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Climate Change, Land Use, and the Decline in Traditional Fulani Cattle Practices: Drivers of Antimicrobial Resistance in Kwara, Nigeria

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Abstract: This paper presents a case study of Fulani herdsmen in Nigeria, whose traditional ethnoveterinary practices risk being lost as the country transitions to more intensive and enclosed livestock practices. We use a planetary health framing to make visible the value of indigenous practices that are less damaging to the environment, animal welfare, and human health. Through ethnographic observation, focus group discussions (FGDs), and key stakeholder interviews, we show that the Fulani use a complex system of herbal medicines and traditional herding practices to maintain herd health, and to manage and treat animal disease when it arises. However, their traditions often sit uncomfortably with commercial farming practices. As traditional Fulani grazing lands are eroded, dispossessed Fulani take employment from businessmen farmers. Both parties' inexperience with shed hygiene, artificial feed, and less environmentally resilient crossbreeds leads to an increased incidence of infectious disease. This, in turn, drives the higher use of antibiotics. There is, thus, a 'causal chain' of underlying drivers that lead, through poorer environmental, animal, and human health, to the increased use of antibiotics. The antibiotic resistance that emerges from this chain threatens human health now and in the future. Through a planetary health framing, we advocate for a deeper understanding of the knowledge held by Fulani herdsmen and their traditional ethnoveterinary practices as an alternative to increasing antibiotic use (ABU).

Keywords: ethnoveterinary; indigenous knowledge; antibiotics; antibiotic resistance; cattle

1. Introduction

Antimicrobial resistance (AMR), which occurs when microbes evolve to be no longer susceptible to drugs once used to treat the infections they cause, poses a worldwide

challenge to human and animal health [1,2]. More than two-thirds of antibiotics globally are used for livestock [3], with animal-sourced food production commonly identified as a key driver of antibiotic overuse [4]. The (over)use of antibiotics in livestock is undoubtedly a serious concern, but blaming the livestock industry is a reductionist approach. The health effects of antibiotic resistance—like many of the problems of the Anthropocene—sit at the end of a complex causal chain comprising underlying drivers, ecological drivers, proximal causes, and mediating factors [5] none of which should be considered in isolation.

Planetary health advocates for a complex systems approach to human health [6–8]: systems thinking and complexity is one of the five pillars of the field, set out in the Planetary Health Educational Framework [9]. Planetary health also advocates respect for indigenous knowledge and worldviews, and recognition of their value [10–12], as such views can help humanity re-engage with nature and pull back from the more damaging behaviours that have characterized the Anthropocene, such as overconsumption and environmental pollution [13].

This paper explains how a planetary health framing can help to identify the complex factors that compromise human, animal, and environmental health, and how they intersect. We use a case study that shows how the impact of climate change and the erosion of indigenous cattle management practices drives antibiotic use (ABU) in cattle in Kwara State, Nigeria, the largest country in Western sub-Saharan Africa. This is the region of the world most adversely affected by AMR, with mortality rates twice that of Western Europe [14].

Approached through this framing, the underlying drivers of climate change are positioned at one end of a causal chain that, at the other, threatens the future efficacy of antibiotics and human, as well as animal, health (Figure 1).



Figure 1. The casual chain begins with loss of Fulani grazing lands in Northern Nigeria due to climate change and ends with increased risk of antibiotic-resistance that threatens human health.

The case study we use to illustrate this framework—cattle management in Nigeria, Sub-Saharan Africa—is being investigated under a grant from the International Development Research Centre (IDRC) (IDRC. Developing bacteriocin-rich extract from engineered lactic acid as an alternative to antibiotic in ruminants and aquaculture. No date. Accessed from: <https://idrc-crdd.ca/en/project/developing-bacteriocin-rich-extract-engineered-lactic-acid-bacteria-antibiotic-alternative>, 1 August 2024) to conduct field trials for the use of bacteriocin-rich extract (BRE) as an alternative to antibiotics for mastitis, a disease of the teat/udder in ruminants (IDRC, n.d). BREs are low-cost, engineered, bacteriocin-producing lactic acid bacteria extracts with high antimicrobial activity. Mastitis is usually caused by bruising/grazing of the udder by sharp grass or bushes, overmilking (particularly in intensive systems), and/or the infection of open wounds. Mastitis sometimes resolves on its own, but, if untreated, it can lead to the affected udder(s) becoming unproductive; cows being unable to feed calves, impacting calf health; spontaneous abortion in pregnant cows [15]; and losses to farmer livelihood. As much as 70% of all losses in dairy farming are caused by mastitis [16]. It is the most economically damaging cattle disease worldwide [17].

The cattle production system in Nigeria is somewhat unique [18]. Ninety percent of the >15 million cattle heads in Nigeria are owned by the Fulani, a traditionally nomadic people who have driven cattle across the Sahara, Sahel, and West Africa for at least 2000 years. The Fulani are the largest pastoralist ethnic group in the world; in Nigeria, 15 million people, or 6.6% of the population, are of Fulani descent [19]. Fulani cattle are primarily kept for beef, although Fulani women milk the cows and make cheese, which is sold commercially. Fulani graze cattle (as well as sheep and goats) on common ground or on land traditionally owned by settled Fulani or Fulani-tolerant farmers. However, a combination of climate change in northern Nigeria, which has pushed Fulani further south [20], and a rising population across both Fulani and non-Fulani peoples in Nigeria [21], is constraining land resources and creating rising tensions between farmers and Fulani.

The Fulani are an excluded minority within Nigeria, increasingly seen as problematic (e.g., [22,23]) and unwilling to engage with the ‘proper’ authorities; their children receive little formal schooling [19], marry young, and have a high birth rate [24]. At the same time, Fulani herdsman are key stakeholders in the expanding Nigerian cattle sector. Beef production in Nigeria increased from approx. 180,000 tonnes per year in 1990 to approx. 330,000 tonnes per year in 2019 [25], with many Fulani employed by farm owners who often live away from the farm, to look after the animals in systems that range from fully pastoral to intensive. Of interest to planetary health, and to efforts to combat AMR, is the fact that Fulani indigenous practices include a well-developed herbal medicine tradition [26] that may offer alternatives to antibiotic use in livestock; however, the modernization and intensification of the cattle sector in Nigeria risks this opportunity being lost.

This paper recognizes fully the criticisms that have been levelled at the field of planetary health for not sufficiently considering animals within its holistic view of human and environmental health (e.g., [27,28]). It is outside of the scope of this paper to challenge such critique but we also hope to assure those primarily concerned with animal and livestock health that the topic is not outside the remit of the planetary health field. In fact, the lead author was part of the advisory group that drafted the Berlin Principles on One Health [29] and is a current Senior Editor with CABI One Health [30]. She, thus, spans the One and Planetary Health fields and seeks to build bridges between them by helping to highlight how the health of animals, humans, and the environments in which they live cannot be addressed in isolation.

2. Materials and Methods

BAC4RumA, the project under which the research for this paper was conducted, is funded by the IDRC (Project Number 110337). The project will conduct on-farm trials in Nigeria and Turkey, including challenge trials, to determine the efficacy of using BRE as an alternative to antibiotics in ruminant farming and aquaculture. Unlike antibiotics, BRE does not become less effective over time due to the emergence of resistance and, thus, offers a

long-term solution to replacing antibiotics for animal health and preserving them for human health [31]. Part of the successful replacement of antibiotic therapies with BRE will depend on social and economic factors such as key stakeholders' acceptance of the technology and willingness to pay for it. Thus, one work package (WP) of the main project is dedicated to social science assessments that will draw on the technology acceptance model and its later iterations [32], and cost–benefit analysis (CBA) for the economic assessment. Assessment depends upon a robust understanding of the cultural practices and social norms of the key stakeholders in the animal-sourced food value chain in Nigeria.

The research reported in this paper consisted of one week of rapid ethnography assessment (REA) [33] between 31 July and 5 August 2024, including fieldwork, visits to farms, and two days of focus group discussions (FGDs) with key stakeholders, on 1 and 5 August 2024, at Ilorin University, Nigeria. During the fieldwork, researchers visited farms within 20 km of Ilorin and conducted informal interviews with farm owners, farm managers, animal health workers, and herdsman in the field. Interviews were conducted with bilingual research assistants in attendance, who acted as translators and took notes. On arrival at each farm, the research team explained the purpose of the research to the farm staff and obtained consent to record (written notes and audiovisual recording) the proceedings and to take photos. In most cases, permission was given verbally due to cultural preference. During the focus groups (which were attended by 35 stakeholders on 1 August and 30 stakeholders on 5 August), the room was split into café-style tables of 8–10 participants, each with a facilitator—a senior member of the research team—a note-taker (a postgraduate student) and an observer (a second senior member of the research team). Bilingual facilitators and note-takers were allocated where appropriate. Each focus group session lasted for three hours in total, with a mid-morning break and lunch provided. Ethical approval for the activities was granted by University of Ilorin, Nigeria and Royal Holloway, University of London, UK ethics review boards (RHUL Research Ethics Committee Project ID 4210).

3. Results

Key stakeholders and FGD participants reported 39 cattle diseases/causative agents of disease, many of which had both English and Fulani names including mastitis/koti; Contagious Bovine Pleuropneumonia/Gunya; and Foot and Mouth Disease/Boru. Many antibiotics including amoxicillin, penicillin, streptomycin, and Tylosin were named as common treatments. Also prominent in the discussions were ethnoveterinary treatments, with more than 50 named and described, including Yangyang leaf (*scientific name undetermined*), which is mixed with water into paste and applied to the udder to treat mastitis caused by tick bites; baheda tree bark (*Terminalia bellirica*), mixed with water and given as a drink or applied externally to treat snakebite; and konta (soda soap) for treating wounds. Fulani and non-Fulani farmers reported often using allopathic and ethnoveterinary methods in combination. Many of the challenges to prudent antibiotic use observed in Nigeria—and examined in the following sections—mirror those seen elsewhere in dairy production [34,35], such as the ready availability of over-the-counter antibiotics; financial and geographical difficulty in accessing vet services; and challenges in keeping cattle sheds hygienic in low-resource settings. There were also some elements unique to the production system in Nigeria, such as the relationship between Fulani herders and the businessmen farmers who employ them.

In addition to the disease knowledge and management practices, and of equal importance to the field of planetary health, the FGDs and key stakeholder interviews suggest that the confluence of changes in the environmental and political climates in Nigeria is challenging distributive justice, a key planetary health ethic [36]. Disenfranchised Fulani herdsman are being pushed into intensive practices with which not only are they unfamiliar, but so too are the business-focused new farm owners who employ them. In such environments, unhygienic sheds and artificial feeds challenge animal health and, combined with poorly-regulated antibiotic use, create optimal conditions for AMR emergence.

Seen through the planetary health framework of underlying drivers leading to human health effects [5], we observed a causal chain leading to antibiotic resistance risk in Kwara State, Nigeria, which is illustrated in Figure 1 and described in more detail in the sections below.

3.1. Climate Change Impacts in Northern Nigeria

Climate change is an ecological driver in the planetary health causal chain framework proposed by Sam Myers in 2017, ref. [5], the result of underlying drivers such as over-consumption, demographic shifts, and an increasing reliance on technology use. Links in a chain between climate change and AMR are slowly gaining recognition, refs. [37–39], although the impact of environmental changes remains under-represented in the AMR literature [34]. During FGDs and interviews, our study’s participants discussed the impact of climate change in Northern Nigeria, where drought and aridity are causing traditional grazing lands to dry up [40]. Fulani herdsmen are being pushed further south, where there is more fertile land and a milder year-round climate, but climate change is also beginning to affect the south.

“[We] have difficulty sustaining irrigation system to sustain feeding, especially during dry season.”—Farmer, FGDs

The increasingly challenging conditions create competition for land between Fulani and new farmer owners who are not of Fulani descent.

It is not only the environmental climate that is influencing the current situation in Nigeria but also the political environment, of which planetary health is mindful when planning solutions [8,41]. The Nigerian Government shows little respect for the Fulani pastoral culture and traditional practices [42]. Programmes in south Nigeria to settle nomadic tribes by giving them land, schools, piped water, and other amenities, as well as to designate routes from the north to the south for them, have not been entirely successful [43]. With little evidence of consultation or co-production with the Fulani, and little regard for their culture or traditions, these political decisions deprive Fulani of land to graze their cattle, resulting in the challenges experienced in the next link we will explore in the causal chain.

3.2. Depletion of Traditional Grazing Lands for Fulani Herdsmen, and Competition for Land Between Fulani Herders and Business-Oriented New Farmers

FGD participants expressed beliefs that there is no longer enough available pasture in Nigeria to feed the Fulani’s animals, and also the following belief;

“The system has to change.”—FGD participant

The challenges farmers reported in maintaining pasture during the dry season have a particularly detrimental effect on milk production, which, in turn, affects the Fulani’s income.

“The pot of dairy products coming from traditional practitioners is getting smaller.”—Farmer, FGDs

Some key informants and FGD participants felt that the situation is exacerbated by rapid urbanization and Nigeria’s high birthrate among both the Fulani and non-Fulani populations: Nigeria has an average birthrate of 5.1 live births per woman [21], rising to 8.2 within the Hausa/Fulani [44], against a world average of 2.3.

FGD participants felt that land shortages are making the intensification of livestock rearing—in enclosures and indoor sheds—unavoidable. The contraction of grazing land may be driven as much by business interests that are seeking to emulate intensive North American and European farming practices, often with influence from foreign dairy industry players such as the Dutch-owned Wamco, as by environmental necessity, however [45]. Other literature suggests Nigeria is not lacking in abundant, fertile land, but that this is currently under-utilized for agricultural productivity and pasture [46,47].

A move from pastoral grazing to intensive livestock rearing has implications for climate change, as well as land use change, as beef is one of the most inefficient forms of protein production for human consumption and a major contributor to greenhouse gases [48]. Intensive farming systems have higher carbon footprints than extensive systems due to imported feed supplements and fossil fuel use for powering on-farm machinery [49–51], creating a feedback loop in which intensification is responsible for climate change, one of its own underlying drivers.

The contraction of grazing areas is eroding traditional Fulani pastoral lifestyles and pushing them to seek livelihoods elsewhere, many in new farms on land being bought up by affluent Nigerians who see farming as a business opportunity rather than a way of life. This leads to the next link in the causal chain, as Fulani move from owning their own means of production to being employees in a capitalist system.

3.3. Loss of Access to Traditional Grazing Lands Leads Fulani Herdsmen to Take Wage Labour on Commercial Farms

The Fulani are currently sandwiched between their pastoral, nomadic herding cultural traditions and a rapidly developing Nigeria whose government seems determined to settle them [42]. With climate change depleting their traditional grazing lands in the north and an increase in the number of commercial farmers coming into the cattle industry for business purposes, many Fulani take jobs as herdsmen on commercial farms, tending to the herds in fields, enclosures, or sheds in exchange for a salary, and for any milk the cattle produce. In many cases, this arrangement seems to work well, with businessmen farmers recognizing the Fulanis' greater experience with cattle but there are also clashes. Fulani are used to the freedom to roam across West Africa, grazing more or less where they please on open ground, and on farms where more affluent Fulani have settled. This is changing, however, with more and more of the new generation of farmers wanting to keep the Fulani off their land, often for good reason:

"Infection came when some cows graze on where our cattle graze."—Non-Fulani farmer, FGD

As cattle rearing is increasingly seen as a business opportunity, investors who are not of Fulani heritage do not want the Fulani on their land. Some local government authorities, for example, Édé, are demarcating lands to provide settlement points and serve as grazing areas for nomads in a bid to reduce farmer/herder clash, but these programmes seem to have little input from the Fulani themselves and do not appeal to them.

"Why we still have nomadic animals is because this is an ancient traditional method."—Fulani farmer, FGD

This means that, while the Fulani provide labour on such farms, the farms do not make use of their expertise in a particular kind of cattle production system—low-input, low-output pastoral herding. This results in the threat of the loss of important and animal-health-relevant ethnoveterinary knowledge.

3.4. Increase in Commercial Farming and Move to Intensive Production Methods: Challenges and Opportunities

Cattle production systems in Nigeria range from traditional herding of indigenous breeds (in southern Nigeria, Bunaji—White Fulani—are preferred to Bokolo (*Sokoto Gudali*), which are less resilient in the dry season), which graze on wild ground or cultivated pasture, to enclosed or shed-raised crossbreeds (indigenous breeds crossed with foreign breeds such as Holstein Friesians) fed on silage and artificial feed [18]. Many farms contain more than one production system. Even in commercial farms, most indigenous cattle are predominantly kept for beef, as the milk yield is too low for commercial production (~1 L per day per cow, which may be increased to ~3 L per day if fed on cultivated pasture and/or silage).

Many of the new generation of farmers are neither of Fulani heritage nor from farming backgrounds: key informants we spoke to came from backgrounds as diverse as civil engineering and public administration, for example. They buy land and set themselves up as farmers as cattle ownership is seen as an indicator of social status and wealth, as well as a means of beef production and income. These businessmen farmers' relationship with their animals, and the Fulani herders who tend to them, is purely transactional.

"I bought 10 Bororo [Fulani Red Cattle], cost of transport and purchase 103 k [naira] and sold for 450–480 k after 6 months."—Farm owner, FGD

One Fulani farmer at the FGDs remarked:

"[The] problem in Nigeria [is that the] majority [are] after profit, we don't look into major problems affecting the production system."—Fulani farm owner, FGD

Such farmers often employ Fulani herdsman to look after herds of 50–250 cattle for them. They experiment with crossbreeding the local Fulani cattle with foreign breeds (mostly Holstein Friesian) to increase milk production, as well as with cultivation of Napier grass and 'Savia' (Agrosavia Sanabera, a commercial variety of Guinea grass) for silage. These experiments have mixed success: the exotic breeds are more susceptible to disease, including FMD and foot rot, when they graze on uncultivated land, and they do not tolerate ticks well. They are only likely to survive and be productive if kept indoors all day, with implications for animal welfare, hygiene, and resource costs, e.g., of artificial feed, as well as increases in greenhouse gas emissions linked to the transportation of the imported feed and the operation of machinery [49–51]. While some farmers in the FGDs spoke of Maizube, an intensive integrated farm in Niger State, Nigeria they had heard can produce up to 60 L of milk per cow per day, 20–30 L was the most they were aware had been achieved in Nigeria and most farms produced much less. Foreign breeds are seen as essential to increasing milk production, but high-milk-yield cattle do not prosper in the Nigerian bush.

Many farmers gave examples of poor experiences with modern farming methods:

"There was a machine milking (mechanical dairy farm) at Shonga, but this was discontinued due to climate."—Farmer, FGD

Farmers, farm owners, and the Fulani appreciated that there is market value from commercial milk yields, but, if this can be achieved only with supplementary feed, the cost/benefit calculations may bring little economic benefit from more modern methods. Fulani herdsman mentioned dry cassava peel, maize concentrate, and molasses as supplementary feed, but commercial pellets increase the price of production further and present a risky entry point for premixed antibiotics into the production system [52]. Combined with food price rises and shortages of food for human consumption in Nigeria, a move away from grazing systems does not offer an attractive business model at present.

A move to more commercial farming is also likely to bring with it the commercial pharmaceutical industry to maintain herd health. Intensification is a recognized risk factor for antibiotic use, a touchpoint where antibiotics begin to enter the system [53,54]. Aligning with evidence from low–middle-income countries (LMICs) across the world [55,56], the farmers we spoke to described buying drugs directly (over-the-counter) from pharmacies and drug company representatives without a prescription or even consultation. Pharmaceutical drugs are also often added to feed. The farmers we visited on farms, and who participated in FGDs, displayed little knowledge of (or control over) the contents of the ready-mixed feed they bought for cattle raised in more intensive systems. This largely unregulated use of antibiotics within commercial farms raises challenges for prudent antibiotic use, which is considered in the next link of the causal chain.

3.5. Inexperience (Fulani and Farm Owners) of Modern Farming Practices Leads to Use of Antibiotics as 'Infrastructure'

The non-Fulani farm owners who attended the FGD had been farming for between two months and 15 years; the Fulani in contrast come from generations of herders. The

Fulani are highly experienced in traditional farming methods; however, they have less or no experience of intensive farming practices. This can raise some tensions and challenges for animal health management practices in general and for the use of antibiotics in particular.

Farm owners complained that Fulani employees will often push them to cull a sick animal rather than try to treat it. Considering the Fulani's nomadic heritage, this makes sense as a biosecurity measure—without modern veterinary medicine, culling a sick animal is the best way to ensure that disease does not spread through the herd.

When a herd is on the move, a sick cow will slow it down and cannot easily be isolated, leaving culling as the only option.

The Fulani will often leave a sick animal on its own, isolated from the rest of the herd if they are able to, but this is again less easy when cows are enclosed. They will often move herds if sickness is detected; this may move the herd away from an environmental source of pathogens but also risks spreading disease over the distances travelled if animals are already infected.

On the other hand, Fulani traditional knowledge includes ways to spot emerging disease, e.g.,

“If milker is milking and the colour of milk is changed it is easily detected and tasted and then is it discarded if this.”—Fulani farm owner, FGD

“For mastitis (breast), once there is a problem with milk, you’ll know from the taste, and you prevent the calf from suckling.”—Fulani farm owner, FGD

Fulani employees are quick to push farmers to take cows with mastitis—or which have already lost teats to mastitis—to market and to quickly dispose of cattle suffering from ‘Gunya’, a catch-all term for infectious respiratory disease. Non-Fulani farmers claimed the Fulani had a way to mask mastitis at markets so that it would not affect the cow's value. Farm owners, in contrast, prefer to call a vet when mastitis is suspected and to treat the animal with drugs. However, in rural farms, access to a vet was not always straightforward or even possible. It may be uneconomical for the vet to visit, or only possible by charging a farm further away more than one that is nearer, a challenge that has been identified previously [35]. Another factor is cost, which often comes up in dairy cattle literature (e.g., [57–59]): some farmers simply cannot afford veterinary charges. The decision to engage a vet, or not, remains a complex cost–benefit analysis for LMIC farmers, based on the lost opportunity costs associated with a sick animal as well as the cost of the vet's fees and the medication he or she prescribes. This affects vaccination uptake, as well as treatment (we observed no vaccine refusal or hesitancy other than due to an inability to afford the vaccination).

“We’ll call the vet if they’re near.”—Farm manager, FGD

“If the vet is near, we call them and if they are not near, you’ll go to them to explain to them and then you’ll get the drugs they describe to you to use.”—Fulani farm owner, FGD

Veterinarians also pointed to the lack of a cold chain for vaccines, both in terms of transporting them from veterinary practices to the farms, and storage at either end, exacerbated by frequent power cuts that make maintaining consistent low temperatures challenging, an issue we have highlighted previously in India [37]. The cold chain was also an issue for Nigerian academics, who reported that often as much as 80% of samples they take from fieldwork can be lost due to freezer failure during power outages. Potentially damaged drugs also cause mistrust of veterinarians and their products, as the Fulani and farmers knew that some drugs deteriorate if they cannot be kept cold.

“Poor drug storage and fake drugs leading to inefficiency (under sunlight for long periods—expired). The sellers don’t disclose this to the farmers buying them.”—Farm owner, FGD

“Most drugs are fake, hence we don’t get results well.”—Fulani farm owner, FGD

In human medicine, antibiotics have become ‘infrastructural’ [60], used as a quick fix [61] for more deep-rooted issues such as poor hygiene, overcrowding, and poor nutrition: this is mirrored in livestock. Animal welfare in indoor sheds is poorer than in extensive systems [62,63]; this can leave farms, particularly in LMICs, dependent on antibiotics to maintain herd health with the immediate needs of keeping the herd productive outweighing concerns about the externality of the impact of AMR on human health due to the emergence of resistant infections [64].

There is, however, an alternative—and this is not only the BRE we will trial in the next phase of our project—but, rather, one that looks through a planetary health lens to the possible benefits offered by the ethnoveterinary practices of the Fulani and advocates for reducing the risk of these practices being lost by ensuring they are properly appreciated. This danger of losing traditional knowledge is the next link we will consider.

3.6. Disease Management in Fulani Ethnoveterinary Tradition

Discussions with the key stakeholders and FGD participants indicated that Fulani herdsman have a wide variety of traditional ethnoveterinary practices and herbal remedies available to identify sickness, manage herd health, and treat sick animals.

“We are cattle rearers and we usually use our own local knowledge, for Gunya, we use Guinea corn and local oils and rub on the body.”—Fulani farm owner, FGD

“[To prevent/treat mastitis] the nipple should be massaged before delivery so that dirt can be removed. Pus is not hygienic to calves.”—Fulani farm owner, FGD

Armed with this knowledge, Fulani herdsman may attempt to treat a sick animal themselves for up to two weeks before reporting the issue and calling in a vet (in later stages of our project, we hope to explore the impact of this on both health outcomes and antibiotic use).

While the field of planetary health seeks to incorporate and make visible the valuable contribution of traditional practices [12], we must also be careful not to fetishize traditional healers: their knowledge is not perfect [26] and needs to be seen as complementary to modern veterinary science, not as a replacement for it or in opposition to it. One Fulani farmer who attended the FGD believed that FMD is incurable once the cow is infected, for example, while another did not know that vaccination is available for some diseases. Fulani farmers recognize themselves that herbal remedies do not always work:

“When herbs are used, they work well except for Gunya which is highly tedious to manage due to case of recurrence about a month or two after.”—Fulani farm owner, FGD

One Fulani farmer was happy to admit that they were not always able to detect cases of mastitis early enough, suggesting that they may be open to using point-of-care diagnostic tools. Recognizing on which diseases herbal remedies work effectively and on which they do not may open opportunities for discussing better cooperation between vets and traditional healers and identifying points at which treatment needs to be handed over to stronger, but more expensive, allopathic medicine. A traditional Fulani herbal treatment was reported as costing as little as a tenth of the cost of the veterinary alternative (1–2000 Naira compared to 8–10,000; 1 US\$ = approx. 1600 Naira), and most Fulani remedies are homemade, at an even lower cost, which may be all that local farmers are able to afford.

Some of the veterinarians at the FGDs who saw value in learning more about the traditional Fulani practices claimed such knowledge exchange is hampered by the Fulani being very secretive about their traditional knowledge and generally unwilling to share it with outsiders; one veterinarian said that the Fulani would not even use these remedies in the presence of non-Fulani.

“We don’t know the traditional ways and their ways of preventing [mastitis].”—Veterinarian, FGD

“I want to implore you that if you have proven effective herbal remedy [for snake bite] don’t hide it, inform the authority so that knowledge can be utilized effectively.”—Veterinarian, FGD

The Fulani had similar opinions of vets, who they claimed (and vets confirmed) remove labels from drugs they administer when Fulani herdsman are watching to prevent the herdsman from buying the same drugs themselves in the future without a prescription. The Fulani spoke of using traditional and allopathic medicine together, rather than seeing one as exclusionary of the other:

“I’ve treated TB with herbs after diagnosis from a vet before.”—Fulani farmer, FGD

The traditional knowledge is clearly valuable, but there is a feeling that it is in danger of being lost:

“It is the elderly ones among the Fulani that knows most of the herbs. The knowledge of the herbs is waning along the lineage. They have the methods of application of these herbs.”—Veterinarian, FGD

There was broad support from veterinarians for scientific research on the Fulani natural remedies to better understand their efficacy, with suggestions that research into this topic should receive Nigerian Government investment—as the existing literature has also highlighted [65]. Kenyan traditional medicinal plants are starting to gain more academic attention but more is clearly needed.

3.7. Use of Antibiotics to Manage Disease

Awareness of antibiotics, antibiotic resistance, and its causes was reasonably high amongst participants. FGD participants named several antibiotics that were regularly used in animal health (including Amoxicillin, Enrofloxacin, Penicillin, Streptomycin, and Tylosin). They knew that drugs for human use should not be used for animals or vice versa and that the overuse of antibiotics leads to resistance. It was generally agreed that, in Nigeria, anyone can buy antibiotics over the counter from a pharmacy without a prescription, and some antibiotics (such as ‘PenStrep’—Penicillin and Streptomycin)—were considered to be probiotics, used to improve general health. Farmers and herders will often note what the veterinarian uses, and, the next time the animal is ill, they will buy that drug again directly from the pharmacy.

Little testing is carried out to determine the causative agent of the disease or which drugs it may be susceptible to, largely due to the inability to afford such testing and the paucity of laboratories—none of the veterinarians we engaged had testing facilities at their surgeries. It was thought that some of the commercial dairy farms may be able to afford this, but we did not come across any directly.

“Who can afford it [testing]? One who cannot afford treatment can’t afford the [antibiotic susceptibility] testing (AST).”—Farm owner, FGD

“Animals are owned on average by poor people.”—Veterinarian, FGD

One FGD participant suggested that key private sector players in the EU, where antibiotic use (ABU) in livestock has reduced significantly in recent years, could be engaged to promote prudent ABU in LMICs, giving examples and sharing best practice of how the reduction has been achieved.

Whilst the farm owners and managers expressed a preference for using veterinarians as soon as illness was detected, the Fulani preferred to try traditional practices first and go to the vet only if these practices failed. There has been little research into the risks associated with this practice—i.e., whether delayed treatment does in fact lead to poorer health outcomes in the sick animals, or if it has an impact on the emergence of antibiotic resistance. Existing papers [66–68] are increasingly pointing to the value of ethnoveterinary practices for treating low-level ill-health, and Fulani farmers reported that their treatments are often effective. Many non-Fulani farmers respected and had faith in the traditional

remedies and one farmer had set up an area within his farm where the herbs could be grown, which he jokingly called his ‘lab’. It may well be the case that there is space for traditional remedies and allopathic veterinary practices to exist along a continuum and to lie side-by-side for much of it: it may be effective for the initial treatment to be carried out using traditional remedies, and veterinary doctors to step in only when these treatments fail. It is the intermediary step, of using over-the-counter allopathic veterinary medicines without a prescription, that raises problems, including sub-dosing, not following the complete regimen, and using the wrong drug for the infection.

Several of the participants recognized that there would be value in conducting more extensive scientific research into the Fulani traditional remedies and their efficacy, both for the purpose of better integrating the ethnoveterinary and allopathic practices, and for creating improved treatments using the active ingredients of traditional remedies. A more scientific understanding of, for example, the appropriate doses, combinations of ingredients, specific qualities such as anti-inflammatory actions, or conditions for use would be valuable to capture. This is something our team hopes to focus on in future stages of our research and with future funding.

3.8. The End of the Causal Chain

The stages noted above lead to the end point of the causal chain—the risk of human health being compromised by the loss of antibiotic efficacy.

3.9. Further Issues of Note

Common tropes of farmers and herdsman being uneducated, ignorant, and unwilling to change were rampant. Typical comments recorded during the research included the following:

“The vets should educate the farmers.”—Veterinary practitioner, key informant

“The problem is that they are uneducated, they need to be trained.”—Farm manager, FGD

“They do not have the knowledge of these things [hygiene, especially in cow sheds], especially in [their] dialect.”—Farm manager, FGD

“They are not careful enough.”—Farm manager, FGD

Unfortunately, this is an attitude often mirrored in the academic literature on the Fulani (e.g., [69]). Other accusatory comments such as *“They don’t like to mix with people”* suggested that some participants did not even consider the Fulani to be ‘normal’ people.

Elite FGD participants made suggestions that the Fulani *“should be encouraged to have Android phones”*, with little regard for the cost, lack of WiFi, or data coverage in rural fields. Many Fulani do use phones, for example, as one Fulani farmer described:

“We make concoction to treat diseases immediately we notice and local herbs—by calling our father.”—Fulani farmer, FGD

However, they were criticized for using these phones to connect with their own networks and radio stations broadcasting programmes in their own dialect, rather than these channels being considered as ways of disseminating information to the Fulani.

The Fulani farmers were willing to consider different approaches—but want proof that, if things are done a different way, results will be better.

“If the BRE is proven effective would farmers be prepared to use them, despite all the local remedies and alternatives available?”—Facilitator, FGD

“You’ve not introduced the drug yet, so we can’t know.”—Farmer, FGD

“After trials, it would be introduced with results.”—Facilitator, FGD

“[I would use it] as long as it is effective and cost effective.”—Farmer, FGD

“Farmers like to give a new product a trial especially if it is relatively cheaper than existing similar products.”—Drug seller, FGD

More business-oriented approaches to farming could be beneficial in changing farmers’ practices away from antibiotics towards alternatives such as BREs that do not threaten human health, by proving the economic benefit of the alternatives.

“We need to explain to them [the farmers] how these projects directly affect their income and how it can be of benefit to them and not only for AMR.”—Veterinarian, FGD

There were also suggestions that training on sanitation and housing in modern farming practices, as well as animal nutrition and farm finance, for both farm owners and Fulani workers would be beneficial; this is more practical than training in ‘antibiotic resistance’ which may be outside of the farmers’ powers to address [34], and needs to be tackled at a more systematic level through tighter government regulation that ensures veterinary prescription only. Better water, sanitation, and hygiene conditions for cattle, combined with good, natural nutrition and plenty of access to outdoor space, will have a strong positive influence on animal health, and is likely to reduce the need for antibiotics to clean up problems caused by poorer welfare conditions.

It was not clear from the FGDs that the farmers or Fulani are indeed ‘uneducated’ and ‘ignorant’, however; while they may not have undertaken a veterinary medicine degree, the discussions indicated they understood complex issues, such as the microbiome and its role in immune response, and often referred to pathogens by their scientific names. ‘Educating’ them further but leaving them with no easier access to affordable veterinary services, water, and sanitation infrastructure or practical training in modern herd management practices is unlikely to change the current situation significantly.

4. Discussion

In recent years, increasing attention has been given to traditional livestock management practices and ethnoveterinary knowledge [29,65,66] and, separately, livestock’s role in climate change [66], how climate change is disrupting centuries-old patterns of practice across Africa [67], and how traditional pastoralists are adapting [68,69]. Attention given to such pastoralists in government and international policies, however, if they are represented at all, tend to problematize them amid agricultural and food policies focused on moving towards more intensive and sedentary systems [42,43]. Less of the existing literature positions such practices as viable alternatives to antibiotic stewardship and/or attempts to incorporate them into climate change policies by seeking to learn from them [70]. Literature on the relationship between pastoralism and antibiotic stewardship does exist, but little of this focuses on the benefits of pastoralism for lower ABU, and, instead, it more often tends to blame pastoralists for unregulated ABU [69–71]. In Europe, in contrast, it is well-established that a lower ABU is correlated with higher animal welfare and more access to grazing and pasture, which results in fewer infections and lower veterinary costs [72–74].

Access to pasture has positive effects on udder health, in particular, mastitis, although most literature is from regions that have resisted development away from pasture grazing systems, such as the Swiss Alps [74], or on organic farming systems that have made a deliberate return to higher welfare systems [72]. In many ways, the intensification of dairy cattle and the increase in infectious disease that comes from living in overcrowded, unhygienic conditions mirror the ‘urban penalty’ observed in human European populations from the Middle Ages to the industrial revolution, when large numbers of people moved from agricultural work in the country to overcrowded, unhygienic cities before the sanitation infrastructure caught up [75]. The plight of animals in the Global South is tied up with the plight of humans in the Global South in countries that lack sufficient progress towards the Sustainable Development Goals on sanitation [76]. Willis and Chandler’s paper on antibiotics as “quick fixes” in health and animal productivity [61] is highly relevant to this discussion but the literature that has responded to it has tended to focus on the need for more surveillance to better understand ABU in low-income settings [77], better

regulation to ensure more appropriate use [78], or more education and awareness for communities [79,80]. Few offer workable alternatives to practices that drive the requirement for antibiotics in the first place. Several potential solutions arose from the discussions undertaken for our study that may provide a way forward for Nigerian cattle production that maximizes the health of humans, animals, and the environment, and which respects the indigenous knowledge of the Fulani herders, so that the use of antibiotics within the cattle sector can be minimized and optimized.

First, spaces for Fulani practice that enable them to maintain their nomadic way of life and graze cattle on open ground, at which they are skilled and experienced, is necessary. The benefits to humans, animals, and the environment from grass-fed rather than intensive dairy and beef production systems has long been recognized [81–85]. Settlement programmes for the Fulani seem to be focused on encouraging them to stay in one place, and to intensify cattle production for the benefit of external actors, rather than to allocating land along migratory routes that would enable Fulani pastoralists and their herds to move around, grazing and stopping where this fits with their lifestyle. This needs to be considered in light of the extensive literature that points to more extensive systems, with better housing and more opportunities for grazing, resulting in the much lower use of antibiotics—a finding that is evidenced in studies from as far afield as Kenya [84], Poland [85], and Mongolia [86], and is explained by less crowded, higher welfare conditions being a natural barrier to disease emergence and spread. The current literature also suggests that concerns that grazing may increase the ARGs in soil and water around grazing land are largely unfounded [86]. Such literature is particularly important in light of the reduction in access to grazing land for Fulani cattle, as it suggests that extensive systems are much better for low antibiotic use than enclosure—although the literature also suggests there is a dearth of knowledge on the levels of ABU in different farming systems in Sub-Saharan Africa in general [87].

Second, more research is needed on Fulani practices and ethnoveterinary knowledge, to ensure indigenous knowledge is preserved, and to determine how it fits best with, and can complement, modern veterinary science. This needs to include research on active ingredients, dosing regimens, and outcomes following delayed allopathic treatment. Recent literature has pointed to valuable Fulani practices in using locally made insecticides to prevent African Animal Trypanosomiasis (ATT) caused by tsetse flies [88], herbal treatments for worm infestations [89,90], and for diarrhea [91]; the latter may be particularly important as diarrhea is a symptom of bacterial infection but also has many other causes, and so alternative treatments can both reduce rational and irrational antibiotic use. The key challenge is balancing ethnoveterinary knowledge with the (un)regulated use of antibiotics—namely, better cooperation between ethno- and allopathic veterinary practitioners—and understanding how these treatments are best used to maintain herd health in extensive grazing systems. Fulani ethnoveterinary knowledge has developed to maintain and treat herd health under certain conditions: it may not be easily translatable to intensive systems.

Third, more research is needed into the impact of climate change on animal health and ABU in dairy cattle in Nigeria (and globally) including thresholds at which ill health is triggered, low-resource mitigations—such as grazing cattle amongst trees, which we witnessed on several farms—and likely future challenges to pasture and grazing crops under different climate change predictions, which will affect the available fodder as well as animals. Silvopasture—grazing animals among trees to help keep them cool whilst also utilizing the land for additional food production—has shown success across the world, including in the United States [92], where cattle are grazed amongst honey locust trees [93], in Ethiopia where they are grazed among fig trees [94], and alongside mulberry bushes in India [95]. The Fulani grazing their cattle on farmland does not per se make that land unproductive for crops.

Finally, communication needs to be better facilitated between Fulani healers and veterinarians to share knowledge in both directions. Our FGDs suggested that both groups

withhold knowledge from one another, stemming from and leading to mistrust: mistrust of veterinarians and the pharmaceutical sector by the Fulani, who fear their traditional knowledge may be stolen and commercialized (with good reason, as it has often happened elsewhere [96,97]), and mistrust of the Fulani by the veterinarians who fear that drugs they are seen using will be bought over the counter from unregulated pharmacies the next time an animal is ill, as veterinary doctors we interviewed have reported having seen happen. This results in missed opportunities, however, for the key stakeholders to work together: animal health knowledge can be shared by veterinarians over Fulani radio stations and through traditional Fulani communication channels, but this needs to respect their culture and practices and acknowledge the challenges they face, with the awareness that they are largely operating in open countryside without running water, electricity, or access to (affordable) veterinary services. In our research, the Fulani and farmers would generally try to consult a veterinarian when they could afford one, if one was available and where there was trust. Spending time to build up this trust could be a valuable short-term solution. In turn, the Fulani could be encouraged to share their ethnoveterinary practices with the veterinary and livestock sectors to determine how these can be better integrated into animal health regimes, ideally with funding and investment into studies to prove the efficacy of their treatments, how best to practice them alongside allopathic veterinary medicine, and, perhaps in the long-term, encouragement to move towards incorporating more understanding of their practices into Nigerian veterinary school curriculums. This might, in turn, encourage more Fulani to undertake a formal study on animal health and management and to become a more embedded part of the transition towards future food animal production systems.

5. Conclusions

“I appreciate the stakeholder meeting because it makes us have a sense of belonging and coming back here after this discussion. I’ve learnt much of the traditional medication others use and shared knowledge of the vaccines I use with them.”—Veterinarian, FGD

Our research, and the literature it directed us to, shed light on how the plight of Fulani herdsman and cattle in the changing environmental and political climate of Nigeria is intertwined, illustrating the value of approaching Anthropocene challenges through planetary health and One Health lenses, respecting and learning to work with indigenous knowledge and ethnoveterinary practices rather than seeing them as in opposition to modern science, a practice described as “two-eyed seeing” [10]. Herd management and health was not a binary of traditional practices *or* modern veterinary medicine for the Fulani, and both approaches have much to learn from the other, particularly if planetary health is to address the critiques that it lacks interest in animal health [27,28]. In turn, One Health has much to learn from planetary health’s valuing of indigenous knowledge, and rights for the more-than-human world: if feeding the world within planetary boundaries does indeed require a significant reduction in the levels of meat consumption commonly seen in developed country diets [98], and a return to less environmentally destructive food animal production systems [99], then systems such as Fulani pastoralism offer valuable case studies. Nigeria’s somewhat unique system should be nurtured and supported so that it provides valuable lessons on alternate models of animal production. In our future research, we hope to explore more fully the relationship between herd management practices, herd health, health outcomes under herbal and ABU, and the emergence of AMR in such systems. BRE is one alternative, but perhaps not the ideal one, if, like antibiotics, it simply becomes a ‘quick fix’ to cover over what is causing animal ill-health to begin with, even accounting for its advantages over antibiotics in terms of the lack of development of resistance.

This paper has used a planetary health framework to illustrate how a complex interplay comprising underlying drivers (rapid urbanization; political ecology; and population increase), ecological drivers (climate change in northern and southern Nigeria), proximal causes (competition for land resources; and increasing interest in commercial farming), and mediating factors (farmers’ inexperience of intensive farming practices; poor access

to veterinary services; and poor antibiotic regulation) drives ABU in the Nigerian cattle sector, which, in turn, is likely to impact human health. The paper thus advocates for the complexity of planetary health as a way to understand high ABU in livestock farming and how this may be tempered by the better integration of indigenous ethnoveterinary practices and a retention of traditional, extensive herding systems for beef and dairy cattle in Nigeria. It also highlights that such challenges do not exist in isolation: they are themselves parts of complex systems that include the political ecology [41], as well as the natural environment, social attitudes, and power relationships between groups, legal structures relating to land, drug regulation, and advances (or not) in the water and sanitation infrastructure in rural regions.

Cattle management in Nigeria is not yet fully intensified. The current mix of extensive, intensive, settled, pastoral, local, and crossbreeds is largely still managed by traditional pastoralists with decades of experience in animal health—but experience of animal health in settings increasingly unfamiliar to a more commercialized farming sector. The model could act as a case study for other low-resource settings across the world, offering opportunities to explore the production of animal-sourced food within planetary boundaries and within planetary health ethics, respecting indigenous knowledge and the more-than-human rights of both animals and the environment [29].

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