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Review Article

Linking Climate Change Research to the Paris Agreement and NDCs: Evidence from Agriculture and Livestock Sectors in East Africa

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Abstract

Climate change is projected to have severe impacts on developing countries, including East African countries whose economies depend on climate sensitive sectors such as agriculture and livestock. While the Paris Agreement (PA) and nationally determined contributions (NDCs) emphasize both mitigation and adaptation, the extent to which East African countries align their national research agenda and policies with these frameworks remains underexplored. This study presents a systematic review aimed at analyzing the connection between regional climate research and the implementation of the PA and NDCs with a particular focus on agriculture and livestock production. A Google Scholar search conducted on March 22, 2025, identified 1,000 documents, of which 70 met the inclusion criteria. The review examines bibliometric trends and key thematic areas, including NDC commitments, geographic coverage of studies, reported climate impacts, and the alignment of adaptation and mitigation strategies with the goals of the PA. Findings reveal that climate change research in East Africa is geographically skewed, with Kenya and Tanzania accounting for most studies, while countries like Burundi and the Democratic Republic of Congo are significantly underrepresented. Drought, heat stress, and reduced rainfall were the most frequently reported climate indicators. Adaptation strategies commonly cited include livelihood diversification, improved livestock and crop practices, and irrigation. However, the effectiveness of these strategies is often constrained by limited institutional support and socio-economic barriers. Notably, mitigation in agriculture and livestock sectors receives limited attention, despite the sectors' growing contribution to greenhouse gas emissions. Moreover, most studies do not explicitly engage with NDC frameworks, indicating a weak science–policy interface. This review concludes that while significant research exists, it is unevenly distributed, lacks integration with policy, and pays insufficient attention to mitigation. To support effective and inclusive climate action, East African countries should strengthen institutional capacity, enhance policy-research alignment, and invest in underrepresented regions and low-carbon agricultural and livestock production systems.

Keywords

East Africa, Paris Agreement, Nationally Determined Contributions, Climate Change

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1. Introduction

The impact of climate change on agriculture and livestock sectors in Africa has been severe, hampering livelihoods and lives of many communities, particularly those in rural areas. Addressing and adapting to its impacts are essential for the survival and sustainability of the African continent. Nevertheless, Africa must also contribute to global efforts to reduce greenhouse gas emissions from agriculture and livestock production, despite its relatively small share in overall global emissions.

Agriculture remains the second-largest source of emissions after the energy sector [1]. These emissions lead to climate change. It is established that agricultural lands are among the leading global sources of greenhouse gas (GHG) emissions, contributing over 20% of total emissions. This challenge is particularly severe in Sub-Saharan Africa (SSA), where agricultural activities are highly dependent on climatic conditions, yet access to mitigation technologies remains limited [2]. Since agriculture is a major economic driver in many African countries, adopting climate-smart, resilient, and sustainable farming practices is essential. Making this transition offers numerous advantages, such as improved productivity, greater agricultural output, higher earnings, expanded value-chain opportunities, and the creation of lucrative jobs [1].

Moreover, Livestock sector also plays a significant role in green-house gas (GHG) emissions. The livestock production cycle contributes greatly in GHGs emissions [3]. Methane (CH_4) eructed during rumination and nitrite oxide from manure are among of the contributors of greenhouse gas emissions (GHGs). A study by [4] reported that 18% of GHGs emissions come from livestock especially ruminants such as cattle and shoats. Moreover, the study of [5] showed that livestock sector contributes about 14.5% of total GHGs. Despite some progress in mitigating and adapting to climate change impacts in agriculture and livestock sectors, efforts remain insufficient [6-10]. Thus, further emphasizing on the mitigations and adaptation are needed to be put in place. Unfortunately, the lack of adequate scientific solutions exacerbates food insecurity in SSA and globally, as this region is central to the continent's food production. Addressing these challenges requires urgent action to transform Africa's agricultural systems for a sustainable future, such as research, policy reforms on climate change and its impacts to agriculture and livestock sectors [2].

The East African region, which includes countries such as Tanzania, Kenya, Uganda, Rwanda, Burundi, the Democratic Republic of Congo (DRC), and South Sudan, is highly susceptible to the impacts of climate change, especially within its agriculture and livestock sectors. As highlighted earlier on, these sectors are critical to the livelihoods, food security, and economic stability of millions of people across the region [11]. Agriculture and livestock production are not only central to local economies but also contribute significantly to national income and employment [12].

However, these sectors are increasingly vulnerable to the effects of climate change, including rising temperatures, shifting rainfall patterns, and an increased frequency of extreme weather events such as droughts and floods. These changes directly affect crop yields, livestock health, water availability, and overall productivity [13, 14]. Thus, the Nationally Determined Contributions (NDCs) that have included mitigation and adaptation measures on Agriculture, Forestry and Other Land Use (AFOLU) were launched by CoP21 (Paris Climate Conference, 30 November-11 December 2015) [1]. The Paris Agreement, adopted in 2015, aims to limit global temperature increases to below 2 ℃, with the goal of keeping the rise even lower at 1.5 ℃. Along with these targets initiatives, the Agreement intends to strengthen the countries' ability to cop to the impacts of climate change, and emphasizes the importance of financial flows in supporting low greenhouse gas emissions and climate-resilient growth [15], where rich countries are required to pay developing countries around 100 billion USD per year as 'climate finance' to adapt to climate change. To achieve these global targets, countries are required to submit NDCs, which detail the actions they will take to mitigate and adapt to climate change [15].

In East Africa, climate change research has played a pivotal role in identifying vulnerabilities within the agricultural and livestock sectors and in proposing strategies for adaptation and mitigation [16]. Various studies have been conducted on the impacts of climate change, adaptation strategies and factors influencing the choice of adaptation strategies in different areas of SSA [10, 17-24].

The 2015 Paris Agreement represents one of the most significant global policy frameworks of the 21st century. Yet, the extent to which East African nations have aligned their national commitments to these frameworks remains unexplored. Such analysis is crucial to prevent unintended consequences when countries set targets and craft implementation strategies for the SDGs and formulate their NDCs under the Paris Agreement without coordinated, cross-sectoral planning.

According to the author's best knowledge; currently there is no review on the contribution of climate change research to implementing the Paris agreement and NDCs across the region. Thus, this systematic review explores the extent to which climate change research has informed and supported the implementation of PA and NDCs in East Africa, with particular attention to the agriculture and livestock sectors. Specifically, the review addresses the following guiding questions: (a) What NDC commitments related to the PA have been articulated by East African countries? (b) What is the geographic distribution of existing studies across the region? (c) What are the documented impacts of climate change on the agriculture and livestock sectors in East Africa? and (d) To what extent do the identified mitigation and adaptation strategies align with the objectives of the PA?

By exploring case studies from Tanzania, Kenya, Uganda,

Rwanda, Burundi, DRC, and South Sudan, the review provides valuable insights into how these countries are addressing climate change within their NDCs and the role that research has played in shaping these efforts. Furthermore, this review aims to inform policymakers, researchers, and stakeholders on the critical contributions of climate science in building climate-resilient and sustainable agricultural and livestock production systems in the region.

2. Methodology

2.1. Searching Strategy

The systematic review was conducted focusing mainly on the role of Climate Change Research in Achieving the Paris Agreement and Nationally Determined Contributions in Agriculture and Livestock Sectors of East Africa. For the purpose of this review, East Africa meant East African countries (Tanzania, Kenya, Uganda, Rwanda, Burundi, DRC, and South Sudan). The time range of searched publications in this review was ten years (from 2015 - 2025) and only original (empirical) research papers were used, while reviews, conference papers, and technical reports were excluded in this review. Other papers (non-empirical papers) were excluded to minimize the risk of bias, which leads to confounding effects in the study. In addition, only articles written in English were considered.

2.2. Data Bases, Key Words and Search String

The database used for screening (including and excluding) was Rayyan software, and search engine Google Scholar was used to search those publications. Limited access to databases such as Web of Science or Scopus in African academic institutions led to the use of Google Scholar as the main search source. In addition, in order to ensure that all relevant articles are included, manual search was performed.

The review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) procedures [25, 26]. A search was conducted on 22nd of March 2025.

To formulate the search string, the following key words and their synonyms linked with OR and different words linked with AND were used:

1) Role of climate change research: topic = (“Role” OR “roles” AND “climate change” OR “climate”, “change” AND “research” OR “researches” OR “findings” OR “studies”).
2) Achieving the Paris Agreement and Nationally Determined Contributions: topic = (“achieving” OR “attaining” AND “Paris agreement” OR “PA” AND “Nationally determined contributions” OR “NDCs” OR “NDC” OR “Intended Nationally Determined Contributions” OR “INDCs” OR “INDC”).
3) Agriculture and Livestock Sectors: topic = (“agriculture” OR “agriculture” AND “livestock” OR “agro-pastoralists” OR “agro-pastoral communities” OR “pastoralists”).
4) East Africa: topic = (“East Africa” OR “East African countries” OR “Tanzania” OR (united republic of Tanzania” OR “Kenya” OR “Uganda” OR “Rwanda” OR “Burundi” OR “Democratic republic of Congo” OR “DRC” OR “South Sudan”).

Then from the key words above, the search string was:

(“Role” OR “roles” AND “climate change” OR “ climate change” AND “research” OR “researches” OR “findings” OR “studies” AND “achieving” OR “attaining” AND “Paris Agreement” OR “PA” AND “Nationally determined contributions” OR “NDCs” OR “NDC” OR “Intended Nationally Determined Contributions” OR “INDCs” OR “INDC” AND “agriculture” OR “agriculture” AND “livestock” OR “agro-pastoralists” OR “agro-pastoral communities” OR “pastoralists” AND “East Africa” OR “East African countries” OR “Tanzania” OR (United Republic of Tanzania” OR “Kenya” OR “Uganda” OR “Rwanda” OR “Burundi” OR “Democratic Republic of Congo” OR “DRC” OR “South Sudan”). The searching of literature in Google scholar, gave 8020 results, whereby there were 1000 documents.

Thus, the papers selected (screened) were viewed if they cover those issues above and NDCs containing agricultural and livestock sectors in E.A countries, such as climate smart agriculture, climate smart livestock production, diversified livelihoods of agro-pastoralists, sustainable agriculture, policy etc.

2.3. Study Selection and Selection Criteria

Information searching, excluding, including, duplicate deletion and data extraction were carried out between March 2025 to May 2025. The retrieved literatures from Google scholar were saved, and then imported into Rayyan software for duplicate detection and deletion, exclusion and inclusion of literatures based on criteria set. Duplicates were deleted in the database. For articles to be considered eligible for this review, must mention climate change impacts to the agricultural and livestock sectors and strategies/adaptation measures/strategies for adaptation and mitigation. The database (Rayyan) was set to include research papers written in English only in the 10-year time range (2015–2025) and exclude review papers. Then after duplicate deletion, the remaining articles were subjected into screenings to obtain relevant studies. The titles and abstracts of identified publications were screened manually in the first stage of screening to determine their inclusion or exclusion in the review, whereby reasons for exclusion of the articles were given. Then the remaining, articles after the first screening, were subjected into full paper screening, in which articles were read entirely and screened to remain with articles to extract data. Equally, at this stage; the reasons for exclusion of articles were given. Then the eligible/included articles were down-

loaded and saved in pdf format for data extraction. Then, the systematic review was conducted using data extracted and recorded onto an Excel sheet.

For being eligible for the current study, each article had to meet concurrently all the three criteria: the topical focus (i.e., document dealing with climate change impacts on the agricultural and livestock sectors and strategies/adaptation measures/strategies for adaptation and mitigation), geographical location (i.e., document deals with one of the seven East African counties, Tanzania, Kenya, Uganda, Rwanda, Burundi, DRC, and South Sudan) and the type of document (i.e. document is an article (empirical paper), whereas, a book chapter; a conference paper or; editorial comments; letters to editors; reviews and notes were excluded). Generally, the inclusion criteria were:

1) Language: the article had to be written in English,
2) Study country: it should be from E.A countries,
3) Relevance: it should be related to climate change impacts on livestock and agricultural sectors, adaptation and mitigation measures taken,
4) Type of the study: it should be an empirical study (reviews, reports, notes, etc. were excluded),
5) Time range: ten years range (2015-2025).

2.4. Inclusion and Exclusion of Studies Processes

The screening processes (inclusion and exclusion of papers based on predefined criteria) were preceded by deletion of duplicates. Then, the first phase of screening process that involves screening papers based on reading titles and abstracts was conducted. Thus, after the titles and abstract screening, the remaining (included) documents were subjected to the second phase of screening/full text screening (involving reading entire papers and making decision whether to include or exclude it in data extraction). Then, included papers in the second extraction were used for data extraction along with those searched manually from other sources and gray literatures.

2.5. Type of Data Extracted

In this review, two types of data were extracted from eligible papers/articles:

1) Bibliographical data: such as author's name, study country, study year, and journal's name.
2) Thematic/topical focus area of the study: this tells information such as type study design of the articles and their sample size. Moreover, qualitative and quantitative data are extracted from the articles concerning the main themes of the study (type of agricultural system (e.g. pastoral, agro-pastoral, smallholder farmer, etc.), impacts of climate change on agriculture and livestock sectors, adaptation, mitigation strategies employed to avert the impacts, and the contribution of the study to NDCs as per PA's requirements). The Microsoft excel sheet was used for qualitative and quantitative data extraction and analyses of the finally eligible articles. The eligible articles' data were coded by using predefined typology in each topical focus areas related to this review's questions as described by [27].

2.6. Data Analysis and Synthesis

Firstly, in each country the current NDC was downloaded, then NDC targets for Agriculture and livestock were reviewed, and then those targets for each country were filtered. Subsequently, the extracted papers were evaluated to understand how climate change researchers are generating knowledge that can inform the implementation of NDCs in their respective countries.

Through the systematic review process, the author recognized that several of the selected studies employed qualitative, quantitative, or mixed-methods research approaches. Descriptive statistics (Excel 2024) were employed to summarize patterns in the publications, using categories based on the typology questionnaire. However, the use of inferential statistics was not practical because of the incorporation of mixed methods approaches in the reviewed studies [27] and due to the fact that most of data extracted were qualitative.

Microsoft Excel (version 2024) was employed for the extraction and analysis of the final set of eligible studies. Each paper was systematically coded according to predefined thematic categories derived from the review questions. The primary coding themes included: the literature-based impacts of climate change identified by the author; the study's geographical focus and sample size; the methodological approaches used to analyze determinant factors; types of experienced by respondents (i.e., climate indicators); reported impacts climate change; climate change adaptation strategies adopted by respondents; factors investigated as determinants of climate change adaptation; key determinant factors identified; and policy recommendations proposed by the studies. Based on these themes, coding categories were developed and organized accordingly. All papers were then re-examined in detail, and relevant text segments were manually assigned to the appropriate codes within Excel. The coded data were subsequently retrieved, synthesized, and compared with quantitative findings to identify the dominant adaptation strategies and the most influential determinant factors.

3. Results

3.1. Screening and Data Extraction Results

The screening processes were preceded by deletion of duplicates, whereby by a total of 30 articles were detected and deleted, remaining with 970 articles (Figure 1).

By screening titles and abstracts, 819 articles were excluded at this stage due to various reasons, (e.g. documents from outside E.A (136), documents do not relate to CC (411),

documents do not relate to the topic (167), articles not retrieved (10) and reviews (95). Thus, 151 documents remained for full text screening. Following full text screening, 95 documents were excluded because they were studies from outside E.A countries, do not relate to CC, do not relate to agriculture and livestock sectors, un-retrievable, reports and reviews (Figure 1). Thus, from full-text screening, the eligible articles for extracting data were 56 and 14 documents were added from manual searches, hence making a total of 70 eligible papers that were used in this study (Figures 1 & 2).

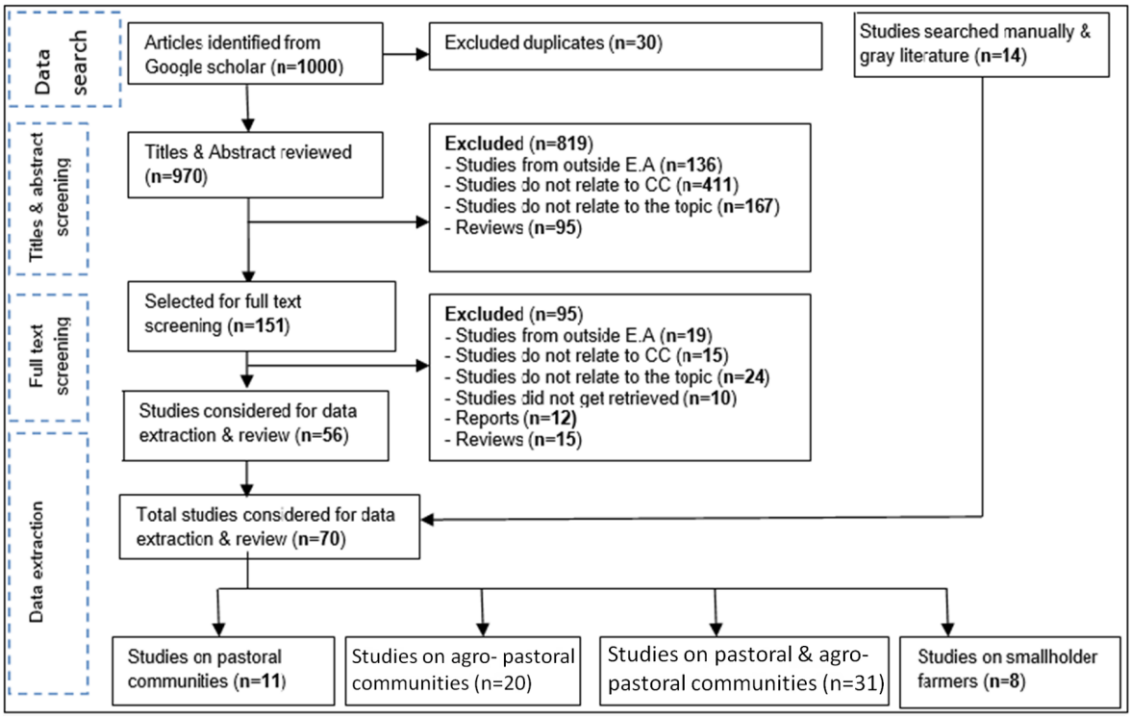
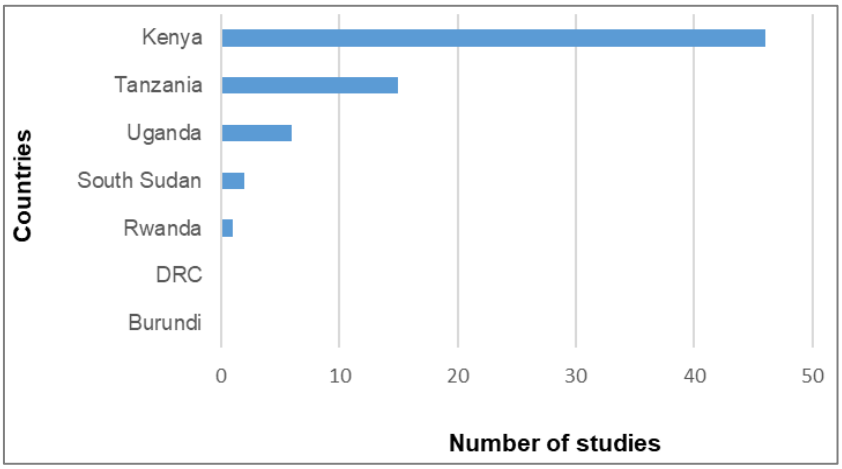


Figure 1. *PRISMA (Preferred reporting items for systematic review and meta-analysis).*

3.2. Geographic Distribution of the Studies

Of the 7 East African countries, 70 research addressing the climate change on the agriculture and livestock sectors were extracted with the following distributions: Kenya accounted for the largest number of studies, 46 (65.71%), with Tanzania following closely behind, 15 papers (21.43%), then Uganda, 6 (8.57%), South Sudan followed with 2 publications (2.86%), then followed by Rwanda, 1 paper (1.43%) (Figure 2). In this search, no any paper was obtained from Burundi, and DRC.



Note: DRC = Democratic Republic of Congo

Figure 2. *Geographic distribution of studies by countries.*

3.3. Year of Publication of the Studies

Out of 70 studies, most of the studies were published in 2018 (11 studies), followed by 2016 and 2017 (9 studies each), 2023 (8 studies). The year 2025 had the least number of papers, 1 paper (Figure 3).

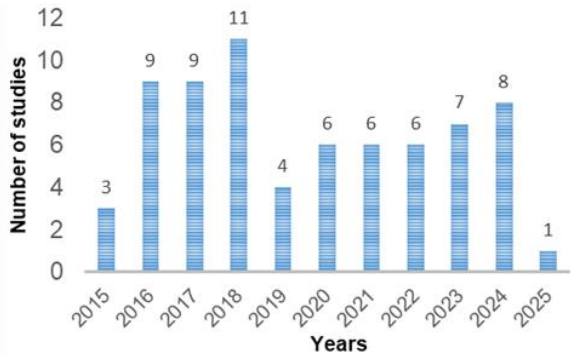


Figure 3. *Number of published studies per year.*

Table 1. *Articles included in the review.*

Year	Number of articles	Reference
2015	3	[28-30]
2016	9	[19, 31-37]
2017	9	[38-46]
2018	11	[18, 47-55]
2019	6	[56-61]
2020	4	[62-65]
2021	6	[17, 23, 66-69]
2022	6	[21, 70-74]
2023	7	[75-80]
2024	8	[81-88]
2025	1	[89]

3.4. Indicators of Climate Change

Indicators of climate change were as shown in Table 2. Out of 70 publications, 40 papers mentioned some indicators of climate change. The results revealed that the most mentioned climate change indicators were drought occurrences, high temperature, and low rainfalls.

Table 2. *Indicators of climate change.*

Indicators of climate change	Number of mentions (n=40)	Percent (%)
Drought occurrences	23	57.5
High temperature	20	50.0
Low rainfalls	19	47.5
Extreme weather events	3	7.5
Erratic rainfalls	2	5.0
High frequencies of dry spells	1	2.5
High rainfalls	1	2.5
Strong winds	1	2.5
Temperature variability	1	2.5

3.5. Impacts of Climate Change

Impacts of climate change were presented in Table 3. Out of 70 publications, 43 (61.4%) papers mentioned some impacts of climate change to agro-pastoralists in East African countries. The results revealed that the most mentioned climate change impacts were conflicts over resources and livestock-wildlife conflicts, water shortage, pest and diseases, Erratic rainfalls (e.g. rainfall distribution, delayed onset, heavy rains and low rainfall trend), food shortage, hunger and human death from hunger, agriculture and crop failures and low yield, drought and dry spells increase, shrinkage of grazing land and feed shortage as well as high temperature.

Table 3. *Impacts of climate change.*

Impact	countries							No. mention (n=43)	Percent (%)
	TZ	KN	UG	RN	BR	DRC	SSD		
Agriculture and crop failures& low yield		8						8	18.6
Aridification		1						1	2.3
Erratic rainfalls, rainfall distribution, delayed onset, heavy rains and low rainfall trend	3	7	1					11	25.6

Impact	countries							No. mention (n=43)	Percent (%)
	TZ	KN	UG	RN	BR	DRC	SSD		
Low rainfalls and decrease in rainfalls		7		1				8	18.6
Low crop and livestock production		5						5	11.6
Change of human activities patterns	1							1	2.3
Change in access to resources		1						1	2.3
Conflicts over resources & livestock-wildlife conflicts	5	8	1				1	15	34.9
Economic loss& poor livelihoods		3						3	7.0
Water contamination &poor water quality		1	1					2	4.7
Drying off water points &increase of distance to water sources	2	3						5	11.6
Water shortage	2	10	2				1	15	34.9
Pest, livestock &human diseases &health issues	5	9	1					15	34.9
Drought and dry spells increase	2	3	1					6	14.0
Ecosystem disturbance &environmental destruction	2	2						4	9.3
Extreme weather events	1	3						4	9.3
Shrinkage of grazing land and feed shortage	1	4						5	11.6
Food shortage, hunger & human death from hunger		9						9	20.9
High temperature		2		1				3	7.0
Land degradation, &land shortage	1	3					1	5	11.6
Livestock death & losses		6						6	14.0
Livestock theft		1						1	2.3
Low milk yield			1					1	2.3
Malnutrition		1						1	2.3
Rustling		1						1	2.3

3.6. Adaptation Strategies

Adaptation strategies were as shown in Table 4. Out of seventy, 55 (78.6%) studies outlined the adaptation strategies employed by pastoralists/agro-pastoralists/smallholder famers to combat climate change impacts. In this review adaptation strategies were grouped into three groups: adaptation strategies in livestock sector, adaptation strategies in crop production and livestock and crop adaptation strategies. The most dominant practiced climate change adaptation strategies in livestock sector were Economic diversification &bee keeping, livestock migration, destocking and restock, traditional grazing management and rangelands management, improved animal breed and drought tolerant animals, and feed storage and conservation. In crop production; the widely used adaptation strategies included drought tolerant trees, crops and pastures and early maturing varieties, crop diversification and intercropping, and irrigation and irrigation schemes. In both livestock and crop production, the most used adaptation strategies were water harvesting and conservation techniques, bore holes, ponds/dams and water supply, as well as shift from livestock to other economic activities.

Table 4. *Adaptation strategies to climate change employed by agro-pastoralists in East African countries.*

Adaptation strategies	**countries**							**No. mention (n=55)**	**Percent (%)**
Livestock production	**TZ**	**KN**	**UG**	**RN**	**BR**	**DRC**	**SSD**		
Economic diversification &bee keeping	3	14	2	0	0	0	0	19	34.5
Improved animal breed and drought tolerant animals	2	5	1	0	0	0	0	8	14.5
Traditional grazing management &rangelands management	2	8	0	0	0	0	0	10	18.2
Economic diversification &shift from livestock keeping	3	9	0	1	0	0	1	14	25.5
Destocking &restocking	3	9	2	0	0	0	0	14	25.5
Herd splinting & livestock sharing	3	2	0	0	0	0	0	5	9.1
Drought-tolerant animals and improving breeds	2	5	1	0	0	0	0	8	14.5
Livestock migration and mobility	6	11	2	0	0	0	0	19	34.5
Vaccination &ethnoveterinary		3	1	0	0	0	0	4	7.4
Feed storage& conservation	2	5	1	0	0	0	0	6	10.9
Rotation grazing	2	1		0	0	0	0	3	5.4
Hay purchase, &supplementary feed supply	1	3	1	0	0	0	1	6	10.9
Reseeding		2	0	0	0	0	1	3	5.4
Crop production									
Afforestation &agro-forestry	0	5	0	0	0	0	0	5	9.1
Tree planting	0	1	0	0	0	0	0	1	1.8
Land ploughing	0	1	0	0	0	0	0	1	1.8
Change of planting dates	0	3		1	0	0	0	4	7.3
Climate smart agriculture	0	2	0	1	0	0	0	3	5.4
Control soil erosion, cover crops& soil fertility	0	6	0	0	0	0	0	6	10.9
Crop diversification &intercropping	3	8	2	1	0	0	0	14	25.5
Mulching	0	3	0	0	0	0	0	3	5.4
Irrigation and irrigation schemes	1	12	0	0	0	0	0	13	23.6
Drought tolerant trees, crops and pastures &early maturing varieties	3	12	1	0	0	0	0	16	29.1
Crop rotation	0	4	0	1	0	0	0	5	9.1
Use of fertilizer and manure		3		1	0	0	0	4	7.3
Both (livestock &crop)									
Access to asset and accumulation	2	0	0	0	0	0	0	2	3.6
Alternative food and ecosystem accessibility	0	0	2	0	0	0	0	2	3.6
Bore holes, ponds/dams & water supply	0	7	1	0	0	0	0	8	14.5
Water harvest & conservation techniques	2	13	1	1	0	0	1	18	32.7
Managing floods (e.g. terraces& gabions)	0	1	0	0	0	0	0	1	1.8
Extension services & capacity building	1	2	0	0	0	0	0	3	5.4
Aids, subsidies &working for food	1	3	0	0	0	0	0	4	7.3
Early warning on weather and use of indigenous knowledge	0	2	1	0	0	0	0	3	5.4

Adaptation strategies	countries							No. mention (n=55)	Percent (%)
Livestock production	**TZ**	**KN**	**UG**	**RN**	**BR**	**DRC**	**SSD**		
Food, fodder, seeds &financial aids	1	2	0	0	0	0	0	3	5.4
Food security &storage	1	3	0	0	0	0	0	4	7.3
Shift from livestock to other economic activities	2	4	0	0	0	0	0	6	10.9
Livestock keeping, increasing livestock number & extensive cultivation	3	2	0	0	0	0	0	5	9.1
Reduced consumption	1	0	0	0	0	0	0	1	1.8
Mixed farming	0	1	0	0	0	0	0	1	1.8
Social and political organization/institutions	1	0	0	0	0	0	1	2	3.6
Educating children, & farmers' training	0	2	0	0	0	0	0	2	3.6

Notes: TZ=Tanzania, KN=Kenya, UG=Uganda, RN=Rwanda, BR=Burundi, DRC=Democratic Republic of Congo, SSD=South Sudan

3.7. Factors for Choice of Adaptation Strategies to Climate Change Among East African Agro-pastoralists

The results of factors for choice of adaptation strategies to climate change are shown in Table 5. Out of seventy, 47 (67.1%) studies outlined the factors for choice of adaptation strategies to CC by East African pastoralists/agro-pastoralists/smallholder famers. The factors were grouped into social, institutional, economic and geographic factors. In social economic factors, the most dominant ones were gender, education level of the household head, family size and land tenure. In addition, the result revealed that dominant institutional factors were access to extension services, access to climate information, access to assets, and access to market services and inputs. Moreover, economic factors showed that economic status was the most mention, followed by land and farm sizes, as well as herd size. Moreover, in geographic/environmental factor; geo-location was the only leading of all in this group.

Table 5. *Factors for choice of adaptation strategies to climate change among East African agro-pastoralists.*

Factors	Countries							No. mention (n=47)	Percent (%)
	TZ	**KN**	**UG**	**RN**	**BR**	**DRC**	**SSD**		
Social factors									
Age	0	9	0	0	0	0	1	10	21.3
Education level	0	13	1	0	0	0	1	15	31.9
Family size	1	7	0	0	0	0	1	9	19.1
Gender	3	11	1	0	0	0	1	16	34.0
Social factors									
Land tenure &ownership	1	7	0	0	0	0		8	17.0
Marital status	0	3	0	0	0	0		3	6.4
Farming experience	0	2	0	0	0	0	1	3	6.4
Year lived in the community	0	1	0	0	0	0		1	2.1
Land use change	0	1	0	0	0	0		1	2.1
Institutional factors	*0*		*0*	*0*	*0*	*0*			

Factors	Countries							No. mention (n=47)	Percent (%)
	TZ	KN	UG	RN	BR	DRC	SSD		
Access to assets and capital	1	4	1	0	0	0		6	12.8
Access to extension services	2	2	3	0	0	0	1	8	17.0
Access to climate information	1	6	1	0	0	0		8	17.0
Access to market services &inputs	1	2	1	0	0	0	1	5	10.6
Access to training & advice		2	1	0	0	0		3	6.4
Access to land &grazing land	1	1		0	0	0		2	4.3
Economic factors									
Land size & farm size		5	2	0	0	0	1	8	17.0
Herd size		4	1	0	0	0		5	10.6
Livestock ownership		2		0	0	0		2	4.3
Economic status	1	13	2	0	0	0	1	17	36.2
Geographical factors									
Geo-location		2	0	0	0	0		2	4.3
Culture		1	0	0	0	0		1	2.1
Land location		1	0	0	0	0		1	2.1

Notes: TZ=Tanzania, KN=Kenya, UG=Uganda, RN=Rwanda, BR=Burundi, DRC=Democratic Republic of Congo, SSD=South Sudan.

4. Discussion

This systematic review demonstrates that climate change research in the agriculture and livestock sectors of East Africa is unevenly distributed, with Kenya and Tanzania accounting for the majority of studies. This pattern reflects broader disparities in research capacity, donor investment, and institutional infrastructure across the region [27, 90]. The absence of studies from Burundi and the Democratic Republic of Congo highlights a critical knowledge gap that undermines the capacity to design inclusive, region-wide adaptation policies. The lack of studies from Burundi and DRC might be due to various reasons, including but not limited to; limited institutional research capacity, reduced access to international funding and underdeveloped academic infrastructure. This leads to more vulnerability to climate change impacts among agro-pastoralists in those countries as compared to their counterparts in the region. In addition, it caused low adherence to PA commitment by those countries due to limited knowledge as well as fundings to support climate change adaptation strategies. Regional cooperation under platforms such as the East African Community (EAC) and the African Group of Negotiators (AGN) requires balanced evidence from all countries to ensure that NDC implementation strategies are both equitable and representative [91].

A striking finding is the prominence of drought, heat stress and reduced rainfall as the most reported climate change indicators in reviewed studies. While this aligns with observed and projected climate trends in East Africa [92], the emphasis on drought risks oversimplifying the multi-hazard nature of climate risks. Emerging threats such as flooding, pest outbreaks and livestock diseases remain underexplored in the reviewed literature [93, 94]. Neglecting such compound risks may constrain the ability of adaptation strategies to effectively safeguard food security and rural livelihoods.

The adaptation measures reported such as agro-pastoral diversification, crop and livestock management, feed conservation, irrigation and the use of drought-tolerant species of crop, pasture and livestock mirror well-established climate-smart agriculture practices [95, 96]. However, the review indicates that these strategies are mediated by socio-economic factors, including access to credit, extension services, education, and weather information. This supports findings from other African contexts, which show that adaptive capacity is shaped not only by technology adoption but also by governance quality, institutional support, and social capital [97, 98]. Consequently, national policies should integrate both technological and institutional dimensions to ensure that adaptation strategies are sustainable, scalable, and inclusive.

Importantly, the disconnect between research and NDC processes is evident. While many reviewed studies implicitly inform NDC adaptation priorities, few explicitly situate their

findings within the NDC framework. This reflects a weak science–policy interface, where research outputs are insufficiently translated into actionable policy insights [99]. Bridging this gap requires knowledge co-production platforms, participatory policy dialogues, and deliberate efforts by governments to align academic research with NDC monitoring and reporting mechanisms [91]. Without this alignment, East African countries risk underutilizing scientific evidence in climate negotiations and in the design of sector-specific adaptation pathways.

Another dimension is the temporal distribution of research, with a concentration of studies around the period of the first NDC submissions (2016–2018). This surge suggests that international climate policy processes stimulate academic interest but that momentum is not always sustained. Long-term investment in climate research and monitoring, independent of negotiation cycles, is crucial for informing successive NDC revisions and enhancing adaptive learning [100]. Furthermore, the review reveals that most studies rely on qualitative or descriptive approaches, with limited use of integrated, interdisciplinary methods. Combining biophysical data with socioeconomic and policy analysis would provide a more holistic understanding of adaptation outcomes, particularly in relation to gender, equity, and intergenerational justice [101, 102].

Finally, the findings emphasize the urgency of amplifying East African research within global climate discourse. The region contributes minimally to global greenhouse gas emissions yet experiences disproportionate climate risks [92]. Strengthening regional scientific visibility not only supports evidence-based policymaking but also enhances Africa's negotiating position under the Paris Agreement. Systematic reviews such as this can contribute by synthesizing fragmented research, highlighting priority gaps, and guiding investment toward under-researched geographies and adaptation domains.

5. Conclusion

This systematic review set out to assess how climate change research contributes to advancing the goals of the Paris Agreement and the implementation of NDC within East Africa's agriculture and livestock sectors. The findings show that although considerable research has been undertaken on climate impacts, adaptation practices, and influencing socio-economic factors, there are still notable shortcomings in geographic coverage, emphasis on mitigation, and the practical integration of research into policy frameworks. A disproportionate volume of studies originates from Kenya and Tanzania, leaving countries such as Burundi, the Democratic Republic of Congo, and South Sudan underrepresented. This imbalance may undermine region-wide climate planning efforts and highlights the need for more equitable distribution of research resources and capacities.

The evidence gathered also reveals that climate change is affecting agriculture and pastoral systems in complex and far-reaching ways including declining yields, water shortages, pasture degradation, disease outbreaks, and resource-related conflicts. In response, agro-pastoral communities have adopted a variety of coping mechanisms, such as improved livestock management, crop diversification, and water conservation techniques. However, the scale and effectiveness of these adaptation strategies are often limited by systemic constraints such as weak institutional support, inadequate access to climate services, poor infrastructure, and socio-economic inequalities.

A critical insight from this review is the limited attention given to mitigation research in the agricultural context, despite the sector's growing role in greenhouse gas emissions. Current research predominantly focuses on adaptation, with relatively little effort directed toward low-emission agricultural innovations or livestock-sector mitigation pathways. This oversight needs to be addressed, particularly in light of the growing pressure for countries to meet global mitigation targets and develop resilient, low-carbon food systems. Equally important is the observation that many climate-related studies do not directly engage with national NDC frameworks or the broader objectives of the Paris Agreement. The weak alignment between scientific research and policy development presents a missed opportunity to ensure that climate actions are grounded in evidence. Enhancing the contribution of research to NDC formulation, implementation, and monitoring is essential for building coherent and effective climate responses.

6. Recommendations

The review highlights an urgent need for East African countries to enhance the integration of climate research into policy and planning, especially within the agriculture and livestock sectors. Although a growing number of studies address climate change impacts and responses, there is limited evidence that these findings are actively shaping national climate commitments. To address this gap, it is essential to establish structured mechanisms such as national climate information centers or research-policy interface platforms that facilitate the flow of scientific evidence into decision-making processes. Government ministries responsible for agriculture, livestock, and the environment should adopt formal protocols requiring the use of up-to-date research to guide the implementation and periodic revision of their NDCs.

A further concern is the geographic disparity in research coverage, with Kenya and Tanzania contributing the bulk of published studies, while countries like Burundi, DRC, and South Sudan are scarcely represented. This imbalance reflects unequal access to funding, weak institutional capacity, and limited academic infrastructure in some parts of the region. To rectify this, regional organizations such as the East African Science and Technology Commission should lead efforts to fund targeted research initiatives and foster collaboration

across national borders. Strengthening research capacity in underrepresented countries will promote more inclusive and regionally coordinated climate responses.

The review also reveals that research on climate mitigation in agriculture and livestock systems is severely lacking, despite the sectors' substantial contributions to greenhouse gas emissions. While many studies focus on adaptation, there is a growing need to explore and invest in mitigation strategies. These could include innovations such as improved animal feeding practices, sustainable manure management, agroforestry, and climate-smart land use techniques. Governments and donors should allocate resources toward such research and integrate the findings into national development plans, carbon market readiness strategies, and mitigation components of NDCs. Lastly, integrating research findings into national Monitoring, Reporting, and Verification (MRV) systems will enhance accountability and learning. Many East African countries struggle to assess the effectiveness of their climate interventions due to weak tracking systems. To improve this, research institutions and statistical agencies should be formally engaged in developing and updating NDC indicators, analyzing climate impacts, and evaluating outcomes. Establishing standardized tools for measurement and reporting will allow governments to make data-driven adjustments and ensure alignment with long-term climate goals under the Paris Agreement.

7. Limitations and Future Research

This review excluded non-English literature and gray literature, which may have excluded valuable policy briefs or local innovations not captured in peer-reviewed publications. Furthermore, the focus on only empirical studies may have omitted conceptual or theoretical insights that could enrich understanding. Future studies should include a broader range of documents and explore interdisciplinary approaches to climate solutions in the agriculture and livestock sectors.

Abbreviations

AFOLU	Agriculture, Forestry and Other Land Use
BR	Burundi
CC	Climate Change
CCA	Climate Change Adaptation
CH_4	Methane gas
DRC	the Democratic Republic of Congo
EA	East Africa
GHG	Greenhouse gas
KN	Kenya
NDCs	Nationally Determined Contributions
PA	Paris Agreement
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
RN	Rwanda
SSA	Sub-Saharan Africa
SSD	South Sudan
TZ	Tanzania
UG	Uganda
USD	United States Dollar

Author Contributions

Dominico Benedicto Kilemo is the sole author. The author read and approved the final manuscript.

Conflicts of Interest

The author declares no conflicts of interest.

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