Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

From Policy to Practice: Governing Veterinary Antimicrobial Use in Tanzania

Lazaro Edward Kapella

kaplazaro@gmail.com

International Fund for Agriculture Development (IFAD)

Suzana Samson Nyanda

Sokoine University of Agriculture

Research Article

Keywords: Veterinary antimicrobial use, Antimicrobial resistance, Institutional framework, One Health, Tanzania

Posted Date: June 17th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-9579001/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License

Additional Declarations: Competing interest reported. The authors declare that they have no competing interests.

Abstract

Background

Veterinary antimicrobial use (VAMU) is increasing in Tanzania alongside livestock intensification, raising concerns about antimicrobial resistance (AMR) and the effectiveness of existing governance systems. While multiple policies and legal frameworks exist, evidence on how these institutional arrangements translate into practice remains limited. This study assesses how Tanzania's institutional framework governs VAMU and identifies gaps affecting prudent use within a One Health context.

Methods

A mixed-methods approach was used. Data were collected through documentary review of formal institutions, farmers' survey (*n* = 138), Agrovet shop survey (*n* = 55), in-depth interviews (*n* = 11), and focus group discussions with livestock farmers (*n* = 4). Qualitative data were analysed using content analysis, and quantitative data were summarised using descriptive statistics.

Results

Findings show that Tanzania's institutional framework provides partial coverage of VAMU governance, with most policy issues only indirectly addressed. Implementation remains weak. Major gaps include limited access to veterinary services, weak enforcement of regulations, over-the-counter antimicrobial sales, and inadequate diagnostic capacity. Agrovet shops and paraprofessionals function as de facto gatekeepers of antimicrobial access, often operating beyond formal regulatory oversight. Additionally, weak biosecurity and unclear antimicrobial waste management practices contribute to environmental and food safety risks.

Conclusions

The study highlights a persistent gap between Tanzania's formal institutional framework for VAMU and implementation at the field level. Strengthening enforcement of existing regulatory functions, improving coordination among One Health institutions, expanding access to qualified veterinary services and diagnostics, and developing clearer operational guidelines are essential to promote prudent VAMU and reduce risks to public, animal, and environmental health.

Background

Tanzania's livestock sector is vital for livelihoods and nutrition, yet it operates in disease-prone environments where farmers often rely on veterinary antimicrobials to maintain animal health and productivity. Globally, food-animal production is a major driver of antimicrobial consumption, and

inappropriate use including non-therapeutic practices such as routine prophylaxis or production-oriented dosing can accelerate antimicrobial resistance (AMR) across the One Health interface [1]. In many smallholder settings, the underlying drivers of non-prudent VAMU are structural: limited access to affordable, supervised animal health services, weak prevention (biosecurity, vaccination), and poorly regulated retail access to medicines. Evidence from Tanzania shows that Agrovet shops and other private outlets frequently function as the primary entry point for antimicrobials, enabling over-the-counter sales and self-diagnosis when professional care is constrained [2, 3].

This study defines an antimicrobial as an agent or substance derived from any source (microorganisms, plants, animals, synthetic or semi-synthetic) that acts against any type of microorganism, such as bacteria (antibacterial), mycobacteria (anti-mycobacterial), fungi (antifungal), parasite (anti-parasitic) and viruses (antiviral). In this study, “antimicrobials” refers to therapeutic agents including antibiotics, antifungals, antivirals, and antiparasitic agents that kill microorganisms or inhibit their growth [4]. Furthermore, “Antimicrobial resistance (AMR)” refers to the loss of susceptibility whereby bacteria, fungi, viruses, or parasites survive and continue to multiply despite exposure to drugs that were previously bactericidal or bacteriostatic [5]. It is reported that AMR emerges through mechanisms such as target modification, enzymatic drug inactivation, reduced permeability, and active efflux, which collectively defeat antimicrobial action [6].

In Tanzania, livestock keepers commonly obtain veterinary antimicrobials through Agrovet shops [2, 7]. This study refers to Agrovet shops as private veterinary retail outlets that sell animal health products including antimicrobials alongside other farm inputs such as feeds and crop inputs operating under oversight of the trained animal health personnel [8, 9]. National sales and import figures help describe overall antimicrobial consumption, but they rarely indicate which specific drugs are administered on farms, to which animal species, or for what purpose. Farm-level VAMU monitoring addresses this gap by documenting use by product, indication, and animal population, enabling more precise stewardship and accountability[10]. This farm-level evidence strengthens decision-making by showing where and why antimicrobials are used, helping countries target stewardship actions, track progress, and curb inappropriate practices [11].

Risks related to misuse of antimicrobials in the country have been reported in different areas including Kigoma [12], and Mwanza [13, 14] Regions. In the wake of enforcing smallholder farmers’ compliance with prudent VAMU, the country has been mainstreaming various institutional frameworks but less is known about how such policy strategies are faring in practice. This study posits that current practices, including VAMU, are enabled or constrained by formal institutions. Specifically, it hypothesizes that existing laws, regulations, and guidelines may: (i) explicitly support or oppose VAMU (wholly or in part); (ii) fail to state whether antimicrobials should be used for treatment while outlining procedures that can enable non-prudent use; or (iii) omit VAMU considerations altogether. Determining which of these scenarios (alone or in combination) applies is the central puzzle this study investigates. This paper therefore contributes towards this end. The following questions are answered in this article: (i) What policy issues/strategies exist in the livestock related policies that can enhance prudent VAMU? and (ii)

How do the practices in Ujiji and Nyamagana Municipalities compare with the identified policy issues? The findings in this paper can inform strategies to achieve the United Republic of Tanzania's Development Vision 2050, which aims to build a highly productive, competitive, and sustainable sector that makes Tanzania a leading regional food hub. Prudent VAMU is therefore essential for protecting human health.

Conceptual framework

This study is anchored in Institutional Theory as advanced by [15] and further elaborated by [16]. North defines institutions as humanly devised constraints that structure interaction through formal rules (e.g., laws, regulations) and informal constraints (e.g., norms, customs, culture). Scott extends this perspective by emphasizing the processes through which rules are interpreted, enforced, and adjusted over time. In the context of VAMU in smallholder livestock systems, this theoretical lens is relevant because VAMU carries public and animal health risks, meaning that formal institutions should guide how antimicrobials are accessed, prescribed/dispensed, and used. At the same time, emerging challenges such as AMR may require new institutions or the redesign of existing ones to remain effective [17]. Accordingly, the study focuses on the formal "rules of the game" that govern VAMU in livestock production in Tanzania. These include policies, Acts, regulations, guidelines, strategies, and by-laws, and the study generates evidence on how the existing institutional framework enables or constrains prudent VAMU. This focus aligns with the view that effective action against AMR depends on understanding the institutional arrangements, incentives, and governance structures shaping antimicrobial-use practices [18].

Figure 1 presents the study's conceptual pathway toward prudent VAMU. The framework depicts a reciprocal relationship between institutional frameworks (policies, Acts, strategies, plans) and animal health services (veterinarians, para-professionals, Agrovet shops, and laboratory/diagnostic services).

Institutional frameworks define the standards and accountability mechanisms that shape service delivery such as prescribing authority, licensing requirements, quality assurance, supply-chain controls, and enforcement. In turn, everyday practices within animal health services generate feedback that can reinforce, expose gaps in, or prompt adjustments to these rules (e.g., compliance constraints, implementation bottlenecks, or adaptive practices on the ground). Overall, both institutional and farm-level factors such as the cost of antimicrobials and access to veterinary extension services are largely influenced by farmers' financial capacity. Within this pathway, livestock farmers are positioned as the proximal decision-makers who translate upstream institutional and service conditions into VAMU behaviour. Where rules are clear and enforceable, and services are accessible and responsive, farmers are more likely to receive appropriate advice, benefit from accountable dispensing, and make informed decisions, thereby supporting prudent VAMU. In this study, prudent VAMU is reflected through (i) improved access to animal health services and (ii) safer and more responsible VAMU practices.

Materials and Methods

Study design

This study adopted a convergent mixed-methods design combining documentary review, quantitative surveys, key informant interviews, focus group discussions, field observations, and secondary data review. The design was selected to allow triangulation of evidence from formal institutional frameworks and implementation practices at the field level. The documentary review assessed how existing policies, laws, regulations, strategies, and institutional mandates govern veterinary antimicrobial use, while the empirical component examined how these formal arrangements are understood and implemented by livestock farmers, Agrovet shop operators, animal health service providers, and regulatory actors.

The study was exploratory and descriptive in nature. It did not aim to establish causal relationships, but rather to assess the alignment between formal rules and actual antimicrobial-use practices in selected livestock production systems. The analysis was guided by Institutional Theory, which views institutions as formal and informal rules that shape human behaviour, incentives, compliance, and enforcement.

Study Area

The study was conducted in Tanzania, with national-level documentary review and field-based data collection in Ujiji Municipality in Kigoma Region and Nyamagana Municipality in Mwanza Region (Fig. 2). These municipalities were selected purposively because they represent contrasting but relevant contexts for examining veterinary antimicrobial use and governance.

Ujiji Municipality was selected due to its location near international borders with Burundi and Rwanda, where cross-border livestock movement and informal trade in veterinary medicines may influence antimicrobial access and use. Nyamagana Municipality was selected because it forms part of the urban core of Mwanza City and is characterised by relatively intensive livestock production, high population density, and the presence of several animal health service outlets. These characteristics made the two municipalities suitable for examining how national antimicrobial-use governance frameworks are translated into practice under different livestock service delivery and market conditions.

Source

Authors' preparation using GIS administrative boundary data and open-source basemap layers.

Study population

The study population comprised actors involved in or affected by VAMU governance in Tanzania. These included livestock farmers, Agrovet shop operators or attendants, animal health professionals, district and regional livestock officials, national-level government officials, and regulatory authority

representatives. Farmers included those keeping dairy cattle, pigs, and/or poultry. Agrovet shops included private veterinary retail outlets selling animal health products, including antimicrobials and related livestock inputs.

Key informants were drawn from institutions involved in livestock, health, agriculture, environmental management, and medicines regulation. These institutions were selected because veterinary antimicrobial use and antimicrobial resistance are cross-sectoral issues requiring a One Health governance perspective.

Sampling strategy and participant recruitment

A combination of purposive and non-probability sampling techniques was used. The two study municipalities were purposively selected based on their relevance to VAMU governance, livestock production, Agrovet shop presence, and potential antimicrobial access risks. Livestock farmers were identified with the support of local leaders, village chairpersons, and livestock officers. Selection considered livestock type, farm location, willingness to participate, and experience with animal health service use or antimicrobial purchase. A total of 138 livestock farmers participated in the survey. A total of 55 Agrovet shops were surveyed. These were identified through district livestock offices, local market observation, and available lists of registered or operating veterinary input outlets.

Documentary review

A documentary review was conducted to assess the extent to which Tanzania's formal institutional framework addresses VAMU, AMR, animal health services, drug regulation, food safety, environmental protection, and One Health coordination. The documents reviewed included policies, Acts, regulations, guidelines, strategies, and institutional frameworks relevant to antimicrobial-use governance. These documents included the National Livestock Policy (NLP) (2006); the Animal Diseases Act (ADA), Cap. 156 (R.E. 2023) (Act No. 17 of 2003); the Veterinary Act (VA), Cap. 319 (R.E. 2023); the Tanzania Medicines and Medical Devices (TMDA) Act, Cap. 219 (R.E. 2021); the Public Health Act (PHA), Cap. 99 (R.E. 2023); the Grazing-land and Animal Feed Resources (GLAF) Act, Cap. 180 (R.E. 2023); the Government Chemist Laboratory Authority Act (GCLA), Cap. 177 (R.E. 2023); the Environmental Management Act (EMA), Cap. 191 (R.E. 2023); and the National Environmental Policy (NEP) (2021). The aim was to determine how these rules of the game shape incentives, responsibilities, oversight, and enforcement, and how they can be leveraged to strengthen prudent VAMU in veterinary practice. These documents were reviewed to identify provisions related to antimicrobial access, prescription, sale, use, surveillance, residue monitoring, animal health service delivery, feed regulation, waste management, and institutional coordination. A documentary extraction matrix was used to capture the name of the document, year of publication or revision, responsible institution, relevant provisions, antimicrobial-use governance issues addressed, implementation responsibilities, and observed gaps. The review focused on whether antimicrobial-use issues were addressed directly, indirectly, partially, or not at all.

Farmer survey

A structured questionnaire was administered to 138 livestock farmers in Ujiji and Nyamagana Municipalities. The questionnaire collected information on livestock species kept, sources of animal health advice, access to veterinary services, sources of antimicrobials, self-treatment practices, adherence to dosage and withdrawal periods, use of antimicrobials for treatment or prevention, awareness of antimicrobial resistance, and disposal of unused or expired veterinary medicines. Before the main survey, the farmer questionnaire was pre-tested with livestock farmers who had similar characteristics to the target respondents but were excluded from the final sample. The pre-test assessed question clarity, flow, relevance, and interview duration. Feedback was used to refine ambiguous questions, improve Kiswahili wording, adjust response options, and ensure consistent understanding of questions on antimicrobial access, use, dosage, withdrawal periods, and disposal practices. Thereafter, the questionnaire was administered through face-to-face interviews. Where necessary, questions were translated or explained in Kiswahili to ensure proper understanding. Participation was voluntary, and respondents were informed of the purpose of the study before data collection. The farmer questionnaire was developed specifically for this study and is provided in English as Supplementary Material.

Agrovet shop survey

A structured Agrovet shop survey was conducted among 55 veterinary input outlets. The survey assessed licensing status, personnel qualifications, types of veterinary medicines sold, antimicrobial dispensing practices, record keeping, prescription requirements, farmer advisory practices, awareness of antimicrobial resistance, disposal of expired products, and interaction with regulatory authorities.

The survey also captured whether Agrovet shop attendants provided technical advice to farmers and whether antimicrobials were dispensed with or without veterinary prescription. Observations were made, where possible, on product labelling, storage conditions, and the availability of products with non-therapeutic indications such as prophylaxis, stress management, or productivity enhancement. The Agrovet shop questionnaire was developed specifically for this study and is provided in English as Supplementary Material.

Key informant interviews

The study interviewed 11 key informants from government institutions, including four from the ministries responsible for livestock, environment, health, and agriculture; two from Regional Livestock Departments in Kigoma and Mwanza; two District Livestock and Fisheries Officers from Ujiji and Nyamagana Municipalities; and three regulatory officers from TVC, TMDA, and NEMC. Key informants were identified in consultation with the respective institutions based on their mandates, technical roles, and relevance to the study objectives outlined in the introductory letter. The government officials were drawn from the livestock, health, environment, and agriculture sectors that are central to the One Health understanding of VAMU/AMR at the human-animal-environment interface [19, 20]. Additionally, three key informants

were regulatory officers from the Tanzania Veterinary Council, the Tanzania Medicines and Medical Devices Authority, and the National Environment Management Council. The interviews explored institutional mandates, coordination arrangements, enforcement capacity, VAMU regulation, veterinary service delivery, diagnostic capacity, Agrovet shop supervision, antimicrobial waste management, residue monitoring, and perceived gaps in policy implementation. The interviews with key informants examined, from a practice perspective, the relevance of existing policies, laws, and regulatory frameworks in shaping prudent VAMU in livestock production systems. The interviews also captured participants' views on coordination and enforcement arrangements across relevant sectors and regulatory authorities. A semi-structured interview checklist was used to guide all interviews.

Focus group discussions

Four focus group discussions were conducted with livestock farmers, two in each municipality. Each FGD comprised 7–8 participants and included farmers of mixed sex to deepen understanding of VAMU practices beyond the survey findings. Participants were selected to ensure representation by sex, farm location (urban/peri-urban), livestock type, and primary source of antimicrobials (animal health service provider, Agrovet shop, or informal market). Livestock farmers were purposively identified from lists provided by Village Chairpersons and verified through consultations with Agrovet shop service providers. All participants joined voluntarily. FGDs explored practical and institutional factors shaping VAMU.

Secondary data

Secondary data were drawn from relevant reports on livestock production institutions, animal health services and treatment practices, antimicrobial disposal, and quality monitoring systems. Reports were obtained from relevant offices and, where necessary, from publicly available online sources. Key reports consulted included those from FAO, TMDA, and the Tanzania Veterinary Council (TVC).

Data analysis

Quantitative survey data were analysed using IBM SPSS Statistics (version 26) and summarised using descriptive statistics. Findings were interpreted through triangulation across data sources. The analytical workflow is summarised in Fig. 3. The analysis focused on patterns of animal health service access, antimicrobial sources, Agrovet shop licensing, prescription practices, farmer self-treatment, withdrawal-period observance, and awareness of antimicrobial resistance. Where appropriate, findings were disaggregated by municipality to compare patterns between Ujiji and Nyamagana. Regulatory documents were coded to extract provisions relevant to VAMU in livestock production systems, and the resulting codes were organised into themes. Interview and FGD transcripts were then coded using these themes, while allowing for additional emergent codes where needed.

Qualitative data were analysed using thematic content analysis. An initial coding framework was developed from the study objectives, Institutional Theory, and key VAMU governance themes identified during the documentary review. These themes included animal health service delivery, Agrovet shop regulation, prescription and dispensing practices, diagnostic services, antimicrobial residues, waste

management, enforcement capacity, and One Health coordination. Additional emergent themes were added during coding where participants raised issues not captured in the initial framework. Triangulation was used to compare evidence across document review, survey findings, interviews and FGDs. This allowed the study to assess whether formal institutional provisions were reflected in practice and to identify areas where implementation diverged from policy or legal expectations.

Results

Institutional issues in relation to veterinary antimicrobial use

Table 1 summarizes institutional frameworks governing veterinary VAMU in Tanzania. The VA (Cap. 319) and TMDA (Cap. 219) mandate licensing of Agrovet shop and service providers, while the NLP (2006) and NAP - AMR 2023–2028 recognise the need for supervised services and AMR awareness (URT, 2006; URT, 2022).

Table 1
Summary of institutional framework governing veterinary antimicrobial use in Tanzania and comparison with field practices.

Key Policy Issue	Institutional Mandate	Practice
Licensing of professionals and premises	Policies recognise need for supervised services; the VA mandates registration of veterinarians and supervision of paraprofessionals.	Severe shortage of registered veterinarians (956) vs paraprofessionals (5,418); informal/unregistered providers active; farmers often self-treat without prescription.
Antimicrobial sale, distribution and storage	TMDA Act requires licensed premises; Animal Diseases Act empowers inspectors to control and safely dispose of contaminated wastes; GLAFA defines “feed additives” to cover in-feed medicinal effects.	Informal and unregistered providers persist; Agrovet shop are main source; unregistered, low-quality antimicrobials sold in open markets; weak control over in-feed antimicrobials.
Waste management	Hazardous Waste Regulations classify pharmaceutical waste (including antimicrobials) as hazardous; ADA mandates approved carcass/waste disposal.	Expired antimicrobials often disposed with household waste; poor withdrawal-period compliance; manure containing residues applied to crops.
Product registration, quality control, and post-market surveillance	TMDA Act establishes product register, pharmacovigilance, post-market monitoring, and laboratory quality control.	Import controls relatively strong, but post-entry enforcement limited; informal market circumvents quality checks.
One Health Governance	NAP-AMR provides a One Health coordination framework.	Regulatory responsibilities fragmented across livestock, health, environment, agriculture sectors; weak inter-sectoral coordination and enforcement due to financial constraints.

Surveillance of VAMU/AMR is mandated under the Animal Diseases Act (Cap. 156) and NAP-AMR, and quality assurance falls under the TMDA Act. Control of antimicrobial storage, use, and waste is spread across the Veterinary Act, TMDA Act, Environmental Management Act (Cap. 191), and the Grazing Land and Animal Feeds Act, though operational rules for non-therapeutic use are lacking. One Health governance is explicitly promoted in the NAP-AMR but remains poorly coordinated. In the forthcoming sections, relevant VAMU/AMR issues highlighted in the different institutional frameworks are analyzed, with emphasis on how the policy environment aligns or diverges from implementation realities. Table 1 also shows that several crucial operational issues are either only partially addressed or not consistently addressed across the reviewed instruments, and this is more pronounced when compared with the “Practice” column. The most visible gaps in practice are in availability of affordable, supervised animal health and extension services, prudent VAMU guidance in day-to-day use (correct product, dose, duration and limiting prophylaxis), routine VAMU/AMR surveillance with feedback, and antimicrobial residue control through withdrawal observance and testing of animal-source foods. This pattern suggests that

while the policy and legal environment provide important direction, translation into routine implementation is constrained by service delivery limitations, enforcement capacity, and weak operational systems at field level.

Another important finding is that, regardless of being critical, some issues appear weakly covered in key instruments and remain difficult to operationalize. These include control of non-therapeutic VAMU (growth promotion and in-feed medication) and safe storage, collection and disposal of expired or unused veterinary antimicrobials and related waste. Even where the laws and policies “somehow tackle” these issues, the practice column shows persistent challenges, implying that implementation arrangements, incentives, and monitoring mechanisms are not yet strong enough to secure compliance. In the forthcoming sections, relevant VAMU/AMR issues highlighted in the different policies and laws are analyzed, with emphasis on how the policy environment aligns or diverges from implementation realities.

Animal health services

Results from documentary reviews and in-depth interviews with government officials indicated that the provision of animal health services is a vital aspect of food safety. According to the National Livestock Policy [21], the responsibility of the Government is to control, eradicate and prevent the introduction of animal diseases, control of Trans-boundary Animal Diseases (TADs) and diseases of economic importance. Tanzania, under the Tanzania Development Vision 2050 (Vision 2050), positions livestock production and food safety as central to its long-term development agenda. Vision 2050 sets an ambitious target for the country to become a leading food producer in Africa and among the world’s top ten by 2050, which will require higher livestock productivity, more resilient food systems, and stronger food safety controls across value chains. This indicates that consumption of safe livestock products will remain a key source of nutritious food, essential for sustainable livelihood development.

Additionally, the policy recognizes veterinary public health and food safety services as a coordinated effort. Accordingly, one policy statement under Section 3.11.7 of the NLP (2006) notes that the Government, in collaboration with other stakeholders, should strengthen the infrastructure and facilities required to deliver these services. Similarly, strategic objective three of the National Action Plan On Antimicrobial Resistance (NAP-AMR) 2023–2028 emphasizes the strengthening surveillance of antimicrobial residues, with activities explicitly focused on residue surveillance in foods of animal origin and the environment, consistent and harmonized with international standards [22]. The surveillance and research interventions focus on strengthening AMR and VAMU surveillance systems, building laboratory capacity, and advancing research and development to catch up with the fast-growing livestock population in the country. Nevertheless, Section 3.11.1 of the National Livestock Policy underscores a weak private sector, inadequate infrastructure, the high cost of veterinary inputs and inadequate technical support services as constraints affecting the animal health sector. Literature shows that human resource shortages remain a binding constraint on animal health service delivery in Tanzania, especially in smallholder systems where access to routine preventive care and timely treatment is already limited [23–25]. Therefore, strengthening and sustaining a competent animal health workforce,

alongside upgrading animal health care facilities, should be prioritised to mitigate AMR risks in an expanding livestock sector.

This study underscores that animal health services have yet to gain meaningful priority. FGD findings indicate that farmers expressed frustration that the livestock sector is perceived as neglected compared with other sectors whose programmes are routinely implemented and monitored up to the village level. One youth farmer noted that district human health officers frequently visit their village to oversee various medical issues, whereas for livestock services, villagers typically must travel to the district office or nearby Agrovet shop to seek technical advice and support. Although a veterinary officer is stationed at ward level, discussants reported that inadequate tools and facilities constrain service delivery, resulting in livestock problems being addressed ineffectively; this mirrors wider evidence that access to professional veterinary care in many rural/remote livestock settings in Tanzania remains limited [3, 26]. Collectively, these accounts point to a clear misalignment between policy commitments and operational realities on the ground.

Government officials interviewed acknowledged that animal health services in their communities are inadequate and generally viewed this service gap as creating space for untrained individuals to provide care, thereby increasing public health risks, particularly through inappropriate use of veterinary medicines, including antimicrobials. They argued that the number of animal health professionals should be increased to meet demand, while strengthening governance and oversight mechanisms to ensure the prudent use of antimicrobials. For example, a key informant from Nyamagana District Council stated that:

…Animal health service delivery continues to lag behind sector needs, and the market is increasingly characterized by unqualified providers, posing a growing risk to livestock and human health

Further to views expressed by some government officials, the farmers' survey revealed pronounced municipal differences in animal health service use: respondents in Ujiji more frequently relied on veterinarians (63.4%) than those in Nyamagana (9.0%), whereas para-veterinarians were more commonly used in Nyamagana (83.6%) than in Ujiji (67.6%). Taken together, the findings suggest that many farmers, especially in Nyamagana where veterinarian use is minimal, may depend on paraprofessionals and, in some cases, informal or unregistered providers for animal health services, which can heighten the likelihood of unsupervised access to veterinary antimicrobials and inappropriate use. For example, the study reveals that more than a third (38%) of farmers in Ujiji Municipality adopt self-treating their animals due to the influence of other farmers in their community. Similar locality-driven variation in the mix of professional and paraprofessional service providers has been documented in Tanzania, with paravets often filling routine service gaps where affordability, distance, and limited veterinary infrastructure restrict access to qualified veterinarians [27].

Agrovet shop services

Agrovet shop survey results show higher licensing of Agrovet shop premises in Nyamagana (93.5%) than in Ujiji (66.7%). Government officials further explained that, even where outlets are licensed in principle, day-to-day operations are frequently handled by clerks with limited veterinary training, and farmers rarely seek technical guidance from Agrovet shop attendants. Consistent with this, only 77.4% of over-the-counter Agrovet shop personnel in Nyamagana compared with 45.8% in Ujiji were licensed by the Veterinary Council of Tanzania, indicating substantial non-compliance (particularly in Ujiji) and reinforcing a lay-driven pathway for antimicrobial access and use. Literature shows that Tanzania's Agrovet shop are a key and often inadequately regulated point of access to veterinary antimicrobials, enabling widespread over-the-counter sales [2, 3]. In-depth interview with key informants indicated that, in areas where professional veterinary services are limited, farmers frequently self-diagnose and purchase these drugs directly for self-treatment, with minimal guidance on appropriate product choice, dosage, duration, and withdrawal periods [28].

FGD participants described a common "trial-and-error" pathway in which farmers first self-treat their animals using products purchased from Agrovet shop or other suppliers based on their previous experience or advice from their fellow farmers, and only consult animal health professionals when the initial treatment fails. Professional advice was reported to be infrequent; instead, farmers often rely on guidance from fellow farmers and drug sellers or suppliers, and some perceive themselves to have limited technical knowledge when selecting and administering antimicrobials. This finding is consistent with that reported by Kiambi et al. [29] in Kenya, who indicated that where over-the-counter access and lay decision-making contribute to delayed professional consultation and higher risks of inappropriate VAMU.

Against this backdrop, the widespread over-the-counter dispensing of veterinary antimicrobials through Agrovet shop creates clear compliance gaps, because it can effectively extend into veterinary practice and advice provision by persons who may not be duly authorised. This runs counter to Section 43 of the Veterinary Act (Cap. 319, R.E. 2023), which prohibits practising as a veterinarian, veterinary specialist, paraprofessional, or paraprofessional assistant without registration, enrolment, or enlistment [30]. Similarly, the storage, supply, and sale of regulated medicines outside duly licensed premises contravenes the registered-premises requirement under Section 18(1) of Cap. 219 (now the Tanzania Medicines and Medical Devices Act, R.E. 2021). If not addressed, these regulatory and professional practice gaps among animal health providers and Agrovet shop may further elevate VAMU risks, with downstream implications for residues, treatment failure, and AMR.

The findings suggest that farmers' objectives and government objectives are not aligned; the government should therefore enforce controls to ensure safe VAMU. Consistent with recent evidence on VAMU and AMR in livestock systems, Agrovet shop and other private veterinary drug outlets remain the primary points of access to antimicrobials for farmers, and therefore play a decisive role in shaping patterns of antimicrobial use at farm level [31, 32]. At the same time, governments are increasingly recognized as the central authorities responsible for regulating and governing VAMU through policy formulation, standard setting, enforcement of regulations, and surveillance of antimicrobial consumption

and resistance trends [33]. Such an institutional arrangement is essential for promoting prudent VAMU in livestock production, protecting food safety, and minimizing the emergence and spread of AMR within a One Health framework.

Antimicrobial Waste Management

Formal institutional reviews indicate that soil and water resources are increasingly vulnerable to contamination linked to livestock production practices. In particular, the application of manure from treated animals – often in the context of inappropriate dosing and limited adherence to recommended withdrawal periods – may facilitate the release of veterinary drug residues into the environment. Results from FGDs show that livestock manure is commonly used in crop fields. One FGD participant contended that most farmers are not aware of the effect of drug residues; as such, they discard unused or expired medicines and containers through household garbage and other uncontrolled routes (Male livestock farmer in Nyamagana Municipality). Results from in-depth interviews with government officials indicate that, although institutions partly acknowledge antimicrobial waste management, they have not adequately translated these strategies into practice. This concern was further reinforced by interview findings, which revealed that:

"*…many farmers have limited biosecurity measures; for example, uncontrolled livestock manure disposal can create pathways for human exposure through water, crops, and the food chain, increasing public health risks.*" (Veterinarian, Ujiji Municipal Council, December 2024).

In Tanzania, the Environmental Management (Hazardous Waste Control and Management) Regulations [34] classify waste pharmaceuticals – including antimicrobial products such as antibiotics – as hazardous waste. These regulations require that such wastes and related effluents be treated to prescribed standards before discharge into open land, public sewers, or receiving water bodies, under a permitting and compliance regime overseen by the Vice President's Office through the National Environment Management Council (NEMC). The same is reflected in Section 8(2) and Section 19 of the Animal Diseases Act (Cap. 156, R.E. 2023) [35], which reinforce biosecurity measures by empowering veterinary inspectors to control, seize, and ensure safe disposal of animals, animal products, and potentially contaminated wastes that are moved or handled contrary to the law, and by requiring that carcasses and related wastes be disposed of only through approved methods under official direction, thereby reducing the risk of disease and antimicrobial-resistant organisms spreading through farms, water sources, and the food chain. Consistent with these findings, the literature shows that AMR bacteria, including *E. coli*, have been isolated from manure, vegetables, and fish, with patterns suggesting cross-compartment spread from manure into food and aquatic pathways [36]. These risks are amplified where farms rely on shared wells, canals, and rivers during the dry season, reinforcing the need to operationalize statutory prohibitions against discharging wastes into water sources [37]. These residue pathways are most concerning where manure and farm wastes can reach shared water sources. FGDs reported that during the rainy season some farmers easily access water from wells, canals, and rivers. Runoff, farm effluents, and improper drug disposal can introduce antimicrobial residues into these

watering points [37], exposing animals to sub-therapeutic doses that select for and spread resistant bacteria [38].

Although the Environmental Management (Hazardous Waste Control and Management) Regulations, 2021 (GN No. 389) [39] do not classify manure or litter as 'hazardous waste,' they are highly relevant where livestock-system wastes include hazardous characteristics or where expired/unused antimicrobials and certain chemical additives enter the waste stream. The Regulations establish a permitting and control system for collection, storage, transportation, treatment, and disposal (Reg. 15–16), and impose conditions to prevent spillage, scattering, and environmental harm, including tracking and safe transport requirements. These provisions indirectly contribute to mitigating risks associated with antimicrobial waste. Results from the in-depth interviews with the government officials show that although the institutions have mentioned on solid waste management, they fall short of the strategies.

"*…Environmental Management Policy has mentioned the solid waste in livestock production but the standards are not clearly stipulated*" (NEMC Key informant January 2025).

Animal Diseases Act (No. 17 of 2003) anchors animal-disease control and carcass disposal, practical, farm-level guidance for routine disposal of veterinary antimicrobial waste remains under-specified across the principal legal instruments. Whereas the TFDA Act (No. 1 of 2003) largely addresses disposal in the context of forfeited drugs, the Government Chemist Laboratory Agency Act (Cap. 177, 2016) frames veterinary antimicrobials mainly as regulated chemicals for import control, and the Public Health Act (No. 1 of 2009; Cap. 99) treats medicines waste primarily as healthcare or abattoir waste, leaving farmers and frontline practitioners without clear, actionable disposal procedures. This lack of clear disposal procedures weakens environmental stewardship within the One Health response envisaged in Tanzania's NAP-AMR 2023–2028 and sits uneasily with global evidence that unmanaged antimicrobial discharges are a material environmental driver of AMR [40].

Animal Product Safety and Food-Borne Risks

Provisions within the National Livestock Policy (Sect. 3.11.7), the Public Health Act (Part V on food hygiene and safety), the Animal Diseases Act (Sections 8(2) and 19), and the Tanzania Medicines and Medical Devices Act (Sections 54 and 58) collectively recognise the need to ensure the safety of animal-source foods prior to consumption through veterinary public health services, inspection systems, disease control, and regulation of veterinary medicines. However, these provisions are more explicit on general food safety than on antimicrobial-specific risks. In response to this gap, the National Action Plan on Antimicrobial Resistance prioritises "strengthening surveillance of antimicrobial residues in food of animal origin and the environment" (Strategic Objective 3), although implementation remains constrained by limited laboratory capacity and resources, a challenge widely documented in low- and middle-income countries [1].

Evidence indicates antimicrobial residues in animal-source foods are widespread in Tanzania, reflecting poor adherence to withdrawal periods and weak surveillance. A recent review reported detectable

antimicrobial residues in beef (35–71.1%), milk (1.7–42. %), eggs (up to 100%), and chicken meat (50–90.5%) across formal and informal markets, with a substantial proportion exceeding recommended safety limits [41]. These findings highlight the ongoing human exposure risk through food consumption pathways. During FGD, several farmers acknowledged that, despite knowing about withdrawal periods, they were reluctant to withhold livestock products because doing so would lead to income loss. Direct residue studies also provide quantitative evidence of current contamination. In a cross-sectional analysis of broiler chicken liver tissues in Dar es Salaam, 10 % of samples contained tetracycline residues and 21. % contained sulphonamide residues, with 90. % of the samples exceeding the acceptable daily intake (ADI) for tetracyclines and 13. % exceeding maximum residue limits (MRLs), indicating significant food safety concerns associated with non-observance of withdrawal periods [1].

Overall, while the institutional framework provides a foundation for food safety through inspection and regulatory control, it does not fully translate into effective antimicrobial-specific quality assurance. This gap allows both environmental and food-borne pathways to persist. Strengthening residue surveillance, enforcing withdrawal compliance, and improving hygiene and inspection systems particularly at slaughterhouses, milk handling facilities, and egg production points are essential to ensure that animal-source foods do not become a pathway for antimicrobial resistance transmission within the One Health framework [41–43].

Regulatory Authorities

The Tanzania Medicines and Medical Devices Authority (TMDA) plays a central role in safeguarding public and animal health by regulating the manufacture, importation, distribution, and sale of regulated products, including veterinary medicines. In this mandate, TMDA conducts inspections of manufacturers and business premises and issues permits and licences for premises handling regulated products. In particular, domestic manufacturing facilities and importing wholesale premises for human and veterinary medicines are registered and licensed by TMDA. Thus, TMDA should be commended, as it supports prudent VAMU through a range of complementary regulatory functions. These include evaluating and granting marketing authorisation for products before they enter the market, conducting laboratory testing to verify product quality, and implementing pharmacovigilance and post-market surveillance to detect and respond to safety and quality problems in products already in use. The Authority also promotes rational use by providing regulatory information and education to stakeholders and the wider public. Section 54(2) of the TMDA Cap 219 (The Tanzania Medicines and Medical Devices Act, R.E. 2021) establishes the official register with Part II relating to veterinary drug products, providing the legal basis for controlling which veterinary antimicrobials can be supplied or used. However, in-depth interview with government officials indicated that the informal market pathways for veterinary antimicrobials persists, suggesting limited regulatory oversight. According to Mdegela et al [44], antimicrobials sold through informal pathways are often unregistered and therefore cheaper, yet their quality is difficult to verify because the trade occurs outside routine monitoring and remains challenging for regulators to access. Since farmers are rational producers, they usually opt for unregistered, cheaper drugs in situations of limited regulations enforcement.

Related to the above, Section 58 (1) of the TMDA Cap 219 [45] empowers the Minister to make regulations to prohibit, control, or restrict the manufacture, possession, sale, or use of drugs or substances – a basis that can be used to restrict non-therapeutic use. Equally, Part VII on promotion, Sections 95–96 of the Act enables regulation of promotional activities and restricts misleading advertising; also limits advertising of certain products to professional channels including veterinary sector. This supports control of marketing that could encourage non-therapeutic use. Contrary to the "rule of the game", investigation of antimicrobial labels and inserts sold at the Agrovet shop revealed non-therapeutic indications. FGD accounts suggest that VAMU is often embedded in routine on-farm decision making, rather than being consistently guided by antimicrobial labels or veterinary oversight. [29] contends that non-therapeutic indications are uses of antimicrobials not meant to cure a diagnosed infection, but to support routine production and risk management. They include giving antimicrobials for "prophylaxis" (preventing disease before animals are sick), for "growth promotion" (boosting weight gain or feed efficiency), and for "improving egg production" (maintaining or increasing laying performance). In practice, as argued during FGD, farmers claimed that they may administer antimicrobials even when animals appear healthy using them not only for treatment, but also to keep livestock performing and to reduce the chance of anticipated disease outbreaks linked to stress, crowding, hygiene gaps, or seasonal risk. This further implies that farmers may use antimicrobials as a substitute for good husbandry compensating for gaps such as weak biosecurity, overcrowding, poor sanitation, inadequate nutrition, and limited vaccination rather than addressing the underlying management problems that drive disease risk. Strategic Objective 5/stewardship ("Optimize the Use of Antimicrobial Agents in Human and Animal Health") of the 2023–2028 National Action Plan on Antimicrobial Resistance, embraces strengthening the regulatory system and reviewing policies, laws, regulations and developing guidelines for VAMU in animals, supporting the operational pathway for implementing restrictions on non-therapeutic use. For example, section 2.5 clearly underlines that the use of culture and antimicrobial susceptibility testing (AST) to inform treatment has remained extremely low as such treatment decisions are often not guided by laboratory confirmation through AST. Therefore, diagnosis underpins the rational use of antimicrobials. Section 3 of the Animal Diseases Act (Cap. 156, Revised Edition 2023) [46] mandates the Director of Veterinary Services (DVS) to establish and maintain a national veterinary laboratory system and a national epidemiological system for disease control. Pursuant to this mandate, the Tanzania Veterinary Laboratory Agency (TVLA) established in 2012 [30], is responsible for diagnosing animal diseases, regulating veterinary laboratories, conducting research on diseases and vectors, and developing vaccines and other biologicals. TVLA-managed laboratories provide diagnostic services to the veterinary administration and livestock producers, including fee-based testing. However, the laboratories are limited and not easily accessible by farmers due to long distance as well as the associated costs.

Although the Grazing Land and Animal Feed Resources Act No. 13 of 2010 (GLAFA, 2010) empowers the Director responsible for grazing lands utilisation and animal feed resources acting as the "Competent Authority" to regulate and control the use of feed additives, Tanzania's governance of VAMU in animal feed and related feed resources remains weak, leaving the country lagging behind in VAMU regulation.

For-example, Section 3 of the Act, defines “feed additives” to include substances used to “provide a medicinal effect” in animal feed this is the clearest hook for in-feed medicated feeds. This was evidenced during the FGDs, where farmers acknowledged that on-farm feed formulation by farmers themselves and by unregistered local feed formulators is a common practice. As a result, certain feed additives, including coccidiostats and antibiotics, may be incorporated into animal feeds without veterinary prescription or oversight, increasing the risk of inappropriate VAMU. When delivered through feed, these products can be administered at low concentrations over extended periods, which may increase selection pressure for AMR compared with short-course therapeutic use at higher doses under veterinary oversight.

From a theoretical perspective, the National Livestock Policy (2006) emphasizes the need for an efficient veterinary laboratory system capable of delivering adequate services for effective disease control and quality assurance of animal products. Therefore, such services include proper choice of the antimicrobials. The National Livestock Policy (2006) also acknowledges persistent constraints in veterinary public health and food safety, notably limited knowledge, inadequate infrastructure and facilities, weak technical support and inter-institutional collaboration, and low stakeholder awareness. In addition, in-depth interview findings further revealed that limited financial resources constrain the ability to conduct quality compliance monitoring, as explained by two of the interviewed government officials:

“*…limited laboratory infrastructure underscores the need for government investment to restore and enhance facilities, ensuring reliable access to diagnostic services”* (TVLA key informant, November 2024).

“*…TMDA regularly conducts post-market surveillance…however, in my view the number are few due to limited financial resources…*” (Officer, TMDA December 2024).

The findings suggest that the regulatory authority’s effectiveness in governing VAMU is shaped not only by its own mandates and capacity, but also by external factors beyond its direct control. In this regard, their technical capacity can be enhanced if they receive financial support from the national government and/or development partners. Research findings by [47] and [48] indicate that law enforcement may become unsuccessful due to the lack of capacity of enforcers. Key informant interviews revealed that financial constraints contribute to an influx of unregulated veterinary products, leading to the widespread availability of substandard and falsified medicines. Observational findings further showed antimicrobial product labels promoting non-therapeutic uses such as stress reduction, prophylaxis, and productivity enhancement which suggests that regulatory bodies in Tanzania have not yet established effective standards to regulate the use of antimicrobial growth promoters in livestock production systems [2, 27, 49].

Discussion

The findings have indicated that Tanzania has an extensive legal – policy architecture for animal health, animal health services, and medicines regulation; however, the governance of VAMU at farm and market level remains constrained by fragmented mandates, weak enforcement capacity, limited diagnostic

access, and existing informal supply pathways. These constraints contribute to non-prudent VAMU, thereby increasing selection pressure for AMR. Further results reveal a persistent implementation gap whereby formal rules of the game are not consistently translated into practice at the last mile where farmers obtain advice and products. In such settings, VAMU is shaped by cumulative everyday decisions which are rarely visible to regulators unless a surveillance, inspection, and accountability system is sufficiently resourced and decentralised. In addition, the findings underscore that the differences in reliance on veterinarians versus para-veterinarians observed in this study reinforce how local service ecosystems influence VAMU.

This pattern suggests that where professional veterinary access is constrained, para-professionals and informal providers become the default interface between policy and practice. Unless governance strategies explicitly incorporate these front-line actors, the most well-designed laws and strategies can fail to shape real-world VAMU [50]. A key implication is that paraprofessionals and Agrovet shop attendants are not peripheral to VAMU governance; they are de facto gatekeepers. Registration of Agrovet shop premises varied across the study areas, and qualitative accounts suggest that formal compliance does not always translate into effective control; even licensed outlets may be staffed by clerks with limited veterinary training, and over-the-counter sales of antimicrobials remain common, undermining the practical force of prescription-only rules. This pattern is consistent with evidence that Agrovet shop and other retail outlets are major access points for veterinary antimicrobials in Tanzania and often enable farmer self-treatment without professional referral or a prescription [28, 51, 52]. It also aligns with findings that informal advice networks and retail vendors strongly influence antibiotic decision-making in livestock systems [51].

The results further imply that antimicrobials may be used as a substitute for weak husbandry. Where biosecurity, housing, nutrition, vaccination coverage, and hygiene are inadequate, antimicrobials become an all-purpose risk-management tool. From a governance perspective, this reframes the policy problem from farmer misuse alone to the structural deficits that make antimicrobials the most accessible solution. The findings have further indicated that the Environmental Management Act, Cap. 191 (R.E. 2023) [39] and the Animal Diseases Act Cap. 156 (R.E. 2023)[46] provide broad provisions on solid, hazardous waste management and disposal of animal wastes, including directions for disposing animal wastes and handling veterinary-related wastes. However, because these provisions are not explicitly framed around AMR risk control, they can leave an under-governed pathway in practice. This means that farmers can normalise uncontrolled disposal practices, including the use of manure in crop fields, which increase the environmental dissemination of antimicrobial residues and resistant organisms. Environmental antimicrobial residues from wastewater, agricultural runoff, and contaminated ecosystems create selective pressure that drives the emergence and persistence of resistant bacteria. These residues, together with resistant microorganisms and resistance genes, form environmental reservoirs that facilitate their spread between humans, animals, and ecosystems, thereby reinforcing and sustaining antimicrobial resistance [53, 54]. Research from elsewhere shows that a large share of veterinary antimicrobials is excreted in faeces and urine, making manure and slurry application an

important environmental exposure pathway that can support persistence and spread of residues and resistance [10, 55, 56].

Additionally, the findings show that having regulatory authorities overseeing antimicrobial supply chains and compliance of the animal health workforce, alongside institutions supporting interventions such as laboratory services and feed management, is essential for promoting prudent VAMU in livestock production. The authors found that the animal health workforce and facilities are overstretched, with limited financial facilitation – an aspect that hinders regular monitoring of veterinary antimicrobials as per [11] guidelines. Research elsewhere indicates that the effectiveness of quality standards depends on their enforcement, which in turn depends on political will [57, 58]. Since the primary purpose of VAMU limits is to safeguard the environment and protect public health; including reducing antimicrobial contamination and the spread of antimicrobial resistance (AMR), we argue that compliance with the VAMU guidelines supports the prudent VAMU in livestock production. The presence of regulatory authorities governing antimicrobials indicates the availability of institutional structures that can be strengthened for veterinary VAMU in livestock production systems. The United Republic of Tanzania's NAP-AMR 2023–2028 is structured around six strategic objectives: strengthening governance and coordination; improving awareness and education; strengthening surveillance and research; reducing infections through IPC, sanitation/hygiene and on-farm biosecurity; optimising antimicrobial use (including stewardship and regulatory measures); and promoting sustainable investment in AMR solutions, with key roles for relevant national authorities across the One Health sectors [22]. Therefore, if well managed through antimicrobial stewardship, judicious VAMU is achievable, helping protect public health and reduce AMR [59]. Nevertheless, negative views by farmers on the use of livestock manure in fertilizing soil for food crop production should not be ignored. The use of the resource is associated with health risks if appropriate measures are not in place [60]. Acknowledgement of limited animal health services and animal health facilities/infrastructures in the reviewed institutions is of limited importance if there is lack of coordination among the sectors on how to mitigate risks associated with AMR.

Policy implications

Antimicrobial resistance is a major global public health threat. This study's findings from Ujiji and Nyamagana Municipalities reveal specific, recurring gaps in the governance of veterinary VAMU in Tanzania: weak enforcement of licensing and prescription rules, over-the-counter sales through Agrovet shop, limited diagnostic support, fragmented One Health coordination, and unmanaged environmental disposal of antimicrobial residues. Based on these empirical findings, the following actionable policy implications emerge.

Most existing policies and laws address VAMU only indirectly (e.g., via general veterinary service or medicines regulation provisions). Implication: The Veterinary Act (Cap. 319) and TMDA Act (Cap. 219) should be amended to include explicit provisions for prudent VAMU – defining it, mandating prescription-only dispensing for all systemic antimicrobials, prohibiting non-therapeutic uses (growth promotion, routine prophylaxis), and requiring withdrawal period compliance. Survey findings show that 32% and

39% of the respondents do not observe withdrawal period in Nyamagana and Ujiji Municipalities respectively. A separate National Veterinary VAMU Stewardship Guideline should be developed and legally enforceable, not merely advisory.

Agrovet shop and paraprofessionals are de facto gatekeepers, yet licensing and supervision are weak. For example, only 66.7% of premises were licensed in Ujiji implying that the Veterinary Council of Tanzania and TMDA should conduct risk-based, unannounced inspections at least quarterly in high-density Agrovet shop areas. Penalties for operating without a licence or dispensing without a prescription should be escalated. This includes fines scaled to shop turnover, temporary closure, and, for repeat offences and permanent revocation. A mandatory electronic logbook for antimicrobial sales (product, quantity, buyer's farm ID, purpose) would enable traceability and targeted enforcement.

Farmers and Agrovet staff rarely use culture and susceptibility testing (AST); treatment is empirical. Implication: The Tanzania Veterinary Laboratory Agency (TVLA) should establish low-cost, rapid AST services at district or zonal level, subsidised for smallholder farmers. Mobile phone-based reporting of AST results via SMS or a simple app can shorten turnaround time. In parallel, train Agrovet attendants and paraprofessionals in sample collection and interpretation to close the knowledge-to-practice gap.

Current hazardous waste regulations classify antimicrobials as hazardous waste, but on-farm disposal practices (household waste, manure spreading) remain uncontrolled. This implies that NEMC, in collaboration with district livestock officers, should issue simple, illustrated guidelines for safe disposal of expired or unused antimicrobials. This may include designated collection points at Agrovet shop and incineration protocols for small farms. Manure from treated animals should be composted or stored for a defined period before field application to reduce residue and resistance gene load – a requirement that can be included in farm registration conditions.

Fragmented mandates across livestock, health, environment, and agriculture sectors hinder joint action. As such, the existing NAP-AMR coordination mechanism should be operationalised as a permanent, funded inter-ministerial task force with quarterly meetings, shared surveillance data related to human, animal, environmental, and a joint enforcement budget. A pilot One Health inspection team comprised of veterinary, environmental health, and TMDA officers should be tested in one municipality before national scale-up.

Farmers avoid withdrawal periods because withholding milk/meat causes income loss without compensation. Therefore, the Ministry of Livestock and Fisheries should design a small-scale insurance or compensation pilot for farmers who comply with withdrawal periods and can provide evidence such as sales records and veterinary prescription. Alternatively, create market incentives like certifying farms with low VAMU or full withdrawal compliance, allowing them to sell products at a premium "AMR-safe milk". This aligns with TDV 2050's goal of a competitive, sustainable livestock sector. Consistent with [61], this study provides evidence to inform decisions on revising existing institutions and, where necessary, establishing new, enforceable measures so that VAMU in livestock production is explicitly recognised, regulated, and embedded within a coherent One Health governance framework.

Limitations of the Study

This study has some limitations. First, the field component was conducted in two municipalities and may not represent all livestock production systems in Tanzania. Second, some survey responses relied on self-reported practices, which may be affected by recall or social desirability bias. Third, the study used mainly descriptive statistics; therefore, findings should be interpreted as exploratory evidence on institutional and practice-level gaps rather than causal relationships. Despite these limitations, triangulation across documentary review, surveys, interviews, FGDs, and observations strengthened the credibility of the findings.

Conclusions and recommendations

Improved animal health services and supporting infrastructure are identified in the reviewed institutional documents as key measures for mitigating AMR risks. In practice, however, enforcement is weak and institutional responsibilities remain poorly coordinated. There is a general mismatch between what has been indicated in the institutional frameworks and what actually occurs at the practice level. With few exceptions, the critical issues relevant to governing VAMU in the study areas are addressed only indirectly, if at all, in the various institutional frameworks. However, the rules of the game are partially implemented.

According to North [15], weak formal institutions have enabled informal practices to shape behaviour. In the context of livestock intensification and constrained access to affordable animal health services, farmers increasingly rely on self-directed antimicrobial use for perceived benefits such as disease control and growth promotion, while consumer health risks receive limited attention. At the same time, the existence of AMR-related institutions suggests that Tanzania has a foundational platform from which to operationalise “the rules of the game”; the challenge lies in the absence of clear, enforceable, and well-aligned institutional arrangements that either support good practice or deter misuse. The findings further indicate that institutions recognise access to quality animal health services as a pathway to prudent VAMU, yet inadequate access to these services continues to drive misuse.

This study argues that the limited formal recognition and institutionalisation of good husbandry and animal health practices undermine safe VAMU. Despite awareness of antimicrobial resistance (AMR) risks, farmers often misuse antimicrobials due to financial constraints and lack of compensation for losses during the withdrawal period. Institutions should explicitly position prudent VAMU as a core strategy for reducing AMR-related public health risks and strengthen multisectoral governance through enforceable measures that promote biosecurity, sanitation, and responsible VAMU, thereby preserving antimicrobial efficacy. Accordingly, the study recommends revising or establishing institutions to close identified governance gaps and to embed clear, implementable, and enforceable provisions regulating VAMU in livestock production.

Abbreviations

AMR
Antimicrobial resistance
AMU
Antimicrobial use
AST
Antimicrobial susceptibility testing
FAO
Food and Agriculture Organization of the United Nations
FGD
Focus group discussion
GCLA
Government Chemist Laboratory Authority
GLAFA
Grazing-land and Animal Feed Resources Act
KII
Key informant interview
NAP-AMR
National Action Plan on Antimicrobial Resistance
NEMC
National Environment Management Council
NLP
National Livestock Policy
TMDA
Tanzania Medicines and Medical Devices Authority
TVC
Tanzania Veterinary Council
TVLA
Tanzania Veterinary Laboratory Agency
VAMU
Veterinary antimicrobial use
WOAH
World Organisation for Animal Health

Declarations

Declaration of generative AI and AI-assisted technologies in the manuscript preparation process

During the preparation of this work the author(s) used a large language model (DeepSeek) in order to improve grammar, language, and readability. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the published article.

Ethics approval and consent to participate

Administrative authorization for field access and data collection was granted by the Permanent Secretary, President's Office – Regional Administration and Local Government (PO-RALG), Dodoma, Tanzania, following the introductory letter issued by the Office of the FAO Representative in the United Republic of Tanzania for the researcher. The introductory letter was issued under reference number OSRO/URT/166/USA and dated 12 August 2024. The letter described the work as a short-term consultancy under the Global Health Security project and requested support to access relevant institutions, places and documents for surveys, interviews, focus group discussions and consultations with relevant stakeholders.

The authors clarify that the above authorization was an administrative/introductory approval for conducting the field activity and was not an institutional review board (IRB) or research ethics committee approval. No separate ethics committee/IRB reference number was issued. In accordance with the applicable local institutional requirements for this minimal-risk, non-clinical social science and governance study, separate ethics committee review was not required because the study involved adult stakeholders only and did not involve clinical intervention, biomedical procedures, collection of biological specimens, access to medical records, or collection of personally identifiable health information. The study was conducted in accordance with relevant local legislation and institutional requirements.

Verbal informed consent was obtained from all participants before data collection. Participants were informed about the purpose of the study, voluntary participation, confidentiality, anonymity, data use, and their right to decline to answer any question or withdraw from the interview or discussion at any time. Verbal consent was documented in the study tools before surveys, interviews and focus group discussions. No names or direct personal identifiers were included in the dataset or manuscript, and findings are reported in aggregated or anonymised form.

Consent for publication

Not applicable. The manuscript does not contain identifiable individual person's data, images, or videos.

Availability of data and materials

The datasets supporting the conclusions of this article are available in the Zenodo repository (https://doi.org/10.5281/zenodo.19629043). The repository contains anonymised farmer survey data, Agrovet shop survey data, thematic coding frameworks from interviews and focus group discussions, and documentary review extraction tables. Qualitative interview transcripts are not publicly available to protect participant confidentiality, but anonymised illustrative quotes are included in the manuscript.

Competing interests

The authors declare that they have no competing interests.

Funding

The authors received no specific funding for this work.

Authors' contributions

LEK conceptualized the study, curated the data, conducted formal analysis and investigation, developed the methodology, administered the project, prepared resources, contributed to software and visualization, and drafted and revised the manuscript. SSN contributed to conceptualization, methodology, supervision, validation, drafting, and manuscript review and editing. Both authors read and approved the final manuscript.

Acknowledgements

The authors express sincere gratitude to the livestock farmers, local leaders, district leaders, and all study participants for their cooperation, time, and support throughout the research process.

Authors' information

Not applicable.

References

1. Van Boeckel TP, Pires J, Silvester R, Zhao C, Song J, Criscuolo NG, et al. Global trends in antimicrobial resistance in animals in low- and middle-income countries. Science. 2019;365:eaaw1944. 10.1126/science.aaw1944.
2. Caudell MA, Quinlan MB, Subbiah M, Call DR, Roulette CJ, Roulette JW, et al. Antimicrobial use and veterinary care among agro-pastoralists in northern Tanzania. PLoS ONE. 2017;12(1):e0170328. 10.1371/journal.pone.0170328.
3. Caudell MA, Dorado-Garcia A, Eckford S, Creese C, Byarugaba DK, Afakye K, et al. Towards a bottom-up understanding of antimicrobial use and resistance on the farm: A knowledge, attitudes, and practices survey across livestock systems in five African countries. PLoS ONE. 2020;15(1):e0220274. 10.1371/journal.pone.0220274.
4. Davies J, Davies D. Origins and Evolution of Antibiotic Resistance. Microbiol Mol Biol Rev. 2010;74:417–33. 10.1128/MMBR.00016-10.
5. Ferraz MP. Antimicrobial Resistance: The Impact from and on Society According to One Health Approach. Societies. 2024;14:187. 10.3390/soc14090187.
6. Liu HY, Prentice EL, Webber MA. Mechanisms of antimicrobial resistance in biofilms. npj Antimicrob Resist. 2024;2:27. 10.1038/s44259-024-00046-3.
7. Caudell M, Mangesho PE, Mwakapeje ER, Dorado-García A, Kabali E, Price C, et al. Narratives of veterinary drug use in northern Tanzania and consequences for drug stewardship strategies in low-

income and middle-income countries. BMJ Glob Health. 2022;7(1):e006958. 10.1136/bmjgh-2021-006958.

8. Musoke D, Lubega GB, Obeng MB, Brandish C, Winter J, Niyongabo F et al. Knowledge, perceptions and practices on antimicrobial resistance in humans and animals in Wakiso district, Uganda: A cross sectional study. Sabiiti W, editor. PLOS Glob Public Health. 2023;3: e0002701. 10.1371/journal.pgph.0002701
9. Mutua F, Lindahl J, Grace D. Availability and use of mycotoxin binders in selected urban and Peri-urban areas of Kenya. Food Sec. 2019;11:359–69. 10.1007/s12571-019-00911-4.
10. Sanders P, Van Geijlswijk I, Bonten M, Mughini-Gras L, Van Hout J, Heederik D. Comparing human and animal antimicrobial usage: a critical appraisal of the indicators used is needed. JAC-Antimicrobial Resist. 2023;6:dlae005. 10.1093/jacamr/dlae005.
11. FAO and WOAH. Guidelines on monitoring antimicrobial use at the farm level (Regional series, Vol. 5). 2024. Available from: https://openknowledge.fao.org. Accessed 20 Apr 2026.
12. Sabatino R, Sbaffi T, Corno G, Cabello-Yeves PJ, Di Cesare A. The diversity of the antimicrobial resistome of lake Tanganyika increases with the water depth. Environ Pollut. 2024;342:123065. 10.1016/j.envpol.2023.123065.
13. Mayenga EL, Edward CP, Kagaruki P, Salah T, Benju R, Nganga B, et al. Antimicrobial resistance against fluoroquinolones and cephalosporins of Escherichia coli and Klebsiella pnuemoniae in chickens entering the food chain in Mwanza, Tanzania. JMEN. 2024;12:1–5. 10.15406/jmen.2024.12.00408.
14. Mtemisika CI, Nyawale H, Benju RJ, Genchwere JM, Silago V, Mushi MF, et al. Epidemiological Cut-Off Values and Multidrug Resistance of Escherichia coli Isolated from Domesticated Poultry and Pigs Reared in Mwanza, Tanzania: A Cross-Section Study. Animals. 2022;12:835. 10.3390/ani12070835.
15. North DC. Institutions, institutional change and economic performance. Cambridge University Press; 1990.
16. Scott WR. Institutions and organizations SAGE publications. Inc USA; 1995.
17. Young OR, King LA, Schroeder H, editors. Institutions and Environmental Change: Principal Findings, Applications, and Research Frontiers. Cambridge (MA): MIT Press; 2008.
18. Hibbard R, Mendelson M, Page SW, Ferreira JP, Pulcini C, Paul MC, et al. Antimicrobial stewardship: a definition with a One Health perspective. npj Antimicrob Resist. 2024;2:15. 10.1038/s44259-024-00031-w.
19. McEwen SA, Collignon PJ. Antimicrobial Resistance: a One Health Perspective. Aarestrup FM, Schwarz S, Shen J, Cavaco L, editors. Microbiol Spectr. 2018;6: 6.
2.10
. doi:10.1128/microbiolspec.ARBA-0009-2017.
20. Velazquez-Meza ME, Galarde-López M, Carrillo-Quiróz B, Alpuche-Aranda CM. Antimicrobial resistance: One Health approach. Vet World. 2022;743–9. 10.14202/vetworld.2022.743-749.

21. URT. National Livestock Policy. Government Printer, p55; 2006.
22. URT. The National Action Plan on Antimicrobial Resistance 2023–2028. Government Press, Dar es salaam; 2022.
23. Enahoro D, Galiè A, Abukari Y, Chiwanga GH, Kelly TR, Kahamba J, et al. Strategies to Upgrade Animal Health Delivery in Village Poultry Systems: Perspectives of Stakeholders From Northern Ghana and Central Zones in Tanzania. Front Vet Sci. 2021;8:611357. 10.3389/fvets.2021.611357.
24. Msoffe PLM, Bunn D, Muhairwa AP, Mtambo MMA, Mwamhehe H, Msago A, et al. Implementing poultry vaccination and biosecurity at the village level in Tanzania: a social strategy to promote health in free-range poultry populations. Trop Anim Health Prod. 2010;42:253–63. 10.1007/s11250-009-9414-8.
25. Williams S, Endacott I, Ekiri AB, Kichuki M, Dineva M, Galipo E, et al. Barriers to vaccine use in small ruminants and poultry in Tanzania. Onderstepoort j vet res. 2022;89:11. 10.4102/ojvr.v89i1.2007.
26. Kimera ZI, Frumence G, Mboera LEG, Rweyemamu M, Mshana SE, Matee MIN. Assessment of Drivers of Antimicrobial Use and Resistance in Poultry and Domestic Pig Farming in the Msimbazi River Basin in Tanzania. Antibiotics. 2020;9:838. 10.3390/antibiotics9120838.
27. Frumence G, Mboera LEG, Sindato C, Durrance-Bagale A, Jung A-S, Mshana SE, et al. Practices and Challenges of Veterinary Paraprofessionals in Regards to Antimicrobial Use and Resistance in Animals in Dar Es Salaam, Tanzania. Antibiotics. 2021;10:733. 10.3390/antibiotics10060733.
28. Azabo R, Mshana S, Matee M, Kimera SI. Antimicrobial usage in cattle and poultry production in Dar es Salaam, Tanzania: pattern and quantity. BMC Vet Res. 2022;18(1):7. 10.1186/s12917-021-03075-6.
29. Kiambi S, Mwanza R, Sirma A, Czerniak C, Kimani T, Kabali E, et al. Understanding Antimicrobial Use Contexts in the Poultry Sector: Challenges for Small-Scale Layer Farms in Kenya. Antibiotics. 2021;10:106. 10.3390/antibiotics10020106.
30. URT, The Veterinary A. 2003; Act No.16 of 2003; Government Press: Dar es Salaam, Tanzania; 2003. Available: https://www.mifugouvuvi.go.tz/uploads/publications/sw1595836341-The%20Veterinary%20Act,%202003. pdf.
31. Kemp SA, Pinchbeck GL, Fèvre EM, Williams NJ. A Cross-Sectional Survey of the Knowledge, Attitudes, and Practices of Antimicrobial Users and Providers in an Area of High-Density Livestock-Human Population in Western Kenya. Front Vet Sci. 2021;8:727365. 10.3389/fvets.2021.727365.
32. Sangeda RZ, Baha A, Erick A, Mkumbwa S, Bitegeko A, Sillo HB, et al. Consumption Trends of Antibiotic for Veterinary Use in Tanzania: A Longitudinal Retrospective Survey From 2010–2017. Front Trop Dis. 2021;2:694082. 10.3389/fitd.2021.694082.
33. Mhone AL, Muloi DM, Moodley A. One Health: governance and regulatory framework for antimicrobial use in Malawi. Sci One Health. 2025;4:100119. 10.1016/j.soh.2025.100119.
34. URT. The Environment Management Act, CAP 191 Regulations. Dodoma: Government Printer; 2023.
35. URT. The Animal diseasse Act; No 17 of 2003. Government: Dar es Salaam, Tanzania;; 2003.

36. Mwanza F, Komba EVG, Kambarage DM. Occurrence and Determination of Antimicrobial Resistant Escherichia coli Isolates in Fish and Vegetables as Indicator Organism of Faecal Contamination in Dar es Salaam, Tanzania. Prasad S, editor. International Journal of Microbiology. 2021;2021: 1–9. 10.1155/2021/6633488
37. Kümmerer K. Antibiotics in the aquatic environment – A review – Part I. Chemosphere. 2009;75:417–34. 10.1016/j.chemosphere.2008.11.086.
38. Manyi-Loh C, Mamphweli S, Meyer E, Okoh A. Antibiotic Use in Agriculture and Its Consequential Resistance in Environmental Sources: Potential Public Health Implications. Molecules. 2018;23:795. 10.3390/molecules23040795.
39. URT. The Environment Management Act, (CAP.191) Regulations. Government Press, Dar es salaam; 2021.
40. WHO. Global Action Plan on Antimicrobial Resistance. World Health Organization of the United Nations. 2015. Available: https://www.who.int/antimicrobial-resistance/global-action-plan/en
41. Mashauri HL, Max BL, Makweba SM, Nonga HE. Antimicrobial Residues and Food Safety: A Public Health Crisis of Concern in Tanzania. Rev Health Sci Rep. 2025;8:e71155. 10.1002/hsr2.71155.
42. Van Boeckel TP, Brower C, Gilbert M, Grenfell BT, Levin SA, Robinson TP, et al. Global trends in antimicrobial use in food animals. Proc Natl Acad Sci USA. 2015;112:5649–54. 10.1073/pnas.1503141112.
43. Ulomi WJ, Mgaya FX, Kimera Z, Matee MI. Determination of Sulphonamides and Tetracycline Residues in Liver Tissues of Broiler Chicken Sold in Kinondoni and Ilala Municipalities, Dar es Salaam, Tanzania. Antibiotics. 2022;11:1222. 10.3390/antibiotics11091222.
44. Mdegela RH, Mwakapeje ER, Rubegwa B, Gebeyehu DT, Niyigena S, Msambichaka V, et al. Antimicrobial use, residues, resistance and governance in the food and agriculture sectors. Tanzan Antibiot. 2021;10(4):454. 10.3390/antibiotics10040454.
45. URT. The Tanzania Medicines and Medical Devices Act (Cap. 219, Revised Edition 2021). Government Press, Dar es salaam; 2021.
46. URT. The Animal Diseases Act (Cap. 156, Revised Edition 2023). Government Printer, Dodoma; 2023.
47. Goodman C, Kachur SP, Abdulla S, Bloland P, Mills A. Drug shop regulation and malaria treatment in Tanzania why do shops break the rules, and does it matter? Health Policy Plann. 2007;22:393–403. 10.1093/heapol/czm033.
48. Zonabend E, Okeyo AM, Ojango JMK, Hoffmann I, Moyo S, Philipsson J. Infrastructure for sustainable use of animal genetic resources in Southern and Eastern Africa. Anim Genet Resour. 2013;53:79–93. 10.1017/S2078633613000295.
49. Fimbo AM, Maganda BA, Mwamwitwa KW, Mwanga IE, Mbekenga EB, Kisenge S, et al. Post marketing surveillance of selected veterinary medicines in Tanzania mainland. BMC Vet Res. 2022;18:216. 10.1186/s12917-022-03329-x.
50. Frumence G, Mboera LEG, Sindato C, Katale BZ, Kimera S, Metta E, et al. The Governance and Implementation of the National Action Plan on Antimicrobial Resistance in Tanzania: A Qualitative

Study. Antibiotics. 2021;10:273. 10.3390/antibiotics10030273.

51. Loosli K, Nasuwa F, Melubo M, Mnzava K, Matthews L, Mshana SE, et al. Exploring drivers of self-treatment with antibiotics in three agricultural communities of northern Tanzania. Antimicrob Resist Infect Control. 2024;13(1):94. 10.1186/s13756-024-01453-x.
52. Nthambi M, Lembo T, Davis A, Nasuwa F, Mmbaga BT, Matthews L, et al. Quantifying farmers' preferences for antimicrobial use for livestock diseases in northern Tanzania. Q Open. 2023;3:qoac032. 10.1093/qopen/qoac032.
53. Kaw HY, Yu J, Ma X, Yang Q, Zhu L, Wang W. The significance of environmentally bioavailable antimicrobials in driving antimicrobial resistance in soils. Environ Int. 2024;190:108830. 10.1016/j.envint.2024.108830.
54. Shafiq M, Obinwanne Okoye C, Nazar M, Ali Khattak W, Algammal AM. Ecological consequences of antimicrobial residues and bioactive chemicals on antimicrobial resistance in agroecosystems. J Adv Res. 2025;74:99–120. 10.1016/j.jare.2024.10.013.
55. Marutescu LG, Jaga M, Postolache C, Barbuceanu F, Milita NM, Romascu LM, et al. Insights into the impact of manure on the environmental antibiotic residues and resistance pool. Front Microbiol. 2022;13:965132. 10.3389/fmicb.2022.965132.
56. Sarmah AK, Meyer MT, Boxall ABA. A global perspective on the use, sales, exposure pathways, occurrence, fate and effects of veterinary antibiotics (VAs) in the environment. Chemosphere. 2006;65:725–59. 10.1016/j.chemosphere.2006.03.026.
57. Boakye J. Enforcement of logging regulations in Ghana: Perspectives of frontline regulatory officers. For Policy Econ. 2020;115:102138. 10.1016/j.forpol.2020.102138.
58. Short JL. The politics of regulatory enforcement and compliance: Theorizing and operationalizing political influences. Regul Gov. 2021;15:653–85. 10.1111/rego.12291.
59. Dyar OJ, Huttner B, Schouten J, Pulcini C. What is antimicrobial stewardship? Clin Microbiol Infect. 2017;23:793–8. 10.1016/j.cmi.2017.08.026.
60. WHO. What to do about resistant bacteria in the food-chain? Bull World Health Organ. 2015;93:217–8. 10.2471/BLT.15.030415.
61. WHO. Antimicrobial Resistance and The United Nations Sustainable Development Cooperation Framework. 2021. Available: https://www.who.int/publications/i/item/9789240036024

Figures

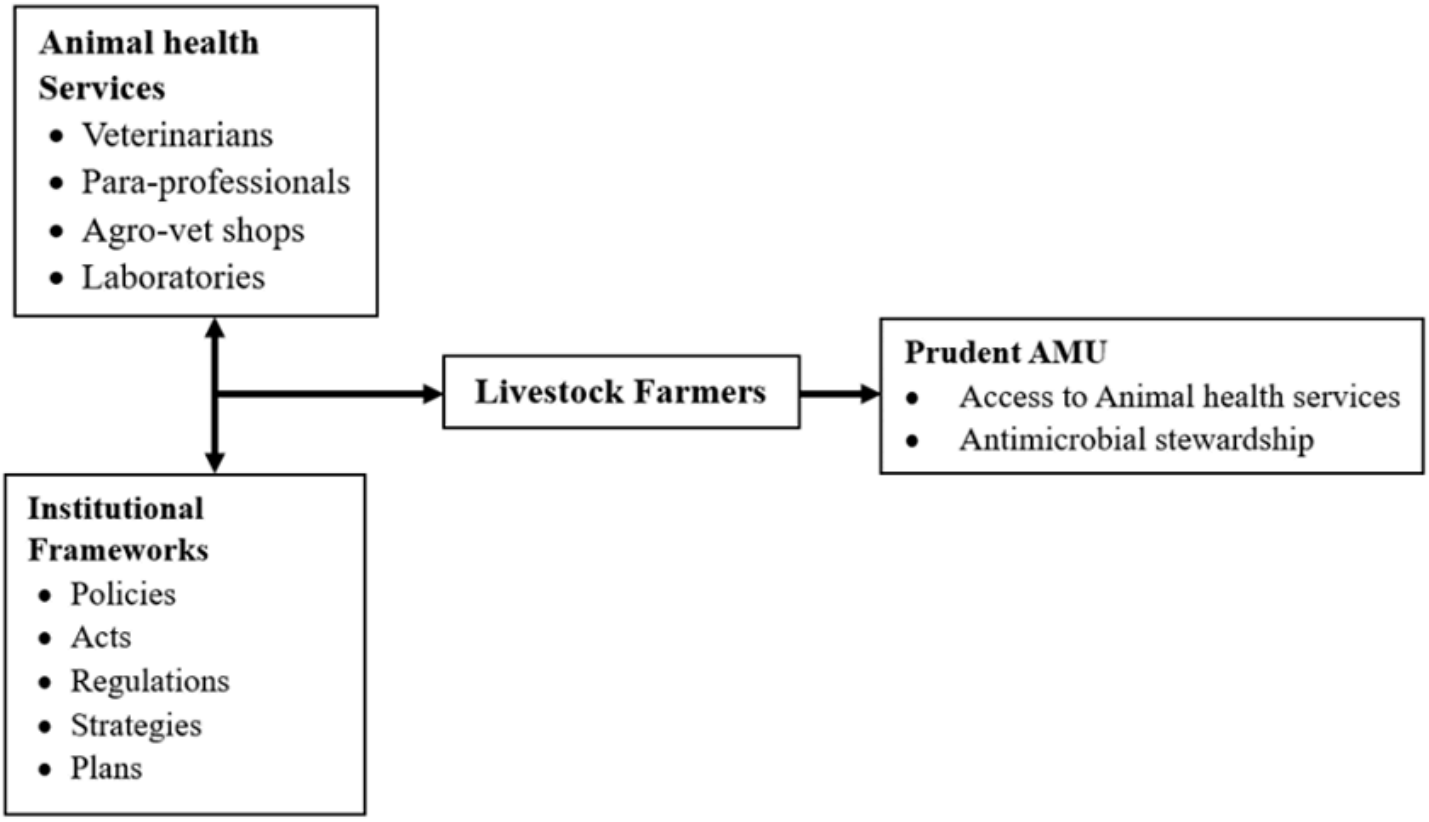


Figure 1

Conceptual framework

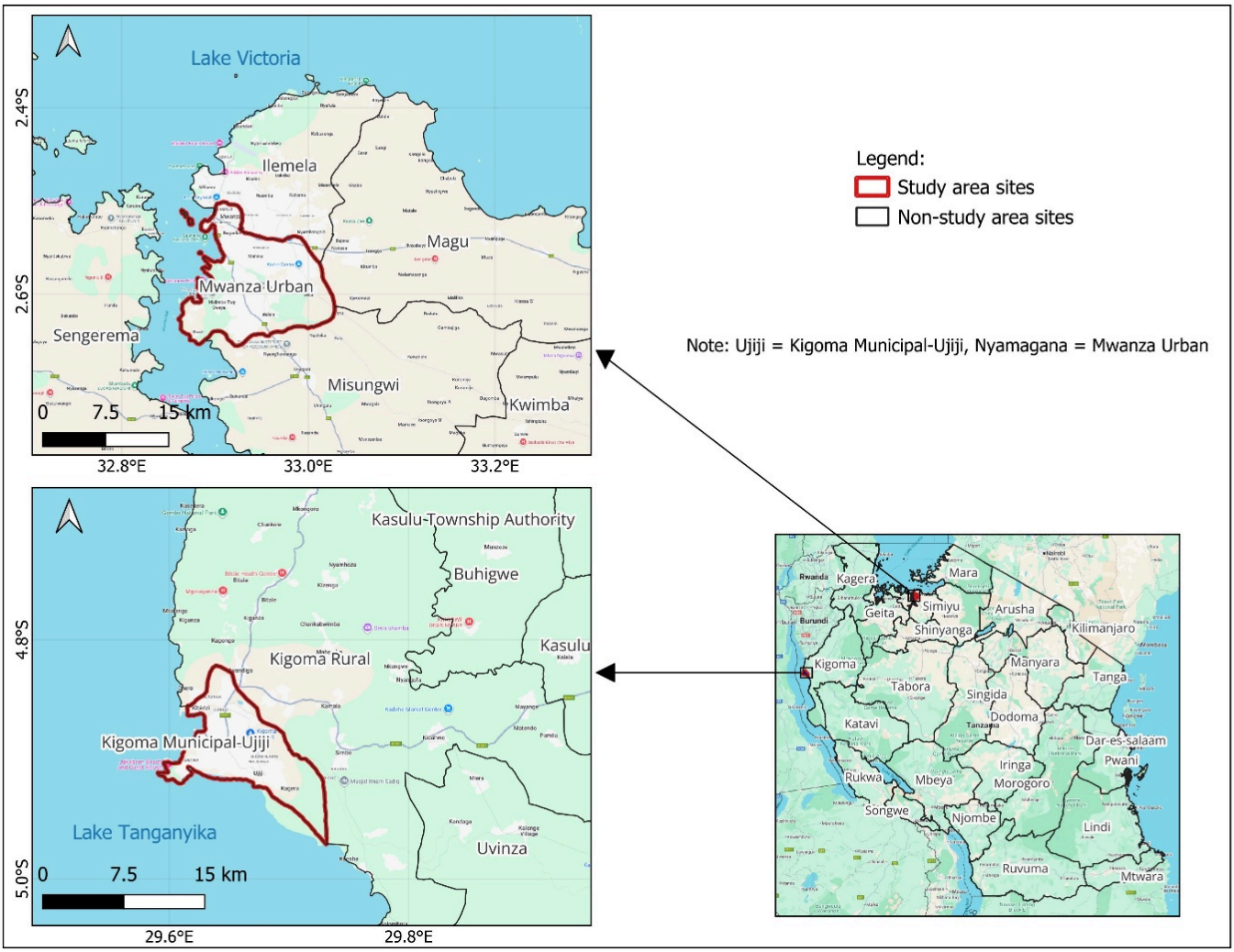


Figure 2

Study areas showing Ujiji Municipality in Kigoma Region and Nyamagana Municipality in Mwanza Region, Tanzania.

Source: Authors' preparation using GIS administrative boundary data and open-source basemap layers.

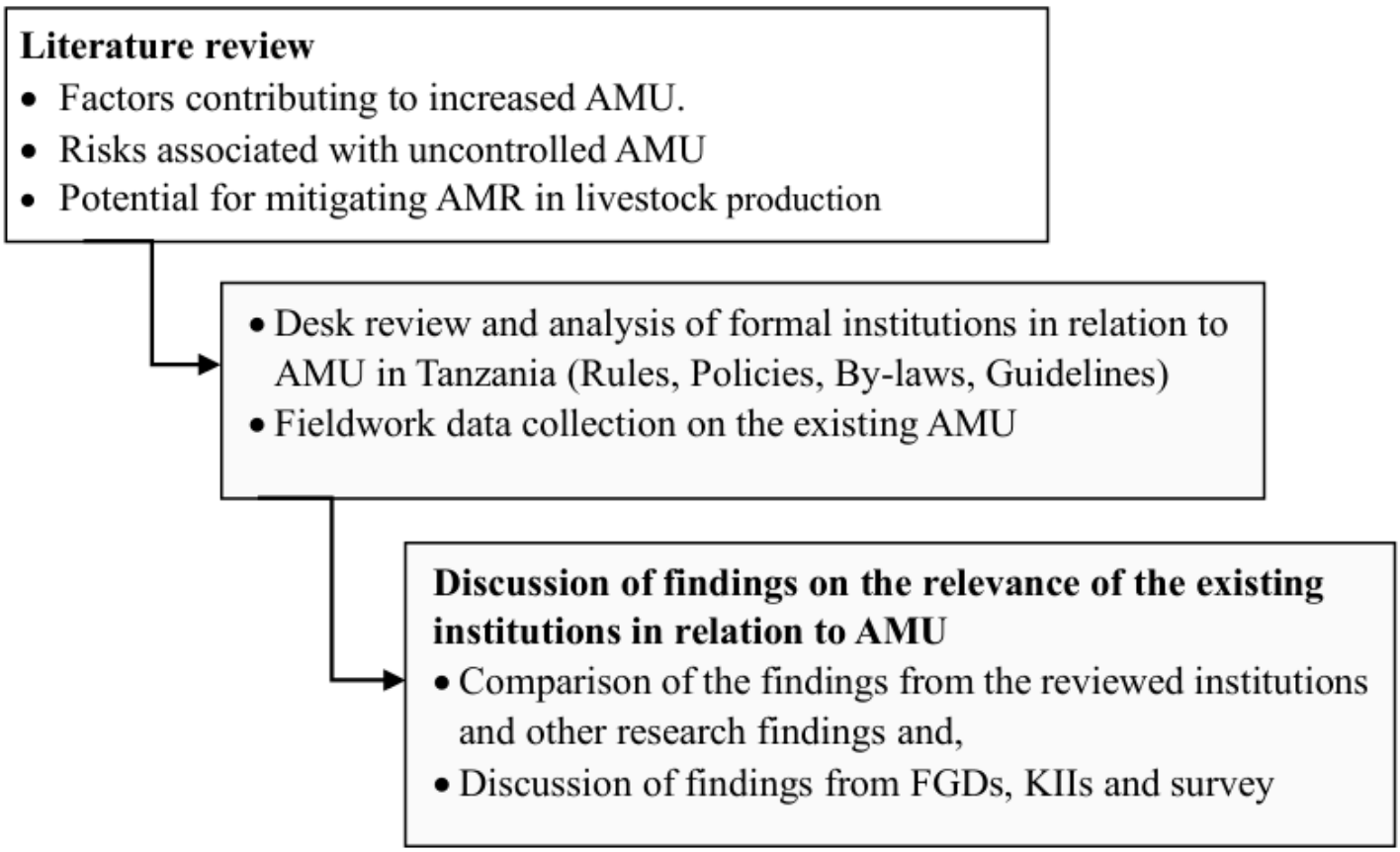


Figure 3

Analytical workflow showing the integration of documentary review, field data collection, quantitative analysis, qualitative analysis, and triangulation of findings on VAMU governance in Tanzania.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- DocumentaryReviewExtractionSummary.docx
- ThematicCodingFrameworksInterviewsFGDs.docx
- FARMERAGROVETQuestionnaires.docx