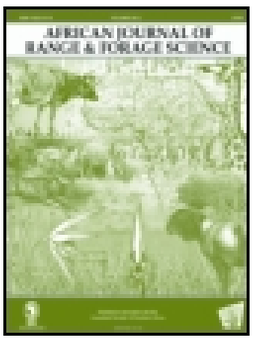

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Review Article

Potentials of leys or pasture-based forage production in Nigeria

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Fulani pastoralists are widely distributed across the six geographical zones of Nigeria and migrate from north to south in search of natural grazing lands at times of forage scarcity. This migration leads annually to resource use conflict and deadly attacks between migrating pastoralists and sedentary arable farmers. These conflicts have generated heated scholarly debates over the last few decades. Here, we provide an overview of the nexus between the farmer-herder crises, grassland management, and livestock production and argue for the establishment of irrigated pastures to increase forage production and quality and, thereby, reduce land-use conflicts. This recommendation is offered in place of the often-called-for transition to a ranching system for livestock production. We recommend an interdisciplinary approach to investigate the willingness of stakeholders in the livestock business to pay for fresh or conserved forage resources, as well as robust policies that could attract investment into the establishment, management, and sustainability of commercial forage production.

Keywords: climate change, conflicts, forage conservation, fodder trade and policy, Fulani pastoralists.

Introduction

Pastoral livestock production is widely practiced in diverse rangeland ecosystems across the world (Humphrey and Sneath 1996; Singh et al. 2015; Majekodunmi et al. 2017). In Sub-Saharan Africa, this type of livestock production system is exposed and vulnerable to the effects of climate change (Aremu and Abraham 2018; Ajibefun 2018) and socio-political pressure (Sandford 2006; Moritz et al. 2009; Turner and Schlecht 2019) with implications on the livelihood of pastoralists. In Nigeria, the consequences of climate change (e.g. drought and desertification) are more pronounced in the north (i.e. arid region) (Aremu and Abraham 2018) and thus significantly contribute to the migration of herders southwards in search of forage and water for their livestock. Land use conflict often ensues between sedentary arable farmers and pastoralists during the migration of the latter, which threatens food security. In this regard, this paper offers an overview of the current situation of livestock farming in Nigeria and the challenges arising from seasonal migration into the less climatologically disadvantaged middle and southern parts of Nigeria by herders from the northern part, then concludes with a proposal for commercial forage production as a possible way of increasing pastoralists' access to forage and reducing social conflict.

The Fulani herders

The Fulani or Fulbe pastoralists (hereafter referred to as Fulani herders) are a prominent socio-linguistic group whose origin is traceable to the Berbers of North Africa dating to the 8th or 11th century AD (Anter 2015). They are found in Central and West African countries, with half of their population concentrated in northern Nigeria (Lott and Hart 1977; ICG 2017). They have migrated across the Sahelian region for free-range grazing since approximately 1800 (Lott and Hart 1977), which has led to the emergence of kingdoms that are governed based on standard Fulani ethnic dominance across the West African States (Anthony 2014; Ajibefun 2018). In Nigeria, the Fulani herders represent more than 90% of the pastoralists (Ajibefun 2018) and own greater than 90% of the livestock population, estimated at 19.5 million cattle, 975 000 donkeys, 28 000 camels, 72.5 million goats, and 41.3 million sheep (ICG 2017) that make up one-third of agricultural gross domestic product (GDP) and 3.2% of the country's GDP (Fabiyi and Otunuga 2016).

The Fulani herders preserve their traditions (e.g. *pulaaku* [Fulbeness]). *Pulaaku* is a moral value that entails the manner in which the Fulani herders conduct themselves

regarding their daily activities (Akpan 2015). They speak the *Fula* language as well as Hausa, possess local ecological knowledge of pasture, livestock disease, rainfall and national boundaries (Rass 2006; Kwaghga 2018), and are found in nearly all Nigerian states (Amusan et al. 2017). The subgroups of Fulani herders in Nigeria include *Fulbe* Adamawa, *Fulbe* Gombe, *Fulbe* Mbororo, *Fulbe* Sokoto, and *Fulbe* Borgu (Eyekpimi 2016), with an estimated total population greater than 7 million, making them the fourth-largest ethnic group in Nigeria (Burton 2016). They are the major rearers of goat, sheep, and cattle, with the latter valued for ritual and prestige, but not as a market commodity *per se* (Herskovits 1926; Akpan 2015); therefore, having a reduced herd size would be perceived as a downward trend on the social ladder by Fulani herders. Their survival is based on mobility (i.e. constant migration in search of pastures) and low-cost feed (Blench 2001; Aremu and Abraham 2018), and they have demonstrated their ability to switch between livestock species and production output (e.g. the Fulani herders in Southeast and South-south Nigeria have shifted from dairy to meat production) (Aremu and Abraham 2018). This indicates that Fulani herders are forced and willing to respond to changing ecological and economic circumstances, which are largely determined by region (Aborisade and Carpio 2017), consumer preference for livestock products (Ogundari 2012; Ducrotoy et al. 2016) and institutional frameworks (Ogboru and Adejonwo-Osho 2018).

Nigerian savannas and livestock production

Nigerian grasslands, which support Fulani herders, can be classified into savannas and temperate grasslands and occupy 37% of the country's landscape (Dingess 2015; Jimoh et al. 2020; Figure 1). They are used for livestock or arable farming (Olanite et al. 2018). The majority of this class of natural resources are found in the northern region of the country, where they are exposed to the vagaries of the weather, particularly irregular and increasingly sparse rainfall (Ibrahim et al. 2015). Over the years, the natural resource base (grassland) has deteriorated to varying degrees around the country, as a result of the expansion of crop production (Daodu and Babayemi 2008) and intensive resource utilisation with few or no programs and practices to sustain soil fertility and grassland quality (Tanko 2014; ICG 2017). This affects animal performance, which already tracks the seasonal availability of forage resources: the quantity and availability of nutrients that are required by animals (protein, energy, minerals, and vitamins) declines in standing forage during the dry season (Lamidi and Ologbose 2014; Jimoh et al. 2015; Oyaniran et al. 2018). To bridge the seasonal gap between the nutritional requirements of animals and the nutrients available from forage, supplementing animal grazing in the dry season with forage cut and conserved from the excess yield of nutritious pastures in the wet season has been widely advocated as a sound approach to prevent overgrazing and animal loss (Onifade and Agishi 1988; Bohnert and Stephenson 2016; Mengistu et al. 2016).

Wild fires in native grasslands are also prevalent during the dry season, decreasing the amount of available forage (Babayemi et al. 2014). Some notable weight losses of approximately 300 to 400 g per head of cattle per day (Zemmelink 1974) and 15% body weight in sheep (Otchere et al. 1977) have been reported as a result of the combined factors of low-quality roughage and bush burning (Kubkomawa et al. 2015), which reduced the quality and quantity of available meat. The decline in the crude protein of grasses as the dry season advances can be extreme, even to lower than the 5% required for maintenance and prevention of weight loss (Kubkomawa et al. 2015). Grasses found in Nigerian savannas that are persistent, hardy and highly tolerant to dry seasons have a low crude protein and a high fibre content (Bolaji et al. 2015). In comparison, forage conservation from the wet season could alleviate animal weight loss during the peak period of feed scarcity.

That climate change will diminish biomass yield and quality of forages from natural pastures has, moreover, been widely mentioned (Dumont et al. 2015; Giridhar and Samireddypalle 2015; Rojas-Downing et al. 2017). Although there is a paucity of information on the relationship between climate change and forage production in Nigeria, agricultural production, in general, is facing diverse threats under the influence of climate change (Ayinde et al. 2011; Enete 2014). Records show that, in the 105 years following 1901, temperatures increased by 2 °C in the Northern extreme of Nigeria (Ojugbo 2010), and drought conditions, as a result of climate change have reduced the availability of water and pasture grass for livestock (Ladan 2014). These are foreboding conclusions when considered alongside reports that predict that the demand for food, water, and forage will double as a result of population increase (Davidson et al. 2003; Enete and Amusa 2010).

Nuru (1978, 1983) reported that 75% of the cattle slaughtered annually in Nigeria could produce an additional 25 000 to 45 000 tons of meat if the animals were raised with some conserved forage/fodder. Elsewhere, Jolaosho et al. (2011) reported that both the intake and performance of Nigerian cattle breeds can be improved by feeding animals conserved forage in the form of hay or silage. Studies reporting the effects of an altered climate (e.g. warming and increased precipitation) in Nigeria remain limited (e.g. Ogungbenro and Morakinyo 2014), making it difficult to predict grassland ecosystem responses and resilience to altered climate. In light of this, the merits of forage production to supplement grazing becomes apparent: production of additional forage with irrigated pastures could mitigate the effects of climate change on forage availability, enhance animal performance, and increase the yields from livestock.

However, more research is needed on the willingness of livestock owners to adopt the use of commercially produced fresh or conserved forage. Also, policies that will enable commercial pasture businesses, as well as government provision of contracts for large expanses of land at subsidised rates in suitable locations in southern and/or central Nigeria, are necessary.

Ranching versus commercial pasture production

In the context of this paper, ranching is defined as the use of a large demarcated area of land for livestock grazing, with the aim of formalising land-tenure rights for pastoralists (mainly the Fulani herders) and fostering the development of the Nigerian livestock industry (Awogbade

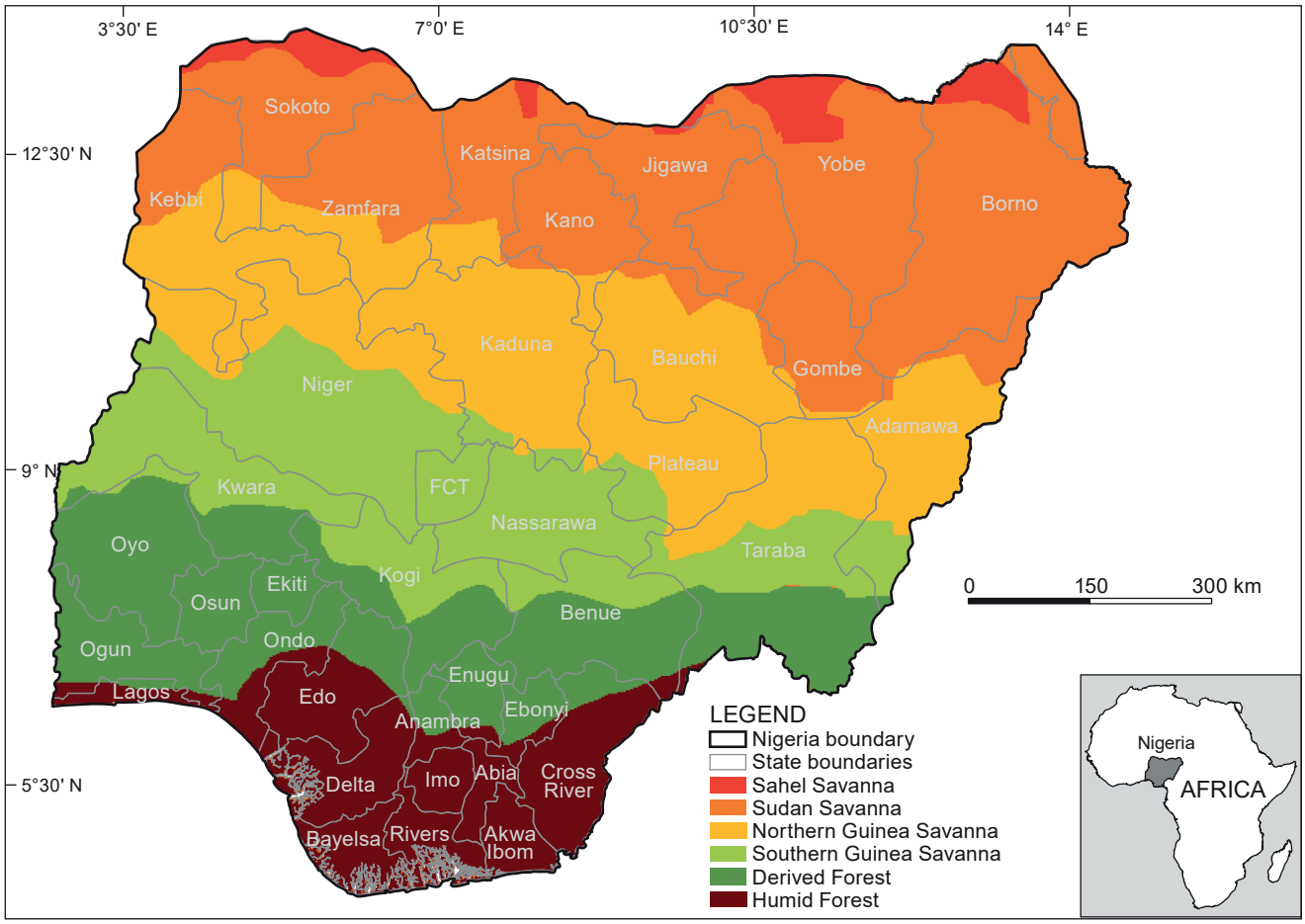

Figure 1: Map of Nigeria showing its agro-ecological zones. Source: ArcMap 10.7 (ESRI, Environmental Systems Research Institute)

1987; Kwaghga 2018; Ogboru and Adejonwo-Osho 2018). Historically, ranching has failed several times in Nigeria, notably in the 1910s, 1960s, and 1990s (Dunbar 1970; Blench 2017). The state-owned ranches established across different regions of Nigeria failed for several reasons (Table 1). These include the lack of a well-organised agricultural sector, political instability, bad road networks, the location of ranches on marginal lands (Dunbar 1970), lack of technical know-how, unsustainable financing, and the lack of a regulatory framework to address environmental degradation (Ogboru and Adejonwo-Osho 2018). Furthermore, the settling down of nomadic or transhumant Fulani herders into ranch managers, as it's being canvassed by the state and federal government, is not only inappropriate, but also at variance with the nomadic culture of the pastoralists (Akpan 2015; Ogboru and Adejonwo-Osho 2018). For instance, the 'Open Grazing Prohibition and Ranches Establishment Law' enacted in Benue State in 2017 prohibits the open grazing of livestock and encourages the establishment of ranches, threatening five years' imprisonment, a fine of 1 million naira, or both for violators (Ogboru and Adejonwo-Osho 2018). Nonetheless, Fulani herders fail to comply with this law, as a result of factors such as the level of training and education required to run a ranch, the restriction on mobility, and the technical and the financial requirements for ranch establishment (Kwaja and Ademola-Adelehin 2017). Other factors include perception of the law as antagonistic to nomadic culture and economic interests, as well as the lack of consultation with herders prior to the passage of the law, for example, the Miyetti Allah Cattle Breeders claim that the geography and climatic conditions in Nigeria, as well as their breed of cattle, are not suitable for ranching (Kwaja and Ademola-Adelehin 2017; Ogboru and Adejonwo-Osho 2018).

Presently, many stakeholders (e.g. policymakers; arable crop farmers) are again calling for the establishment of ranching in the country (Umoh 2017; Kwaghga 2018), whereas others (e.g. Miyetti Allah Cattle Breeders Association; community leaders) are sounding a note of caution against solving one problem only to create a new one (Taiye et al. 2017). Against this backdrop, we advocate for irrigated pastures to ensure year-round forage production and supply as a rational approach to address seasonal forage scarcity. This could help to sustain animal performance as well as enhance social stability when compared with the intrusion of pastoralists onto farmers' croplands to the south, which is the main cause at present of farmer-herder clashes across the country.

This paper provides an overview of the link between farmer-herder crises, grassland management, and livestock

Table 1: Ranches established across Nigeria and their attributes

Name	Mode of establishment	Land Area (acres)	Year of Est.	Location
Rigachikun Ranch	Directly leased from the government during colonial times	9 000	1914	Kaduna
Allagarno Ranch	Directly leased from the government during colonial times	11 520	1914	Allagarno, Bornu
African Ranches Ltd	Lease from Allagarno Ranch	16 667	1915	Allagarno, Bornu
African Ranches Ltd	Lease from Rigachikun Ranch	9 333	1915	Rigachikun, Kaduna
Obudu Cattle Ranch formerly Obudu Ranch Resort	By colonial dispensation	5 930	1951	Cross rivers state
Manchok Fattening Ranch	Established by Northern Nigerian Government in collaboration with USAID	5 280	1963	Jos Plateau
Mokwa Ranch	Established by Northern Nigerian Government in conjunction West German Government.	6 400	1964	Jebba
Borno Ranch	Established by Northern Nigerian Government in conjunction with USAID	20 000	1967	Bornu
Kachia Grazing Reserve	Kaduna State Ministry of Animal and Forest Resources	77 500	1967	Kaduna
Odu'a Farms Cattle Ranch.	Established by the Western Region Government at different locations		1970	Old Western Region
		19 919		Akunu Akoko, Ondo State
		4 942		Ikere Gorge Dam
		12 355		Ibarapa
		9 884		Imeko, Ogun State
		29 652		Oke Ako via Ayedun Ekiti

Sources: Dunbar (1970); Ducrotoy et al. (2017); Akpan et al. (2019), The Guardian, Saturday Magazine, August 25, 2019.
African Ranches Limited applied for leases/certificate of occupancy at the respective locations mentioned.
On 1 January 1915, African Ranches Ltd. fully acquired the cattle business of Rigachikun and Allagarno ranches valued at £40 000

production. We contend that there is a need to consider irrigated pastures to promote year-round high-quality forage and enable fodder conservation for a sustainable livestock production, and we put forward a framework for action in this regard.

Climate change, pastures, and Fulani herders' migration in Nigeria

Climate change and pastures in Nigeria

According to IPCC (2014), climate change is "any change in climate over time, whether as a result of natural variability or as a result of human activity". Nigeria has been designated a 'hot spot' for climate change (IPCC 2007). The most common manifestations of climate change in Nigeria are changes in precipitation and temperature, with the latter reported to have been above normal since 1979 (Ojo 2008). For example, drought and desertification have become frequent in the semi-arid region of Nigeria (including Sokoto, Kano, and Katsina States), as a result of increased temperature, decreased precipitation, the occurrence of flooding as a result of heavy downpours in the southern regions, and faster-than-normal rates of recession of large water bodies (Ayuba 2005; Idowu et al. 2011).

According to Pereira (2017), mean annual temperature could increase by more than 2 °C by 2100, and this would have serious implications for pasture production. Some forages are well-adapted to Nigerian ecological zones (Tables 2 and 3); nevertheless, erratic rainfall combined with high temperatures reduces soil moisture, causing forage to grow slowly and become lignified, which reduces its quality (e.g. crude protein) (Ojo et al. 2016). Thus, climate change threatens a viable livestock production by impacting the quality and quantity of forages available for feeding ruminants (Enete 2014).

Climate change and Fulani herders' migration

We define 'forced migration' in the context of this paper as the movement of people, as a result of compelling environmental reasons (e.g. lack of water or pasture), with the intention to temporarily or permanently settle at their destination (Brown 2007; Aremu and Abraham 2018). Climate change exacerbates the need to migrate in Nigeria (Asueni and Godknows 2019), as a result of its negative effect on forage and water availability for grazing livestock (Aremu and Abraham 2018). With increasing aridity in the north-western and north-eastern parts of Nigeria, and pursuant to human interaction with the environment that has increased the vulnerability of the Nigerian soils (Akamigbo and Nnaji 2011), the majority of natural grasslands in those regions are desertifying at the rate of 0.6 km y^{-1} (ICG 2017; Aremu and Abraham 2018). Hence, Fulani herders are spending more time farther south in search of pastures for their livestock (Figure 2), causing a higher probability of land use conflict between the Fulani herders and sedentary farmers (Fasona and Omojola 2005; Ajibefun 2018). The farmers, also subject to the changing climate, need more land than in the past to produce adequate crop yields (Odoh and Chigozie

Table 2: Suitable grasses for commercial forage production in Nigeria

Latin name	Common name	Ecological zones of occurrence	Mode of propagation	Seeding rate (kg ha^{-1})
Andropogon gayanus	Northern gamba	1, 2, 3, 4	S, V	60–80
Andropogon tectorus	Southern gamba	–	S, V	60–80
Anthephora nigritata	–	1, 2, 3	S, V	10–15
Urochloa brizantha	Signal grass	1, 2, 3, 4, 5	S, V	10–15
Urochloa decumbens	Signal grass	1, 2, 3, 4, 5	V	25–30
Urochloa ruziziensis	Signal grass	1, 2, 3, 4, 5	S, V	25–30
Urochloa hybrido	Mulato II	1, 2, 3, 4, 5	S, V	25–30
Cenchrus ciliaris	Buffel grass	1, 2, 4	S	10–15
Cenchrus biflorus	Karangiya/bargrass	1, 2, 3, 4, 5	S	10–20
Cenchrus prieurii	Spinless karangiya	1, 2	S	10–15
Chloris gayana	Rhodes grass	1, 2, 3, 4, 5	S	10–15
Cynodon dactylon	Bermuda grass	1, 2, 3, 4	V	–
Cynodon plectostachyus	Giant star grass	2, 3	V	–
Digitaria eriantha	Pangola grass	1, 2, 3, 4	S, V	10–15
Digitaria smutsii	Wooly finger grass	2, 3, 4, 5	V	–
Eragrostis tremula	Burburwa/lovegrass	1, 2, 4	S	5–10
Hyparrhenia rufa	Jaragwa grass	1, 2, 3	S	10–15
Melinis minutiflora	Molasses grass	1, 3, 4	S	10–15
Megathyrsus maximus	Guinea grass	2, 3, 4, 5	S, V	5–10
Megathyrsus maximus cv. Gatton	Gatton panic	2, 3, 4, 5	S, V	5–10
Megathyrsus maximus var. *trichoglume*	Green panic	2, 3, 4, 5	S, V	10–15
Cenchrus clandestinus	Kikuyu grass	2, 3, 4, 5	S	15–20
Pennisetum pedicellatus	Kiyasuwa	1, 2, 4	S	15–20
Pennisetum purpureum	Elephant grass	1, 2, 3, 4, 5	V	–
Cenhcrus americanus cv. Maiwa	Maiwa millet	1, 2	S	2–5
Setaria sphacelata	Setaria	2, 3, 4, 5	S	5–10
Sorghum x *almum Parodi*	Columbus grass	1, 2, 3	S, V	15–20
Tripsacum laxum	Guatemala grass	1, 2, 3, 4	V	–
Chrysopogon nigritanus	Vetiver grass	1, 2, 3, 4	V	–
Paspalum notatum	Bahia grass	2, 3, 4, 5	S, V	5–10
Echinochloa stagnina	Hippo	2, 3, 4, 5	V	–
Chrysopogon zizanoïdes	Vetiver grass	2, 3, 4, 5	V	–

1 = Sahel/Sudan, 2 = Northern Guinea Savannah, Southern Guinea/Derived Savannah, 4 = Montane and 5 = South of Derived Savannah. S = seed propagation, V = vegetative propagation. Source: Kallah (2004). Species name were according to the Germplasm Resources Information Network (GRIN).

2012; Figure 2) and are themselves restricted in their search for more arable land by oil mining leases and oil prospecting leases that have been granted by the government (Fasona and Omojola 2005). Such considerations have caused some to attribute the ensuing conflicts to poor responses to climate change at the local, regional, and national levels (Odoh and Chigozie 2012; Aremu and Abraham 2018).

Extensive literature has shown that pastoral migration is a socio-ecological strategy of coping with climate variability in rangelands (Hauck and Rubenstein 2017; Kwaghga 2018). Within the concept of the 'new rangeland paradigm', mobility has been validated as appropriate in environments with variable and unpredictable weather conditions (Adriansen 2005). The Fulani herders' migration from the northern to the southern part of Nigeria to access resources was, in the past, enabled by social capital and particular social relations and structures (Adriansen 2003; Hauck and Rubenstein 2017). This social connection is theoretically reproduced during migration to villages and camp sites (Ingold 1986), which leads to the spatial creation of new spaces where resources can be utilised (Greiner 2011).

A socio-ecological strategy (e.g. advance scouting) is used by the pastoralists to get information on where forage is available (Niamir-Fuller 1999). For the Fulani herders that embark on long-distance migration, they need stronger and wider social connections to access pastures and use water points owned by their host communities (Galaty 2013). However, the reciprocal social relationship between the Fulani herders and sedentary farmers has been disrupted for a long time.

The reason for this is the fierce competition for land between the two parties (Odoh and Chigozie 2012; Ducrotoy et al. 2017; Obayelu et al. 2017) as opposed to the extensive social links that existed between them in the past (Awogbade 1983; Okoro 2018). These links include labour exchange, manuring of agricultural fields by grazing livestock, keeping of animals for villagers as a source of reserve investment, and the trading of agricultural produce for milk and cattle (Awogbade 1983). The consequences of the broken social relations include violence (Kwaja and Ademola-Adelehin 2017), loss of human lives, and a decline in the output and income of herders (Majekodunmi et al. 2017; Ajbefun 2018). Presently, the Fulani herders access land increasingly by force (Amusan et al. 2017) rather than negotiation or tradition (Hauck and Rubenstein 2017; Aremu and Abraham 2018). This has the consequence that

Table 3: Suitable legumes for commercial forage production in Nigeria

Latin name	Common name	Ecological zones of occurrence	Seeding rate (kg ha^{-1})
Alyscarpus vaginalis	Gadagi/alyce clover	1, 2, 3	5–10
Arachis hypogaea	groundnut	1, 2, 4	20–30
Arachis pintoi	Forage groundnut	1, 2, 3, 4	
Cajanus cajan	Pigeon pea	2, 3, 4, 5	20–30
Centrosema molle	Common centro	2, 3, 4, 5	10–20
Centrosema pascourum	Centro	1, 2, 3, 4, 5	
Calopogonium mucunoides	Calopo	1, 3, 5	3–10
Crotalaria macrocarlyx	Gujjiyar awaki	1, 2, 3	5–10
Desmodium intortum	Greenleaf desmodium	1, 3, 4	2–5
Gliricidia sepium	Almond blossom	1, 2, 3, 4, 5	5–10
Glycine max	soybean	1, 2, 3, 4	30–50
Indigofera bracteolata	indigo	1, 2, 3, 4	2–5
Indigofera pulchra	indigo	1, 2, 3, 5	5–10
Lablab purpureus	Lablab, Hyacinth bean, dan-inusa	1, 2, 3	25–30
Leucaena leucocephala	Leucaena	1, 2, 3, 4, 5	5–10
Macroptilium atropurpureum	Siratro	2, 3	5–10
Macrotyloma axillare	Axillaris	2, 3	5–10
Macrotyloma uniflorum	Horsegram bean	1, 2, 3	10–15
Neonotonia wightii	Glycine	1, 2, 3	15–20
Nuestanthus phaseoloides	Puero (kudzu)	1, 2, 3	5–8
Stylosanthes guianensis cv. Schofield	Schofield stylo	1, 2, 3, 4, 5	3–8
Stylosanthes guinensis cv. Cook	Cook stylo	1, 3, 4	3–6
Stylosanthes hamata cv. Verano	Verano stylo	1, 2, 3	3–8
Stylosanthes humilis	Townsville stylo	1, 2, 3, 4, 5	3–8
Tephrosia bracteolata	Tephrosia	2, 3, 4, 5	5–10

1 = Sahel/Sudan, 2 = Northern Guinea Savannah, Southern Guinea/Derived Savannah, 4 = Montane and 5 = South of Derived Savannah. Source: Kallah (2004). Species name were according to the Germplasm Resources Information Network (GRIN).

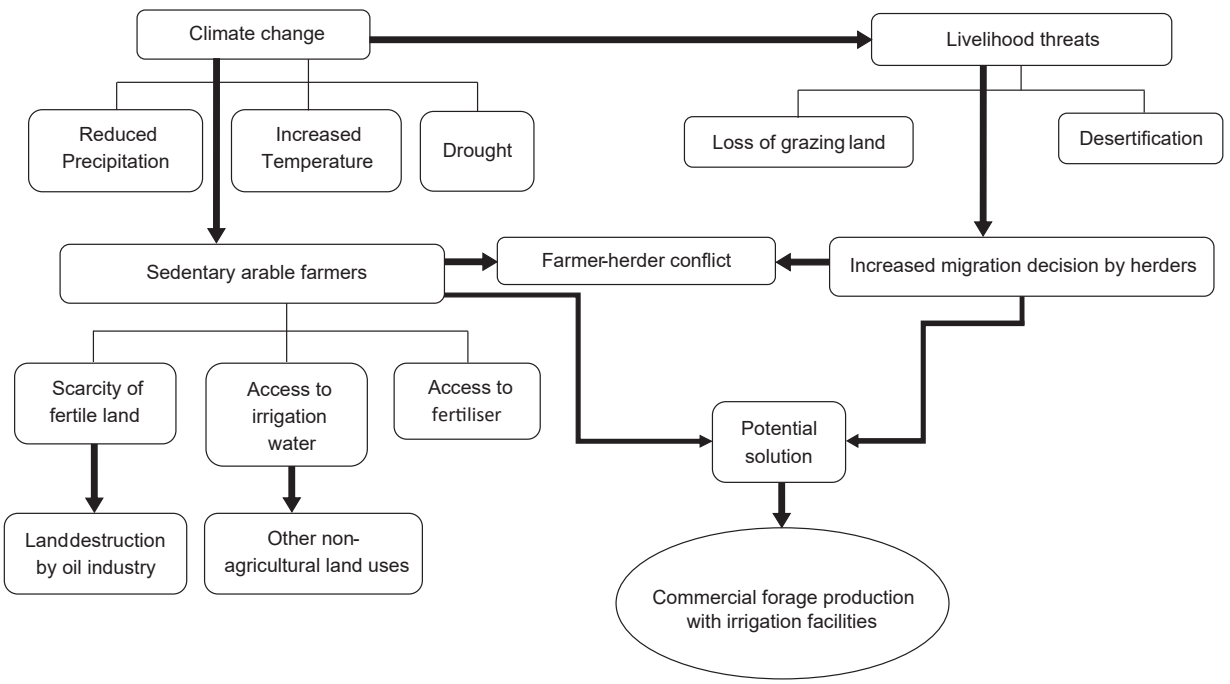

Figure 2: Schematization of climate-induced migration by Fulani herders. Climate change (e.g. reduced precipitation, increased temperature) threatens the livelihood of Fulani herders (e.g. loss of grazing land) who migrate to search for pastures for their livestock. Climate change also affects sedentary arable farmers, though to a lesser extent, and the challenges they face include scarcity of fertile land and access to irrigation water. The increased Fulani herders' migration and the challenges faced by sedentary arable farmers leads to increased competition for fertile land and conflict. Potential solutions lie in commercial forage production with irrigation facilities

their migration to southern Nigeria has become criticised and fought against by their previous host communities (Olayoku 2014).

The need for commercial pastures in Nigeria

Irrigated pastures to meet forage needs of livestock

Producing forage from irrigated pastures is a potentially viable approach to achieving feed resource adequacy using forage species, such as those listed in Tables 2 and 3. Many studies have been conducted on yield, quality, and conservation (hay or silage) of Nigerian forages (Oni et al. 2014; Hassan et al. 2016; Ojo et al. 2016; Jimoh et al. 2019). These studies have shown the potential of local forage species to produce high dry matter yield and quality, with the ability to be adequately conserved, provided that all management practices are carried out appropriately. A promising fact is that, with sound management, grass farming is more lucrative than crop farming, bringing in cash already after four to five months of establishment (Saffina 2017).

A commercial pasture enterprise could sell bales of hay, forage seeds, and silage made from conserved forage (Saffina 2017). It could also allow animal grazing for an agreed fee per head of animal, depending on the size of the enterprise. Forage conservation is readily feasible as soon as the established pasture is ready for harvest, but there is limited understanding of the duration for which conserved forages can be stored to provide year-round feed (Dele et al. 2013; Adeyemi et al. 2015). There is thus a need for more research in this direction, particularly where storage as hay is adopted as the method of conservation, because there is ample literature on silage (e.g. Oni et al. 2014; Ojo et al. 2018). Whereas research from China has shown that pastoralists pay per head for their animals to gain access to winter pastures during cold weather (Conte 2015), we acknowledge that conducting a series of surveys across Nigeria to determine the willingness of livestock owners to pay for pasture resources is critical to any meaningful advocacy for a setup of commercial forage production. Such a change in pasture provision could reduce the Fulani herders' anticipated travel distance alongside their herds in search of feed, especially during the dry season. Perhaps livestock owners would look favourably upon continuity in the supply of forage resources, should such commercial pasture enterprises be created, or their products made available, in proximity to them.

The necessity of addressing the farmer-herder crisis

Setup of irrigated pastures in Nigeria would help to reduce violent strife between migrating Fulani herders and sedentary agrarian communities across the country (Figure 2) by providing year-round feed resources for ruminants. Historically, herders and sedentary farmers have coexisted in symbiotic relationships where cattle manure and grazing rights were traded between the parties (ICG 2017). According to Tonah (2006), farmer-herder crises first became widespread in the coastal areas of West Africa in the early 20th century. Specifically, in Nigeria, the migration of Fulani herders from the north through the middle belt to the southern part of the country in search of forage resources is currently contributing to the farmer-herder clashes. Farmers, who are already facing crop failures, and Fulani herders seeking new land for grazing and water resources, end up in clashes. Damage to crops by animals exacerbates the losses of sedentary farmers, which makes the situation more volatile and a big threat for food security in the future. The former are aggrieved, whereas the latter retaliate when their animals are killed. The crisis continues to escalate, and incidents have been recorded in at least 22 of Nigeria's 36 states (ICG 2017).

In the first six months of 2018, the farmer-herder crisis claimed the lives of an estimated 1 300 people and forced approximately 300 000 people out of their homes (Dionne 2018; Kwaghga 2018; Shaibu 2018). The efforts of the government and regional bodies to curb this menace have yielded little relief. For example, the Economic Community of West African States (ECOWAS), through its action plan for cross-border transhumance in West Africa, committed itself to support the herdsmen, but only modest action has been taken so far (FAO 2012). The Nigerian government has the intention of carving out land for herders, but this has not yet materialised amidst increasing unemployment that is causing more people to return to farming (Dionne 2018). In addition, failed agricultural policies (because of lack of finances to enforce policies) are a sign of the hindrance to progression in the livestock industry (Eze et al. 2010; Bamaiyi 2013). There is a need to propose alternative solutions to the burning issue of the farmer-herder crises that arise from competition for land, water, and forage required by livestock for sustainable animal production. Similarly, there is a need for significant state-private sector investment into irrigated pastures as an emerging field of specialisation in livestock production (FAO 2012).

Constraints to commercial pasture production in Nigeria

High cost of establishment of such a new industry

Pasture establishment in Nigeria is labour intensive, as a result of a lack of adequate machinery (Olanite 2009; Table 4). The stages involved in pasture establishment include land preparation, acquisition of seeds/vegetative planting materials, planting, fertilisation, weeding, harvesting and conservation. These stages present challenges that significantly reduce pasture establishment both by smallholder farmers and big farms. However, this challenge could be overcome by mechanisation for large-scale production. In addition, the supply of good pasture seeds and fertilizers at affordable prices are vital to successful pasture establishment (Kidunda et al. 1990). Furthermore, the incorporation of legumes into sown pastures (i.e. leys) is a beneficial replacement for N fertilisation and this will also enhance nutrient cycling and sustainability of the farming system (Rethman 2000).

Availability of suitable land

For successful establishment, pastures require well-prepared land with relatively fertile soil (Rocky 2016). Shallow soils are unsuitable because they can easily erode and increase the sensitivity of pastures to drought. When and where rainfall is not adequate to sustain productivity, pastures should be placed where irrigation is available. Mechanical cultivation

Table 4: Steps in pasture setup

Step	Sowing/planting	Recommendation
(1)	Site selection	The site should have adequate rainfall, good drainage and soil texture. Shallow soils are unsuitable, because of erosion and drought. Acidity can be corrected using lime.
(2)	Land preparation	The land should be ploughed and harrowed twice to provide clean seed bed for good germination and establishment. It should be relatively free from trees and stones. The preparation of seedbed also depends on whether a new pasture is to be established with conventional tillage or an existing pasture is to be renovated with no–till drill.
(3)	Forage species selection	Select suitable species based on biomass yield, persistence, resistance to drought, adaptation to the local weather condition, response to fertilizer and compatibility with other crops and/or legumes.
(4)	Seed treatment for legumes	It is advisable to scarify (chemically, thermally or mechanically) hard seeded legumes for improved seed germination. The simplest method is to wrap the seed in a cloth bag and immerse in hot water at 70 °C for 4 to 8 minutes or in cold water for 10 hours before planting. Sow scarified seeds as soon as possible to prevent loss of viability. Germinating rate varies from one species to another.
(5)	Seed rate	Seeding rate depends on seed vigor, forage species, the level of land preparation, seed purity (should be free from inert materials, chaff, stones and husk). Poor quality seeds should be seeded at higher rates to obtain a desirable stand.
(6)	Planting methods	Plant seed when the soil is moist. Grasses are sown using drilling and broadcasting methods. We advise farmers to adopt drilling method for ease of management and control of weeds, and do not cover your grass seeds with soil after drilling. Legumes are sown using drilling for small seeds and dibbling for large seeds. Grass species, such as Woolly finger grass, Signal grass, Elephant grass are planted vegetatively. Intercropping grass with legumes will help to improve the quality of the grass. For example, Columbus grass can be intercropped with Lablab, Centrosema and Stylo species.
(7)	Time of sowing	It is important to plant/sow when the soil is moist to guarantee good establishment.
(8)	Weeding	The frequency of weeding operation depends on the severity of weeds (at least 2–3 times). It can be done manually using hoes or mechanically with powered tiller.
(9)	Fertilizer application	Apply 4 to 8 bags of 50 kg NPK (15:15:15) per ha for grasses, and 2 to 6 bags of 50 kg SSP per ha for legumes preferably when the root system is well established against drought and erosion. Organic fertilizer (e.g. manures) may be used for environmental sustainability.
(10)	Seed harvest	Harvesting can be done using sickles when seeds are mature. Avoid delaying seeds harvest to prevent shattering.
(11)	Processing	After harvesting of seeds, allow it to dry under the shade for approximately 7 days before threshing, beating, winnowing and separating the seeds from the chaff.
(12)	Preservation and storage	Seeds are preserved in jute bags and kept in a well-ventilated, cool and dry room.

Source: Mohammed-Saleem (1986); Olanite (2009); Barnhart (2013); Rocky (2016)

of pastures is feasible on land with up to 15% slope (Olanite 2009). Given the unfavourable climate condition that characterises arid and semi-arid northern Nigeria, it is suggested that commercial pastures should be established in central and southern Nigeria, which have relatively better climatic condition. This would help to guarantee the efficiency and sustainability of such forage production farms.

Inadequate seed quality

Many grass species are planted by vegetative means, and only a small proportion produce high numbers of good quality seeds. The majority of the legumes are sown using seeds, because at the National Animal Production Research Institute (NAPRI) in Shikka, Zaria, tertiary institutions in other locations with majors and professors of pasture production and management could produce good quality seeds to assist with efficient forage production. NAPRI now produces seeds of the grass *Megathyrmus maximus* for commercial purposes (Idowu, Department of Animal Science, Federal University, Dutsin-Ma, Katsina State, Nigeria, pers. comm.). These contributions would assist with the provision of seeds for successful pasture establishment by prospective business owners.

Species for forage conservation in Nigeria

In the tropics, forage is the main component of ruminants' feed. It is the cheapest feed (compared with concentrate) and comprises grasses and/or legumes (Tables 2 and 3). Although grasses mainly supply energy, herbaceous legumes can be used as protein supplements. Reductions in quality and quantity of these plants, as a result of inadequate temperature and precipitation cause ruminant production to decline. In Nigeria, as a result of climate change, there is a lush during the wet season, but challenges surface in the dry season, causing Fulani herders to search for ways to feed their livestock.

It is important to note that maize is the major species in the Gramineae family used for making silage in the temperate region. If the same was done in the tropics, then competition between men and animals for that crop would increase. In light of this, other grasses deserve attention as alternatives to maize (Singh et al. 2015; Sharma and Sahoo 2017). Grasses are harvested for making silage at flowering. The physiognomies, such as type, maturity, dry matter (DM) and water-soluble carbohydrate (WSC) content at the time of ensiling play a critical role in the ease of ensiling and, ultimately, for silage quality (Dele et al. 2013; Adeyemi et al. 2015).

In Nigeria, grassland resources like species of the genus *Brachiaria* (Table 2) are well-adapted to soils that are acidic and low in fertility (Maass et al. 2015). This forage primarily originated from eastern, central, and southern Africa, where it is naturally the main constituent of grasslands (Boonman 1993). Another example of a potential forage crop, the legume *Stylosanthes guianensis* cv. Cook, was primarily introduced into Nigeria from Australia (Agishi 1992). It is known as 'Cook stylo' and remains green fairly well into the dry season (Agishi 1992; Hueze 2015). More importantly, it is suitable for cultivation across the ecological zones of Nigeria (Saffina 2017). Generally, plant species found in Nigeria are of low quality, especially in the dry season (crude protein = 5.3%, neutral detergent fibre = 70.1%, Ojo et al. 2016), with variations from south to north (Ogunbosoye and Babayemi 2010). The reason for this is factors such as climatic variation, species make-up of the forage, and the nature and fertility of the soil, all of which affect the chemical composition, nutritive value, and productivity of grasslands.

Implications of commercial fodder production for Fulani herders' livelihoods

Socio-cultural implications

For Fulani herders, shifting from nomadism or transhumance to the purchase of commercial forage for the feeding of livestock would lessen the need for migration to southern parts of Nigeria. This overarching transition is expected to be met with reservations from the Fulani herders on account of possible changes to their social relations and cultural lifestyle (Kwaja and Ademola-Adelehin 2017). Conversely, if commercial pasture production facilitates a reduction in farmer-herder conflicts, it could have a positive influence on the present cultural and social isolation of Fulani herders. This type of enterprise could, as well, significantly reduce cattle rustling while herders are in transit to the south and back to the north (ICG 2017) and promote a viable livestock industry (Lawal-Adebowale et al. 2018).

Other social impacts of making commercial forage available could include improved quality of social relationships (e.g. reduced fighting between herders and farmers), more opportunity for social activity among both Fulani and farmers without fear of fresh or reprisal attacks, less use of illegal weapons, fewer cases of rape, and a reduction in the loss of human lives, because of conflicts. There is a paucity of empirical information about how Fulani herders would perceive some of the aforementioned socio-cultural changes, although there are relevant studies demonstrating that herders and farmers perceive the causes (Dimelu et al. 2016) and social effects (Ajibefun 2018) of farmer-herder clashes in Nigeria differently. For commercial fodder production to be supported by relevant government policies in the interest of the herders, the farmers, and the nation at large, future feasibility studies could consult with the 'Miyetti Allah group', the widely acknowledged representative of Fulani herders in Nigeria, as a starting point to assess the willingness of herders to pay for forage. An informal discussion with a Fulani herder by the lead author in Ilorin, Kwara State, Nigeria in 2016 showed that herders could adopt the use of purchased fodder, but their major concern would be about continuity in the supply of forage after its introduction. A study of contemporary Fulani herders in the Ferlo region of Senegal "did not find evidence that mobility affects the cultural construction of (ethnic) identity" (Adriansen 2003, p. 16). Rather, "[i]f [Fulani herders] did not stay in the *rumaano* this was because the needs of the livestock had forced them to move" (Adriansen 2003, p. 16). Whereas, in Senegal, the installation of boreholes allowed Fulani to reduce their migration distances (Adriansen 2003), the same might be achieved in Nigeria by intensive forage production and conservation for trade.

Economic implications

Studies have shown that Fulani herders, sedentary farmers, and the federal government all incur losses, because of farmer-herder conflicts, which increase food insecurity and poverty levels beyond the affected communities (ICG 2017). The federal government reportedly loses $13.7 billion every year, whereas Kaduna, Nasarawa, Benue, and Plateau states lost 47% of their internally-generated revenue in 2015 as a result of the conflicts (Mercy Corps 2015). Against this backdrop, commercial forage production could help resuscitate the economic prosperity of all the affected individuals and the nation at large. Once commercially produced forage is incorporated into Fulani herders' livestock production system, the herders could also profit economically (Blench 2001; Ajibefun 2018), attract investment from urban dwellers (Awogbade 1989), and become exposed to better market opportunities (Adriansen 2003).

Ecological implications

One of the ecological implications of pasture-based forage production is increased grassland regeneration potential (Lawal-Adebowale et al. 2018), because the Fulani herders could purchase fodder at times of scarcity. The provision of desirable conserved forage to livestock during times of natural forage scarcity would allow for less intensive grazing by livestock, thereby improving grassland health and productivity in the climatologically disadvantaged regions. Also, there could be reduced competition for the 'commons' (Kwaja and Ademola-Adelehin 2017; Amusan et al. 2017; Aremu and Abraham 2018), with implications for grassland sustainability.

Emergence of commercial pastoralists

A new paradigm that could potentially emerge as a result of commercial pasture production is what Adriansen (2003) described as 'commercial pastoralists' as found among the Fulani herders of the Ferlo region in Senegal. These pastoralists specialise in purchasing and selling

animals, keeping each animal for only a short time. One factor that could lead to the creation of the 'commercial pastoralist' niche in Nigeria is the fact that Fulani herders are historically good traders. In the Nigerian Fulani herders' context, commercial pastoralists could potentially play the aforementioned role in addition to sourcing commercial forage for their communities. The commercial pastoralists can be viewed as middlemen; hence, they could be instrumental to the development of a pastoral economy.

Framework for action

Bills sponsored on the floor of the senate with regard to establishing grazing reserves are not passed, and the government has failed in its attempts to advance the agricultural sector, not least by its effort to import forage species from Brazil when, instead, local forage species could be improved to boost quality and yield. In the meantime, public-private investments could foster the emergence of resilient pasture systems, sustainable resource management, the introduction of technology, and robust funding for sustainable fodder production (Enete and Amusa 2010; Kwaghga 2018). It is in this spirit that we strongly advocate for commercial forage production in Nigeria. However, we understand that establishment of sown pastures for commercial purposes rests on additional research to ascertain the willingness of livestock owners and other stakeholders, 90% of whom are Fulani herders, to pay for forage whether in the fresh or conserved form. In this regard, we propose the following recommendations for action.

Nomadic education

Nomadic education, designed to aid the acquisition and transfer of knowledge among nomads (including Fulani herders) in Nigeria, has witnessed a series of changes in nomenclature, innovations, and strategies through various policy reforms (e.g. Decree 41 of 1989/National Commission for Nomadic Education; Indigenous Language Policy of 2004; and Mobile Education Policy of 2007) (Akpan 2015; Abdulrahman 2016). Despite the effort of successive governments to fulfil the part of the Nigerian Constitution of 1979, which stipulates that 'the government shall strive to eradicate illiteracy by promoting equal and adequate educational opportunities at all levels among Nigerians', the policies have achieved minimal success, because of inadequate funding (Kwaja and Ademola-Adelehin 2017), lack of motivation and incentives for teachers within the nomadic population (Aderinboye-Abdulwahab and Adefalu 2012), implementation and monitoring (Abdulrahman 2016), cultural diffusion and lack of feedback by nomads (Akpan 2015), and the mobile lifestyle of the targeted Fulani herders. Although it is interesting to note that the evolution of nomadic education in Nigeria was partly influenced by the Fulani nomads themselves (i.e. through agitation by the Miyetti Allah Cattle Breeders Association of Nigeria (MACBAN) to curtail the excesses of tax officials), some scholars have argued that nomadic education policies were enacted to earn political points by the successive governments (Akpan 2015; Abdulrahman 2016; Umar 2000).

Notwithstanding, there is the need for a paradigm shift in the system of education from what the government thinks Fulani herders need to the type of education nomads want. It is suggested that the existing education policies are strengthened by (i) addition of relevant technical and vocational skills that could improve herders' livelihoods and their livestock husbandry practices (Kwaghga 2018), (ii) the use of local dialects as the medium of instruction (e.g. *Fulfulde*) and teaching of English language as a subject, as in Kenya where Kiswahili, Kikuyu, and other local dialects are used in schools for nomads (Osella and Osella 2006; Akpan 2015), and (iii) detailed consideration of the nomadic lifestyle and culture in the current curriculum (Ezeomah 1993). This would help preserve nomadic native languages and allay the fears of the Fulani herders that their culture could become infiltrated through by the education system.

To increase the participation in and acceptance of nomadic education policies, the leaders of Fulani herder associations need to be included among the stakeholders responsible for the drafting and/or amending of nomadic education policies (Akpan 2015; Kwaja and Admeola-Adelehin 2017). Moreover, because schooling is not part of Fulani traditional lifestyle (Narman 1992), the federal government should direct the National Orientation Agency (NOA) to make materials available on a continuous basis for the Fulani herders to become part of the education system. All these actions combined could potentially increase the knowledge of Fulani herders about fresh and conserved forages for the feeding of their animals as an innovative way to boost the productivity of their livestock business. Subjects of traditional and modern styles of pasture management and animal health could be introduced into education curricula to further aid knowledge transfer with regard to livestock feeding with conserved forage.

Provision of land for potential investors into a forage industry

Given that land use is exclusively a state government prerogative (ICG 2017; Obayelu et al. 2017), the central and southern states are encouraged to allocate agricultural land for forage production on a commercial basis through public-private partnerships, with a robust legal and institutional framework that will attract investors (Ogboru and Adejonwo-Osho 2018). Similar policies have been implemented with regard to agricultural production in some states, where large areas are designated for agricultural production. In Ogun State, such lands are contracted out to investors (for cheaper than the cost of private acquisition) without prejudice toward an individual or corporate entity's tribal affiliation or state residency (Obayelu et al. 2017). Corporate applications for land are subject to appraisal by the Cabinet Committee, a subset of the Agricultural Land Allocation Committee (ALCA), headed by the State Commissioner for Agriculture. The minimum land area that can be allocated is 20 hectares, and the beneficiary may pay an annual ground rent to maintain rights to the land until the contract must be renewed, which occurs every 45 years (Obayelu et al. 2017). This implies that investors can acquire exclusive rights to large areas of land (Adamu 2014) to achieve the dual goal of profitability and sustainability. Adapting this method for forage production across the central and southern states in Nigeria could encourage investors to consider commercial forage production as worthy of their investment and create employment opportunities (Amusan et al. 2017; Kwaghga 2018).

Provision of infrastructure

Owing to ecological constraints, such as drought and desertification, which already preclude adequate production of forage in the northern part of the country during the dry season and encourage migration of herders down to the central and southern regions, it is suggested that commercial pasture enterprises are set up in the central and southern regions. However, there is need for the government to provide a good road network (Babatunde and Qaim 2010; ICG 2017) to ease the conveyance of fodder from the point of production to the destinations of need in the north. This could be challenging at first, but surely will improve with time. The railway transportation system could provide great relief in this regard.

Policy

Robust policies that will address the needs of investors considering commercial forage production and encourage the establishment, management, and sustainability of commercial pastures are required. As a new innovation, such policies should address pertinent topics, such as how pasture seeds and planting materials could be made available to commercial farms and how advocacy could be encouraged as to the merits of feeding commercially produced forages to livestock for improved productivity. This would require state policies that promote the marketing of conserved forage to encourage Fulani herders to incorporate conserved forage into their livestock production systems (Hauck and Rubenstein 2017; Blench 1998). Simultaneously, as noted by Adriansen (2003), the establishment of opportunities for effective livestock marketing could encourage Fulani herders to change their operations, in order to take advantage of the commercial market. Her paper shows that pastoralists who particularly focus on producing rams for the religious Tabaski feast, "[i]f they find other ways of fattening their sheep, e.g. by import of fodder, … are likely to diminish their use of mobility" in search for better feed (Adriansen 2003, p. 19).

Another study by Ducrotoy et al. (2017) in the Kachia Grazing Reserve of northern Nigeria showed that the Fulani herders, specifically the 'Lawol-Bote' dairy producers, opined that the establishment of fodder banks within the grazing reserve and forage conservation are viable ways of adapting to the changing socio-ecological conditions. Furthermore, some studies have shown that pastoral livelihood transition is premised on risk sharing (Majekodunmi et al. 2017; Achiba 2018) and that it is impacted by factors such as assets (Lawal-Adebowale et al. 2018), household head's age and market access (Dinku et al. 2018), and livestock number (Dai et al. 2020). This confers the ability to resist external shocks on households (Ding et al. 2018). More importantly, herders' engagement in non-pastoral income generating activities is an adaptation to livestock livelihood risks, but not a surrogate for pastoral livelihood (Achiba 2018). In summary, the simultaneous implementation of policies creating livestock-marketing opportunities and conserved forage-marketing opportunities could encourage some pastoralists to reduce their migration distances in order to take advantage of both.

Additional research

As mentioned earlier, additional research is required to investigate the willingness of pastoralists and other stakeholders in the livestock industry to pay for fodder (fresh or conserved), as well as to investigate other associated matters that merit scientific exploration. Feasibility studies could start with the 'Miyetti Allah group' on their members' perception about using purchased fodder to feed their animals and how the new innovation would influence the lifestyle of Fulani herders. In addition, the impact of the innovation on grassland productivity, health, restoration of degraded lands, and food security in states and the nation merits future research attention. We hope that the results of such research will provide comprehensive guidance on the way forward to enable a commercial forage production in Nigeria for national peace and development.

Conclusion

This paper describes the potential for commercial forage production in Nigeria to meet the need for year-round feed for ruminants and diminishing strife between crop farmers and Fulani herders. The farmer-herder crisis in Nigeria is rooted in decreasing forage availability, which has been exacerbated by climate change, population explosion, land acquisition by large-scale crop farmers, and the destruction of designated grazing reserves by the former Northern regional government after independence (ICG 2017). Although many stakeholders have called for the establishment of ranching, the bills sponsored in pursuit of this have failed several times. The plodding pace of the government, coupled with the lack of incentives to convince herders to settle for ranching and the absence of veterinary and feed distribution services needed to aid the transition from open grazing to ranching remain topical issues in the ongoing debate (Kwaja and Ademola-Adelehin 2017).

As a logical preference, commercial forage production seems a feasible alternative to ranching at present. Although it yet requires a survey of livestock owners and other stakeholders, we claim that a public-private partnership could boost forage production, enhance the quality of fodder, and build a pasture system that is resilient to climate change and provides sufficient forage. Presently, unlike crop farmers, Fulani herders are in a situation with limited political might to address these problems. Manifestation of government promises is not forthcoming, and the larger society watches as the contenders engage in apportioning of blame (Momale 2017). To address these challenges, commercial pastures could assist with sufficient fodder production, improve animal nutrition, and reasonably decrease, if not totally eradicate, the conflict between farmers and Fulani herders in Nigeria.

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