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The Application of Geospatial Analytical Techniques in the Assessment of Land Use Conflicts Among Farmers and Cross-Boundary Nomadic Cattle Herders in the Gombe Region, Nigeria

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Abstract

In Nigeria, many land use conflicts among the teeming rural agrarian communities in the northern parts of the country are often wrongly attributed to ethno-religious differences while ignoring the salient role environmental degradation, climate change, and urbanization play in exacerbating the conflicts. The two traditional farming groups (crop producers and cattle herders) that contribute immensely to the country's food security are in constant conflict, thereby threatening sustainable agricultural production. The objective in this article is to investigate the nature and extent of land use changes in the Gombe region using geospatial analytical techniques and assess the implications on land conflicts. The work also examined the people's perceptions of the land conflicts. Data for the study was obtained from LANDSAT images (MSS 1986, TM 1999 and Nigeria Sat-1 2012 for a 20-year period) and through the administration of 300 questionnaires at rural household levels, and from focus group discussions. The results revealed general lack of appreciation of the significant role played by land/environmental factors in the conflict and weak institutional conflict management strategies adopted by the state authorities. The study produced maps of cattle routes and potential conflict zones and thus developed a community based land use management model to guide the government, NGOs, community representatives, and other stakeholders in resolving farmers'/herders' land use related conflicts.

Introduction

The prevalence of conflicts between herders and farmers is not peculiar to Nigeria. Studies have shown (Afifi, 2011; Bello, 2013; Benjaminsen & Boubacar, 2009; Benjaminsen, Fautin & Moshi, 2009; Blench & Dendo, 2003; Hussein, James & David, 1999) that it is widespread in sub-Saharan Africa and is being exacerbated by both human and natural factors. This has been largely attributed to population growth and urbanization, and environmental degradation, which have all intensified the competition for land resources thus ensuing in conflicts. The conflicts do have deleterious impact not only on national food security and income, but has consistently threatened the very source of livelihood of both the farmers and herders (Ibrahim et al., 2014; Tuner et al., 2011). Being the main traditional agrarian groups, cattle herders and farmers make significant contributions to food security and nutritional needs of the nation. The cattle herders own over 90% of the nation's livestock and account for about 3.2% of Nigeria's GDP (Bello, 2013; Julius, 2012), while the farmers who live in sedentary agrarian communities are engaged mainly in subsistence crop production.

The nomads move through traditional cattle routes (*Burtali*) that were established based on agreements between the Fulani leaders (*Ardo'en, jauro*) and agrarian communities to allow access to *hurumi* (for the dry season) and *mashekari* (for the rainy season) grazing away from farmland (Blench & Dendo, 2003). Owing to population pressure, which necessitated increasing demand for land, the farmers unilaterally encroached on and prevented access to cattle routes by expanding cultivation and human settlements. This forced the cattle herders to deviate from their traditional transhumance routes (Benjaminsen et al., 2012; Hussein, James, & David, 1999), thereby creating animosity and conflicts. Awogbade (1980) reported that scarcity of grazing fields caused Fulani herders to take their herds to marginal fields on the outskirts of towns and villages to scavenge on playgrounds, open school yards, residential areas, streets, and roadsides where they cause obstruction to traffic flow and endanger road users.

The symbiotic relationship that once existed between the two groups, for example, farmers selling farm residues for cattle feed in exchange for milk and animal dung (Ibrahim et al., 2014), has completely collapsed leading to incessant conflicts and loss of lives and properties. Government agricultural land policies often encourage farmers to invade pasture land (Afifi, 2011) or encroach on cattle routes (Ibrahim et al., 2014; Issiake, Yambe, & Yansheng, 2012). According to Vedeld (1992) in Hussein, James, & David (1999), government policy to expand agriculture not only encouraged farmers to encroach on grazing lands and convert forest areas to farmland, but also reduced access to water bodies for cattle herders. It is against this background that this article examined the nature and extent of land use changes in the Gombe region using geospatial analytical techniques and assesses the implications on land conflicts. The work also examined the varying community perceptions of the land conflicts.

Study Area and Methodology

The Study Area

The Gombe region is located in the north eastern geopolitical zone of Nigeria (Figure 1) on latitude $10^{\circ} 15'N$ and longitude $11^{\circ} 10'E$, deep within the savannah vegetation belt, where there are excellent natural habitats for grazing livestock. The region has two distinct seasons, a dry season from November to March, and a rainy season from April to October, with an average rainfall of about 850mm. The region is bounded by Bauchi state to the west and northwest, Yobe and Borno states to the north and northeast, respectively, and Taraba and Adamawa states to the south and southeast respectively (Figure 1). It has 21 locally spoken languages, which include Fulfulde, Hausa, Tangale, and Waja and a population of about 2.4 million according to the 2006 national census. The people of the region share diverse cultural and ethnic affiliations and are predominantly sedentary farmers in the southern part, while the northern part is made up of mixed sedentary agro-pastoralists and nomadic pastoralists. The Gombe region covers an area of 20.265km², which is divided into 11 administrative local government areas (GSUelearning, 2014).

The Gombe region is centrally located in the northeast and plays a significant role particularly in the north-south and vice versa transhumance migration during dry and rainy seasons. In Figure 2, the main international and national transhumance nomadic migration routes to the south (during the rainy season) and to the north (during the dry season) are depicted. Most of the cattle routes pass through Gombe town shown in Figure 3. The choice of the area is therefore attributed to its geo-strategic location, the magnitude of cattle trade (Mohammed et al., 2014), and high density of cattle routes.

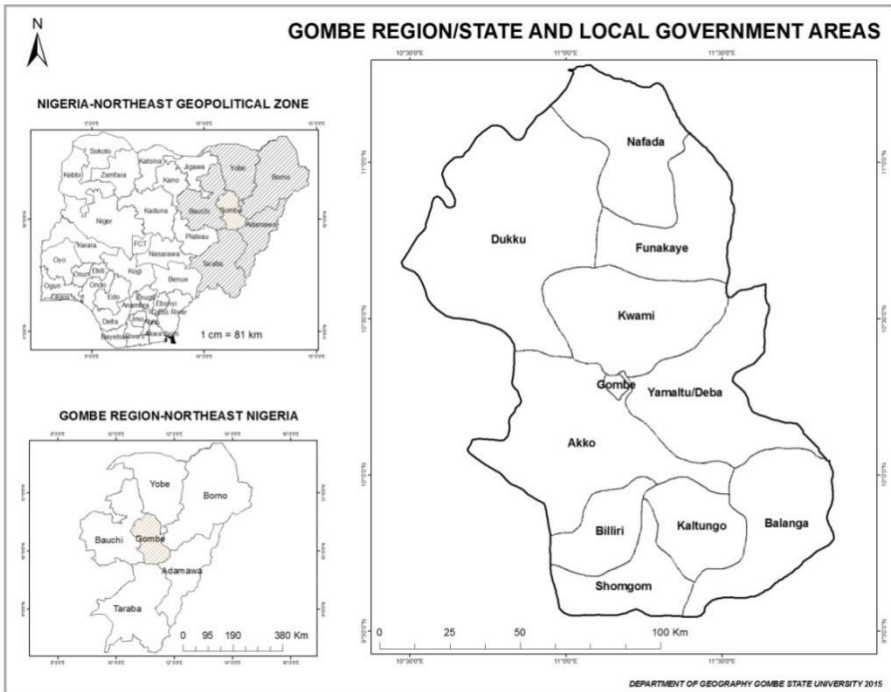
Methodology

The study is built on spatial and non-spatial data sets acquired from primary and secondary sources. The primary data were obtained through administration of 300 questionnaires (250 to farmers and 50 to cattle herders), field observations, discussions (with focus groups and individuals), and thematic map layer development by on-screen digitization. The skewed distribution of the questionnaires in favour of the majority farming group was informed by the differences in population and the transient nature of the cattle herders. Thus, questionnaires were administered in 10 randomly selected communities that were identified within a 3km buffer of international and inter-state transhumance cattle routes in the region. The spatial analysis was done using satellite images of Deba, Kumo, and Gombe towns on a 10-year interval. These towns were chosen on the basis of the records of cattle routes land use conflicts.

The secondary data from records of conflicts between farmers and herders were obtained from the Gombe State Ministry of Animal Husbandry and Nomadic Affairs, and public-based knowledge database, while the shape files and satellite images (Landsat MSS 1986, Landsat ETM 1999 and Nigeria Sat-1 2012) were

obtained from National Remote Sensing Centre, Jos and from private collection as well as commercial vendors. The geospatial analysis and map display were done with ArcGIS 9.3, while Microsoft excel and SPSS software packages were used as stand-alone tools for statistical analysis and for updating attribute tables in the ArcGIS platform based on the loose coupling approach.

Figure 1: Nigeria Showing Location of Gombe Region and Local Government Administrative Areas



Earth features reflect different wavelengths of energy on the electromagnetic spectrum, which are captured by sensors on remote sensing platforms. The remotely sensed images (satellites) are then processed and interpreted using reference data and ground truthing. The satellite images consist of three bands (“RED”, “GREEN” and “BLUE”) and cell sizes X,Y of 28.5, 28.5 for both landsat images (1986 and 1999) and 22, 22 for the Nigeria Sat image (2012). In order to achieve uniformity of cell size, the Nigeria Sat was re-sampled to X,Y (28.5, 28.5). The images were subsequently reclassified using the ISO Cluster tool in ArcGIS 9.3 to produce a generalized land cover bands for the study area. To enable change detection, a supervised classification procedure was performed with the “Maximum Likelihood Classification” tool of ArcGIS 9.3. Bands were assigned to specific geographic features for image interpretation, which is the process for identifying spectral

signature or reflectance characteristics of features in the images. In this case, a 2013 high resolution (9 meter) satellite image from Google Earth Pro was used for visual comparison to aid image interpretation. The change detection approach followed a simple procedure, in which progressive changes in number of cell count for particular features over time was used to determine eventual changes in percentage (e.g., increase or decrease in cells representing built up areas, vegetation, etc.).

Figure 2: Northeast Transhumance and Pasture Routes for Dry and Wet Season Migration

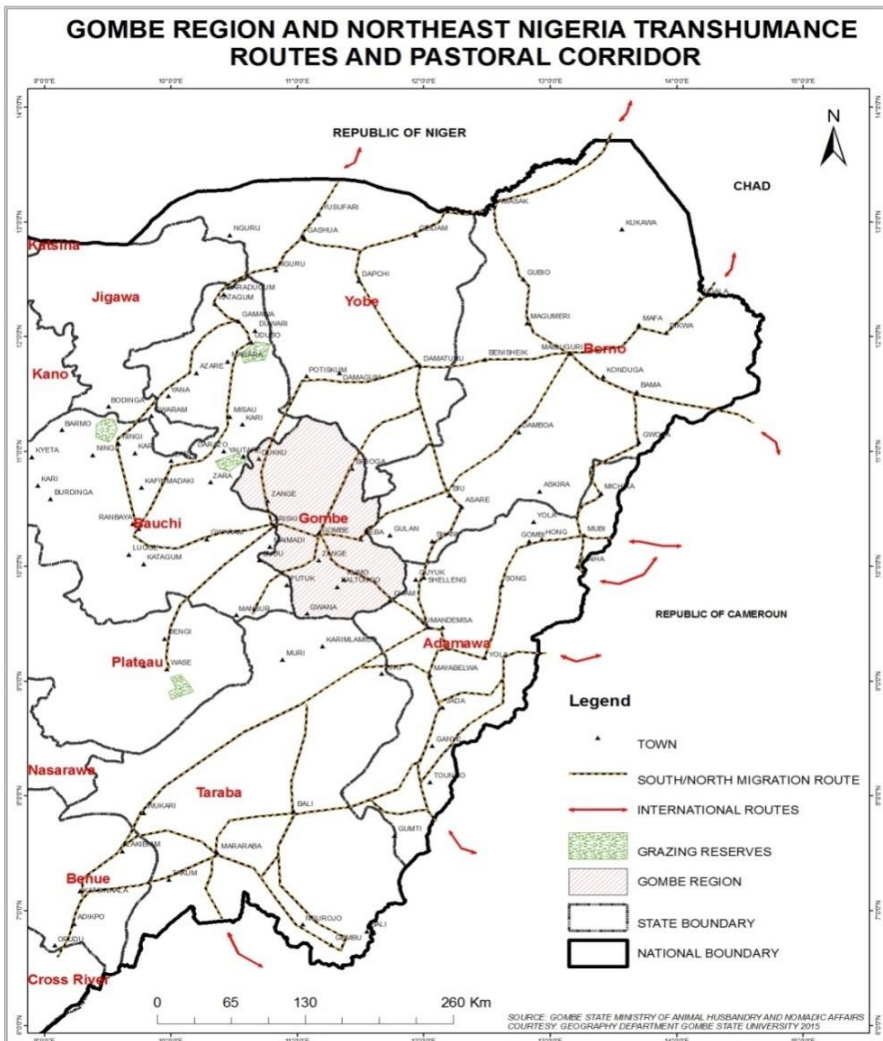
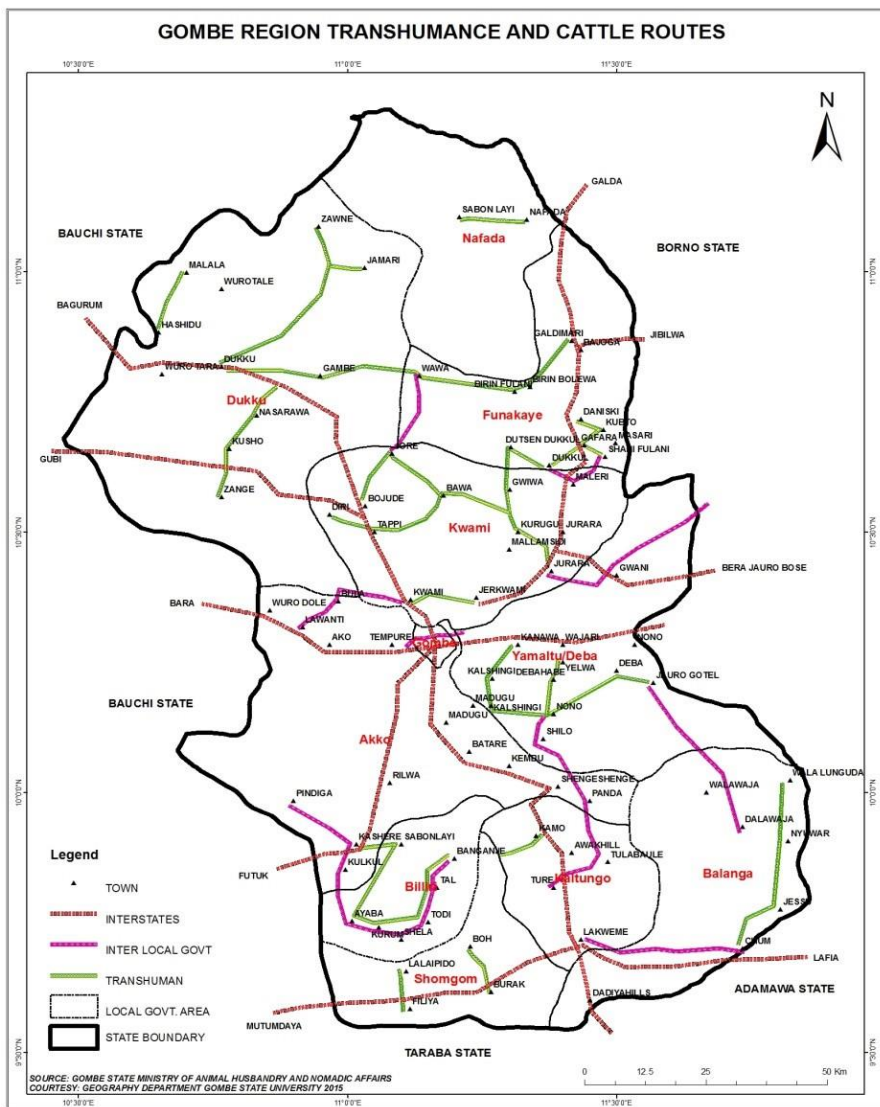


Figure 3: Categories of Cattle Routes in Gombe Region



Results and Discussion

Spatial Analysis of Conflict Zone

Information gathered from the public domain revealed several conflicts between cattle herders and farmers in the 20 years under review. A total of 246 previous conflict incidents were recorded across the 11 Local Government Areas (LGA) in the region. Of this total, only 38 incidents that occurred in Akko, Balanga, Gombe, and Yamaltu Deba were cattle route related. Figure 4 shows the spatial distribution of the conflict incidents overlaying a choropleth population density map of Gombe region. The LGAs in the south and Gombe town have higher population density than the more arid northern LGAs, also shown in Figure 3 are the network of inter-state, intra-regional, and transhumance routes concentrated in the southern LGAs. The southern part of Gombe region is less arid, and is the gateway for most nomads to the southern parts of Nigeria, where cattle herders migrate to during the long northern dry season. Consequently areas in the southern parts of the Gombe region could be classified as “HOT SPOT” with high tendencies of conflicts because of high population density (Figure 4) and route connectivity (Figure 3).

In Table 1, the density of cattle routes and transhumance corridors was rated by respondents in terms of the pattern, length, and connectivity of routes in each LGA, on a scale of 1-5, with 5 being the highest score and 1 the least. The LGAs with the highest scores are Yamaltu Deba, Balanga, and Akko with 4.7, 4.3, and 4.0 ranking respectively. Incidentally these LGAs have high records of cattle route related conflicts shown in Figure 4.

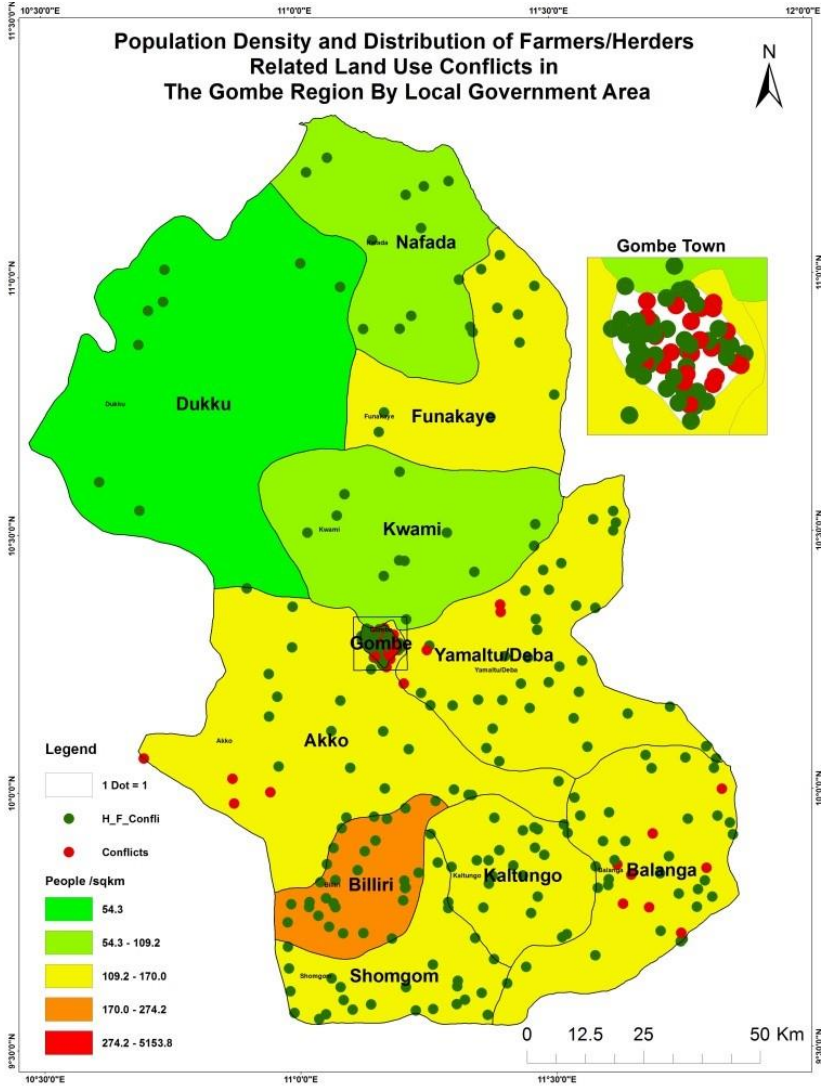
Table 1: Ranking of Density of Cattle Routes and Transhumance Corridor Connectivity

SN	LGA Name	Rating of Cattle Routes and Transhumance Corridor				Total Score	Ranking
		Inter State	Inter LGAs	Transhumance			
1	Yamaltu/Deba	4	5	5	14	4.7	
2	Balanga	4	4	5	13	4.3	
3	Akko	5	4	3	12	4.0	
4	Kwami	3	2	5	10	3.3	
5	Funakaye	4	2	3	9	3.0	
6	Billiri	0	4	4	8	2.7	
7	Dukku	4	0	4	8	2.7	
8	Gombe	5	0	3	8	2.7	
9	Kaltungo	4	2	2	8	2.7	
10	Shongom	5	0	3	8	2.7	
11	Nafada	0	0	2	2	0.6	

Note. Ratings are based on Figure 3, and scored from 1-5 with 5 being the most significant and 1 less significant.

Figure 4: Distribution of Conflict Incidents and Population Density across the Gombe Region

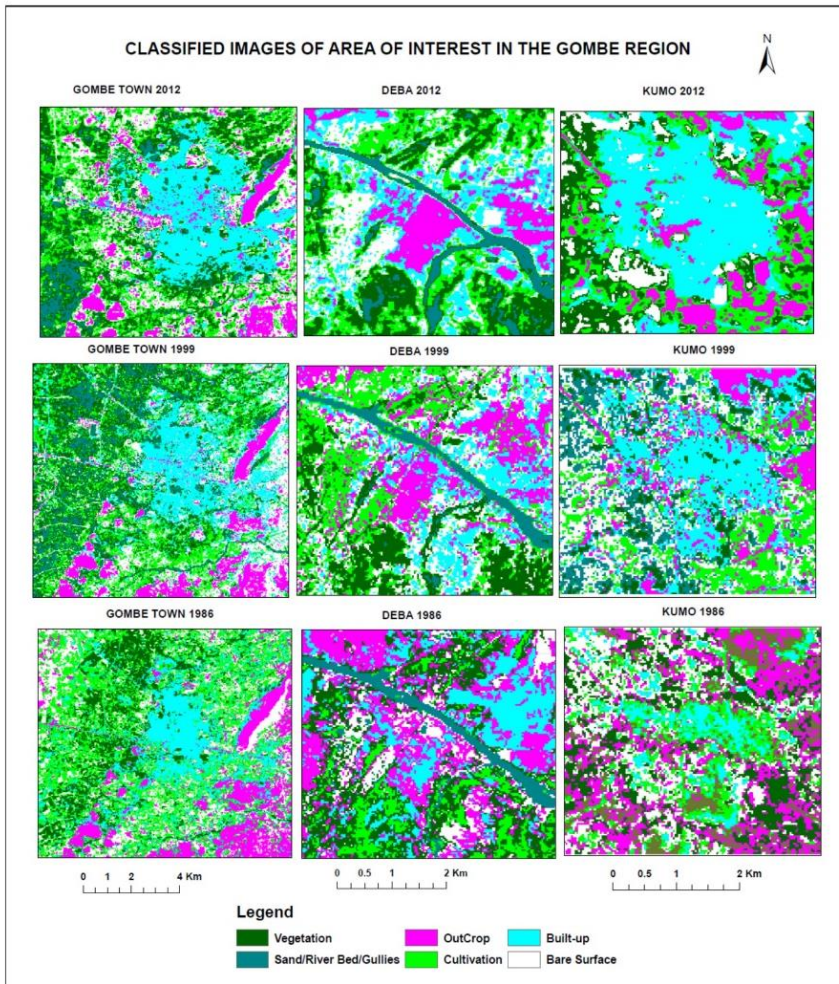
RED dots represent cattle route related conflicts; GREEN dots are all other conflicts between herders/farmers.



Classification of Results

Using a reference satellite image, six generic land cover types were identified and classified for the change assessment: i) bare surface, ii) built-up areas, iii) vegetation, iv) out crops, v) farms, and vi) sand formations. Of these six features, emphasis is placed only on built-up areas, farms, and vegetation covers because of the direct influence on demand for land. Figure 5 shows variations of physical features and land use in images of 1986, 1999, and 2012 for Gombe town, Deba, and Kumo areas.

Figure 5: Land Use Change Analysis



Change Detection 1986-2012

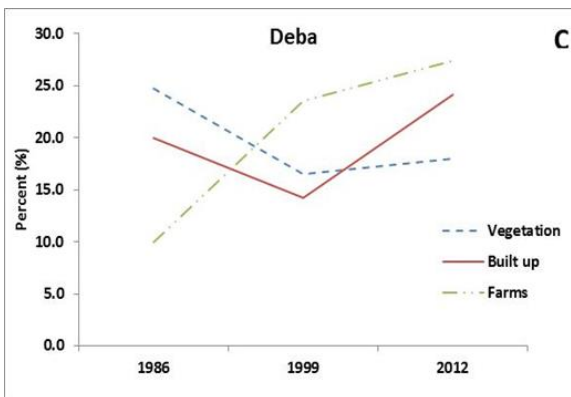
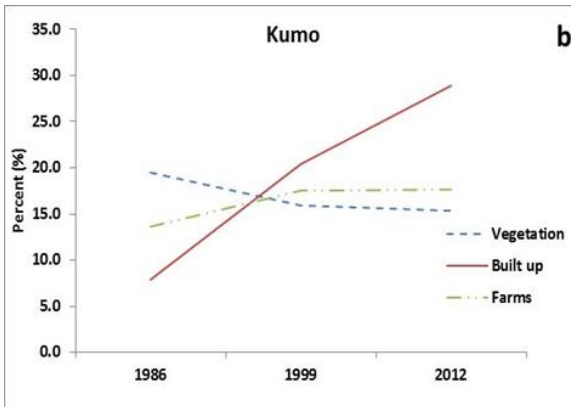
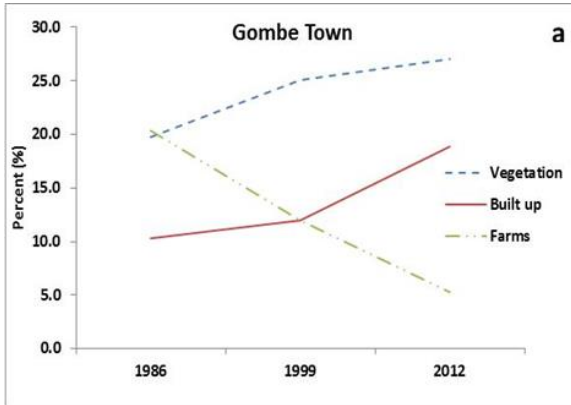
The developed (built-up) areas have increased progressively in Gombe town, Kumo and Deba from 1986 (Table 2). But while there are decreases in farm area in Gombe town, the opposite is the case in Kumo and Deba. This can be attributed to the creation of Gombe state and siting of the capital in Gombe town in 1996 (Figure 6). The state creation attracted tremendous infrastructural development, private and government housing projects to support the ever-increasing influx of people thereby leading to high demand for land. Kumo and Deba are smaller towns where most of the people practice subsistence agriculture. As a result, there has been a relative increase in farm area from 1986, and decrease in vegetation in both towns as more fields are converted to farms. Gombe town, on the other hand, shows increase in vegetation cover, which is an indication of change in land ownership as people buy plots of land from farmers to build homes or leave the land uncultivated until they are ready to develop it. The implication of this practice on animal grazing is that as more open spaces are fenced, the herders find it difficult to gain access to pasture leading to encroachment on private properties and thus ensue in conflict.

Table 2: Percentage Change in Land Use/Land Cover, 1986-2012

Description	Gombe Town			Kumo			Deba		
	2012	1999	1986	2012	1999	1986	2012	1999	1986
Out Crop	10.0	10.6	18.0	12.5	15.2	23.3	13.5	20.4	28.2
Vegetation*	27.1	25.1	19.8	15.3	16.0	19.5	18.0	16.5	24.8
Sand	18.3	18.0	22.0	6.9	7.1	12.8	0.6	4.6	6.0
Built Up*	18.9	12.0	10.3	28.9	20.4	7.9	24.1	14.2	20.0
Farm*	5.3	11.9	20.4	17.6	17.5	13.6	27.4	23.6	10.0
Bare Surface	20.4	22.4	8.3	18.8	23.8	23.0	16.5	20.8	11.1
Total (%)	100	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

* Features of interest (land use feature with potentials to cause conflict)

Figure 6: Profile of Land Use Change over 20 Years, 1986-2012 for: a) Gombe town, b) Kumo and c) Deba areas



Peoples' Perceptions of Land use Conflicts in the Gombe Region

A total of 300 respondents were interviewed at household levels, comprising 250 farmers and 50 cattle herders to ascertain their understanding of land use conflicts and potential causes. The responses gathered indicated that 90% of the farmers interviewed have experienced land use conflicts against 58% of herders. Most of the causes listed in Table 3 are directly or indirectly responsible for the land use conflicts in the Gombe region.

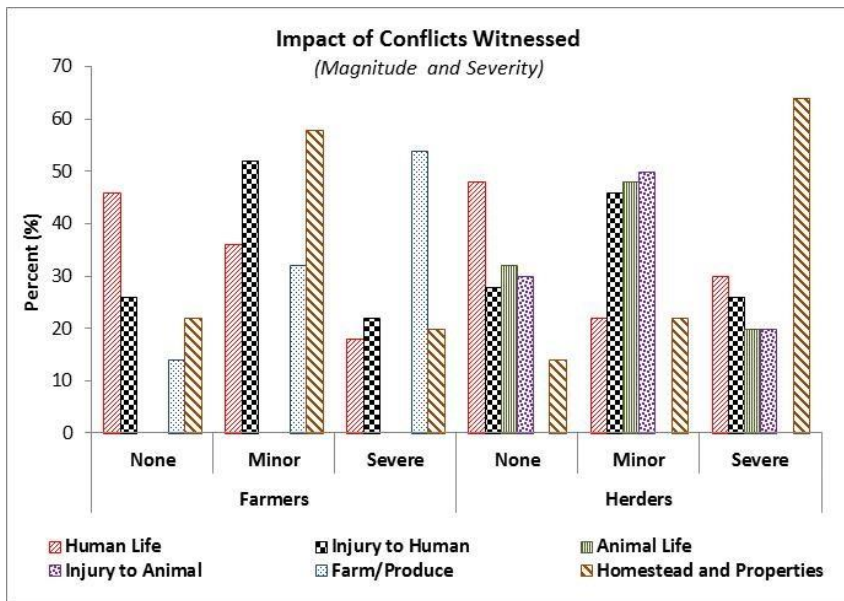
Table 3: Identified Causes of Land Use Conflicts between Herders and Farmers in the Gombe Region

S/N	Cause	Very Significant		Moderate		Not Significant	
		Farmers	Herders	Farmers	Herders	Farmers	Herders
1	Destruction of farm crops	50%	26%	38%	52%	12%	22%
2	Unauthorized grazing on fallow land	18%	20%	68%	32%	14%	48%
3	Bush Burning	16%	20%	66%	56%	18%	24%
4	Contamination of water by cattle	40%	20%	44%	56%	16%	24%
5	Harassment by farmers/herders	48%	22%	40%	50%	12%	28%
6	Cattle theft	18%	20%	22%	32%	60%	48%
7	Obstruction of movement	14%	22%	48%	44%	38%	34%
8	Stray animals	18%	20%	20%	20%	62%	60%
9	Deviation from normal cattle routes	18%	20%	68%	56%	14%	24%
10	Change in land use	42%	38%	40%	42%	18%	20%

The most significant causes of conflict according to the farmers are the destruction of farm crops (50%), harassment by herders (48%), and change in land use (42%) patterns. While the other causes are rated as medium scale or non-significant. The herders on the other hand do not consider any of the causes in Table 3, "very significant." Seven of the 10 listed causes were considered by herders to be of moderate significance, while unauthorized grazing on fallow land (48%), cattle theft (48%), and stray animals (60%) are rated as non-significant. The responses from the herders depict a general lack of understanding of the remote causes of land use conflicts, for instance, change in land use, deviation from normal cattle routes and obstruction of movement should have been the most significant causes that directly affected them (herders). The only area of agreement for both is

cattle theft and stray animals, which they both considered as not a significant cause. In the rating of the severity of the impact of past conflicts on their socio-economic life as in Figure 7, the destruction of farms and produce was scored very severe (54%) by the farmers, while the herders felt destruction of homesteads and properties (65%) was severe. The other cases such as loss of human and animal lives, and injury to humans and animals were seen as minor or not significant. The study therefore reveals that the impact of land use conflict between herders and farmers in the Gombe region has not yet attained very serious dimension though care must be taken to control the present conflicts to avoid adverse effects.

Figure 7: Severity of Previous Conflicts to Farmers and Cattle Herders



To buttress lack of consistencies in responses, 66% of the herders claim their relationship with farmers is cordial, while 72.8% of the farmers believe their relationship with herders is strained. Although Edward (2014) suggested that religion and ethnic differences contributed to conflict instigation, 94% and 96.4% of herders and farmers respectively, felt that religion and ethnicity have not played any significant role in land use conflict in the region. This position is strengthened by the fact that most of the respondents (herders and farmers) have lived in the area for over 19 years (Figure 8c) and have witnessed several land use conflicts between their communities (Figure 8a). Moreover most of the respondents are adults (Figure 8b) and this gave credence to their claim that religious and ethnic differences have no relationship with conflicts between the two groups.

Figure 8: Respondents’ Responses: a) number of conflicts experienced, b) age distribution, c) length of stay in the community, and d) number of herds held by cattle herders

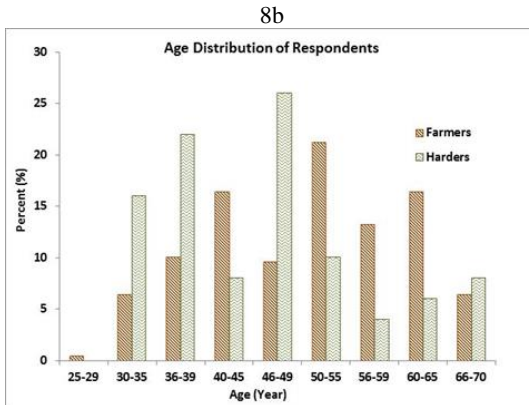
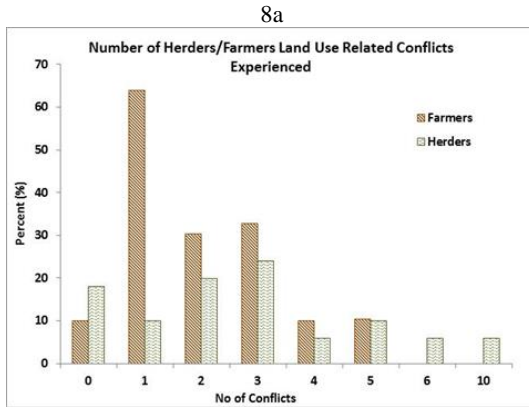
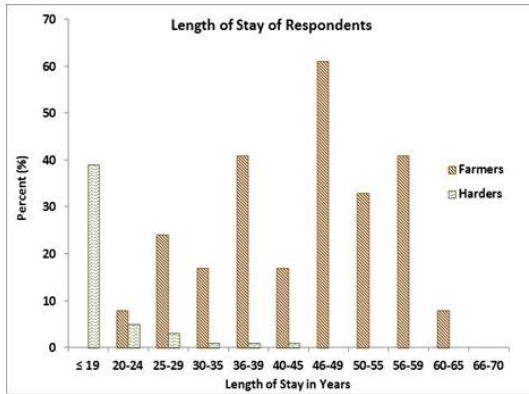


Figure 8d shows the number of herds held under the nomadic practice. About 94% of the herders indicated strong preference for nomadic pasturing, and also believe that nomadism is the only option for better pasture for their herds. However, all the herders agreed to using open space for grazing, and that their only source of water is from rivers/streams (38%) and ponds (62%).

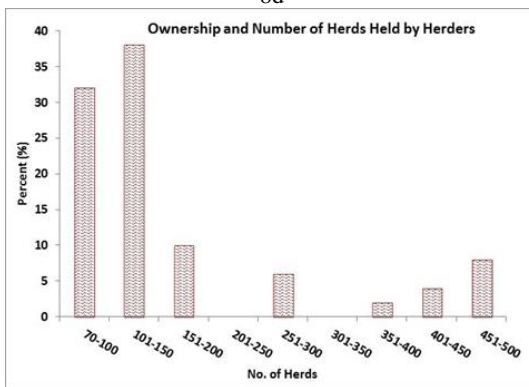
An effective control of the conflicts can be better achieved through a holistic approach by government and stakeholders. Over 92% of the respondents expressed lack of commitment of government institutions in conflict mitigation and management. In the discussions the communities claimed that the conflicts that are reported to government agencies, the police, and the courts are not usually handled transparently. These institutional structures lacked commitment for peace as they

are prejudiced financially especially in matters concerning compensation to victims and punishing culprits. They further identified slow response and poor coordination of activities by the NGOs and other voluntary organizations, and the public organizations such as governmental departments and agencies that are involved in crisis management during and after conflicts. This in the community’s opinion worsens the situation and often led to increase in the number of casualties, displaced persons, and destruction of properties.

8c



8d

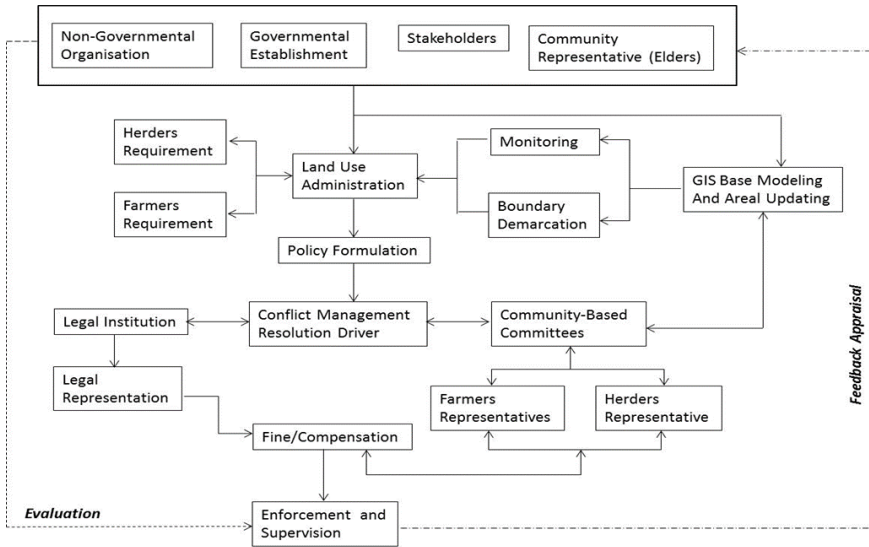


Framework for Land Use Conflict Management Model

The model presented herein (Figure 9) is an all-inclusive land use administration and management framework with inputs from government, NGOs, and other stakeholders. The process provides means for maintaining a database of farmers, sedentary and nomadic herders in a given area. The register will help identify new grazers coming into the area, and ensure strict monitoring and compliance with

demarcated boundaries. This would likely eliminate claims that nomads from foreign countries who are not familiar with the area are usually responsible for causing some of the conflicts.

Figure 9: A Proposed Sustainable Community-based Farmers/ Herders Land Use Conflict Management Model for the Gombe Region



The land use demarcation may be upgraded or updated using satellite images and Geographic Information System (GIS) mapping techniques to determine direction of settlement growth and farm expansion as well as in the maintenance of transhumance routes (corridors), which should be clearly defined with signposts positioned at strategic points to warn and eliminate encroachment. Community based committees shall consist of representatives from farmers and herders, with clear cut responsibilities for performing functions relating to conflict management at community levels. The legal institutions such as the courts should handle cases of land use infringement only when it could not be amicably resolved at the community level. The punitive measures at the government level should be so severe that the culpable individuals would prefer resolving issues at the communal levels. This way the community council would be empowered to investigate and judge without bias. A plaintiff may however be allowed to appeal unfavorable outcomes through government legal institutions with appropriate legal representation. Lastly, culpable parties must be punished through fine or jail term or both to serve as deterrents, while victims should be given adequate compensation.

Conclusion and Recommendations

There is no doubt that scarcity of land due to increases in human population, settlement establishment, and farmland expansion are common human factors that can exacerbate conflicts between cattle herders and farmers. The study has shown areas of high incidents and identified developmental process in the Gombe region that led to increase in demand for land and associated land use conflicts. The presence of an extensive network of cattle routes and transhumance corridor, some of which originate from other parts of Northern Nigeria and from neighboring countries like Chad, Niger, and Cameroon, en route to the southern states of Nigeria, require an appropriate management strategy. Nomadism and transhumance practice is an integral part of the Fulani tradition, a way of life that not only defines their social cohesion but their culture, and the well-being of their herds. Understanding that nomadic movements brings herders in contact with farming settlements, and the fears of people losing their farm produce or risking their only source of water being contaminated by passing herds of cattle, does not depict the absence of a common ground. The study has shown that despite differences in land use practice, the people can co-exist amicably if functional conflict resolution and mitigation strategies can be established to curtail the conflict between farmers and cattle herders in the region.

It has also been observed that government agencies do not maintain up-to-date records of land use conflicts between farmers and herders in the study area, which can present difficulties in conflict management and monitoring.

Therefore it is recommended that,

- i. A comprehensive database should be built particularly to take care of point location (GPS), date of occurrence, nature of conflicts, exact causes, effects, etc.
- ii. Government should involve community leaders in conflict resolution and create public awareness on preventive measures. This will bring back the confidence of the disputing parties in the adjudication processes.
- iii. A national legal framework for managing conflicts between farmers and cattle herders should be established with adequate communal representations at the state and local government levels.
- iv. An agency should be empowered to coordinate activities of relevant government and non-governmental organizations involved in conflict management for effective supervision and implementation of government policies on farmers and cattle herders land use conflicts.
- v. All cattle routes must be properly demarcated and maintained regularly.
- vi. There should be records of different categories of herders using particular cattle routes.
- vii. Local community members should be encouraged to develop mutual understanding and cooperation with cattle herders.
- viii. The nomadic culture should not be eliminated, but supported to ensure its sustainability for the benefit of future generations.

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