(RESEARCH ARTICLE)

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Development of a web-based geospatial intelligent decision support system for control of herders and farmers crisis in Benue State Nigeria

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Abstract

The biggest challenge in Nigeria today is herder-farmer conflict particularly in Benue State Nigeria. This study developed a web-based geospatial decision support system for control and management of herders/farmers crisis in Benue State. Landsat 5 TM (1989), Landsat 7 ETM+ (2004) and Landsat 8 (2019) were pre-processed and classified. The study revealed that forested areas had depleted by -4.17% between 1989 and 2004 and -2.20% between 2004 and 2019. Farmland had an increase of 34.01% between 1989 and 2004 and 17.92% between 2004 and 2019 and grassland had -7.12% between 1989 and 2004 and -3.89% between 2004 and 2019. The study also revealed five conflict zones with Agatu in Very high conflict zone with 88 -230 clashes, the high conflict zone included Guma, Gwer West and Logo with 41 – 87 clashes, the moderate conflict zone include Gwer East, Ohimini Markudi and Okpokwu with 16 – 40 clashes, the low conflict zone include Otukpo with 3 – 15 clashes, the very low conflict zone include Apa, Ado, Obi, Oju, Kwande, Ukum, Katsina Ala, Gboko, Buruku, Tarka, Ushongo, Konshisha, Ogbadibo, and Vandeikya with 0 -2 clashes. The potential sites for grazing reserves were determined using the Analytical Hierarchy Process (AHP). The results revealed a total area of 8361.46hectares (0.27%) of the total land mass as potential grazing reserves, covering 18 local government areas. A database of the potential areas for grazing reserves was implemented in QGIS software. The study recommended potential areas for establishment of grazing reserves in Benue State.

Keywords: Grazing reserve; QGIS; Herders/Farmers; AHP

1. Introduction

Nigeria has been grappling with diverse security challenges, such as insurgency, election violence, kidnapping and most recently, the herder-farmer conflicts among others. The north central states of Plateau, Nasarawa and especially Benue State have experienced conflicts that led to thousands of deaths and displacements as a result of clashes between herders and local farmers in several communities. In January 2018 alone, Amnesty International reports indicated that 168 people were killed as a result of herdsmen-farmer clashes.

The struggle over grazing land over the years has resulted in growing violent conflicts, underpinning the escalation in frequency of conflicts in Nigeria is a confluence of environmental and demographic forces, especially desertification caused by climate change and population explosion. Expectedly, with the depletion of arable land for subsistence farming largely as a result of increasing urbanization and the adverse effect of climate change, there is an increased struggle between herdsmen and farmers, leading to violent confrontations and conflicts, deaths and forced displacement, as well as the destruction of agriculture and livestock. The persistent attacks in Benue state have had a spill-over effect on the neighboring state of Nasarawa. In January 2018, the News Agency of Nigeria reported that over 18,000 internally displaced persons (IDPs) were in 11 camps in Nasarawa State.

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Farmers-herdsmen conflict has remained the most preponderant resource-use conflict in Nigeria. The biggest challenge threatening the corporate existence of Nigeria today is herder-farmer conflict particularly in the middle belt region of Nigeria. There have been unceasing attacks by the Herders against the indigenous farming population. Although, Benue State government has introduced an anti-grazing law as a way of addressing this problem, this has failed to solve or manage the crisis, especially in Kwande, Makurdi and Gwer west L.G.A which has witness mass destruction of farm lands, houses and human genocide. People have deserted their farms and homes to seek refuge in other places therefore becoming refugees and displaced persons. Inconsistencies in government policies seem to exacerbate these conflicts. The studies of [1], [2], and [3] have all opinioned and analyzed the trend and causative factors for the clashes between the herders and farmers. Yet none has tried to apply a pragmatic approach of developing a web-based intelligent decision support system that can aid decision making in terms of the control and management of the herders and farmers crisis in Benue State Nigeria.

The Fulani herdsmen-farmers conflict in Nigeria is a struggle over scarce resources (vegetation, water resources and land) with the claim for ownership and the claim for its position as a common resource. Furthermore, the complex nature of land use system in Nigeria has been largely responsible for the present-day tension and conflicts between Fulani herdsmen (nomads) and host farming communities. Causes of Fulani Herdsmen (Nomads)-Farmers Conflicts in Nigeria include; i) Destruction of Crops by Cattle, 2) Environmental Impact of Climate Change, 3) Contamination of the Stream by Herds, 4) Over-grazing on Fallow Land, 5) Sexual Harassment of Women by Nomads, 6) Disregard of the Traditional Authorities, 7) Indiscriminate Bush Burning by Fulani Herdsmen, 8) Theft of Cattle. The various cases are related to clash of interest, resources destruction and abuse. Though in most cases the conflicts were resolved by the payment of compensation to the offended farmer, yet there are always series of complaints of dissatisfaction due to the nature and manner of resolution and payment of the compensation.

The Government of Nigeria has initiated several policies geared towards resolving the herders-farmers conflict. Such strategic responses include: 1) Creation of Grazing Reserves in 1965, 2) Establishment of the National Commission for Nomadic Education (NCNE) in 1989, 3) The Use of the Armed Forces to Curb Internal Security, 4) Establishment of the National Grazing Reserve Bill 2016, 5) Proposed Cattle Ranching System 2018, 6) Legislation Prohibiting Open Grazing, 6) The Great Green Wall Agency of the Federal Government.

Thus, in order to understand the herders/farmers conflict in Benue State, an in-depth examination of the factors or the leading causes of the herders/farmers crisis, this will help in addressing the pastoral conflict in Benue State and as well help provide a base for decision making and management. This will play a key role in the control and management of herders/farmers conflict in Benue State. To accomplish this task, geospatial intelligent decision support systems will be needed as an important tool for analyzing and providing speedy and accurate information on the management of herders and farmers conflicts. Using the collection of geospatial data to analyze the trend analysis of rangeland and agricultural land, causative and influencing factors, grazing routes, farmland encroachment, potential conflict zones, optimal areas for grazing and farming all integrated in an intelligent decision support system, it is then possible to provide a knowledge-based support system to aid and assist decision makers in the management of herders and farmers conflict in Benue State Nigeria.

This study therefore aimed at developing a novel approach in terms of a web-based geospatial intelligent decision support system in order to demonstrate its usefulness in the management and remediation of pastoral conflicts in Benue State Nigeria. This study can provide a detailed temporal analysis of grazing land and farmland in Benue State, analysis of existing grazing routes, potential conflict zones, optimal areas for grazing in Benue State and a web-based intelligent system that will aid in the decision making and management of herders and farmers crisis in Benue State.

2. Material and methods

2.1. Materials

The data used to achieve the aim and objectives of this study are classified into primary and secondary data.

2.1.1. The Primary Data

The primary data includes:

- Coordinates of previous herders/farmers clash locations
- Herders grazing route

2.1.2. The Secondary Data

The secondary data includes:

- Landsat 5 Thematic Mapper
- Landsat 7 Enhanced Thematic Mapper Plus
- Landsat 8 Operational Land Imager

2.2. Methods

Image preprocessing was done in this study to correct the imageries of atmospheric errors. Before image classification was done, a classification scheme level 1 was adopted for the study area. Image classification was done using maximum likelihood image classification. After image classification, change detection was done to determine the changes that had taken place between 1989 and 2019.

Trend Analysis was used to examine the temporal dynamics of landuse in Benue State with emphasis on grazing and agricultural land. Accuracy assessment was carried out in order to assess the accuracy of the results obtained from image classification. A conflict hotspot analysis was done using conflict data sourced from [4]. The hotspot analysis was carried out by employing natural Jenks classification to classify the occurrence of the clashes and show the area with different levels of conflict in Benue State

In line with the legislation prohibiting open grazing in Benue state, a suitability analysis to establishing potential sites for grazing reserves in Benue State was carried out using GIS, AHP and the following factors; distance to road, distance to water, landuse, slope were adopted. A database was created to show optimal areas established for grazing for herders and farming land for farmers in Benue State. The database was integrated and implemented in QGIS Cloud online platform.

3. Results and discussion

3.1. Temporal Dynamics of Landuse in Benue State

In 1989, the landuse/landcover distribution of Benue State indicated that forested area, accounted for the largest land cover/use of about 74.01% and an area of about 2317110.66 hectares. Grassland had 9.53% and a coverage area of 298514.97 hectares, farmland had 1.96% and a coverage area of 61483.41 hectares. Bare surface had 7.87% and a coverage area of 2465512.61 hectares, rocky area had 5.05% and a coverage area of 158279.31hectares, settlement had 0.97% with area coverage of 30510.9 hectares, while waterbody had 0.58 with area coverage of 18351.54 hectares.
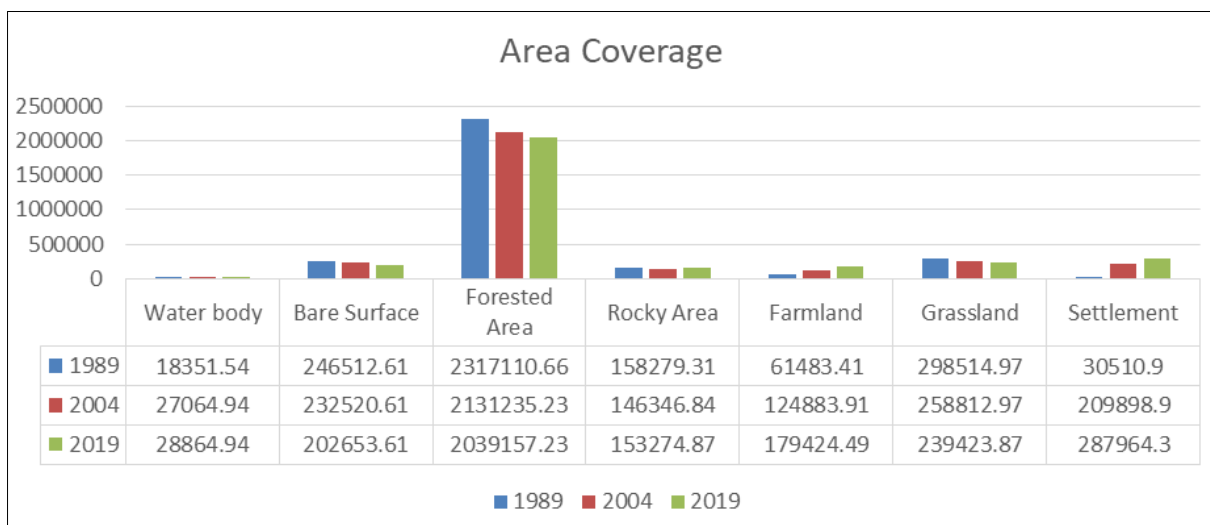

Figure 1 Landcover/landuse distribution of Benue State between 1989 and 2019

In 2004, forested area, decreased to 68.07% to an area of 2131235 hectares. Grassland decreased to 8.26% to an area of 258813 hectares, farmland increased to 3.98% to an area of 124883.9 hectares. Bare surface decreased to 7.42% to

an area of 232520.6 hectares, rocky area also decreased to 4.67% to an area of 146346.8 hectares, settlement increased to 6.70% to area coverage of 209898.9 hectares, while waterbody also increased to 0.86 to an area coverage of 27064.94 hectares.

In 2019, forested area, further decreased to 65.13% to an area of 2039157 hectares. Grassland also decreased to 5.73% to an area of 239423.9 hectares, farmland increased to 5.73% to an area of 179424.5 hectares. Bare surface decreased to 6.47% to an area of 202653.6 hectares, rocky area decreased to 4.98% to an area of 153274.9 hectares, settlement also increased to 9.19% to an area of 287964.3 hectares, while waterbody increased to 0.92 with area coverage of 28864.94 hectares, see figure 1 for details.

3.2. Annual Rate of Change of Landuse

The annual rate of change of Landcover/landuse of Benue State between 1989 and 2019 was given as 1.27% for waterbody between 1989 and 2004, and 0.21% between 2004 and 2019. -0.19% between 1989 and 2004 and -0.45% between 2004 and 2019 for bare surface, -0.27% between 1989 and 2004 and -0.14% between 2004 and 2019 for forested area, -0.26% between 1989 and 2004 and 0.15% between 2004 and 2019 for forested area, -0.26% between 1989 and 2004 and 0.15% between 2004 and 2019 for rocky area, 2.26% between 1989 and 2004 and 1.19% between 2004 and 2019 for farmland, -0.47% between 1989 and 2004 and -0.25% between 2004 and 201 for grassland and 4.97% between 1989 and 2004 and 1.04% between 2004 and 2019 for settlement. See figure 2 for details.
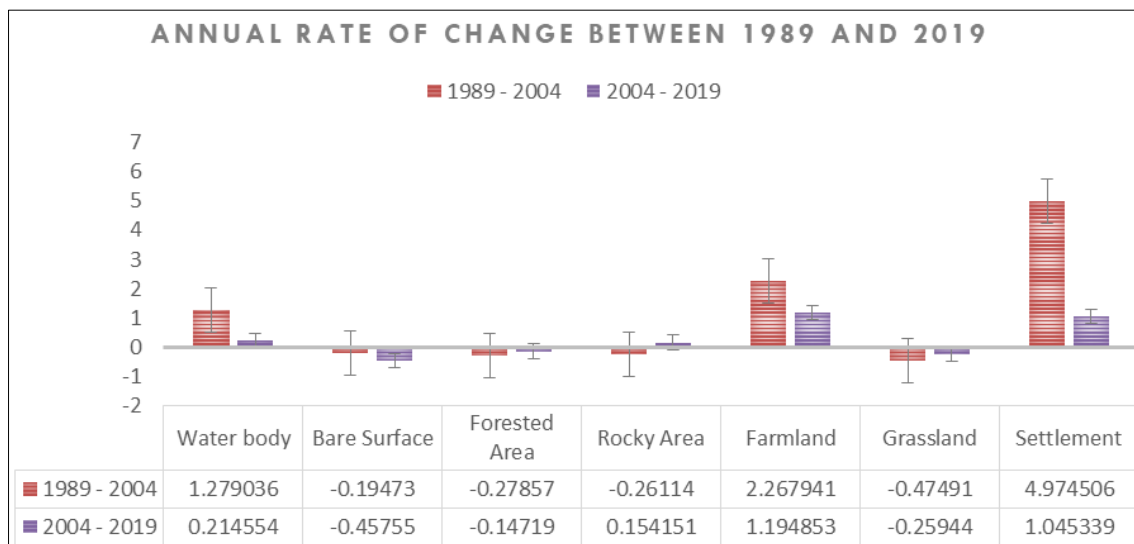

	Water body	Bare Surface	Forested Area	Rocky Area	Farmland	Grassland	Settlement
1989 - 2004	1.279036	-0.19473	-0.27857	-0.26114	2.267941	-0.47491	4.974506
2004 - 2019	0.214554	-0.45755	-0.14719	0.154151	1.194853	-0.25944	1.045339

Figure 2 Annual rate of change between 1989 and 2019

3.3. Potential Conflict Zones

A conflict hotspot analysis was done using conflict data dating back to November, 2011 to January 2018, sourced from [4]. The conflict analysis was done to show the area with the high conflict zone in Benue State. the results revealed five conflict zones namely: very high conflict zone, high conflict zone, moderate conflict zone, low conflict zone and very low conflict zone. The very high conflict zones include Agatu with a natural jenks of 88 -230 clashes, the high conflict zone include Guma, Gwer West and logo with 41 – 87 clashes, the moderate conflict zone include Gwer east, Ohimini markudi and Okpokwu with 16 – 40 clashes, the low conflict zone include Oturkpo with 3 – 15 clashes and lastly, the very low conflict zone include Apa, Ado, Obi, Oju, Kwande,Ukum, Katsina Ala, Gboko, Buruku, Tarka, Ushongo,Konshish, Agbadibo, and Vandeiky with 0 -2 clashesThis is shown in figure 3.
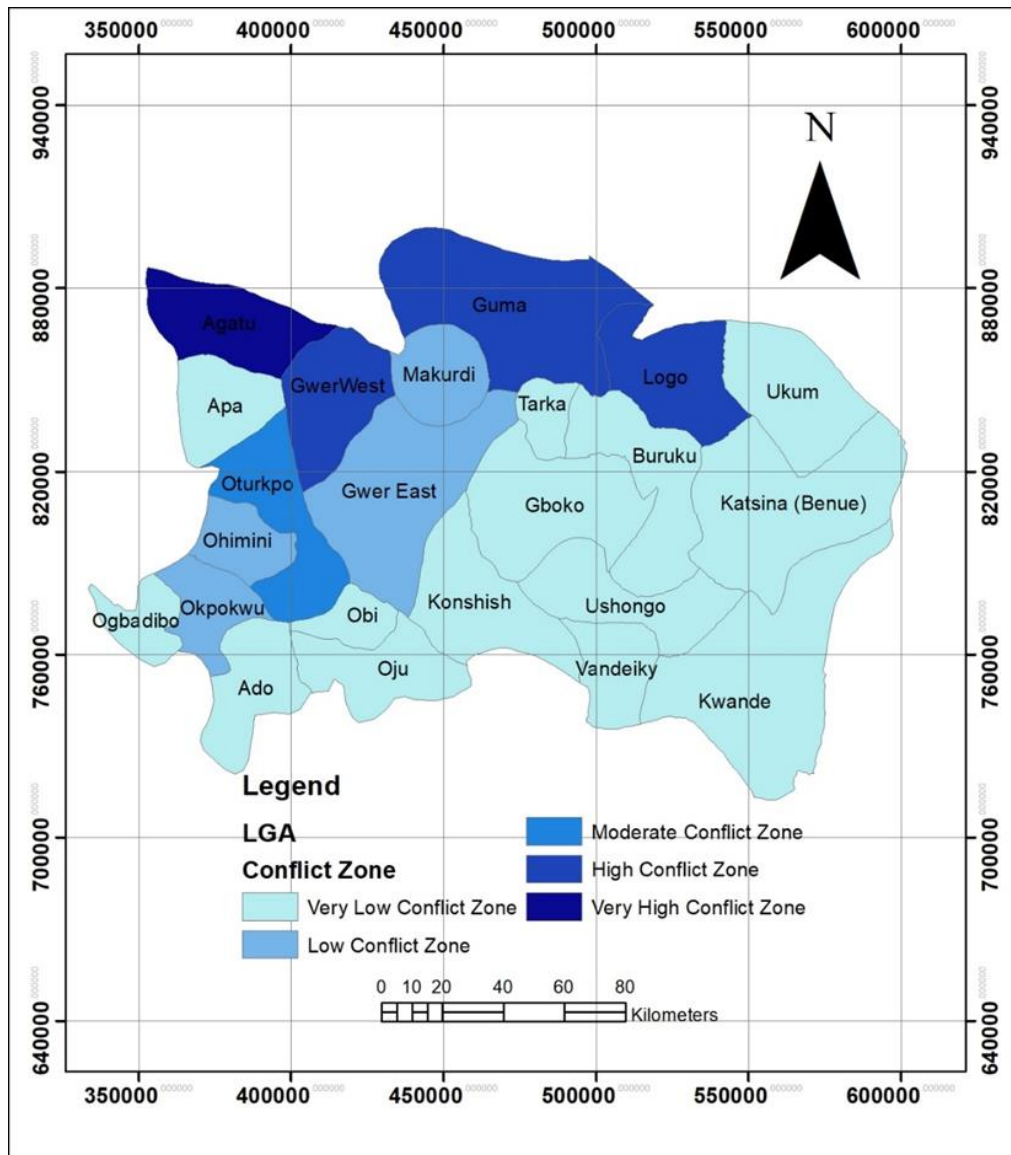
Figure 3 Conflict Zones in Benue State

3.4. Potential Grazing Areas

In line with the legislation prohibiting open grazing as part of measures to end the persistent conflict between herdsmen and farmers in Benue state, reduce the risk of herdsmen destruction of farm lands and the associated conflicts and making open grazing under any guise, an illegal activity punishable by law. According to [5], the primary objective of establishing and developing grazing reserves by the government is to discourage overgrazing and degradation of the diminishing land resources, ensure grazing control, improvement and management of grazing land, and minimize the conflict between herders and farmers.

Hence, it becomes crucial to analyze and present a novel approach to this issue by establishing potential sites for grazing reserves in Benue State Using GIS, AHP and the following factors; distance to road, distance to water, landuse, and slope The results revealed potential grazing reserves holding a combined area of 8361.46 hectares which was 0.27% of the total land mass of Benue State, with potential sites located at 18 local government areas of Benue State with 1.83% of the potential site at Ado, 2.73% at Agatu, 0.92% at Apa, 18.45% at Buruku, 8.46% at Gboko, 16.75% at Guma, 7.59% at Gwer East, 6.18% at Katsina, 4.55% at Konshish, 6.03% at Logo, 4.09% at Makurdi, 1.89% at Obi, 3.37% at Oju, 0.78% at Oturkpo, 5.38% at Tarka, 8.27% at Ukum, 0.91% at Ushongo and 1.82% at Vandeikv. See figure 4 for details. The locations of the potential grazing reserves and conflict zones were extracted and a database was created in ArcGIS, then exported to QGIS where the web GIS was prepared and uploaded on QGIS Cloud. This is seen in figure 5.
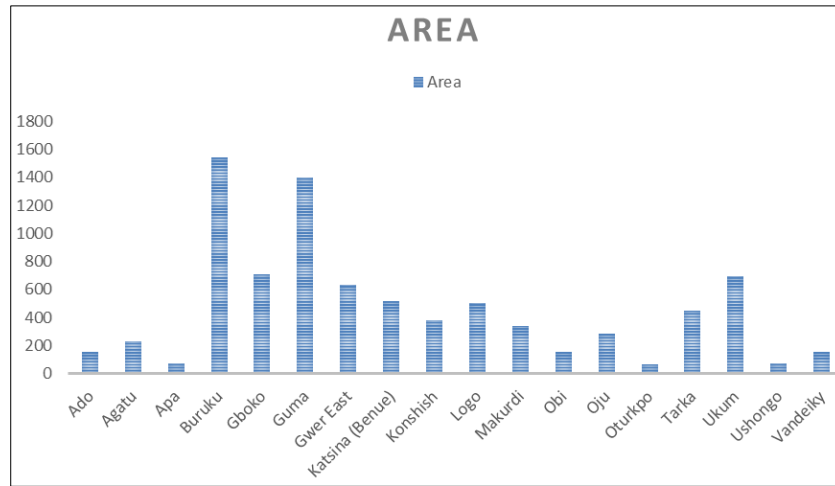
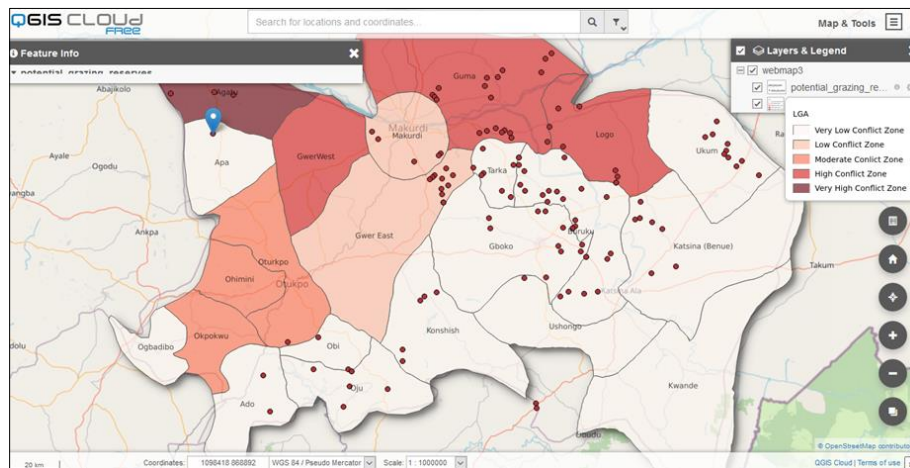**Figure 4** Area coverage of potential grazing reserves located at Benue State Nigeria

Figure 5 WebGIS created in QGIS Cloud

The Web GIS created (figure 5), displays areas in Benue State with high conflict zones as well as potential areas for establishing grazing reserves. It also offers quick update to the data stored in the cloud in its PostgreSQL database. Access to the databases is protected with a password, and accessed through SSH, hence it is safe and secured. The data stored here can be shared to be used for visualization, analysis and easy accessibility, as well as printing maps on the fly.

4. Conclusion

The biggest challenge has been finding a way to contain the herder-farmer conflict particularly in the middle belt region of Nigeria. Therefore, this study applied a novel approach of developing a web-based intelligent decision support system to aid decision making in terms of the control and management of the herders and farmers crisis in Benue State Nigeria. The study objectives were to: examine the temporal dynamics of landuse in Benue State with emphasis on grazing and farmland; identify potential conflict zones in Benue State; establish potential areas for grazing reserves in Benue State; and to develop a web-based geospatial intelligent decision support system to aid in decision making and management of herders and farmers crisis in Benue State. The methodology involved acquisition of Landsat 5 TM for 1989, Landsat 7 ETM+ for 2004 and Landsat 8 OLI for 2019, these images were preprocessing to correct atmospheric errors. After which a classification scheme level 2 was adopted for the study area after Anderson et al (1967). This was followed by maximum likelihood image classification and accuracy assessment in Erdas 2016. Trend analysis was used to examine the temporal dynamics of landuse in Benue State with emphasis on grazing and farmland land, while AHP and weight sum in ArcGIS 10.6 was used to calculate site suitability for potential grazing reserves in Benue State. After suitability

analysis, a database of the potential areas for grazing reserves was developed and implemented in QGIS Cloud platform for quick decision making. The study results provided insightful analysis on the management of herders and farmers crisis in Benue State using a novel approach based on Web GIS.

Based from the analysis and results of this study, the following recommendations are put forward:

- This study results provided a temporal analysis of grazing land and farmland in Benue State, this is recommended as it provides data on the rate of change of grazing land, farmland and forested areas and this will give authorities an insight on how to control and manage the decline of vegetation resources in the study area.
- The study also provided an analysis of conflict zones; this is recommended as it will provide the security agencies the clash hot spots for clashes in the study area. This will help security agencies know which zones to focus their attention on.
- The study was able to provide potential areas for grazing reserves in Benue State. This is recommended as it is in line with the legislation prohibiting open grazing as part of measures to end the persistent conflict between herdsmen and farmers by proffering potential areas for establishment of grazing reserves in Benue state.

The approach and overall results achieved in this study is recommended to serve as a decision-making tool in the control and management of herders and farmers crisis in Benue State.

Compliance with ethical standards

Disclosure of conflict of interest

There is no conflict of interest regarding the research, authorship and publication of this paper.

References

[1] Idakwoji S, Ojomah B, Usman Y, Orokpo Ogbole. Herdsmen/Farmers Conflicts in Kogi State: Security And Developmental Implications. International Journal of Scientific and Research Publications. 2018; 2(3): 476.

[2] Nkwunonwo U, Okeke F, Chiemelu E, Ebinne E. Geospatial Technology Potentials in Reawakening the Consciousness of Soil Distribution in Nigeria's North-Central Region and Mediating the Herdsmen-Farmers Conflicts. Journal of Geoscience and Environment Protection. 2019; 7(8): 156-175.

[3] Augustine DP, Caleb NN, Garba GN. An Agent-Based Modelling and Simulation of Conflict between Fulani Herdsmen and Indigenous Farmers of Barkin-Ladi L.G.A. Of Plateau State. American Journal of Engineering Research (AJER). 2018; 7(7): 120-129.

[4] Ojukwu UG, Osuchukwu NC, Enemuoh NV. Farmers-Herders conflicts and ranch establishment law in Nigeria: a case study of Benue State. International journal of academic pedagogical research. 2020; 4(1): 1-16.

[5] Zumo IM, Galadima M, Bulama AA, Abdullahi, DW. Suitability Site Selection Analysis for Grazing Areas in Yobe State, Nigeria. The International Journal of Science & Technology. 2020; 3(2): 10-15.