magnitude

S. No.	Types of Land Use Land Cover	1991 Area cover (Km^2)	Magnitude (%)	2021 Area cover (Km^2)	Magnitude (%)	Magnitude of changes Km^2	%
1.	Built-up area	93.73	0.37	229.61	0.92	135.88	0.55
2.	Intensive smallholder rain fed agricultural land	1631.99	6.54	1472.05	5.89	-159.94	-0.65
3.	Extensive smallholder rain fed agricultural land	17462.54	69.93	17256.34	69.11	-206.20	-0.82
4.	Agricultural tree crop plantation	60.68	0.24	56.26	0.23	-4.42	-0.01
5.	Riparian vegetation cover	258.13	1.03	259.89	1.04	1.76	0.01
6.	Floodplain agriculture	271.79	1.09	325.30	1.30	53.51	0.21
7.	Woodlot/orchard	3.79	0.02	12.42	0.05	8.63	0.03
8.	Grassland	746.15	2.99	712.49	2.85	-33.66	-0.14
9.	Shrub land	1265.01	5.07	1234.56	4.94	-30.45	-0.13

10.	Natural water body	122.74	0.49	117.78	0.47	-4.96	-0.02
11.	Reservoir	78.24	0.31	70.14	0.28	-8.10	-0.03
12.	Rock outcrop	169.05	0.68	169.04	0.68	-0.01	0.00
13.	Gully	2807.38	11.24	3055.32	12.24	247.94	1.00
	Total	24,971.20 **24,971.00**	**100.00**	24,971.20 **24,971.00**	**100.00**		

Source: Landsat images of 1991 and 2021

From Table 2, gullies form the largest surface cover followed by extensive smallholder rain fed agricultural land while the least is woodlot/orchard followed by a reservoir. From the result, land use land covers such as agricultural tree crop plantation, intensive smallholder rain fed agricultural land, extensive smallholder rain fed agricultural land, reservoir, scrubland, grassland, natural water body and rock outcrop decreased by 1.80% while woodlot/orchard, built-up area, floodplain agriculture, riparian veg. cover and gully increased by 180%.

Detected Trends in Four Categories of Land use and Land Cover

From Table 3, bare surfaces have the largest portion, followed by vegetation covers and land use while natural water bodies have the least portion. Vegetation covers, natural water bodies and land use decreased by 0.26%, 0.02% and 0.72% accordingly while bare surfaces increased by 1.00%. Within the vegetation covers, shrub land and grassland decreased by 0.27% while riparian vegetation cover increased by 0.01%. Natural water bodies decreased by 0.02%. Between the bare surfaces, the gully increased by 247.94 km2 while rock outcrops decreased by 0.01 km2.

Among the land use categories, woodlot or orchard, built-up area and floodplain agricultural land increased by 0.79% altogether while intensive small-holder rain fed agricultural land, extensive small-holder rain fed agricultural land and reservoir decreased by 1.50% equivalent to 374.24km^2 in all.

Table 3 presents four categories of land use land cover, magnitude and rate of changes

Table 3: Detected Trends in Land use and Land Cover Changes in 1991 and 2021

S. No.	Types of Land use Land Cover	Land use land cover types	1991 Area cover (Km^2)	Magnitude (%)	2021 Area cover (Km^2)	Magnitude (%)	Magnitude of changes Km^2	%
1.	Vegetation Covers	Shrub land	1265.01	5.07	1234.56	4.94	-30.45	-0.13
		Riparian veg. cover	258.13	1.03	259.89	1.04	1.76	0.01
		Grassland	746.15	2.99	712.49	2.85	-33.66	-0.14
		Total	**2269.29**	**9.09**	**2206.94**	**8.83**	**-62.35**	**-0.26**
2.	Natural	water body	**122.74**	**0.49**	**117.78**	**0.47**	**-4.96**	**-0.02**
3.		Gully	2807.38	11.24	3055.32	12.24	247.94	1.00

	Bare surfaces	Rock outcrop	169.05	0.68	169.04	0.68	-0.01	-0.00
		Total	**2976.43**	**11.92**	**3224.36**	**12.92**	**247.93**	**1.00**
	Total of all land covers		**5368.46**	**21. 50**	**5549.08**	**22.22**	**180.62**	**1.71**
		Woodlot/orchard	3.79	0.02	12.42	0.05	8.63	0.03
4.	Land use	Agricultural tree crop plantation	60.68	0.24	56.26	0.23	-4.42	-0.01
		Built-up area	93.73	0.37	229.61	0.92	135.88	0.55
		Intensive smallholder rainfed agricultural land	1631.99	6.54	1472.05	5.89	-159.94	-0.65
		Floodplain agriculture	271.79	1.09	325.30	1.30	53.51	0.21
		Extensive smallholder rainfed agricultural land	17462.54	69.93	17256.34	69.11	-206.20	-0.82
		Reservoir	78.24	0.31	70.14	0.28	-8.10	-0.03
	Total of all land use		**19,602.76**	**78.50**	**19,422.12**	**77.78**	**-180.64**	**-0.72**

Total	**24,971.22**	**100.00**	**24,971.22**	**100.00**
	24,971.00		**24,971.00**	

Source: Landsat images of 1991 and 2021

Categorization of Land use from Land Covers and Magnitude of Each

Table 4 presents a summary of categories of land use from land cover of Katsina State.

Table 4: Detected Trends in Magnitude of Land use and Land Cover Categories

S. No.	Types of land use land cover	1991 Area cover (km^2)	Magnitude (%)	2021 Area cover (km^2)	Magnitude (%)	Magnitude of changes Km^2	%
1.	Land use	19,602.76	78.50	19,422.12	77.78	-180.64	-0.72
2.	Land cover	5,368.46	21.50	5,549.08	22.22	180.62	0.71
	Total	**34,971.22** **24,971.00**	**100.00**	**24,971.20** **24,971.00**	**100.00**		

Source: Landsat images of 1991 and 2021

From Table 4, between 1991 and 2021 land use that has more portion decreased from 78.50 to 77.78% while the land covered with a lesser portion increased from 21.50 to 22.22%. Despite the increase in land cover by 0.71% while land use decreased by 0.72%, the transformation of land covers such as scrubland, grassland, natural water bodies and rock outcrop to land use such as floodplain

agriculture affects the environment adversely. For more emphasis, the effects are highlighted below.

Increase in Landuse

From Table 3, land use such as woodlot or orchard, built-up areas and floodplain agricultural land increased by 0.79% in all while intensive small-holder rain fed agricultural land, extensive small-holder rain fed agricultural land and reservoir decreased by1.50% together. From Table 4, land use decreased by 0.72% while land cover increased by 0.71%. The increase in built-up areas and floodplain agricultural lands by 0.76% (189.39km^2) reduces area covers of shrubland and grassland that are well drained and have suitable pastures for wildlife. The effects of an increase in woodlot or orchards by 8.63km^2, and a decrease in intensive small-holder rain fed agricultural land, extensive small-holder rain fed agricultural, and a reservoir by 374.24km^2 are highlighted below.

Reduction in Vegetation Covers

From Table 3, vegetation covers (shrubland and grassland) decreased from 8.06% in 1991 to 7.79% in 2021. The 0.27% decrease is caused by an increase in a woodlot or orchard, floodplain agricultural land and built-up area by 0.79% altogether. The 62.35 km2 reduction in vegetation cover of the state has adverse effects on the environment. Thus, the removal of vegetation covers for any purpose initiates soil erosion. For example, the massive clearing of native shrubland and grassland for floodplain and rainfed agriculture led to erosion around Musawa, Mashi and Rimi LGAs.

The conversion of 62.35km^2 of native vegetation covers into 198.02km^2 on dissimilar land use like agricultural lands and built-up areas leads to a loss of habitat for wildlife that occupy and breed in such natural areas. The transformation of natural vegetation covers reduces the aesthetic value attached to such areas. For example, the conversion of 30.45km^2 of shrubland into floodplain agriculture and woodlots/orchards by 62.14km^2 at Zobe, Jibia, and Dutsinma among

others have reduced native vegetation covers by conversion into agricultural lands.

Increase in Bare Lands

From Table 3, bare surfaces such as gully increased by 1.00%. The 247.94km^2 increase has adverse effects on the environment. For example, the gullies in Baure and Kaita LGAs; dry river valleys in Kafur, Rimi, Sandamu, Baure, and Safana LGAs; dune in Baure LGA; and open pits in Mashi, Rimi and Musawa LGAs convert 64.11km^2 of shrub land and grassland vegetation cover into bare lands by 247.94km^2.

The effects of 247.94km^2 increase in bare land surfaces on the environment include: - The increase in dry river valleys due to erosion in Kauri LGA; siltation and open pits in Rimi LGA reduce area covered by water in Rivers Gada, Karaduwa, Tagwai, Turami, and Gagari by 4.96km^2; and reduce vegetation covers (grassland and scrub-land) by 64.11km^2. The increase in bare land surfaces such as strip mines, quarries, gravel pits, and dump hills creates pools and initiates channel erosion that reduces vegetation cover and surface water.

Decrease in Natural Water Body

From Table 3, between 1991 and 2021, the natural water bodies like rivers Tagwai, Karaduwa, Karaduwa and Gada decreased by 0.02%. The 4.96km^2 decrease is attributed to the massive removal of vegetation cover for arable farming especially on the river catchment regions and basins that initiate erosion and siltation of the river channels. More importantly, the construction of dams like Ajiwa (on River Tagwai), Zobe (on River Karaduwa), Jibia (on River Gada), Malumfashi (on River Tura) and Gwaigwaye (on River Gwaigwaye) reduce the volume of water downstream. Likewise, multiple constructions of dams like Jibia, Dutsima, and Zobe on river Gada and its tributary reduce water quantity in the lower course.

The 4.96 km2 decrease in surface water affects the environment adversely. For example, the initial area covered by water in rivers Tagwai, Karaduwa, Gada, Tura and Gwaigwaye that serve as habitats for aquatic plants and animals has been reduced by conversion into dry

river beds. The species of plants and animals like crocodiles that depend entirely on the wetlands for survival are reduced or endangered. This is because the dry river bed declined to provide significant cover and a source of nutrition to the aquatic animals.

Habitat Fragmentation

Fragmentation of vegetation cover is an effect of arable farming and road construction. The populace massively cleared 64.11 km2 of shrubland and grassland covers on the earmarked places for arable farming that separate larger shrubland and grassland vegetation covers into several smaller areas. For example, the wider clearance around Ingawa, Musawa and Funtua LGAs causes fragmentation driven by road networks that link settlements in the state, neighbouring states like Zamfara, Sokoto, Jigawa, Kano and Kaduna States, and Niger Republic. This means that sedentary animals like chameleons and tortoises have less usable habitat than before that reducing intra and extra-species interactions.

Likewise, the fragmentation of rivers by dam construction is another effect of land use on natural water bodies. The disintegration of upstream from downstream of surface water by dykes on dams like Ajiwa, Zobe, Jibia, Malumfashi and Gwaigwaye have reduced interactions between the up and downstream species of aquatic animals like fish, changed the flow of the rivers, and reduced area covered by surface water downstream and expansion upstream.

Conclusion

The human-transformed land cover for economic purposes like arable farming is the most significant factor responsible for the major causes of environmental problems. This is because the indigenous vegetation covers that are adapted to the environment decreased by 64.11 km2. An increase in population by 16.60% manifested by expansion in diverse land use such as agricultural land and built-up area increased by 198.02 km2 transformed the natural land cover such as vegetation cover, natural water bodies and bare surfaces by 312.05km^2.

The study compared the magnitude of changes in land use and land cover in 1991 and 2021 and assessed the effects of the changes in land use on land cover. The study provided quantitative data on the population sizes and density of Katsina State in 1991 and 2021, the magnitude of the detected trends in specific land use land cover, and the effects of the changes in land use on land cover. These can be used to recognize the relationships between the activities of the increasing population and the environment.

Based on the result of this study, land use decreased from 78.50 to 77.78% while land covers increased from 21.50 to 22.22% between 1991 and 2021. Despite the 0.72% decrease in land use and 0.71% increase in land cover, the transformation of natural surface covers into a manmade environment caused a reduction in vegetation covers by 0.27% and natural water bodies by 0.02% while gully increased by 1.00%.

It is important to state at this point that the increase in riparian vegetation cover by 1.76km^2 reduces erosion around the river banks, traps debris from deposition into surface water, and provides habitat to wildlife by cover from sight. Likewise, the decrease in intensive smallholder rain fed agricultural land, extensive small-holder rain fed agricultural land and reservoir by 1.50% (374.24km^2) contribute to an increase in area cover of woodlot or orchard that reduce erosion in the affected areas and also serves as alternative habitat to wildlife. More importantly, the increase in a woodlot or orchards by 8.65 km2 has adverse effects on the environment because the diverse species of native vegetation cover that are adapted to the environment have been cleared to manage the exotic preferred species.

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