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A Protocol for a Systematic Review

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Abstract

The sub-Saharan African (SSA) region has a large livestock population but low productivity and animal source foods consumption which contributed to nutritional problems. Climate change further reduces productivity, impacting the livelihoods of the rural poor who largely rely on livestock. The agri-food system of SSA is characterized by small holder traditional family farms, poor technological uptake, poor infrastructure, poor veterinary services, and weak adaptability to climate effects. Owing to the unique challenges in climate change and agri-food system interface in SSA, contextualized evidence is very important to design interventions. We aimed to synthesize evidence on the pathways linking climate to livestock production and animal source food consumption in SSA context. Understanding the pathways linking climate change to livestock production and consumption in SSA is essential for formulating strategies that enhance food security, improve nutrition, and support rural livelihoods while mitigating and adapting to the impacts of climate change.

The incoming systematic review will be based on a previously developed systematic map. In the previous systematic map, we searched eight bibliographic databases, institutional website, conducted web-based search, and used citation snowballing to capture all relevant studies. The search was carried out in English and focused on SSA contexts wherever applicable. The search results were imported into Rayyan and screened for relevance based on title, abstract, and full text. At each stage of the screening process, the numbers of studies included and excluded were recorded. From the included studies of the systematic map, we will filter primary, empirical, quantitative articles conducted 2000 and onwards and use for this systematic review. We will extract the main findings of the articles along with key study characteristics and potential sources of heterogeneity. Included studies will be subjected to JBI's quality appraisal checklists. A narrative synthesis of data from all studies included in the systematic review will be generated to describe the existing evidence along with study findings. Where data are suitably comparable, quantitative synthesis (meta-analysis) will be performed.

INTRODUCTION

Since the inception of climate data recording in 1850, 2023 has been recorded as the warmest year in the planet's history[1]. The trends in climate change are more concerning than ever, pushing us into uncharted territory. Climate change stands as the planet's[1] greatest existential threat[2], with widespread occurrences of droughts, hurricanes, wildfires, floods, and other extreme events being direct environmental impacts of this crisis. These events further push for devastating impacts on habitats of the planet, crop failures, species extinction, the appearance of uninhabitable regions, and animal and human climate related risks. The impacts of climate change are more pronounced in lower and middle income countries[3,4].

Africa experienced its warmest year for the 31st consecutive year in 2023[5]. The rising temperatures in Africa are alarming for several reasons: first, the continent's baseline climate is already warmer, with monthly temperatures consistently above average; second, the rate of temperature increase is higher; and third, Africa's temperature is nearing a tipping point[6]. While Africa contributes little to global greenhouse gas emissions, it remains one of the hardest-hit regions by climate change impacts.

Sub-Saharan Africa's economy relies heavily on agriculture, with crop production and livestock rearing as key pillars. Livestock alone accounts for up to 40% of agricultural GDP[7]. Approximately 70% of rural poor populations in SSA depend on livestock for their livelihood[8]. Livestock provides nutritious protein, acts as a safety net during income shocks, offers agricultural input, and serves as a savings mechanism[9,10]. This resilience is crucial in the face of climate-induced shocks, threatening food security and rural livelihoods.

SSA, despite harboring a quarter of global livestock and 16% of cattle population, contributed to only 6% and 2.6% of the global meat and milk supply[11]. The discrepancies in the number of livestock and productivity are attributed to smallholder traditional livestock production, poor infrastructure and technology, higher burden of disease and poor veterinary care, and climate change[12]. Meat and offal provided only 3% of dietary energy in African countries[13]. While African livestock contributed to greenhouse gas emission, the SSA contributed only 3.8% of the total global emissions[14]. This percentage contribution as a continent is lower than that of some individual countries owing to limited industrialization in Africa.

Climate change can adversely affect livestock health and productivity. For example, heat stress can lead to decreased feed intake, lower reproductive performance, and increased mortality rates[15]. Additionally, changing climates can exacerbate the incidence of diseases and parasites, further compromising animal health. As human populations grow, the demand for livestock products is expected to rise, highlighting the importance of understanding the potential impacts of climate change on livestock systems[16]. The rising demand for animal proteins, combined with adverse environmental factors, necessitates the development of effective climate change adaptation strategies. The bidirectional relationship between agriculture and climate underscores the need for holistic approaches that address both climate change's impacts on livestock and livestock's contributions to climate change mitigation and adaptation.

The SSA region faces unique climate challenges, including higher baseline temperatures and rapid temperature increases, compounded by significant agri-food system issues. Given these unique challenges at the intersection of climate change and the agri-food system, contextualized evidence is crucial for designing effective interventions. Our aim is to synthesize evidence on the pathways linking climate change to livestock production and animal source food consumption in the SSA context. Understanding these pathways is essential for formulating strategies that enhance food security, improve nutrition, and support rural livelihoods while mitigating and adapting to the impacts of climate change.

Stakeholder Engagement

The topic of this systematic review was developed in response to an open call for funding by the International Livestock Research Institute (ILRI) under the Climate Impact Platform. The call focused on understanding the impact of climate change across various chains of the agri-food systems—from production to consumption. The draft protocol at the systematic map stage was presented to the CGIAR Climate Community of Practice (COP) and inputs incorporated to refine the mapping protocol.

OBJECTIVES OF THE REVIEW

Objectives

Despite the abundance of reviews on the impacts of climate change on livestock production[17–19], there is a lack of systematic evaluations of these pathways, to the authors' knowledge. The objective of this forthcoming systematic review is to synthesize the existing evidence on the effect of climate change on livestock production and animal source food consumption.

This systematic review will synthesize evidence about the various effects of climate change on livestock production and animal source food consumption in SSA. We will summarize evidence on various outcomes and draw a synthesized possible causal diagram of all available evidence. This will encompass both the direct and indirect effects of climate change on the two outcomes (production and consumption).

Definitions of the Question Components

The main question of the incoming systematic review is what are the direct and indirect impacts of climate change on livestock production and consumption? This work aims to synthesize studies investigating the effects of climate change on livestock production and the subsequent impacts on consumption. It will utilize the PEO framework—Population, Exposure, and Outcome—within the context of SSA, and it will address multiple outcomes.

Our exposure is climate change; climate change encompasses the following concepts; global warming, climate variability, temperature change, Temperature-Humidity Index/heat stress, precipitation, rainfall variability, extreme weather events (drought and flooding).

Our population is SSA agri-food system in livestock production and animal source food consumption landscape.
The outcomes are either livestock production or animal source foods (ASF) consumption. Livestock production includes breeding, mortality, destocking, livestock diversity, milk/meat/egg yield, meat/milk/egg quality, herd size, flock size, calving, litter size, rustling, livestock fertility, abortion, carcass size, body weight, cattle/milk/meat/egg transport, meat/milk/egg storage, income from livestock/products. ASF consumption is defined as meat/milk/egg consumption, and we include patterns and changes such as: dietary shift of ASF, dietary pattern of ASF, diet diversity concerning ASFs, animal fat/protein consumption, nutritional quality of ASFs, social acceptability, and affordability.

METHODS

Search strategy

This systematic review protocol has been developed in accordance with ROSES reporting guidelines[20]. The incoming systematic review will be based on previous published systematic map protocol21 and the systematic map (Additional file 1). Briefly, to explore all available evidence on potential pathways, we used climate change-related substrings, as well as terms related to production, consumption, and context in the systematic map. We utilized quotation marks for multi-word search terms, wildcards, and Boolean operators in our search strategy. Given our team's capacity, language filters were applied to include only English-language documents. There were no restrictions on the year of publication in the systematic map. The types of publications encompassed original articles (both empirical and modeling studies), and reviews. The detailed search string for each database is provided in Additional file 1 and Additional file 2.

Search Databases

We searched Web of Science Core Collections, Scopus, PubMed, CAB Abstracts, AGRICOLA, OpenAlex, Lens.org, and HINARI bibliographic databases. We conducted a Google Scholar web-based search using study keywords by using Publish or Perish Software22 to download and collate the first 500 search results and add them to search results from the bibliographic databases. In addition, we used a simplified version of the search strategy to search the CGSpace website for grey literature. Results were added to other search results for screening. We conducted a snowballing process by evaluating the bibliographies of the included studies (including reviews) using Citation Chaser (https://estech.shinyapps.io/citationchaser/), and identified additional eligible studies for the systematic map. Forward citation searching was conducted as well, Additional file 1.

Comprehensiveness of the Search

To assess the comprehensiveness of our search, we compiled a list of 25 references considered relevant for the systematic map previously, based on the authors' expertise (Additional file 3). We verified whether these indexed articles were captured by our search strategy, including academic bibliographic searches. When benchmark studies were missing from our overall search results, we adjusted our search strategy, refining terms and substrings, to achieve comprehensive retrieval. Our search strategy was able to retrieve these studies from three databases (Additional file 3).

Search Update

We do not anticipate any updates to the search strategy due to the limited time available for this study. We will proceed with the existing search results and focus on comprehensive analysis of the studies identified in the initial search. This decision is made in the interest of balancing thoroughness with timely delivery of results.

Screening Strategy

The search results were exported to Rayyan Software23 and duplicates were removed for the systematic map. Detailed inclusion and exclusion criteria were inserted into the software. We screened search results at three stages, title, abstract and full-text stage. During the title and abstract screening, articles were screened by at least one of the reviewers after a consistency check and double screened at the full-text stage.

Inclusion and Exclusion Criteria

Our previous systematic map included primary studies (either observational or experimental, empirical, modeling, or forecasting), and various types of reviews. We used the FAO's definition24 and applied modifications for livestock species eligibility: we included livestock used for meat, milk, or egg consumption (Table 1). We proposed pathways from climate change to livestock production and consumption. The objective of this systematic review is to explore evidence on these pathways. Causal links in the opposite direction are not eligible. For example, the effects of livestock production on climate change or the impact of animal source food consumption on climate change are not the objectives of this study. From the list of included studies of the systematic map, we will applythe following filters; 1) we will include studies conducted at and after 2000, 2) to ascertain causal evidence/association we will include only quantitative studies, 3) exposures leading to climate change (e.g. CO2 emission) will be excluded, 4) we will include full text primary empirical studies only. Table 1 provides a summary of the inclusion and exclusion criteria.

Table 1: Summary of Inclusion and Exclusion Criteria

Components	Included	Excluded
Document Type	Empirical primary studies (either observational or experimental)	Opinion pieces, books, book chapters, theses, conference proceedings, policy briefs, retracted papers, protocols, qualitative studies, errata, and titles without an abstract and full text, and various types of reviews (systematic reviews, review of reviews, umbrella reviews, narrative reviews, mini-reviews, and meta-analyses)
Climate change	Climate change, climate variability, global warming, rising temperature, changing precipitation, rainfall, flood, drought	Greenhouse gases including CO2 emission
Livestock production	Any livestock, cattle, cow, ox, ruminants, sheep, goat, camel, chicken, buffaloes, pigs, ducks, geese, rabbits, guinea fowl, pigeons, production, breeding, mortality, destocking, rustling, mobility, livestock diversification, shift/preference to specific livestock, milk/meat/egg yield, meat/milk/egg quality, herd size, flock size, calving, litter size, livestock fertility, abortion, carcass size, body weight, cattle/milk/meat/egg transport, meat/milk/egg storage, income from livestock/products	Horse, donkey, mule, dog, cats and other pets, bees, fish, any livestock where much of (>50%) the population is from the excluded, physiological variables that could not provide a comprehensive picture e.g. organ function tests, laboratory measurements (blood parameters, temperature)
ASF consumption	Meat, milk, dairy, egg, poultry, cheese, yogurt, animal source food, ASF consumption, ASF consumption pattern, dietary shift concerning ASF, dietary diversity showing ASF status, animal fat/protein consumption, nutritional quality of ASFs, social acceptability, affordability of ASFs	Honey, seafood, fish, food security without ASF data, dietary diversity without ASF, consumption patterns without ASF, plant proteins

Components	Included	Excluded
Countries	Angola, Benin, Botswana, Burkina Faso, Burundi, Cabo Verde, Cameroon, Central African Republic, Chad, Comoros, DR Congo, Congo, Cote d'Ivoire, Equatorial Guinea, Eritrea, Eswatini (Swaziland), Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mauritius, Mozambique, Namibia, Niger, Nigeria, Rwanda, Sao Tome and Principe, Senegal, Seychelles, Sierra Leone, Somalia, South Africa, South Sudan, Sudan, Tanzania, Togo, Uganda, Zambia, Zimbabwe	Global studies, studies without specific location, multi-country studies which includes countries outside SSA and no separate data for SSA
Type of evidence	Association of the exposure and outcome, causal link, mediation analysis, reviews linking the exposure and outcomes	The effect of livestock production/consumption on climate change, descriptive studies (without linking exposure and outcome, descriptive studies on climate change (trends, severity, and frequency… of climate parameters without outcome variables), descriptive studies on production or consumption (prevalence, incidence, severity, etc. without showing the etiologic role of climate change variables), perception of different stakeholders (knowledge, awareness, attitude studies). The effect of climate change on resources and health without linkage to production or consumption

Consistency Checking

In the initial screening for the systematic map, we conducted consistency checking with a random sample and a block of 50 papers from the search results and each paper was screened by a pair of reviewers during title and abstract screening. Discussions and refinement to the inclusion and exclusion criteria were performed during disagreement in the screening process. We measured inter-reviewer agreements using kappa coefficient, and the kappa values are provided previously. Reviewers did not screen their own work at any stage of the screening.

Reporting Screening Outcomes

In the initial screening for the systematic map, we conducted consistency checking with a random sample and a block of 50 papers from the search results and each paper was screened by a pair of reviewers during title and abstract screening. Discussions and refinement to the inclusion and exclusion criteria were performed during disagreement in the screening process. We measured inter-reviewer agreements using kappa coefficient, and the kappa values are provided previously. Reviewers did not screen their own work at any stage of the screening.

STUDY VALIDITY ASSESSMENT

Critical Appraisal

We will use the Jonnah Bridges Institute (JBI) checklist for observational studies (analytical cross-sectional studies, cohort, and case-control) studies25, and experimental studies (quasi-experimental studies26, or randomized control trials27). Additional file 4 (checklist for observational studies) and Additional file 5 (checklist for experimental studies) are provided. The scoring system has 0 (No), 1(Yes), UC (Unclear), NA (Not applicable). The score for the tool ranges from 0 to 8 for cross sectional studies, 0 to 10 for case-control studies, and 0 to 11 for cohort studies. The smaller number indicates lower quality, and higher numbers indicate higher quality. We will not exclude studies based on the critical appraisal results, but we will compare results during the synthesis based on quality score. This could be in narrative or quantitative (subgroup or meta-regression) synthesis. Despite the absence of clear categorization using JBI checklists, it is a common practice to classify studies as high quality (>70%), moderate quality (50-70%) and low quality (<50%). We will apply this category (or dichotomous) for comparison of results during synthesis.

Critical appraisal strategy

We will conduct subgroup analysis using the quality score of the studies whenever possible or compare the results from the studies in the narrative synthesis.

Consistency checking

We will double appraise 10% of the included papers for consistency. Discrepancies will be discussed and clarified to maximize appraisal consistency for the remaining studies.

DATA EXTRACTION

Data Extraction Strategy

Data from included studies including design, exposure, mediators, outcome, and measurements of these variables will be extracted. The PEO components will include both general and specific information about the population, exposure, mediators, and outcomes. The outcome measurement element will primarily focus on whether the article quantitatively measures the outcome, and if so, the specific measure used for the outcome.
The full details of the data extraction are provided in Additional file 6. Due to the heterogeneous nature of the study types, the extraction strategy may be subject to adjustments, as necessary.

Missing data

Missing information will be coded as "Not Extractable (NE)" due to insufficient time to contact corresponding authors for additional information. Information that does not apply to a specific study will be coded as "Not Applicable (NA)".

Consistency Checking

We will double extract 10% of the included papers for consistency. Discrepancies will be discussed and clarified to maximize coding consistency for the remaining studies.

Potential effect modifiers

Several potential effect modifiers will be identified during the data extraction process. The following are list of possible effect modifiers identified by the authors.

1. Designs of the studies (observational vs experimental)
2. Geographical areas of the studies (country)
3. Species (e.g. camel vs cow for milk production)
4. Source of data for exposure (secondary from meteorological agencies (secondary), measurement during data collection (primary))
5. Data collection season
6. Length of data collection period

The potential effect modifiers will be extracted and used in subgroup and meta-regression analysis provided that adequate number of studies reported the same potential effect modifier in the same outcome.

Data Synthesis and Presentation

We will use R software (or STATA) to conduct descriptive analyses of the results. This description will explore various combinations of variables, including exposure and outcome types (path-dependent), study paths, study types, species, geographical areas, and more.

Narrative Synthesis Strategy

A narrative synthesis of data from all studies included in the systematic review will be generated to describe the existing evidence along with study findings. In our narrative synthesis, we will stratify evidence based on paths of climate change effect on livestock production and consumption. Further schematization will be done based on various exposures and outcomes. The stratification for presentation aimed to create a clear picture of available evidence and the main findings on the paths, exposures, population, and outcomes. Along with the narrative synthesis results of each topic, quantitative summary will be provided where possible. Tables and graphs will used to present the findings.

Quantitative Synthesis Strategy

The possibility of qualitative synthesis is dependent on statistical feasibility. We do not expect quantitative pooling in most outcomes, where data are suitably comparable, quantitative synthesis (meta-analysis) will be performed. Depending on the reported effect sizes and the design of the included studies, we will convert to common effect size (e.g. correlation coefficient) where possible and pooling will be considered. Whenever conversion is not possible (e.g. for mean difference), these effect sizes will be pooled. The details of the meta-analytic process will be described in the final systematic review report. We will provide prediction intervals whenever possible. Due to the exclusion of qualitative studies, we do not expect synthesis of qualitative studies.

Other Synthesis Strategies

We will provide the pathways of effects of climate change to production and consumption based of the quantitative and narrative synthesis. All direct and indirect pathways will be drown based on synthesis results.

Assessment of risk of publication bias

We will observe publication bias visually from funnel plots, where the numbers of studies are adequate, we will apply quantitative methods (e.g. Egger's regression test) to objectively measure the publication bias and small study effects. We will also perform sensitivity (leave one out) analyses to determine the effects of certain studies on the pooled estimates. These analyses will measure how the estimated parameter of a pooled analysis would change if noisy studies were eliminated. The effect of these identified outlier studies will be neutralized by excluding them from the random effect model. P value ≤ 0.05 cut-point will be used to declare statistical significance.

Demonstrating Procedural Independence

Due caution will be taken to not evaluate articles at any stage of the systematic review by an author of that publication from the review team.

COMPETING INTERESTS

The authors declared that they have no conflict of interest.

AUTHOR'S CONTRIBUTIONS

AAT and TAZ were the primary contributors to the study, equally involved in the conception, design, writing of the protocol, and collaborating closely throughout the process. CB and AM contributed to the conception and design of the protocol. WTH supported the review process by contributing to the critical review and analysis of the protocol, ensuring its quality and accuracy.

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