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Climate change, urbanization, sedentarization, and dissipation of pastoral Fulani culture in Ghana

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Abstract

While a lot of research has been conducted on the effects of climate change, urbanization, and sedentarization on pastoralism in Africa, empirical research that synchronizes the combined impact of these three monsters, especially how they conspire to deprive the pastoral Fulani of their beloved culture they strived to protect over the centuries. This study was conducted in Ghana among the Fulani ethnic group, who are notorious pastoralists. Using survey instruments and followed up with detailed interviews, the study found that the pastoralists are drifting towards sedentarization due to the effects of climate change and urbanization that make pastoralism difficult. The study found that *pulaaku*, which denotes a moral code of conduct that regulates the proper behavior of the Fulani ethnic group, is dissipated through sedentarization, intermarriages, and global impacts. The study concludes that to preserve their identity, the Fulani can form vibrant associations to promote their culture and identity.

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Introduction

One of the cultural values Fulani have protected over the centuries is their pastoral identity. Over 90% of Sub-Saharan African Fulani professed to be pastoralists and live by keeping livestock such as sheep, goats, cattle, and camels (African Union, 2013). Pastoralism typically necessitates the movement of herders and their livestock, frequently on a seasonal basis between arid and wet periods and daily between grazing areas and water sources. The seasonal mobility of pastoralists and their animals is referred to as transhumance. West Africa exhibits a diversity of heterogeneous pastoralists. Pastoralist lifestyles encompass nomadic, transhumant, and established or semi-settled agro-pastoralism. The latter integrates agriculture and livestock husbandry, necessitating a fixed location for crop cultivation while preserving cattle mobility for transhumance (UNOWAS, 2018).

Pastoral Fulani in Ghana predates colonialism (Tonah, 2006). Some are Ghanaians legally because, per the 1992 Constitution of Ghana, a child born in Ghana or found in Ghana before independence is a Ghana (Setrana, 2021). Most consider them aliens because they do not have a traditional area, town, or village of origin in Ghana (Al Okoli & Atelhe, 2014). They are scattered throughout the country, usually in the rural and hinterland near pasture and water

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sources (Abubakari, 2024.). Their settlement patterns have enabled them to preserve their cultural identity (Almagor, 1980). Those in the cities, such as Accra and Kumasi, try to mimic their pastoral cultural identity amid the dominant Ghanaian culture. During the celebration of Eid-ul-Fitr[2] in Accra and Kumasi, the Fulani in towns usually embark on the street procession with their women having their hair intricately plaited, wearing beads, necklaces, carrying calabashes with fresh milk and covered with straw plates, and the men wearing straw hats and also holding sticks, uniquely dressed to portray their cultural identity (Oppong, 2017).

However, the cultural resilience the Fulani try to preserve is seriously challenged by the twin impact of urbanization and climate change. Global urbanization has reached unparalleled levels, particularly in developing nations with the most significant growth rates (Kundu & Pandey, 2020). The global population is projected to undergo substantial transformations over the next three decades, with 60–70% of its inhabitants residing in urban areas. In Ghana, the urban population stood at 56.7% in 2020 (GSS, 2021), and urbanization is swiftly escalating and converting arable land possessed by smallholder farmers and pastoralists. This intensifies pressure on agricultural activities and competition for arable land for development, significantly affecting peri-urban farming and grazing lands and the livelihoods of pastoralists.

On the other hand, climate change seriously threatens pastoralists and their livelihoods. The repercussions of climate change pose substantial risks to human well-being, ecological balance, and the vulnerability of livelihoods. The ramifications of rising global temperatures and severe weather conditions provide significant challenges in the 21st century. Nonetheless, the impacts and hazards associated with climate change might differ markedly from region to region. Climate change produces direct and observable effects, including heat waves, hurricanes, floods, wildfires, and droughts. Gradual alterations in mean temperature, sea level, and rainfall patterns will significantly impact people in the future (Masipa, 2017). Africa is universally recognized as highly vulnerable to the effects of climate change. Pastoralist groups worldwide, including those in Africa, have historically faced various social, economic, and climate-related challenges (Tinsley & Gwiriri, 2022). These people, reliant on livestock-based livelihoods and vulnerable to droughts and erratic rainfall, are particularly susceptible to the adverse effects of climate change. Pastoralism has experienced transformations in recent decades that have diminished its resilience to shocks and adaptability to new conditions, resulting in heightened poverty, social stratification, and inequality within pastoralist groups (Food and Agriculture Organization, 2018). Africa is a region significantly affected by climate change. African nations' constrained economic, developmental, and institutional capacities make them particularly susceptible to these effects. As a result, the advancements made in improving the socio-economic well-being of Africans, particularly in West Africa, are jeopardized and may be reversed under the impact of climate change (Food and Agriculture Organization, 2018).

Pastoralist communities in Ghana face threats from climate change, which directly affects the availability of natural resources and cattle production in grazing areas (Dumenu & Obeng, 2016). Climate change significantly affects the livelihoods of these populations, as

[2] Eid-ul-Fitr is the Muslim festival marking the end of the Ramadan fasting.

demonstrated by an observable increase in extreme conditions like droughts and floods. These occurrences disturb the fragile balance among land availability for grazing, livestock presence, and the effects on the human population (Feng et al., 2021). These issues have led to a transformation in pastoral practices and an increased reliance on non-pastoral livelihoods (Herrero et al., 2015). Despite the numerous challenges pastoralist communities face in Ghana, including significant susceptibility to climate change and the ever-expanding nature of urban communities, there is no empirical research that delineates the combined effects of climate change and urbanization on the pastoral Fulani livelihoods and cultural identity. Additional research is necessary to assess the lasting combined impacts of climate change and urbanization on the pastoral culture and gain a deeper understanding of pastoralists' unique challenges and sedentarization in Ghana.

The significance of this study lies in the fact that it reveals another angle of climate change's impact, not only on livelihood but also on how it transforms people's culture, identity, values, and belief systems. The paper argues that a group of people's culture is not only influenced by the social and physical environments but also by climate change and urbanization. The overarching purpose of this article is to analyze the effects of climate change and urbanization on pastoralists' cultural identity in Ghana. It delineates four key specific objectives: (i) to determine the impact of climate change on the pastoralists, (ii) to analyze the effects of urbanization on pastoralists' cultural identity, (iii) to examine how the pastoralists are adapting to the combined impact of climate change and urbanization, and (iv) to determine the combine impacts of climate change and sedentarism on their cultural identity.

Literature Review

There are six major sections to this article. After the introduction, the following section deals with pastoralism, the pastoral economy, and the effects of climate change and urbanization on pastoralist livelihoods. The third section discusses the conceptual framework, while the fourth section focuses on the methodology and data analyses. The fifth is a thematic presentation of the key findings based on the research objectives, while the last section comprises the discussions and conclusions.

Pastoralism

Pastoralism is a livelihood venture in which at least 50% of a household's sustenance and revenue is sourced from livestock. Moreover, pastoralism is defined by mobility, specifically the seasonal relocation of animals to obtain grazing resources and water (African Union, 2010). In West Africa, pastoralists inhabit the Sahelian and semi-arid regions characterized by significant geographical and temporal fluctuation in rainfall. In Sahelian countries, the strategic movement of livestock is a logical and prudent reaction to the unpredictable nature of pasture and water, involving significant cross-border movements of animals (African Union, 2013). Livestock husbandry generally produces milk for household consumption, sale, or exchange for cereals. The fundamental components of pastoralism have, in general, remained consistent for centuries. Pastoralism in the region has numerous forms and is resilient and dynamic, adapting to market possibilities and other economic, social, and environmental factors over time.

In West Africa, the Fulani are the notorious pastoralists. Anter (2011) states that the Fulani are an ethnic group dispersed across multiple West African countries and certain regions in

Central Africa and Sudan. The Fulani people inhabit Benin, Burkina Faso, Cameroon, Central African Republic, Côte d'Ivoire, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone, Sudan, The Gambia, and Togo. The Fulani constitute the predominant ethnic group in Guinea, primarily engaging in pastoral agriculture. Their principal activities include nomadic farming, trade, and herding of cattle, camels, goats, and sheep throughout their extensive territory, often avoiding interaction with the local agricultural populace (Anter, 2011).

The Pastoral Economy

The fundamental economics of pastoralism involve the necessity to mitigate risk and augment household income resources amidst unpredictable rains, resulting in the uncertain availability of grass and water for livestock. Furthermore, pastoralists derive sustenance directly from their cattle, particularly milk, or acquire essential goods, such as cereals, via the sale of livestock. Consequently, pastoral cattle ownership and production encompass not merely the administration of material assets but also the oversight of household food security. In dry and semi-arid regions, where rain-fed agriculture is impractical, animals transform natural plants into milk and meat. The income from livestock is substantial due to the rapid appreciation of livestock assets compared to other forms of investments like savings (African Union, 2010).

Nonetheless, a crucial element of the pastoral economy is that household-level behavior is contingent upon herd size (Barrett et al., 2006). The goal for economically disadvantaged households with limited herds is to optimize herd expansion while ensuring food security (Catley et al., 2016). These households sell cattle to satisfy fundamental domestic requirements, regardless of market conditions. As the herd expands, domestic food needs are more readily satisfied, and excess animals become increasingly accessible for sale. Consequently, affluent households possessing more animals predominantly contribute to domestic, regional, and international markets (African Union, 2010). A significant yet sometimes misinterpreted policy matter is that the economic approach employed by impoverished pastoral households, which focuses on maximizing herd expansion and minimizing sales, is economically sound.

Nonetheless, herd expansion is influenced by many factors and shocks in non-equilibrium settings. Pastoralists must oversee their herds amid recurrent animal losses attributed to drought and, to a lesser degree, sickness. According to Catley et al. (2014), drought-induced losses can be significant. They found that about 37% of losses were recorded in Borana, in Ethiopia, over 17 years from 1980 to 1997. The magnitude of this loss has immediate and severe repercussions for the pastoralist economy and household income. The issue is exacerbated by the physical inaccessibility of traders and marketplaces; as the drought intensifies, animal values decline, and cereal prices rise, resulting in less advantageous trade conditions for pastoralists. Drought-induced livestock mortality significantly affects long-term herd growth, requiring several years to restore herds. During this reconstruction phase, other crises may also arise. Pastoralists employ diverse measures to mitigate drought and disease risks (African Union, 2013; Yator, 2023).

The expansion of herds is fundamental to pastoralists' notions of prosperity and poverty, as livestock signify economic assets, sources of sustenance, and safeguards against shocks, drought, and other adversities. A household requires a requisite quantity and variety of cattle to sustain a livelihood through pastoralism, and in numerous contexts, 'wealth' is significantly

associated with herd size (Tache & Sjaastad, 2010). A 'minimum herd size' fluctuates based on location, environment, social structure, and additional considerations, including non-livestock revenue sources. As indicated below, many households cannot obtain this minimum herd, classifying them as 'extremely poor' or 'poor' wealth groupings. Moreover, these households do not experience a linear trajectory of herd expansion; instead, they become ensnared in a 'poverty trap,' necessitating significant increases in livestock assets to attain a more stable economic condition (Catley et al., 2016). As outlined below, issues such as the commercialization of cattle and the privatization of rangelands and water resources further constrain the capacity of impoverished households to attain significant herd expansion.

Studies by several researchers show that the complexity of climate trends regarding rainfall reveals no long-term decline in rainfall in East African countries, including Kenya, Ethiopia, and Somalia (Catley & Aklilu, 2013; Hermance, 2014), alongside general uncertainty regarding future rainfall patterns as a result of climate change (Erickson et al., 2013). Nonetheless, several reports at local and governmental levels indicate an escalation in the severity or frequency of drought in pastoralist regions. These reports may be attributed to the escalating effects of drought, resulting from the growing population of vulnerable individuals in pastoralist regions who are susceptible to such conditions rather than enduring patterns in rainfall (Catley et al., 2016).

Effects of Climate Change on Pastoral Livelihoods

In Ghana, the movement of the pastoral Fulani from the Sahelien countries is attributed to climate-induced factors such as the Sahelien droughts in the 1980s (Tonah, 2006). Many other researchers have attributed the pastoral movement or transhumance to climate change (Scoones, 2023). This movement is not only peculiar to West Africa but also to East Africa and North Africa (African Union, 2013). Similar climate-induced movements of pastoralists are reported in the Far East, China, and the Himalayas (Singh & Kerven, 2023). Several perspectives agree that climate change has intensified farmer-herder relations, notably regarding rising migration trends, commercialization, commodification, and individualization of land and water resources (Yator, 2023).

The literature is replete with farmer-herder conflicts, insulting in crop destruction, killing of cattle, and killings of human beings (Olaniyan et al., 2015; Uhembe, 2015). Herders and cattle owners reported paying substantial sums for compensation for crops destroyed by their cattle. In the Agogo traditional area in Ghana, research shows that the Fulani and cattle herding was banded in the area due to incessant conflicts between the farmers and the herders (Yeboah et al., 2024) reported that herders now complain that cattle rearing is no longer lucrative, and the Fulani herdsmen are now resorting to agro-pastoralism and gradually transitioning to semi-sedentarization and complete sedentarization (African Union, 2010; Bassett, 1988; Wilson, 1995). Resource users' varying needs and adaptive capacities result in conflicts. Conflicts between farmers and herders stem from competition for essential natural resources, such as land and water, which are crucial for their existence and welfare (McGuirk & Nunn, 2024; Snorek et al., 2017; Yeboah et al., 2024).

Effects of Urbanization on Pastoral Livelihoods

Urbanization is simply the expansion of the cities resulting from rural-urban migration, population growth, and industrialization. In Ghana, 56.7% of the population lives in the urban

areas (GSS, 2021). Literature on the effects of urbanization on pastoralism in Ghana needs to be more detailed and available. Yeboah et al.'s (2023) case study of Atwima Kwanwoma District in Ghana is limited in scope, focusing only on climate change effects on small ruminants in a single district. They found that climate change is real because of high temperatures, the shading of tree leaves, and the prevalence of ruminant diseases and insects such as ticks, fleas, and death.

According to the African Union (2013), urbanization presents challenges and prospects for pastoralists. Urban centers attract individuals, particularly the youth, from rural areas, thereby diminishing the available workforce in pastoral regions in certain instances. Regrettably, the inadequate levels of education and literacy in the pastoral areas result in urban migrants being more prone to securing low-wage employment that demands minimal skills, hence increasing their vulnerability to exploitation. For individuals from pastoral backgrounds who secure employment, remittances to their families constitute a substantial source of income.

For individuals engaged in pastoralism, particularly affluent pastoralists with substantial herds, the expansion of urban areas presents economic prospects. This expansion is typically linked to a burgeoning middle-income demographic, and as earnings rise, so does the demand for livestock products like meat and milk. Provided that fundamental infrastructure, including roads and cell phone networks, is established, pastoralists can capitalize on the growing demand for their products. Urbanization tendencies are not confined to African nations. The increasing export of cattle from Somalia, Sudan, and Ethiopia is partially fueled by the Gulf States' burgeoning markets, urban expansion, and the rise of middle-income demographics in these nations (African Union, 2013).

The expansion of cities damages farming and livestock rearing (Li et al., 2022). Larger tracks of arable land have been converted for residential, educational, commercial, and industrial purposes (Lee-Smith, 2010). The expansion of the cities and the construction of roads are characterized by gravel and sand mining, which leads to environmental degradation and deprives cattle of grazing lands (Zhou et al., 2024). Elevated population growth and expanding urbanization necessitate enhanced agricultural output and livelihood advancement. This exerts pressure on land and other natural resources, thus leading to the spread of agriculture and settlements in grazing regions and transhumance corridors (Bassett, 2009; Mensah et al., 2016; Nwangwu et al., 2020). These effects result in alterations within pastoral regions, progressively challenging pastoralism. This subsequently escalates the frequency and intensity of disputes and conflicts between farmers and herders over critical natural resources, including water, pasture, and arable land, which are indispensable for pastoralism and agriculture. Land disputes have grown increasingly frequent due to the commodification of land driven by the expansion of agribusiness and urbanization, leading to trading and speculation (Gaye, 2017; Nwangwu et al., 2020). This scenario illustrates a broader trend in West Africa characterized by increasing competition among various land uses, including agriculture, grazing, residential development, and biodiversity conservation, which is exacerbated by land grabbing and the privatization of communal lands (Bassett, 2009; Basupi et al., 2017). This is a challenge to advancing pastoral activities in Ghana if no provision for cattle grazing in development planning is made.

Analytical Frame: Elements of the three-Dimensions of Pastoral Cultural Dissipation

The researcher posits that the cultural and identity dissipation of the pastoral Fulani in Ghana has three dimensions: climate change, urbanization, and sedentarization dimensions. This theory seeks to elucidate the interplay between climate change, urbanization, and sedentarisation on the cultural identity of pastoralists in Ghana. It also aims to explain the relationship between climate change and urbanization and the processes of change that impact sedentarization and pastoral identity.

1. Climate change: This indicator evaluates the impact of climate change on livestock rearing. The prolonged dry spells and sometimes heavy rains make livestock breeding that depends heavily on natural pastures difficult.
2. Urbanization: The researcher analyzes the effects of urbanization on livestock rearing
3. Sedentarization: This indicator measures the impact of sedentarization on the pastoral culture

Cultural dissipation: The result of the three dimensions is cultural dissipation, characterized by the loss of the pastoral Fulani cultural value known as *pulaaku*, and the loss of their language and dressing code. The details are shown in Figure 1.

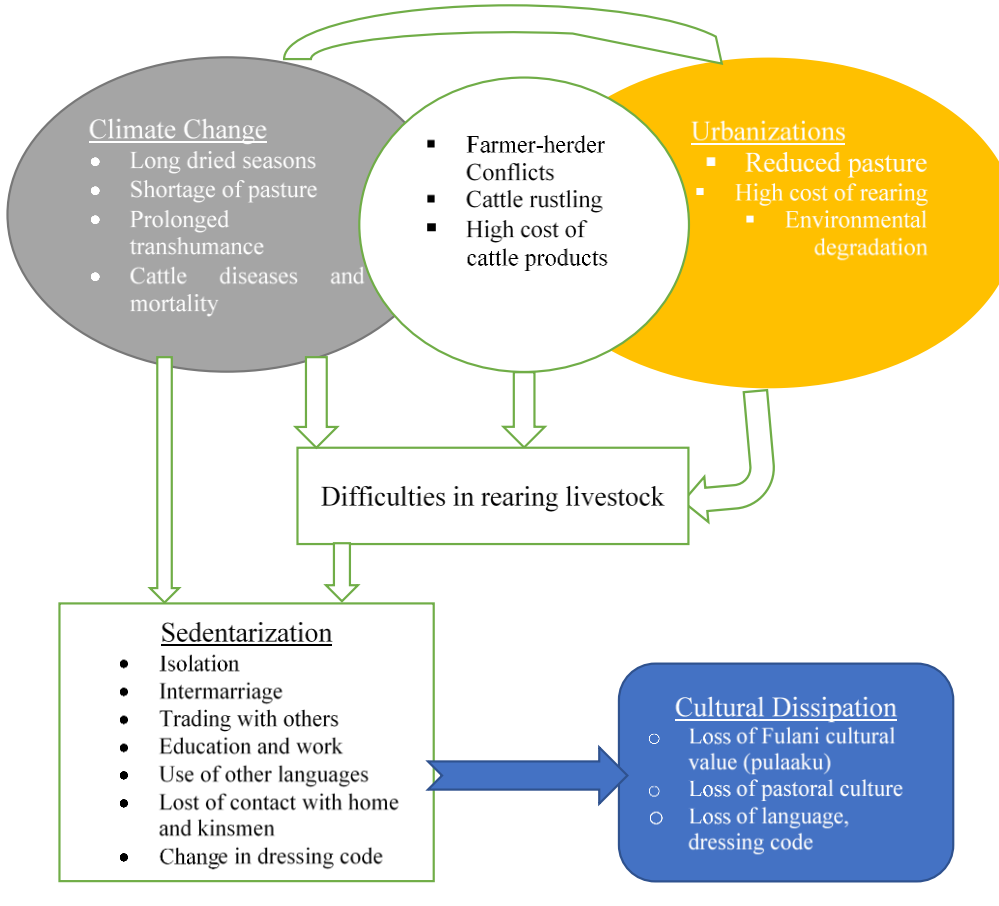


Figure 1. Elements of the three-dimensions of cultural dissipation of pastoralist
Source: Prepared by the researcher

Method

The research for this study was undertaken from March 2022 to June 2023 in the Greater Accra, Ashanti, Northern, Savannah, and North East Regions. The regions were chosen because research shows that most Fulani lived in the Greater Accra, Ashanti, Eastern, and Northern regions (Setrana, 2021). We administered questionnaires and conducted interviews. We conducted follow-up interviews in each research location three times throughout this period. The target population was categorized into four groups: sedentary Fulani (those residing in towns), semi-sedentary Fulani individuals (those engaged in cattle rearing and other enterprises), pastoralists, and agro-pastoralists (those involved in crop cultivation and animal husbandry). Nevertheless, the survey did not encompass seasonal migrant pastoralists from neighboring countries. Due to the dispersed nature of the respondents, it was difficult to hold a focused group discussion with them.

The research encompassed prominent Fulani in the Greater Accra suburbs, including Nima, Mamobi, Madina, Sukra, and in the Shai Osu-Doku district in the Ashanti region; the study was conducted in the Greater Kumasi, Asante Akim North Municipal (AANM), and Sekyere Afram Plains District (SAPD). Data was obtained in the Central Gonja district in the Savannah region, while in the Northern Region, we collected data in the Greater Tamale, Gusheigu, and Karaga districts. Finally, the research was conducted in the West Mamprusi Municipal (WMM) and Mamprugu Moagduri District (MMD) in the North East Region.

We employed snowball and convenient sampling methods to obtain the respondents. For the past two decades, we have conducted studies among the Fulani and cultivated relationships with most of their leaders throughout Ghana. We established contact with our respondents via their leaders. Our study team consisted of six MPhil candidates who served as research assistants, including two from a Fulani background and two supervisors. The team was divided into two groups, each consisting of one supervisor and three research assistants, one of whom was a person of Fulani background.

Data was gathered in stages. First, we used semi-structured surveys for the quantitative data. After the initial analyses, we extracted the emerging vital themes, developed an interview guide, and went back to the field to conduct in-depth interviews with leaders and selected individuals. We also observed their sedentary and migratory lifestyles and corresponding activities. All interviews were recorded and transcribed. We followed the *Salafest*[3] and street processions in Nima, Accra, and Kumasi on April 22, 2022, and April 21, 2023, respectively. We also conducted interviews with some participants during the events. We participated in the annual *Maulud*, organized by the Fulani, at Wungu in the West Mamprusi Municipal on August 25, 2022, and September 5, 2023. We conducted interviews with several Fulani participants of the event.

Out of 515 questionnaires administered, only 412 were completed successfully. We rejected 103 questionnaires for several reasons, including inconsistent information, contradicting data, and incomplete surveys. We also had 35 complete interviews with key informants and leaders of the Fulani. We used SPSS version 29 to analyze the quantitative data after coding and cleaning the data. For the qualitative data, a qualitative content analysis was performed on the

[3] Salafest was recently coined from the Hausa word sallah, which means festival. Salafest is celebrated to mark the end of the Muslim fasting of the Ramadan.

transcribed interviews (Graneheim & Lundman, 2004). We conducted a comprehensive comparative study of the interviews, transcripts, and recorded sessions. To thoroughly understand the data, we meticulously evaluated the interviews multiple times to identify the unit of analysis and themes. The pertinent meaning units and statements offering information aligned with the objective were identified, extracted from the text, and transcribed into distinct Microsoft Word documents. Upon extracting each meaning, a code was allocated and appended to the others with comprehensive explanations. Following deliberation and consensus on suitable classifications, we grouped the subthemes into principal themes.

Findings

Socio-Demographic Characteristics of the Respondents

The study involved 412 respondents, comprising 261 (63.34%) males and 151 (36.65%) females drawn from five regions. Regarding regional composition, 82.8% in the Greater Accra region, 83% in Greater Kumasi, 71% in Greater Tamale, and 62.5% in the North East region were urban-based. Table 1 depicts the details.

Table 1. Socio-demographic characteristics of the respondents

Region	Study Area	M	F	Total	Urban	Rural	Pastoral	Agro-Pastoral	Pastoral-Sedentary	Sedentary
Greater Accra	Greater Accra	43	21	64	53	11	5	8	15	36
	Shai Osu Doku	18	8	26	8	18	2	12	4	8
	Sub-total	61	29	90	61	29	7	20	19	44
Ashanti	Greater Kumasi	33	20	53	44	9	3	4	8	38
	AANM	11	9	20	8	12	7	3	4	6
	SAPD	8	5	13	3	10	5	3	3	2
	Sub-total	52	34	86	55	31	15	10	15	46
Savannah	Central Gonja	36	27	63	24	39	12	17	21	13
	Sub-total	36	27	63	24	39	12	17	21	13
Northern	Greater Tamale	30	15	45	32	13	4	8	10	24
	Gusheigu	10	7	17	4	13	3	8	2	4
	Karaga	8	6	14	3	11	2	7	2	3
	Sub-total	48	28	76	39	37	11	20	14	31
North East	WMM	38	18	56	35	21	8	30	5	13
	MMD	26	15	41	9	32	7	20	5	9
	Sub-total	64	33	97	44	53	15	50	10	22

Table 1 shows that the majority, 44 or 48.89%, of the respondents in the Greater Accra region are sedentary, as against 46 or 53.49 % in the Ashanti region. This means they do not depend on livestock for living. Those who practice only pastoralism are the least in Greater Kumasi (5.66%), 8.67% in Grater Tamale, 7.8% in Greater Accra, and 7.14% in Shai-Osu-Doku. Those who combined crop production with livestock rearing are the majority (51.55%) in the

Northeast region, followed by the Northern region (26.32%), while the Greater Accra region is 22.22%. Lastly, those who combined pastoralism and trading or other works were the highest (33.33%) in the Savannah region, followed by 29.68% in the Greater Accra region, then 18.42% in the Northern region, and 17.44% in the Ashanti region.

The Impact of Climate Change on Pastoralism

Table 2 presents some of the observable impacts of climate change on the Fulani pastoralists the respondents frequently mentioned.

Table 2. Effects of climate change on pastoralism

Variable	No mention (n=412)	%
Shortage of pasture and water	333	80.82
Prolonged dry seasons	309	75.00
Prolonged transhumanance	304	73.78
Cattle diseases and mortality	272	66.01

During the interviews, participants provided details of the explanation. For instance, the prolonged dry spells, according to them, are interspersed with heavy rains and flooding that make the grazing fields extremely difficult, as the cattle get stuck and find it challenging to graze well. They indicated that it sometimes rains all day, making it difficult to send the cattle for grazing. As explained by Bashiru, a herder, 'the initial rains are characterized by thunderstorms and heavy rainstorms that scare and drive the cattle away into the bushes,' 80.82% of the respondents mentioned pasture and water shortages as one of the effects of climate change on pastoral lives. The respondents also mentioned prolonged dry seasons and heavy rains as bad for pasture growth. They frequently experience a shortage of pasture and water, compelling them to converge in areas where pastures are available with it attended problems of cattle rustling, conflict, and contraction of diseases from other cattle. The search for pasture is occasioned by climate change, as indicated by 73.78%

The prolonged transhumance and long-distance movement of cattle. Abubakari and Derkyi (2024) found that some of the pastoralists travel as far as Senegal, Mali, Niger, Burkina Faso, and Nigeria to Ghana in search of grazing pastures. This long-distance movement has a lot of implications for the health of the cattle and the headers. The cattle get emaciated, lose weight, contract disease, and some die. Headers also contract diseases, especially zoonotic diseases, as they have prolonged contact with cattle and wild animals (Abubakari & Derkyi, 2024). This study confirms that climate change affects cattle with disease and mortality, as indicated by more than half (66.01%) of respondents.

The Effects of Urbanization on Pastoralism

Urbanization is the migration to and expansion of cities (Satterthwaite et al., 2010). The study found that urbanization negatively and positively affects pastoralism and pastoral culture. The study found that the adverse effects of urbanization are reduced pastures (74%), environmental degradation (81.52%), and the high cost of rearing livestock (77.3%). However, urbanization also positively affects livestock because it creates a high demand for livestock products (91.02%).

The built environment is characterized by the expansion of cities and reduced land for pastures where cattle are grazed. This pushes pastoralists far into the interior, where they come in contact with crop farmers. The attendant crop destruction leads to farmer-herder conflicts. As one of the headers put it, "Now cattle rearing is endangered! We are now encircled by the deep blue sea and the devil and the ogre." He explained that these are climate change, urbanization, and farmer-herder conflicts. See evidence of land degradation due to gravel mining in the Northern region in Figure 2.

Figure 2. Environmental degradation through gravel mining

The interviews further revealed that urbanization also leads to environmental degradation, as there is a high demand for sand, gravel, and stones for constructing roads, houses, and industries. Pastoralists explain that cattle rearing is now expensive for urban cattle farmers and those who graze on free pastures. The cost elements are associated with buying supplementary feeds, drugs, and hiring herders to care for the cattle.

Figure 3. Urban cattle rearing in Tamale

However, urbanization also increases the demand for livestock and its products, such as meat, milk, cheese, hide, and hooves for decoration (African Union, 2010). The study found that

some Fulani pastoralists, now settled in urban communities and still desirous of keeping their pastoral culture, engage in urban cattle rearing and need the high demand for cattle products. However, this also comes with challenges, such as the high cost of supplementary feeding, cattle causing traffic obstruction, vehicles running over cattle, and stealing, as explained by Alhaji Musah, an urban cattle farmer in Tamale. Figure 3 shows urban cattle rearing in Tamale.

Combined Effects of Climate Change and Urbanization

The study found that three outstanding factors, including climate change and urbanization, have both negative and positive impacts on pastoralism. While farmer-herder conflicts (-78.64%) and cattle rustling (-73.06%) negatively impact cattle production, the high market for cattle products (93.15%) positively impacts pastoralism. The study found that the high market for livestock products is why most pastoralists still keep livestock. According to Alhaji Musah, a sedentary pastoralist in Tamale, 'cattle rearing is now at the brink. The challenges of rearing cattle are many and daunting and outweigh the benefits; these include conflicts, payment of compensation for the destruction of crops, difficulty in getting pasture, cattle rustling, diseases, and many others.' See details in Figure 4.

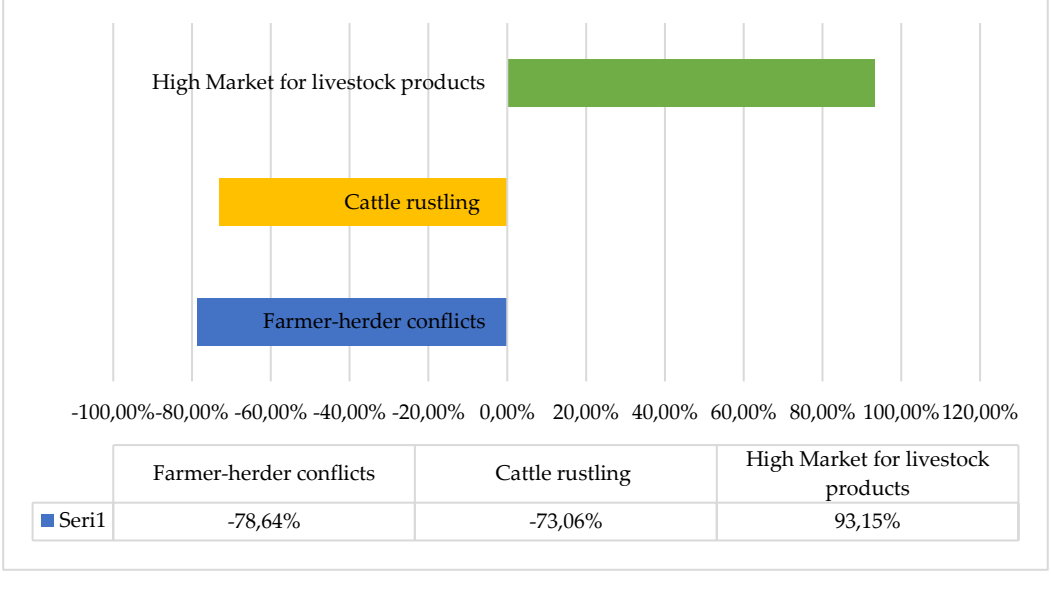


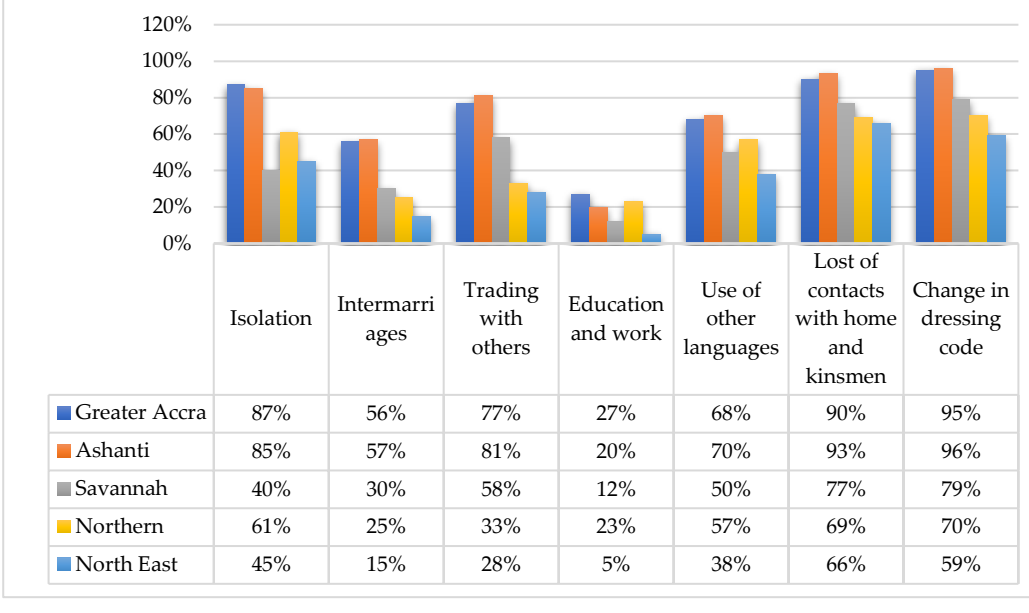
Figure 4. Combined effects of climate change and urbanization

Sedentarization: A Threat to Pastoral Fulani Culture

The data shows that sedentarization is increasingly becoming the best option for pastoralists. For pastoralists, the challenges associated with livestock rearing are daunting. As shown in Table 1, the data shows that more and more pastoralists are settling in urban areas. For instance, in Greater Kumasi, 83% are in urban communities, followed by Greater Accra, 82.8% and 71.1% for Greater Tamale. The lowest urban settlements are Karaga (21.4%), Sekyere Afram Plains District (23.1%), and Gusheigu (23.5%). However, the study found that sedentarization negatively affects pastoral identity and culture. On average, 63.6% of the respondents in all five regions said they are isolated from each other due to urbanization.

Greater Accra recorded the highest (87%), while Savannah recorded the lowest (40%). The interviews explained this further because they are scattered in the cities. Some are in rented houses with other tribes. They hardly meet as a group, even though they have an association.

The Fulani ethnic group used to resist intermarrying with non-Fulani (Ba Konare & Hellweg, 2022). Alhaji Musah explained that apart from the Hausa tribe and a few other tribes like the Busasni, the Fulani would prefer going a long distance to marry their fellow Fulani. However, due to urbanization, there is now a high level of intermarriage with other tribes. The study found that, in all the five regions, on average, 36.6% of the Fulani said there is intermarriage with other tribes now. The Ashanti and Greater Accra regions have the highest of 57% and 56% respectively, while the North East and the Northern regions have the lowest of 15% and 25% respectively. The study further shows that trading with non-Fulani (55.4% on average) and education and work are the least affecting their culture (17.4% on average) in distancing them from their culture. The details are shown in Figure 5.



	Isolation	Intermarriages	Trading with others	Education and work	Use of other languages	Lost of contacts with home and kinsmen	Change in dressing code
Greater Accra	87%	56%	77%	27%	68%	90%	95%
Ashanti	85%	57%	81%	20%	70%	93%	96%
Savannah	40%	30%	58%	12%	50%	77%	79%
Northern	61%	25%	33%	23%	57%	69%	70%
North East	45%	15%	28%	5%	38%	66%	59%

Figure 5. Factors affecting Fulani cultural distance

One of the clear signs of the effects of sedentarization on the Fulani culture is the *fulfulde* transformation. *Fulfulde* is the language of the Fulani. The Fulani observed that there have been significant changes in their language. On average, 56%, as shown in Figure 3, expressed concern about the changes in their language. The highest was in the Ashanti region (70%), followed by Greater Accra (68%). Language is a significant feature of culture and identity. The Fulani acknowledge that they were already facing challenges with their language because of variations in their different sources. The Fulani in Ghana came from other palaces and had different dialects. We have Fulani from Nigeria, Niger, Burkina Faso, Mali, Guinea, Cameron, and Senegal (Abubakari, 2024). Though culture is dynamic, the Fulani expressed worry that the changes will eventually lead to the dissipation of their culture, especially those in the diaspora.

The Fulani observed that their dress style, as it pertains to their culture, is changing faster, especially among the youth. Changes in the dress code are influenced by the dominant Ghanaian culture. The intricate plaiting of hair by Fulani ladies and the wearing of beads and

bangles are gradually disappearing among the ladies. Now, the Fulani ladies go to hair salons and fix artificial hair as most Ghanaian ladies do. The men occasionally wear gowns, carry sticks, and wear straw hats. 'it was easier to identify a Fulani from a distance. Now, it is not. Explained by Zainab, a female respondent in Kumasi. Finally, losing contact with their homes and kinsmen in their countries of origin was a factor. The study found that most are sent or third-generation Fulani in Ghana. On average, 80% of them do not visit their countries of origin in five or more years. Over 90% of such are in Kumasi and Accra.

Symptoms of Cultural Dissipation of the Fulani

Culture has various definitions. The aggregation of symbols, habits, regulations, artifacts, and other societal competencies constitutes the essence of human culture (Levin & Mamlok, 2021). Edward Taylor's famous definition of culture encompasses the diverse forms of knowledge, ideas, and ethical codes that unify a society, and is widely used in sociology. George Herbert Mead (1963) concentrated on organizing collective behaviors within culture and the mechanisms by which such symbols impart socio-historical significance.

One of the critical symptoms of cultural dissipation of the Fulani in Ghana is the loss of *pulaaku*. Riesman (1998) asserts that *pulaaku* is a moral code of conduct that regulates the proper behavior of the Fulani ethnic group. The concept of *pulaaku* encompasses a set of activities, behaviors, or attitudes evident in diverse facets of life, such as language, privacy, and interpersonal relations (Ibrahim, 2014). *Pulaaku*, as articulated by Saleh Momale, encompasses attributes such as shyness (*semteende*), *munyal*, which signifies patience, tolerance, or endurance. Ba Konare and Hellweg, (2022) added nobility (*ndimaagu*), self-esteem, and self-respect. Moreover, it includes bravery, deep empathy or love, wisdom, and perseverance.

Consequently, every Fulani nomad must comply with the tenets of this extensive moral framework (Ujorha, 2014). According to Alhaji, most Fulani youngsters do not have this cultural value. '*Pulaaku* is no longer observed, not only by Fulani in Ghana but by most Fulani in general. In this era of social media, it is common to see boys and girls of Fulani backgrounds posting their naked pictures on social media. This is against the principle of *semteende'*. He attributed this to Western Education, urbanization, and global influences.

Discussion and Implications

Climate change has detrimental effects on pastoralism, compelling pastoralists to gradually turn to sedentarism. It is characterized by prolonged dry seasons that lead to a shortage of pastures and water, compelling pastoralists to converge at places where these resources are available, thereby creating conflicts, cattle rustling, diseases, and loss of market value for cattle due to long hours of movement (Scoones, 2023). In some cases, herders are attacked and killed together with their cattle (Olaniyan et al., 2015). Climate change has forced pastoralists to migrate from as far as Senegal, Mali, Burkina Faso, Nigeria, and Niger to Ghana (Abubakari & Derkyi, 2024). These movements also caused animals and herders to contract zoonotic diseases that could be transferred to the general public (Abubakari & Derkyi, 2024). Due to climate variability, the Fulani pastoralists have to travel long distances in search of pasture and water and meander through rugged terrains and crop farms dotted all over to avoid trampling upon crops. Herding has become very difficult and expensive as the pastoralists must employ more hands to care for the cattle. Traveling long distances also means the cattle owners may only have access to their cattle once they return from the buses.

The cattle are exposed to bandits who steal large numbers across borders. Abubakari (2024) reports that large numbers of cattle were stolen in the northeast region of Ghana, and some of them were found in the Republic of Benin after several months of searching. He indicated that cattle rearing is not only challenging but also risky because some of the cattle rustlers carry dangerous weapons. Pastoralists are increasingly discouraged from rearing cattle as they claim that the risks and the losses now outweigh the benefits (ibid). Given that cattle or livestock rearing is at the center of pastoral Fulani culture, if circumstances like climate change are compelling them to abandon this cultural practice, it implies they are gradually losing their identity. Urbanization, on the other hand, decreases the amount of land available for pasture, thus forcing pastoralists to move deeper into the interior. The reduced arable land for crop farmers and animals leads to competition for land, leading to farmer-herder conflicts (UA, 2013). Urbanization also leads to a high rate of environmental degradation due to gravel, sand, and stone wining for construction (Li et al., 2022).

The study found that pastoralists increasingly abandon pastoralism for sedentarization to avoid the difficulties of accessing pasture and water (Bassett, 1988). Cattle rearing is inversely related to urbanization. The growth and expansion of urban communities are incompatible with cattle rearing in Ghana. While urbanization converts pastures for human settlement, pastoralism requires vast grazing land to feed the cattle. The growth of cities has compelled pastoralists from different localities to converge at points where they compete for pastures and water. Naturally, Pastoralists do not like mixing their cattle with other cattle for fear of cattle rustling, disease transmission, and difficulties in separating the bulls, which might follow other cattle. All these challenges make pastoralism not lucrative, even though there is a high demand for livestock products. The conflicts, killings, and the high money pastoralists use to compensate for crop destructions make it unattractive. Some do this by gradually combining pastoralism with crop farming (agro-pastoralism); others combine herding with trading and other businesses (pastoral sedentarism). Here again, the pastoralists face severe challenges as they try to sedentarize. They lack the requisite skills to engage in trading, carpentry, mason, welding, and plumbing or engage in meaningful businesses to make a living in urban communities. Those who want to engage in agriculture need access to land for cultivation, which is not accessible, available, and affordable to them. Under this circumstance, most Ghanaians perceived them as armed robbers (Bukari & Schareika, 2015; Kojo, 2021) and cattle rustlers (Abubakari, 2024). This further stigmatizes and stereotypes the pastoral Fulani in Ghana.

The combined impact of climate change, urbanization, and sedentarization is the dissipation of Ghana's pastoral Fulani culture and identity. Pastoralists who settled in the big cities like Accra, Kumasi, and Tamale are scattered and isolated from each other as most of them are in rented houses. They are losing their language and identity as they dress and behave like the societies they find themselves in. Most are second and third-generation pastoralists who barely visit their countries of origin. Like many diaspora Africans who form ethnic and tribal associations, the Fulani in Ghana also have various national, regional, and community associations. Such associations include *Tabital Pulaaku* (Legitimacy of the Fulbe), an international association of the Fulani. *Sudu Baaba (Father's Home) national association, and Bantari* (Help Me to Rise) is a local association of the Fulani in The West Mamprusi Municipal (Tonah, 2005). These associations primarily promote the Fulani cultural identity and protect their interests. However, these associations are urban-based and led by a few educated Fulani, who hardly organize their members to champion strategies to preserve their cultural identity.

It is not surprising that the Fulani expressed their disappointment in some of their youth, brandishing their half-naked pictures and videos on social media and speaking vulgar language contrary to the values and spirit of *pulaaku* (Ba Konare & Hellweg, 2022).

The pastoral Fulani in Ghana do not have separate settlements. They are interspersed with the general Ghanaian society. They are engulfed by the larger Ghanaian society, where it takes time to mobilize or enforce their cultural values and identity. They also engaged in intermarriages that further adulterated their culture and identity. This finding contradicts the *pulaaku* as described by Ba Konare and Hellweg (2022).

Conclusion

In Ghana, the expansion of cities, which should have had a positive impact on livestock production because of the high demand for meat, milk, hides, cheers, hooves, and horns, has an inverse relationship with livestock growth because the expansion leads to a decrease in pasture for the animals, which heavily depend on natural pastures. 'Caught in between the deep blue sea and the devil,' pastoralists gradually lose their identity and culture. The combined impact of climate change and urbanization compelled the pastoral Fulani to transition to sedentarization, which deprived them of their cultural identity. This trend could be irreversible because there is no policy in Africa aimed at reversing climate change and urbanization trends. The only solution for the pastoralists in Ghana is to form and strengthen their ethnic associations to promote their culture and identity.

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References

Abubakari, A. (2024). "Then the Fulani herdsmen came with their pastoral culture, and that marked the end of our cattle...": Perspectives on cattle rearing in Wungu Traditional area, Ghana. *Journal of Arts and Sociological Research, 5*(6), 35-54.

Abubakari, A., & Derkyi, M. A. A. (2024). Pastoralists health and public health threat in Ghana. *Sprin Journal of Arts, Humanities and Social Sciences, 3*(8), 24-32.

African Union. (2010). *Policy framework for pastoralism in Africa*. African Union Commission.

African Union. (2013). *Policy framework for pastoralism in Africa*. African Union Commission.

Almagor, U. (1980). Pastoral identity and reluctance to change: The Mbanderu of Ngamiland. *Journal of African Law, 24*(1), 35-61.

Al Okoli, C., & Atelhe, A. G. (2014). Nomads against natives: A political ecology of herder/farmer conflicts in Nasarawa State, Nigeria. *American International Journal of Contemporary Research, 4*(2), 76-88.

Anter, T. (2011). *Who are the Fulani people and their origins?* Retrieved 27 June, 2024 from https://tariganter.wordpress.com/2011/09/17/

Ba Konare, D. A. O., & Hellweg, J. (2022). To be Fula is to be noble and proud": How Pulaaku and contemporary social media are shaping diasporic Fula identity. *Mande Studies, 24*, 175-199.

Barrett, C., Bellemare, M., & Osterloh, S. (2006). Household-level livestock marketing behaviour among northern Kenyan and southern Ethiopian pastoralists. In J. McPeak & P. Little (Eds.), *Pastoral livestock marketing in Eastern Africa: Research and policy challenges* (pp. 15-38). Practical Action Publishing.

Bassett, J. T. (1988). The political ecology of peasant-herder conflicts in the Northern Ivory Coast. *Annals of the Association of American Geographers, 78*(3), 453-472.

Bassett, T. J. (2009). Mobile pastoralism on the brink of land privatization in Northern Côte d'Ivoire. *Geoforum, 40*(5), 756-766.

Basupi, L. V., Quinn, C. H., & Dougill, A. J. (2017). Pastoralism and land tenure transformation in sub-Saharan Africa: Conflicting policies and priorities in Ngamiland, Botswana. *Land, 6*(4), 89.

Bukari, K. N., & Schareika, N. (2015). Stereotypes, prejudices and exclusion of Fulani pastoralists in Ghana. *Pastoralism: Research, Policy and Practice, 5*, 20.

Catley, A., Admassu, B., Bekele, G., & Abebe, D. (2014). Livestock mortality in pastoralist herds in Ethiopia during drought and implications for drought response. *Disasters, 38*(3), 500-516.

Catley, A., Lind, J., & Scoones, I. (2016). The futures of pastoralism in the Horn of Africa: Pathways of growth and change. *Rev. Sci. Tech. Off. Int. Epiz., 35*(2), 389-403.

Dumenu, W. K., & Obeng, E. A. (2016). Climate change and rural communities in Ghana: Social vulnerability, impacts, adaptations and policy implications. *Environmental Science & Policy, 55*, 208-217.

Erickson, P., de Leeuw, J., Thornton, P., Said, M., Herrero, M., & Notenbaert, A. (2013). Climate change in sub-Saharan Africa: What consequences for pastoralism? In A. Catley, J. Lind, & I. Scoones (Eds.), *Pastoralism and development in Africa: Dynamic change at the margins* (pp. 71-81). Routledge.

Feng, X., Qiu, H., Pan, J., & Tang, J. (2021). The impact of climate change on livestock production in pastoral areas of China. *Science of the Total Environment, 20*, 144838.

Food and Agriculture Organization. (2018). *Pastoralism in Africa's drylands*. Food and Agriculture Organization of the United Nations.

Gaye, S. B. (2017). *Conflits entre agriculteurs et éleveurs dans un contexte de menaces asymétriques au Mali et au Burkina Faso*. Séries FES.

Graneheim, U. H., & Lundman, B. (2004). Qualitative content analysis in nursing research: Concepts, procedures and measures to achieve trustworthiness. *Nurse Education Today, 24*(2), 105-112.

GSS. (2021). *2020 Population and Housing Census*. Ghana Statistical Service.

Hermance, J. F. (2014). *Historical variability of rainfall in the African East Sahel of Sudan: Implications for development*. Springer.

Herrero, M., Wirsenius, S., Henderson, B., Rigolot, C., Thornton, P., Havlik, P., de Boer, I., & Gerber, P. (2015). Livestock and the environment: What have we learned in the past decade? *Annual Review of Environment and Resources, 40*, 177-202.

Ibrahim, Y. U. A. (2014). Funding, major obstacle to nomadic education – Executive Secretary. *Daily Trustfile*.

Kojo, E. (2021, April 23). Savannah Region: Migrant Fulani herdsmen commit most armed robberies – Police. *Pulse*. Retrieved 11 August, 2024 from https://www.pulse.com.gh/news/local/savannah-region-migrant-fulani-herdsmen-commit-most-armed-robberies-police/bgjmecw

Kundu, D., & Pandey, A. K. (2020). World urbanization: Trends and patterns. In D. Kundu, R. Sietchiping, & M. Kinyanjui (Eds.), *Developing national urban policies: Ways forward to green and smart cities* (pp. 13-49). Springer Nature.

Lee-Smith, D. (2010). Cities feeding people: An up-date on urban agriculture in equatorial Africa. *Environment and Urbanization, 22*(2), 483-499.

Levin, I., & Mamlok, D. (2021). Culture and society in the digital age. *Information, 12*(68), 1-13.

Li, J., Yang, W., Liu, L., Liu, X., Qiu, F., & Ma, X. (2022). Development and environmental impacts of China's livestock and poultry breeding. *Journal of Cleaner Production, 371*, 133586.

Masipa, T. (2017). The impact of climate change on food security in South Africa: Current realities and challenges ahead. *JÀMBÁ: Journal of Disaster Risk Studies, 9*, a411.

McGuirk, E. F., & Nunn, N. (2024). Transhumant pastoralism, climate change, and conflict in Africa. *Review of Economic Studies, 00*, 1-38.

Mead, G. H. (1963). *Mind, self & society from the standpoint of a social behaviorist*. University of Chicago Press.

Mensah, J. V., Adamtey, R., & Abdulai, A. R. (2016). Governing interests of Fulani herdsmen and peasant farmers in natural resources in the Asante Akim North District of Ghana. *Advances in Social Sciences Research Journal, 3*(10), 36-52.

Nwangwu, C., Mbah, P. O., Ike, C. C., Akanu Otu, O., & Ezugworie, C. (2020). Transhumant pastoral economy and human security in Nigeria: Whither civil society organisations? *Journal of Asian and African Studies, 55*(7), 1033-1053.

Olaniyan, A., Francis, M., & Okeke-Uzodike, U. (2015). The cattle are "Ghanaians," but the herders are strangers: Farmer-herder conflicts, expulsion policy and pastoralist question in Agogo, Ghana. *African Studies Quarterly, 15*(2), 53-67.

Oppong, Y. P. (2017). *Moving through and passing on: Fulani mobility, survival and identity in Ghana* (2nd ed.). Routledge.

Riesman, P. (1998). *Freedom in Fulani social life: An introspective ethnography*. University of Chicago Press.

Satterthwaite, D., McGranahan, G., & Tacoli, C. (2010). Urbanization and its implications for food and farming. *Philosophical Transactions of the Royal Society B, 365*, 2809-2820.

Scoones, I. (2023). Livestock, methane, and climate change: The politics of global assessments. *WIREs Climate Change*, 1-8.

Setrana, M. B. (2021). Citizenship, indigeneity, and the experiences of 1.5- and second-generation Fulani herders in Ghana. *Africa Spectrum, 56*(1), 81-99.

Singh, R., & Kerven, C. (2023). Pastoralism in South Asia: Contemporary stresses and adaptations of Himalayan pastoralists. *Pastoralism, 13*(21), 1-10.

Snorek, J., Moser, L., & Renaud, F. G. (2017). The production of contested landscapes: Enclosing the pastoral commons in Niger. *Journal of Rural Studies, 51*, 125-140.

Tache, B., & Sjaastad, E. (2010). Pastoralists' conceptions of poverty: An analysis of traditional and conventional indicators from Borana, Ethiopia. *World Development, 38*(8), 1168-1178.

Tinsley, J. H. I., & Gwiriri, L. C. (2022). Understanding the representation of pastoralism in livestock-related climate adaptation policies in Ghana and Nigeria: A review of key policy documents. *Nomadic Peoples, 26*(1), 83-105.

Tonah, S. (2005). *Fulani in Ghana: Migration history, integration and resistance*. The Research and Publication Unit Department of Sociology, University of Ghana.

Tonah, S. (2006). Migration and herder-farmer conflicts in Ghana's Volta Basin. *Canadian Journal of African Studies, 40*(1), 152-178.

Uhembe, A. C. (2015). The state and the management of conflict between nomadic herdsmen and crop farmers in North Central Nigeria: Implications for sustainable development. *International Journal of Liberal Arts and Social Science, 3*(7), 20-28.

Ujorha, T. (2014). *Pulaaku: How rustling is crippling this beautiful idea of the Fulbe*.

UNOWAS. (2018). *Pastoralism and security in West Africa and the Sahel: Towards peaceful coexistence*. United Nations Office for West Africa and the Sahel.

Wilson, W. (1995). The Fulani model of sustainable agriculture: Situating Fulbe nomadism in a systemic view of pastoralism and farming. *Nomadic Peoples, 36*(37), 35-51.

Yator, M. (2023). Adaptation measures adopted by pastoralist livestock farmers in Kenya in response to climate change. *Journal of Aquatic and Terrestrial Ecosystems, 2*(2), 22-36.

Yeboah, D. K. L. B., Pilegaard, C. H., Abubakari, A., & Doke, A. D. (2024). Moving beyond the threshold: The escalation of farmer-herder conflicts in Akim North Municipality of Ghana. *African Conflict & Peacebuilding Review, 14*(1), 1-27.

Yeboah, G., Marreh, S., Gubo, Q., & Velankar, Y. (2023). Effect of urbanization and climate change on small ruminant management in Ghana: A case study of Atwima Kwanwoma District. In *IEEE Humanitarian Technology Conference* (pp. 1066-1070).

Zhou, K., Zhou, F., Chen, L., Li, H., Wang, H., & Li, J. (2024). Alleviating environmental pressure from livestock production: A "livestock-resource environmental carrying capacity" perspective in China. *Ecological Indicators, 160*, 111800.