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Assessment Of The Contribution Of Livestock Production Systems To Environmental Degradation In Nyagatare District

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ABSTRACT: The study examines the impact of livestock production systems on the environment in Nyagatare district, highlighting both beneficial and detrimental effects such as soil erosion, land degradation, deforestation, and greenhouse gas emissions. Utilizing random and purposive sampling methods, it assesses 392 farmers to estimate findings for the overall population of 19,554 farmers. Through quantitative analysis, significant positive correlations are found between livestock systems and environmental degradation, with regression analysis indicating strong relationships (r=0.718, sig.004, $p<0.05$). Factors like population density, infrastructure, manure management, feed quality, and feeding frequency also exhibit moderate to strong correlations and significant relationships with environmental degradation. The study emphasizes the need for sustainable practices and policy interventions to mitigate degradation, advocating for farmer engagement in policymaking to promote environmental conservation. Recommendations focus on enhancing adaptation and mitigation practices to safeguard resources for current and future generations without compromising needs.

KEYWORDS: Contribution, Livestock production systems, Environment, Degradation, Nyagatare District

I.INTRODUCTION

The increased production and consumption of animal products in Nyagatare district have led to negative environmental consequences such as biodiversity decline, land degradation, and heightened greenhouse gas emissions. Livestock production systems directly contribute to these issues, causing air and water pollution and exacerbating biodiversity loss. Environmental degradation also impacts livestock production, making them more susceptible to diseases and reducing resource availability. This trend extends beyond Nyagatare to Rwanda, with livestock systems contributing to environmental harm nationwide. Mitigation measures include conservation agriculture and sustainable management of animal products, implemented at individual, national, regional, and global levels. The chapter provides background, problem statement, research objectives, and hypotheses, focusing on how livestock production systems contribute to environmental degradation in Nyagatare district, with implications for broader environmental management.

There are well-established methods for assessing the environmental effects of animal products, yet there's a notable scarcity of resources dedicated to assessing and ranking the potential for animal welfare within animal production systems. The lack of available tools contributes to limited information on both environmental performance and animal welfare concerns, as well as their interconnections. Consequently, there's a dearth of understanding regarding how animal production systems can adapt and progress while considering these two critical production factors.

According to UN estimates, the world's population is projected to increase from 7.2 to 9.6 billion by 2050, marking a 33% rise (UN citation). However, the Food and Agriculture Organization (FAO) in 2009 predicts a 70% increase in demand for agricultural products during the same period (FAO, 2009). The demand for animal products is expected to quadruple globally by 2050, primarily driven by rising living standards worldwide. Despite this, the total cultivated area has remained constant since 1991, suggesting efforts to intensify and enhance output (O'Mara, 2012). Livestock production systems and products play a crucial role in ensuring global food security, providing 33% of the world's protein and 17% of its calories (Rosegrant et al., 2009).

Environmental degradation severely impedes the productivity of livestock production systems, impacting factors like feed crop and forage quality, water availability, animal health and productivity, reproduction rates, and biodiversity. Worsening environmental conditions limit access to resources crucial for animal well-being and productivity. Meeting the projected 70% rise in demand for animal products necessitates expanding agricultural areas, exacerbating environmental strain. For instance, water demand due to environmental stressors is expected to quadruple. This strain on resources raises concerns about food security, especially as a significant portion of the world's cereal harvest is used for livestock feed, highlighting the interconnection between environmental degradation, livestock production, and broader agricultural systems.

The environmental impact of pet ownership, particularly in terms of carbon dioxide emissions, is notable. On average, a cat emits around 310 kilograms of carbon dioxide annually. In contrast, an average-sized dog emits approximately 770 kilograms annually, while larger dogs can emit up to 2,500 kilograms, equivalent to twice the emissions of an ordinary family car over the same period (Author, Year). However, there's potential to mitigate this impact by adopting more environmentally friendly practices in pet ownership and the pet industry, akin to sustainability efforts in other sectors such as business and fashion.

Moreover, the modern food system contributes significantly to greenhouse gas emissions, with meat consumption accounting for roughly 60%. Domestic pets' diets contribute 25–30% of the environmental damage caused by meat consumption in the United States alone. Surprisingly, the collective meat consumption by dogs and cats in the US equals that of major nations like China, Russia, Brazil, and the US combined (Jessica, 2023).

Livestock production system owners should prioritize purchasing animal feed from approved suppliers endorsed by regulatory bodies like the Rwanda Standard Board (RSB), Ministry of Agriculture (MINAGRI), and Rwanda Agriculture and Animal Resources Development Board (RAB). In aquaculture and red meat production, using insect-based pet food can be an environmentally friendly alternative, as it emits fewer carbon emissions and requires less land, water, and fuel for transportation.

Obesity in dogs and cats contributes to food wastage, with excess feed ending up in landfills, posing environmental concerns. Poor cleaning practices result in pet waste, including feces, contaminating the environment. Nitrogen from pet feces runoff can lead to the growth of invasive algae in water bodies, damaging aquatic ecosystems.

Land use changes, such as deforestation, have significant impacts on biodiversity, altering vegetation patterns, climate conditions, and atmospheric carbon dioxide levels. Research highlights land utilization changes as a primary driver of biodiversity decline, with transformations like grasslands into arable land or forests into pasturelands leading to local extinctions. Overgrazing contributes to both soil improvement and degradation, including soil compaction and erosion, impacting soil health.

Problem statement

Livestock production systems interact intricately with ecosystems, largely influenced by management techniques. Conventional systems often rely on locally available resources, such as grazing land and agricultural waste. However, this reliance leads to environmental changes, including deforestation and habitat conversion. Environmental degradation stems from feed production, processing, and transportation, alongside water pollution from husbandry practices. Rwanda's natural environment faces numerous challenges, from soil degradation to air and water pollution, driven by livestock production systems. Despite these issues, the industry holds potential for reducing greenhouse gas emissions and enhancing food security. To achieve sustainability, location-specific assessments and tailored mitigation measures are essential, alongside supportive policy frameworks (Rojas et al., 2017).

Objectives of the study

i. To assess the environmental degradation status in Nyagatare district

ii. To assess the livestock production systems in Nyagatare district

iii. Establish the relationship between livestock production systems and environmental degradation in Nyagatare district

Significance of the study

The increasing demand for animal products due to population growth is expected to exacerbate

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environmental degradation from livestock production systems. This study aims to evaluate the environmental impact of livestock production systems in Nyagatare district, providing valuable data for researchers in this field. By applying theoretical skills and research methods, the study will assess natural resources, livestock practices, and livelihood characteristics. Upon completion, the findings will contribute to the researcher's academic goals and serve as a resource for future research. Aligning with UNILAK's mission of promoting development in Rwanda, the study will offer insights for policymakers to formulate sustainable livestock policies and resource management strategies. Ultimately, the research aims to increase awareness of the environmental impact of livestock production systems and provide recommendations for sustainable practices to benefit current and future generations.

Conceptual framework of the study

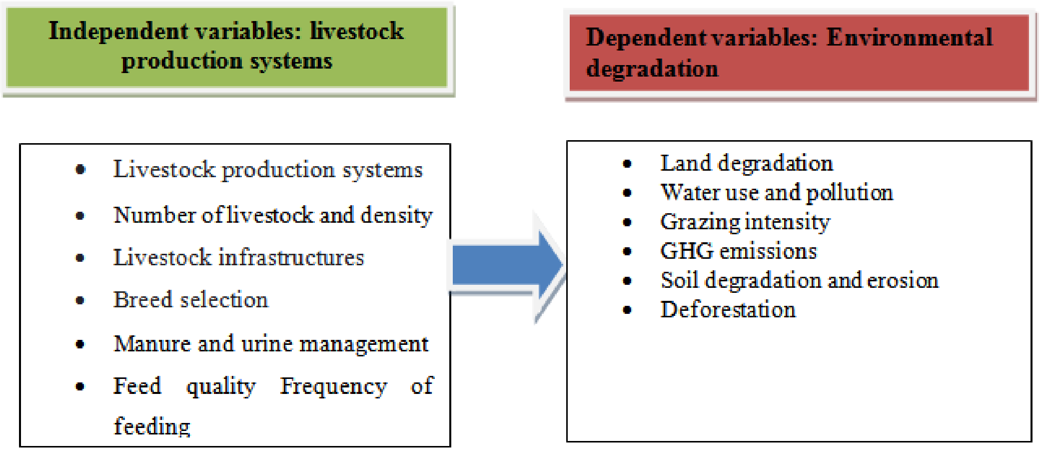

Figure1.1: Conceptual framework of the study

II.LITERATURE REVIEW

Green House Gas Emission

The beef and dairy sectors are major contributors to greenhouse gas (GHG) emissions in livestock production systems, accounting for approximately 65% of total emissions. Among individual commodities, beef cattle are the largest emitters, responsible for 41% of emissions, followed by cows and sheep (20%), pigs (9%), buffalo (8%), chicken (8%), and small ruminants (6%). Enteric fermentation is the primary source of emissions for bovines and small ruminants, contributing 43% to 63% of total emissions. In contrast, the manufacture of feed is the main emission source for pigs and hens, accounting for 25% to 27% of total emissions. Pigs have lower enteric fermentation emissions compared to ruminants due to their digestive processes (Gerber et al., 2013).

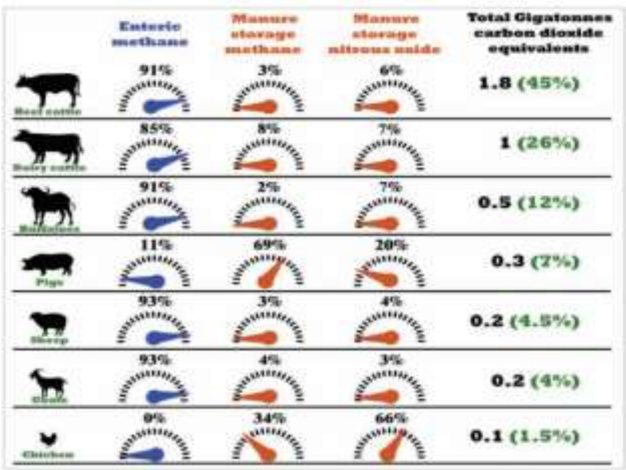

Figure 2.1.GHG incidence of enteric fermentation and manure storage by animal type, expressed as Gigatonnes of carbon dioxide equivalents (FAO, 2017).

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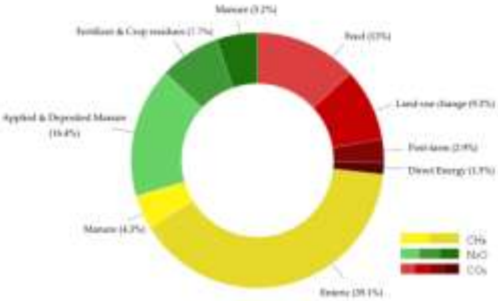

Figure 2.2: Emissions from livestock production systems by category (Gerber, et.al 2013

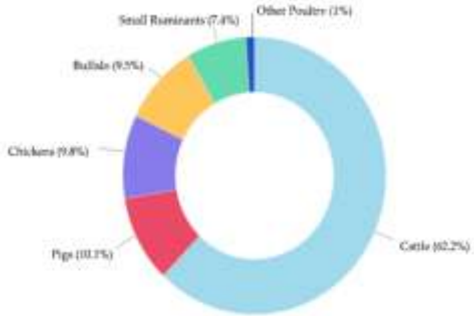

Figure 2.3: Emissions by livestock production systems per species (FAO, 2017)

Livestock production systems contribute to greenhouse gas (GHG) emissions primarily through animal husbandry practices like enteric fermentation, manure management, and associated energy use. Indirect emissions stem from land use changes linked to feed production. While some studies suggest indirect emissions surpass direct emissions, others argue the opposite. Increasing livestock production may exacerbate environmental harm due to resource depletion if not managed properly. Livestock emit CO2, CH4, and N2O, with CH4 comprising 44% of human-generated GHGs, followed by N2O (29%) and CO2. Livestock production accounts for a significant portion of human-generated N2O and CH4 emissions globally. Inefficient production practices contribute to higher concentrations of these gases due to wasted nutrients, energy, and organic matter.

Land use

The demand for animal products and byproducts has increased, resulting in changes to the natural environment. Natural habitats and forests have been replaced with agricultural land and places for animals to graze. The conversion of rich ecosystems (such as forest clearance) to pastureland, the conversion of pastureland to other uses (such as crops, urban areas, and forests), and the degradation of pastureland are the three primary trends concerning pasturelands. Many plant species and their accompanying animals, whose existence is essentially dictated by the composition of plant species, undergo local extinction when temperate grasslands are turned into arable land or tropical forests into grazing.

Roughly two thirds of the land on Earth is used for agriculture, making up 38% of the total land area. Increased livestock production systems output is expected due to factors such as population expansion, urbanization, and income growth, which are driving up demand for animals and their products. Global milk and meat output are expected to increase by 63% and 76%, respectively, by 2050 compared to 2005–2007 levels.

Consequently, grazing intensities are expected to rise by around 70%, with a nearly twofold increase in feed demand. The numerous environmental effects of the rapid growth in the production and consumption of animal products worldwide have come to light in recent years. The FAO study "Livestock production systems' Long Shadow" points out that the world's livestock production systems industry is one of, if not the primary source of, several urgent environmental problems. This essay focuses on the substantial contributions that the production of meat, milk, and eggs makes to air contaminants, shortages of water, loss of biodiversity, land degradation, and climate change, both locally and globally.

Water use

In livestock production systems farming there is need of water for drinking and for good hygiene practices which requires a lot of amount of water. An increase in global temperature leads to livestock production systems to consume more water in order to help them in thermoregulation. Once animals live in areas with abundance water or consume plants with high moisture content, they consume less water.

Systems utilised for producing livestock production systems vary in how much water each animal uses and how these needs are satisfied. When comparing vast systems to intensive or industrialised systems, the amount of water required is increased due to the effort animals must exert in search of food and water. However, because more service water is required for facilities cleaning and cooling, intensive production usually uses a lot more water overall than extensive systems. Both widespread and intensive systems' waste runoff can contaminate water; however, the concentration of cattle in intensive systems exacerbates the problem. Additionally, the processing of cattle products requires a lot of water.

Feed production

Heavy metals like copper and zinc, used in animal feed for growth promotion, pose health risks to humans and animals if they leach into the soil or water. Manure degradation can release these metals into surface and groundwater, leading to pollution, eutrophication, and habitat destruction. Excess nutrients in water can spur algal growth and fish mortality, while high nitrate levels in drinking water can cause methemoglobinemia, particularly in infants. Advanced tools exist to assess the environmental impact of meat, dairy, and egg production, guiding policymakers, industries, and consumers. Livestock production contributes significantly to greenhouse gas emissions, with nitrogenous fertilizer production being a major contributor due to its reliance on fossil fuels. Fertilizer manufacturing releases over 40 million tons of CO2 annually, with synthetic fertilizers accounting for 40% of crop nitrogen uptake. Approximately 14% of mineral fertilizer is lost to ammonia volatilization, with the cattle industry contributing around 3.1 million tons of global ammonia volatilization annually.

Animal Production

Specialization in crop and livestock production, along with the concentration of animal waste, disrupts nutrient cycles in mixed systems. Excessive dumping of manure, particularly in densely populated areas, leads to soil and water pollution. However, the geographical concentration of livestock production reduces enforcement costs and facilitates environmental policy implementation. While livestock respiration is part of the natural carbon cycle, it's not considered a net source of CO2 emissions because animals consume plants, acting as carbon sinks. Although livestock emit methane due to enteric fermentation and waste handling, they also absorb carbon through digestion, with manure and fermentation contributing to 80% of agricultural methane emissions.

Urine and manure collection

Balanced feeding is a major factor to take into account as it affects different emissions. Methane emissions are raised when feed has a lower carbon-to-nitrogen ratio; this effect increases exponentially. Methane emissions from manure with a higher nitrogen content are greater than those with a lower nitrogen content. Therefore, lowering the feed's carbon-to-nitrogen ratio can reduce emissions. Methane generation in manure storage is highly dependent on temperature. Emissions from farming methods that store manure indoors (such as pig farming with pit storage in stable cellars) may be higher than those from outdoor storage in colder climates. In temperate regions, regular and thorough evacuation of manure from indoor storage pits successfully minimizes methane emissions, provided that there is adequate outdoor storage capacity and that other precautions are taken to prevent outdoor emissions of methane. Reducing gas output can also

Additional strategies include burning or flare (chemical oxidation; burning), composting, aerobic treatment, anaerobic digestion (which produces biogas as a byproduct), and specific bio filters (biological oxidation) (Monteny et al., 2006; Melse & van der Werf, 2005). By using bacteria to ferment organic material in a closed vessel under carefully monitored circumstances, controlled anaerobic digestion produces biogas, which is normally made up of 35% carbon dioxide and 65% methane. This gas can be utilized in modified gas boilers to power internal combustion engines or generators, or it can be burned directly for heating or lighting purposes. In cool regions, biogas is thought to reduce methane emissions from manures by 50%. These manures would normally be stored as liquid slurry, which has comparatively significant methane emissions. In regions with warmer temperatures, where liquid slurry emissions of methane. As mentioned above, surface, ground, and atmospheric nitrogen (N) emissions are influenced by the urine of cattle. Hippuric acid, creatine, creatinine derivatives, urea, and other forms of purine make up the majority of that nitrogen.

Feeding energy and mineral-rich meals can lower the amount of nitrogen in urine.

People's level of awareness of environmental pollution caused by the livestock production systems industry

Environmental issues, particularly those related to climate change, remain prominent globally, yet awareness of the environmental impact of the food industry, especially livestock production systems, is lacking compared to other environmental concerns like air and water pollution. Despite awareness of the health benefits of reducing meat consumption, consumers often lack understanding of its environmental implications. Studies on consumer perceptions of food-related environmental actions reveal that reducing plastic bag usage and composting are prioritized over reducing meat consumption. European research on consumer attitudes toward pork consumption indicates varying levels of environmental awareness among different consumer groups. While heavy pork consumers tend to support large-scale production systems, those with intermediate frequency and high diversity consumption patterns show greater environmental concern. Conversely, individuals with low frequency and low diversity consumption patterns prioritize animal welfare and support small-scale production systems. Overall, consumer attitudes toward environmental quality and animal food production are relatively weak, and environmental concerns do not consistently influence consumption behavior.

Farmers' perception and adaptive capacity

A multitude of factors impede the adoption of mitigation and adaptation techniques to the changing climate, with farmers bearing primary responsibility because of their aptitude, willingness, and inclination to develop answers. This will help to address the issues of food security and the environment. It is imperative to collect data on farmers' perspectives regarding mitigation and adaptation strategies very now. In qualitative research on mitigation and adaptation, two techniques are employed for this aim to explore individual and communal attitudes: open-ended survey questions and group discussions during workshops (Barnes et al., 2008).

Social connection, education, and familial farm succession can all help farmers make better decisions by increasing their awareness of risk. Barnes (2013) used a statistical technique known as latent class clustering to evaluate the heterogeneity of risk perception among dairy producers with reference to climate change. Their findings show that family members and the impact of succession planning are significant factors in determining how risky climate change is perceived. To promote the usage of communication techniques for mitigation and adaptation to climate change measures, they proposed strengthening the social and economic assets of farming communities.

Research gap

The aforementioned empirical review assessment indicates that there are gaps in the literature's space, scope, substance, and technique. The majority of studies concentrate on how animals contribute to climate change, but they don't demonstrate how livestock production systems gradually destroys the environment. For the purposes of adaptation and mitigation, livestock production systems must be integrated into environmental degradation more effectively.

However, the purpose of this study was to evaluate how livestock production systems in Nyagatare district contribute to environmental degradation. Both primary and secondary data, as well as qualitative and quantitative data, were be used.

III.RESEARCH METHODOLOGY

Study area Description

Nyagatare, Rwanda's largest district, located in the Eastern Province, covers an area of 1741 km2. With a population of 466,944 in 2012 and 653,861 in 2023, it ranks as the second-most populous district in Rwanda, experiencing a 156% population increase since 2002. The district is characterized by grassy plains and modest hills, offering views of the southern Ugandan mountains and the Virunga volcano range. Nyagatare experiences warmer temperatures and lower precipitation compared to other regions, with an annual temperature range of 25.3°C to 27.7°C and an average annual precipitation of 827 mm. This limited rainfall, insufficient to support crop and animal needs, results in occasional droughts.

Nyagatare District, divided into 14 sectors, is bordered by Tanzania to the east, Uganda to the north, Gatsibo District to the south, and Gicumbi District to the west. The district's hydrographic network is limited, with rivers such as Akagera, Kagitumba, Ngoma, and Karungeli providing water primarily for farming and domestic use. Despite its arid climate, Nyagatare boasts diverse wildlife, including African buffalo, antelopes, hippopotamuses, Nile crocodiles, and various bird species. However, the district faces challenges in meeting the water needs of its inhabitants and animals due to the inadequate river network.

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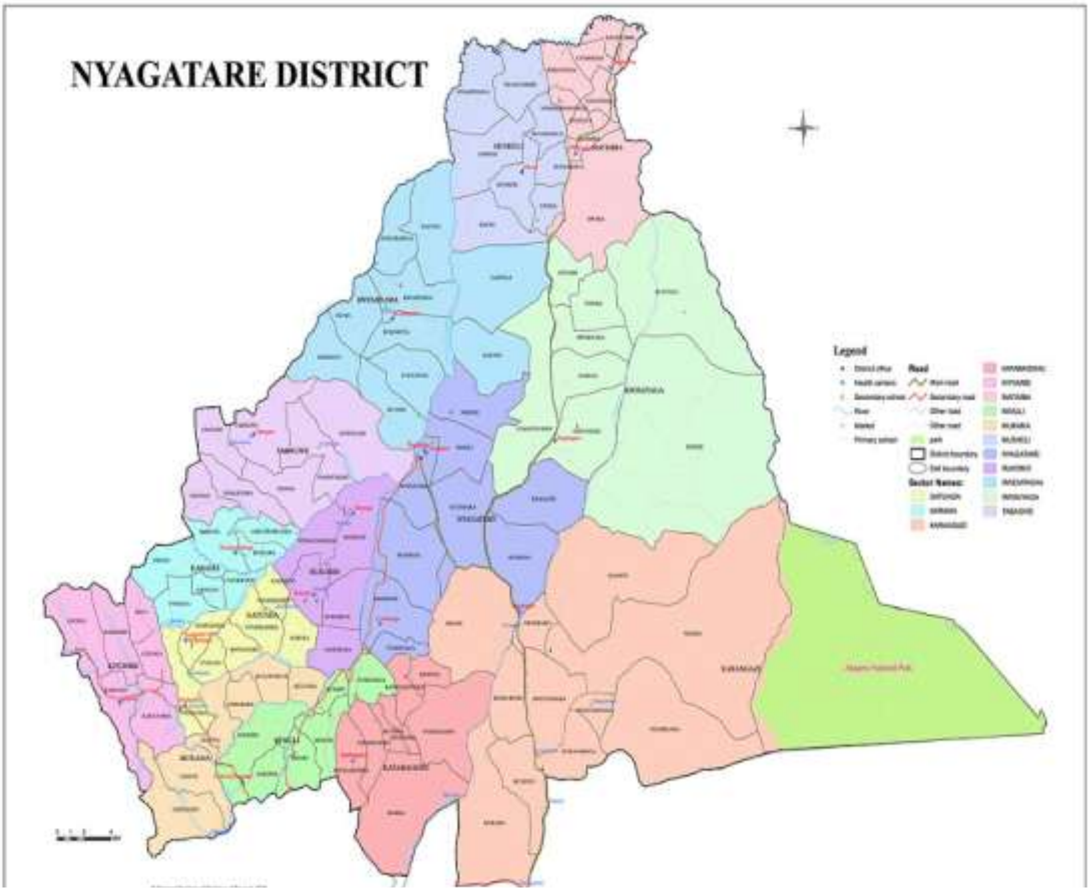

Figure 3.1. Administrative map of Nyagatare District (NISR 2022)

Research design

The nature of this study is descriptive. It is meant to explain how livestock production systems contribute to environmental deterioration in the Nyagatare district and the livestock production systems production practices that the farmers in the district were using. For this reason, the designs are both descriptive and explanatory. This study is quantitative as there were some information that were described mathematically. This study is qualitative as there was some information that were difficult or impossible to be quantified mathematically and it showed the behaviors of the farmers and the reasons why they behave like that.

Sample size and sampling techniques

As the population seems to be large, thus in place of conducting field questionnaire assessment to 19,554 farmers only 392 farmers obtained by using the following Toro Yamane formula are needed and the findings were estimated to the overall population.

$n = \frac{N}{1+N(e)^2}$= Sample People; where:

n is sample size,

N is total population,

e is margin error which may be 0.10, 0.05, 0.01 but here we used 0.05.

$n = \frac{19,554}{1+19,554(0.05)^2} = 391.9 \approx 392$

Thus in place of assessing all 19,554 farmers of Nyagatare District, only 392 farmers were consulted and survey results were generalized to the whole farmers.The purposive sampling was applied to farmers with best practices in animal rearing and their local leaders.

Source of data

In Nyagatare District, the researcher gathered primary data directly from farmers across different sectors, cells, and villages. The data collection process involved meeting with farmers individually, either randomly or purposefully selected. Both qualitative and quantitative primary data were collected. Quantitative data utilized codes linked to respondents' perceptions, while qualitative data included open testimonies, discussions, and interviews with farmers and local leaders.

This is the source of information where it concerned with checking documentary data. References to text books in library, journals, published literature, documentary and newspapers.

Data collection instruments

These instruments included documentation, interviews, and questionnaires.

Data analysis

Quantitative data analysis

To achieve the study objectives and address research questions, the researcher conducted statistical analyses including descriptive statistics and inferential statistics, specifically Bivariate Correlation analysis. Descriptive statistics such as frequency, percentages, mean, and standard deviation were interpreted using Statistical Package for Social Scientists (SPSS) to analyze the data. Bivariate correlation analysis tested the relationship between one dependent variable and one independent variable, generating a Pearson Correlation coefficient (r) ranging between ±1. This coefficient indicates the strength and direction of the relationship, with values closer to ±1 suggesting a stronger relationship. Additionally, a significance level (p-value) of $\leq$ 0.05 was used to determine whether the observed relationship was statistically significant.

Qualitative data analysis

Qualitative data analysis was considered in the case study of the contribution of livestock production systems to environmental degradation in Nyagatare district open views made on each question assessed and the researcher recorded each to ensure that the ideas are fully captured. At the end of each idea received on each item assessed, it was categorized and per each category of idea (based on the study objectives) response of respondents were summarized and ranked based on what clarified by many respondents. Due to that, the researcher later came up with a conclusion and recommendation which stand from the most repeated and insisted by respondent on each item that was assessed.

IV.RESULTS AND DISCUSSION

Background of respondents

Characteristics of farmers sampled	Frequency	Percentage
Ages of respondents		
Between 21 and 31	62	15.8
Between 31 and 41	196	50
Between 41 and 50	84	21.4
50 and above	50	12.8
Total	**392**	**100.0**
Sex of respondents		
Male	305	77.8
Female	87	22.2
Total	**392**	**100.0**
Relation of respondents to the owner of the farm/cow shed		
Owner	86	21.9
Spouse	97	24.8
Child	8	2
Brother/Sister	42	10.7
Farm keeper	159	40.6
Total	**392**	**100.0**
Marital Status of the respondents		
Single	46	11.7
Married	314	80.1
Divorced	23	5.9
Widowed	9	2.3
Total	**392**	**100.0**
Educational Level of the respodents		
Primary	207	52.9

Characteristics of farmers sampled	Frequency	Percentage
Secondary	82	20.4
First level of university	18	4.6
Second level of university	66	16.8
Masters and above level	11	2.8
Special courses	8	2
Total	**392**	**100.0**
Time in years passed after receiving the first livestock production systems.		
0-2 years	21	5.3
2-5 years	34	8.7
5-10 years	101	25.8
10 and above	236	60.2
Total	**392**	**100.0**

Table 4.1: Background of study respondents

Source: Primary data 2024

4.2.The environmental degradation status in Nyagatare district

The environment in Nyagatare District is primarily characterized by lower forests, but it faces significant risk of degradation due to high biomass consumption. Overstocking has led to the degradation of land plots, resulting in overgrazing of paddocks. Natural forests have been cleared to make way for livestock production system infrastructure, such as sheds, feed stocks, and animal keepers' houses. Additionally, natural habitats have been converted into croplands for cereals and legumes to boost production.

Water pollution is a prevalent issue, particularly in rivers where livestock freely graze. Deforestation has further exacerbated environmental degradation, leading to a loss of biodiversity as forests are vital habitats for various animal and plant species. However, efforts to improve livestock production systems include afforestation with ornamental, forest, and agroforest trees, such as legume trees used in livestock feed. These practices aim to reverse environmental degradation and promote sustainability in Nyagatare District.

Figure 4.1: Environmental degradation status in Nyagatare district

Source: Primary data 2024

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4.3. The livestock production systems in Nyagatare district

In Nyagatare district, three main livestock production systems are practiced: extensive, semi-intensive, and intensive. A survey involving 392 respondents revealed that 18.9% utilize intensive production systems, 31.9% employ semi-intensive methods, and the majority, 49.2%, rely on extensive production systems. This suggests that outgrazing on natural grasslands within small fenced areas is the predominant practice among livestock producers in the district.

Item assessed	N	Min	Max	SA+A	NS+D+SD	Mean	Stdv	Comment
The livestock production systems and farm management								
Intensive production system helps in prevention of environmental degradation.	392	1	5	89.0%	11.0%	4.31	1.45	Strong heterogeneity
Semi-intensive production system helps in prevention of environmental degradation.	392	1	5	51.0%	49.0%	4.12	0.99	Strong heterogeneity
Extensive production system helps in prevention of environmental degradation.	392	1	5	8.9%	91.1%	3.99	0.96	Strong heterogeneity
Diversification of livestock production systems within farms slows down environmental degradation, whereas the absence of multi-species farming does not.	392	1	5	59.4%	40.6%	3.47	0.87	Strong heterogeneity
Improperly adjustment of stocking rate increases environmental degradation.	392	1	5	90.6%	9.4%	3.68	0.83	Strong heterogeneity
Land degradation in livestock production systems farming results from the negligence of agroforest trees which play synergistic effect on soil properties while preventing erosion and landslides in the farms and nutrients recycling.	392	1	5	75.8%	24.2%	4.02	0.91	Strong heterogeneity
Valid N (list wise)/ Average	392	1	5	62.45%	37.55%	3.9	1.0	Strong heterogeneity

Table 4.2: Livestock production systems in Nyagatare district

Source: Primary data 2024.

The assessment of 392 respondents in Nyagatare district revealed insights into the perceptions regarding different livestock production systems and their impact on environmental degradation. The intensive production system was viewed positively by the majority of respondents, with a mean score of 4.31 and a standard deviation of 1.45, indicating its perceived role in preventing environmental degradation. Similarly, the semi-intensive production system received favorable feedback, with a mean score of 4.9 and a standard deviation of 0.99. The extensive production system was also considered beneficial, with a mean score of 3.99 and a standard deviation of 0.96.

In contrast, respondents expressed concerns about environmental degradation in relation to

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factors such as the lack of diversity in livestock species on farms, improper stocking rates, and neglect of agroforest trees. These factors received lower mean scores, indicating a perceived negative impact on the environment. For example, the lack of multi-species farming was associated with a mean score of 3.47 and a standard deviation of 0.87, while neglecting agroforest trees had a mean score of 4.04 and a standard deviation of 0.91.

Overall, the findings suggest that different livestock production systems and farming practices have varying implications for environmental degradation, as perceived by respondents in Nyagatare district.

4.4. Environmental degradations caused by livestock production systems in Nyagatare district

In this section, the researcher has assessed the environmental degradations caused by livestock production systems and noticed that there is water depletion and pollution, land degradation, loss of biodiversity, deforestation, and animal wastes deforestation and animal waste.

Item assessed	N	Min	Max	SA+A	NS+D+SD	Mean	Stdv	Comment
Environmental degradations caused by livestock production systems in Nyagatare district								
Animal manure is an environmental hazard due to its high concentration of nitrate, phosphate, potassium and ammonia.	392	1	5	77.0%	23.0%	4.16	0.92	Strong heterogeneity
Introduction of livestock production systems into any area leads to loss of biodivesisty.	392	1	5	52.6%	47.4%	3.79	1.1	Strong heterogeneity
Livestock production systems leads to water depletion and pollution.	392	1	5	92.9%	7.1%	4.95	0.99	Strong heterogeneity
Livestock production systems leads to soil degradation and erosion in the area they are raised.	392	1	5	77.6%	22.4%	3.91	0.93	Strong heterogeneity
Forests and natural habitat have been converted into areas of agriculture and areas for animal grazing.	392	2	5	97.7%	2.3%	3.77	0.86	Strong heterogeneity
Decomposition of manure can release these elements directly into surface waters or they can be reached through soil to ground water sources. This leads to eutrophication of fresh and coastal water and contamination of groundwater, and threatens the quality of drinking water and damage to aquatic and wetland ecosystems.	392	1	5	71.9%	28.1%	3.29	0.87	Strong homogeneity
Valid N (list wise)/ Average	392	1	5	78.3%	21.7%	3.97	0.94	Strong heterogeneity

Table 4.3: Environmental degradations caused by livestock production systems in Nyagatare district
Source: Primary data 2024

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The assessment of 392 respondents in Table 4.3 highlights various perceptions regarding the environmental impacts of livestock production systems. The majority of respondents expressed concerns about the environmental hazards posed by animal manure, citing its high concentration of nitrate, phosphate, potassium, and ammonia, with a mean score of 4.16 and a standard deviation of 0.92.

Respondents also noted that the introduction of livestock farming practices into any area leads to the loss of biodiversity, with a mean score of 3.79 and a standard deviation of 1.1. Additionally, livestock production systems were perceived to contribute to water depletion and pollution, as indicated by a mean score of 4.95 and a standard deviation of 0.99.

Furthermore, the assessment revealed concerns about soil erosion and degradation resulting from livestock production systems, with a mean score of 3.91 and a standard deviation of 0.93. The conversion of forests and natural habitats into agricultural and grazing areas was also highlighted as a significant issue, with a mean score of 3.77 and a standard deviation of 0.86.

These findings underscore the perceived environmental impacts of livestock production systems, including contamination of surface waters, threats to drinking water quality, and harm to aquatic and wetland ecosystems.

4.5. The relationship between livestock production systems and environmental degradation in Nyagatare district

Table 4.4: Correlation analysis between livestock production systems and environmental degradation in Nyagatare district

Correlations Coefficient analysis

		LPS	NL&D	LI	BS	M&UM	FQ	FF	ED
LPS	Pearson Correlation	1	.673	.818*	.780	.817	.842	.782	.718
	Sig. (2-tailed)		.213	.900	.825	.606	.492	.190	.004
	N	392	392	392	392	392	392	392	392
NL&D	Pearson Correlation	.117	1	.051	.149	.260	.173	.255	.383
	Sig. (2-tailed)	.623	.671	.830	.530	.268	.465	.278	.000
	N	392	392	392	392	392	392	392	392
LI	Pearson Correlation	.449*	.051	1	.443	.079	.048	.223	.630**
	Sig. (2-tailed)	.047	.830	.81	.050	.740	.842	.344	.003
	N	392	392	392	392	392	392	392	392
BS	Pearson Correlation	.189	.149	.443	1	.105	.145	.336	.505*
	Sig. (2-tailed)	.424	.530	.050		.659	.541	.147	.023
	N	392	392	392	392	392	392	392	392
M&UM	Pearson Correlation	.123	.260	.079	.105	1	.142	.038	.817
	Sig. (2-tailed)	.606	.268	.740	.659		.550	.873	.002
	N	392	392	392	392	392	392	392	392
FQ	Pearson Correlation	.163	.173	.048	.145	.142	1	.241	.585
	Sig. (2-tailed)	.492	.465	.842	.541	.550		.306	.000
	N	392	392	392	392	392	392	392	392
FF	Pearson Correlation	.306	.255	.223	.336	.038	.241	1	.924
	Sig. (2-tailed)	.190	.278	.344	.147	.873	.306		.002
	N	392	392	392	392	392	392	392	392
ED	Pearson Correlation	.269	.383	.630**	.505*	.189	.117	.029	1
	Sig. (2-tailed)	.252	.095	.003	.023	.424	.625	.904	.00
	N	392	392	392	392	392	392	392	392

*. Correlation is significant at the 0.05 level (2-tailed).

Source: Primary data 2024.

Where LPS: Livestock Production Systems,NL&D: Number of Livestock production systems and Density LI: Livestock production systems Infrastructures,BS: Breed Selection,M&UM: Manure and Urine Management,FQ: Feed Quality,FF: Frequency of Feeding,ED:Environment degradation

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The research findings indicate that Livestock production systems exhibit a strong positive correlation with Environmental Degradation (r=0.718), demonstrating a significant relationship (sig.004, p<0.05). Moreover, the number of livestock production systems and population density display a moderate correlation with Environmental Degradation (r=0.383) and a significant relationship (sig.000, p<0.05), indicating a noteworthy impact. Similarly, Livestock production systems Infrastructures exhibit a strong positive correlation with environmental degradation (r=0.630) and a significant relationship (sig.0.03). In contrast, Breed Selection shows a moderate correlation with Environmental Degradation (r=0.505) but lacks significance at sig.023. Furthermore, Manure and Urine Management demonstrate a positive strong correlation (r=0.817) but maintain a significant relationship with Environmental Degradation (sig 0.02, p<0.05). Feed Quality displays a moderate correlation with Environmental Degradation (r=0.585) but shows a significant relationship (sig.000). Lastly, Frequency of Feeding exhibits a strong correlation (r=0.924) and a significant relationship with Environmental Degradation (sig.0.000), underscoring its influential role in driving environmental impacts within Livestock production systems.

Table 4.5 Regression model summary

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	. .687[a]	.471	.464	.529

a. Predictors: (Constant), LPS, NL&D, LI, BS, M&UM, FQ, FF

The R-squared value, also known as the coefficient of determination, signifies the extent to which environmental degradation is explained by variations in livestock production systems. As depicted in the table above, the R-squared value stands at 0.471, indicating that approximately 47.1% of the variance in environmental degradation can be attributed to variations in livestock production systems,

Table 4.6. Analysis of Variance

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	8.458	7	2.48	5.365	.0012[b]
	Residual	.943	385	.045		
	Total	9.401	392			

a. Dependent Variable: ED

b. Predictors: (Constant), LPS, NL&D, LI, BS, M&UM, FQ, FF

The results shown in Table 4.6 offer a variance analysis of the regression model. According to these results, the model produced an F-ratio of 5.365 and a p-value of 0.012, both of which are below the 0.05 cutoff. This suggests that the influence of livestock production methods is statistically significant in predicting the degree of environmental degradation and implies a significant goodness of fit for overall regression model. The ANOVA section further supports this notion, indicating a substantial level of influence. With a p-value of 0.0012, the test demonstrates that the combined variables exert a significant impact on environment. Hence, the study's results imply a significant relationship between livestock production systems and environmental degradation .

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Table 4.7: Regression coefficient

Coefficients[a]

Model		Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	.797	.954		2.237	.003
	LPS	.191	.211	.063	.579	.564
	NL&D	.439	.155	.387	2.816	.006
	LI	.592	.448	.538	3.276	.002
	BS	.299	.106	.275	2.830	.006
	M&UM	.189	.138	.225	1.322	.008
	FQ	.366	.321	.455	5.813	.001
	FF	.244	.832	.562	2.708	.0023

a. Dependent Variable: Environmental Degradation

The findings displayed in Table 4.7 above illustrate the examination of the statistical significance of the independent variables within the model. This includes the estimation of the independent variables, their standard errors, and the corresponding t-ratios.

The resulting regression model was structured as follows:

Y=0.797 + 0. 191X1+ 0.439 X2+.592X3+.299X4+.189X5+.366X6+.244X7+ε

where:

X1= Livestock production systems production systems, X2= Number of livestock production systems and density, X3= Livestock production systems infrastructures, X4: Breed selection, X5: Manure and urine management, X6: Feed quality X7: Frequency of feeding and ε: Error Term: indicates factors that are not accounted for within the model.

Analysis of the regression coefficients revealed that with Livestock production systems, Number of livestock production systems and density, Livestock production systems infrastructures, Breed selection, Manure and urine management, and Feed quality held constant at zero, the projected environmental degradation rate would stand at 0.591. Notably, a one-unit increase in Livestock Production Systems would correspond to a 0.191 increase in environmental degradation, while a unit increase in Number of livestock production systems and density would lead to a higher environmental degradation by 0.439. Similarly, an increment in Livestock production systems infrastructures by one unit would result in a 0.592 rise in environmental degradation. Breed selection would contribute to environmental degradation with a 0.299 increase per unit, while Manure and urine management would elevate environmental degradation by 0.189 for every unit increase. Additionally, each unit rise in Feed quality would entail a 0.366 increase in environmental degradation, while a unit increase in Frequency of feeding would trigger a 0.244 elevation in environmental degradation.

4.6. Discussion of findings

The study examined environmental degradation in Nyagatare district, focusing on the impact of livestock production systems. It found various forms of degradation, including water pollution, land degradation, deforestation, and biodiversity loss, largely attributed to livestock rearing. Comparisons were drawn to previous research highlighting similar environmental concerns related to animal product production and consumption.

Three main livestock production systems were identified: intensive, semi-intensive, and extensive, with respondents indicating that the extensive system had a more significant environmental impact. The study established a strong positive correlation between livestock production systems and environmental degradation, emphasizing their significant relationship. Factors such as infrastructure, breed selection, and management practices were also found to contribute to degradation.

Regression analysis further supported these findings, indicating that various factors related to livestock production systems contributed to environmental degradation to varying degrees. The study underscores the importance of sustainable practices and policies to mitigate these impacts while supporting local livelihoods.

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V.CONCLUSION AND RECOMMENDATION

Conclusion

In this study we found that land use and land change such as deforestation and overgrazing due to livestock production systems management practices have impacted negatively Nyagatare districts environment. Livestock production systems generated significants amounts of waste products like manure which contaminates local water ways when improperly managed or disposed of. Large amounts water pollution when runoff entered in rivers and ground water sources and couse damage to marine life. We found that farmers which use intensive production systems are the ones who sustainably use resources and their management causes less envirinmental degradations

Recommendations

To The government and other concerned institutions

- The government and other concerned institutions should develop and enact appropriate policies that focus on interactions between livestock production systems and environment. Conservative agriculture which is environmentally friendly is used by few farmers through planting legumes and cereals for feeding their livestock; this should be applied by all farmers.
- The government should put in place technologies that improve land use and management.
- The government should conduct a lot of livestock production systems-environmental awareness campaigns.

To the farmers

- Farmers should have consistent and continuous maintenance of environment-livestock production systems management in order to solve current environmental issues.
- Farmers should use current resources sufficiently without interfering with the future needs.

To other researchers

Other researchers are encouraged to assess and evaluate the significance of livestock production systems and environmental sustainability.

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