

Determinant factors of climate change adaptation by pastoral/agro-pastoral communities and smallholder farmers in sub-Saharan Africa

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A systematic review

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Abstract

Purpose – The purpose of this systematic review was to assess the determinant factors of climate change adaptation (CCA) in sub-Saharan Africa (SSA).

Design/methodology/approach – Studies that focused on determinant factors of CCA by crop–livestock farmers and pastoralists in SSA and written in English were reviewed from five major databases using the applications of Endnote and NVivo. The review process followed a sequence of steps to reach into the final selection.

Findings – A total of 3,028 papers were recovered from the databases and screened for duplicates (777) and publications before 2000 (218). The titles and abstracts of 2,033 papers were reviewed, and 1,903 of them were excluded owing to preliminary exclusion criteria. Finally, 130 papers were selected for full-text review and more detailed assessment, where 36 papers qualified for the final review. The most important determinant factors of CCA by pastoralists were household income, access to information, access to extension services, government support and access to market. In the case of agro-pastoralists, access to information, household income, age and land/livestock ownership were found as the major determinant factors. Household income, land ownership, access to information, farm size, household size and access to extension services were the determinant factors found for CCA by smallholder farmers.

Research limitations/implications – This systematic review identified the major determinant factors according to production systems and highlights the importance of considering specific factors in designing CCA strategies.

Originality/value – After clearly stating the research question, a literature search was conducted from the major databases for climate-related research, and a comprehensive search was performed by two independent researchers.

Keywords Adaptation, Sub-Saharan Africa, Climate change, Smallholder, Determinant factors, Agro-pastoral

Paper type Research paper



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1. Introduction

1.1 Background and justification

Pastoral and agro-pastoral communities and smallholder farmers in sub-Saharan Africa (SSA) are largely dependent on livestock and mixed crop–livestock production systems for their livelihood. These production systems are mainly characterized by arid and semi-arid climates with low and erratic rainfall (Fre and Tesfagergis, 2013). Although climate change (CC) is a global phenomenon, its negative impacts are more severely felt by poor people in developing countries who rely heavily on the natural resource base for their livelihoods (Gerber *et al.*, 2013). Rural poor communities rely greatly for their survival on agriculture and livestock keeping that are among the most climate-sensitive economic sectors. In pastoral and agro-pastoral systems, livestock is a key asset for poor people, and losing livestock assets could trigger a collapse into chronic poverty and could have a lasting effect on livelihoods (Assefa *et al.*, 2010; Freeman *et al.*, 2007).

To cope with the changing climate, pastoralists and agro-pastoralists and smallholder farmers have, therefore, adjusted and adapted themselves by evolving livelihoods mainly dependent on livestock and livestock-related activities and small-scale agricultural practices (Fre and Tesfagergis, 2013). Adaptation is necessary if the world is to manage the risks posed by CC (Ford *et al.*, 2011; New *et al.*, 2011; Stafford *et al.*, 2011). Still, even if significant actions are taken, it is clear that adaptation to the existing level of CC is critical (Ford *et al.*, 2013).

Several research works have been conducted in different corners of SSA on the perception of farmers to climate change adaptation (CCA) and the socioeconomic factors that influence the adaptation of these farmers to the changing climate (Mudombi-Rusinamhodzi *et al.*, 2012; Muller and Shackleton, 2014; Nabikolo *et al.*, 2012; Osumanu *et al.*, 2017; Ozor *et al.*, 2010; Gedefaw *et al.*, 2018; Legesse *et al.*, 2013; Mabe *et al.*, 2014; Mengistu and Haji, 2015; Serkalem *et al.*, 2014; Alemayehu and Bewket, 2017; Mekuyie *et al.*, 2018; Belay *et al.*, 2017; Chingala *et al.*, 2017; Feleke *et al.*, 2016; Kgosikoma *et al.*, 2018; Opiyo *et al.*, 2016; Yila and Resurreccion, 2013; Zampaligré *et al.*, 2014). However, these research findings are fragmented and are not in a position to support policymakers in formulating context-specific strategies. To the best knowledge of the authors, except two systematic reviews conducted on CCA (Ford *et al.*, 2011; Lea *et al.*, 2015), no systematic review was found on the determinant factors of CCA at a global scale in general and in Africa in particular.

1.2 Rationale of conducting systematic review

A systematic literature review is a summary and assessment of the state of knowledge on a given topic or research/review question, structured to rigorously summarize existing understanding (Ford *et al.*, 2011; Kitchenham, 2004). Systematic approaches to research synthesis have been used unevenly across disciplines, and they are widely applied in health science research (Lea *et al.*, 2015). However, their use in CC research is very limited (Ford *et al.*, 2011). The advantages of systematic reviews over the traditional literature reviews are as follows:

- clearly define the research question (e.g. What are the determinant factors of CCA?) and scope of the study;
- use systematic and explicit methods and criteria to select relevant research;
- document search terms and criteria for inclusion and exclusion of papers;
- systematic selection of papers permits the use of quantitative and qualitative analysis of trends in the literature; and

- critical appraisal of study quality (Ford and Pearce, 2010; Lea *et al.*, 2015; Higgins and Green, 2008).

Therefore, undertaking a systematic review on the existing studies will help policymakers to better understand the major socioeconomic determinant factors that influence the adaptive capacity of pastoral/agro-pastoral communities and smallholder farmers to CC impacts in the region. In addition, this review will contribute to design context-specific adaptation strategies in the sub-Saharan region and to the body of knowledge by bringing together the pieces of information from various papers together. Moreover, this review will try to identify the current research gaps and suggest researchable areas for future investigation.

1.3 Research questions

- RQ1. What sort of socioeconomic determinant factors of CCA by pastoral and agro-pastoral communities have been addressed by researchers in SSA?
- RQ2. What is the geographic distribution of studies conducted on socioeconomic determinant factors of CCA in SSA?
- RQ3. What were the gaps of these research findings?

2. Methodology

2.1 Data sources and search strategy

A comprehensive literature search was conducted by two independent researchers focusing on five major databases that are subscribed by Mekelle University and/or Open Access. These databases included the following:

- (1) Scopus (www.scopus.com);
- (2) JSTOR (www.jstor.org);
- (3) Science Direct (www.sciencedirect.com);
- (4) Google Scholar (<http://scholar.google.com>); and
- (5) African Journals Online (AJOL) (www.ajol.info).

In addition, published materials and papers were also searched from major organization databases such as the Intergovernmental Panel for Climate Change, World Health Organization, Health Inter-Network Access to Research Initiative (HINARI), Food and Agriculture Organization and United Nations Environmental Program. Moreover, manual search of retrieved reference lists was performed to make sure that all relevant resources are included. The following groups of keywords and their synonyms linked with the AND operator were used for the search (Lea *et al.*, 2015):

- *Determinant factors*: Topic = (“Social” OR “Economic” OR “Socio-economic” OR “Determinant factors” OR “Influenc* factors”);
- *Adaptation*: Topic = (“adaptation” OR “adapt* capacit*” OR “adapt* strateg*” OR “vulnerab*” OR “resilien*” OR “coping” OR “risk reduction”);
- *Pastoral and agro-pastoral*: Topic = (pastoral* OR agro-pastoral* OR smallholder OR agricultur* OR farm* OR livestock OR “small holder” OR crop-livestock OR livelihood*);

- *Climate change*: Topic = (“climat* chang*”); and
- *Sub-Saharan Africa*: Topic = (“Sub-Saharan Africa” OR Sub-Sahara*).

Undertaking livestock production-related activities as adaptation measures was taken as a prerequisite to consider studies that are based in smallholder production systems. Search from the databases was performed with all the possible combinations of key words and their synonyms to maximize the outputs of the search.

2.2 Study selection and data extraction

The titles and abstracts of retrieved references were reviewed, and reference lists pertinent to CCA researches and systematic reviews were used to identify additional reports. Retrieved references from the various databases were imported into Endnote Version 9 (Karimurio, 2013) and checked for duplication. Duplicated references were removed from the database. For papers to be considered relevant for this review, they must mention strategies against CC or climate-related risk and must explicitly refer the determinant factors of CCA. Adaptation was considered in its broad definition as “anticipating the adverse effects of climate change and taking appropriate action to prevent or minimize the damage they can cause, or taking advantage of opportunities that may arise” (Lea *et al.*, 2015; Locatelli *et al.*, 2015).

2.3 Inclusion and exclusion criteria

In this review, the target group/population of interest were pastoral and agro-pastoral (crop–livestock farmers) communities and smallholder farmers living in SSA. The area of the systematic review was on the major determinant factors that limit the adaptive capacity of pastoral and agro-pastoral communities in SSA. Studies published prior to 2000 were not considered in this review because much emphasis on CCA is given after 2000 and more publications were available within this specified period. Peer-reviewed papers and gray literature published since 2000 were the targets of this systematic review. Studies that focused on determinant factors of CCA by pastoral and agro-pastoral communities and smallholder farmers in SSA and written in English were reviewed (Lea *et al.*, 2015). Papers written in other languages were not considered owing to the challenge to translate them back to English.

Retrieved reference papers in journals that are not related to the research question raised in this systematic review were removed from the database. The main exclusion criteria used in this review were as follows:

- studies on CC impact, adaptation and mitigation studies out of SSA;
- studies that are not focused on CCA by pastoral and/or agro-pastoral communities/farmers;
- reviews on CC impact and/or CCA;
- studies based only on perception of farmers on CC/drought/CCA;
- studies on CC impact and/or vulnerability of farmers to CC and/or climate variability (CV) and mitigation strategies;
- generalized studies on CC and related issues at the global/continental/regional level; and
- studies focused on pastoral/agro-pastoral livelihoods/food security/CC impacts/health/migration.

2.4 Study quality assessment

To ensure the quality of the systematic review, the Centre for Reviews and Dissemination (CRD's) guidelines (Khan *et al.*, 2001) and Cochrane handbook for systematic reviews of intervention (Higgins and Green, 2008) were used. After clearly stating the research question, a literature search was conducted from the major databases for climate-related research, and a comprehensive search was performed by two independent researchers. A clear set of inclusion and exclusion criteria were used; selection bias was avoided by searching for related literature from the websites of major organizations working on climate-related areas; and a clear selection process was followed to screen the papers retrieved from the databases.

2.5 Analyzing and synthesizing evidence

In this systematic review process, the authors came to understand that some of the finally qualified papers used a qualitative, quantitative or mixed-methods research approach. This is a common approach in most of the CCA research works and reviews (Lea *et al.*, 2015). Thus, descriptive statistics (Stata Version 15) was used to summarize trends in the publications with categories guided by the typology questionnaire. However, inferential statistics was not feasible owing to the limited number of studies ($n = 36$) and mixed-methods research approaches used in the studies (Ford *et al.*, 2011). In addition, the applications of Endnote X9 and NVivo Version 12 software (Basak, 2015; Di Gregorio, 2000) were used in the organization, selection and analysis. The NVivo software was used for qualitative extraction and analysis of the finally selected papers. The selected papers were coded using predefined thematic areas related to the review questions. The major thematic areas used for the coding were literature-based impacts of CC identified by authors, study country and area and sample size used, approach used for analyzing the determinant factors, type of CC experienced by respondents (indicators of CC), CC impact experienced by respondents, CCA strategies used by respondents, determinant factors investigated, the major identified determinant factors of CCA and recommendations (policy issues) forwarded. On this basis, coding categories were created and organized around the themes established, and each paper was read in depth again and coded, whereby sections of the text were manually assigned the appropriate code using NVivo software. The coded text was then retrieved, evaluated and compared with the quantitative analysis to identify the major adaptation strategies and determinant factors. For mapping the distribution of studies in SSA countries, the application of qGIS software was used.

3. Results

3.1 Retrieved papers

The search was conducted from September 2018 to January 2019 and resulted in 3,028 papers. After removing duplicates and papers published before 2000, 2,033 papers remained.

3.2 Screening process and results of retrieved papers

After removing the duplicates and papers published before 2000, 2,033 papers were screened based on their title and abstract considering the inclusion and exclusion criteria, which resulted in the exclusion of 1,903 papers (Table I). The remaining 130 papers were reviewed in detail, and 94 of them were excluded for different reasons (Table II). In the final stage, 36 papers qualified for the review, where 9, 8 and 17 of them were studies on determinant factors of CCA by pastoralists, agro-pastoralists and smallholder farmers, respectively. Two of the studies assessed the determinant factors of CCA in both pastoral and agro-pastoral communities in SSA (Figure 1).

Table I.
Excluded references
by reading title and
abstract

Exclusion criteria	AJOL (60)	GS (209)	JSTOR (85)	SD (939)	Scopus (740)	Total (2,033)
Studies on CC impact/vulnerability/livestock/health/ CCA measures, etc. conducted out of SSA	0	16	1	315	212	544
Studies that are not focused on CCA by pastoral and/or agro-pastoral communities/farmers	13	16	13	41	54	137
Reviews on CC impact and/or CCA	4	5	2	11	13	35
Studies based only on perception of farmers on CC/drought/ CCA	10	12	3	21	52	98
Studies on CC impact and/or vulnerability of farmers to CC and/or CV and mitigation strategies	6	48	19	164	105	342
Generalized studies at global/continental/regional level	2	45	32	339	248	666
Studies focused on pastoral/agro-pastoral livelihoods/ food security/ CC impacts/health/migration, etc.	3	34	13	16	15	81
<i>Total excluded</i>	38	176	83	907	699	1,903
<i>Papers selected for detailed assessment</i>	22	33	2	32	41	130

Notes: GS = Google Scholar; SD = Science Direct

Table II.
Excluded references
after detailed
assessment

Exclusion criteria	AJOL (22)	GS (33)	JSTOR (2)	SD (32)	Scopus (41)	Total (130)
Studies on determinant factors of CCA but more focused on crop production/water resources/doesn't consider livestock production/management as CCA	4	12	1	13	14	44
Studies dealing on CC impact/vulnerability and CCA strategies/adaptive capacity	7	8	1	10	8	34
Studies based on indigenous/endogenous/local CCA strategies and perception on CC impacts	3	1	0	3	1	8
Studies based only on one extreme climate event(drought, flood, etc.) and its coping strategies	2	2	0	1	0	5
Studies on determinant factors of CCA by fish farmers	0	0	0	0	1	1
Socioeconomic determinants of pastoralists' camel production/camel production as means of adaptation					2	2
<i>Total</i>	16	23	2	27	26	94
<i>Papers qualified for the final review</i>	6	10	0	5	15	36

At the initial search, majority of the papers were retrieved from the Science Direct (48.2 per cent, 1,461/3,028) database, followed by Scopus (32.8 per cent, 994/3,028). However, after the final screening, 41.7 per cent (15/36) and 27.8 per cent (10/36) of the papers included in the review were from Scopus and Google scholar databases, respectively (Table II).

3.3 Geographic distribution of the studies

Out of the 51 SSA countries, studies related to determinant factors of CCA by pastoral and agro-pastoral communities and smallholder farmers related to the research questions were reported from 13 countries. The highest number of studies was reported from Ethiopia, followed by Kenya (Figure 2). In terms of regional distribution, the highest number of studies was reported from East Africa (21, 58.3 per cent) (Table III).

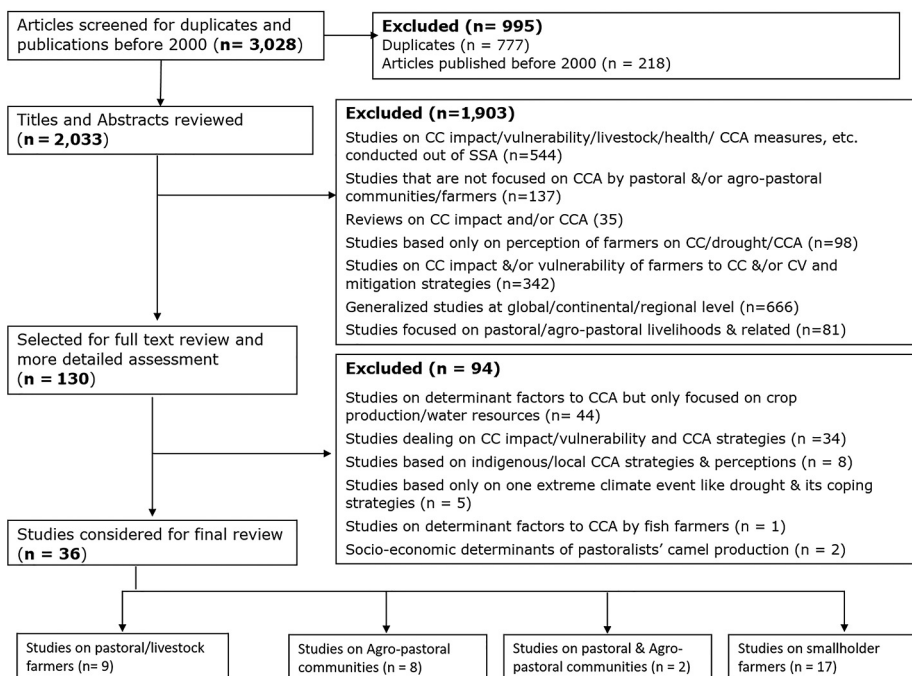


Figure 1. Results of the retrieved literature and the screening process

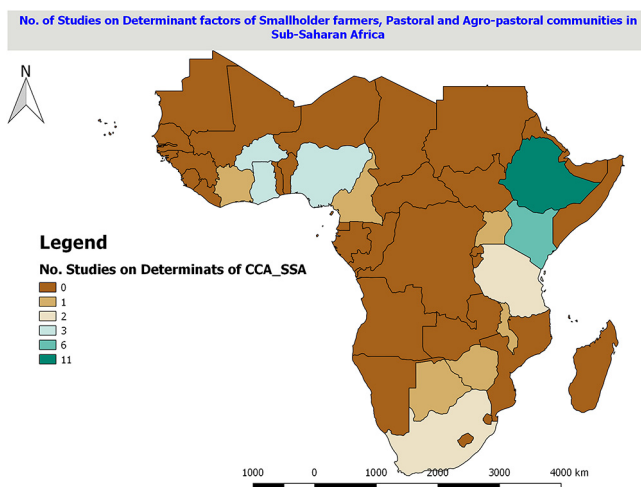


Figure 2. Distribution of studies on determinant factors of CCA in SSA countries

3.4 Approach used to assess determinant factors

The mean sample size used by studies in pastoral, agro-pastoral and smallholder farmers was 203, 173 and 253, respectively. The minimum sample size (50) was recorded in a study conducted in pastoral/livestock production system, and maximum sample size (800) was

recorded in the smallholder farming system. About 36.4 per cent (4/11), 80 per cent (8/10) and 82.4 per cent (14/17) of research papers conducted in the pastoral, agro-pastoral and smallholder production systems, respectively, used Logistic/logit regression models (binary/ordered/multinomial) to evaluate the determinant factors of CCA. Some of the researchers also used more than one tool to assess determinant factors.

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3.5 Climate change adaptation strategies

All the studies conducted in pastoral and agro-pastoral communities assessed the major CCA strategies implemented by the farmers. However, in case of studies that targeted smallholder farmers, 14 out of 17 studies tried to assess the CCA strategies. The most commonly practiced CCA strategies in pastoral communities were purchasing and providing supplementary feed (fodder, crop residues, concentrate), herd destocking and diversification of livestock species/types, followed by changing herd composition (shifting to camel/small ruminants/poultry) and herd mobility/migration (Table IV).

Table III.
Regional distribution of studies on determinant factors of CCA in SSA countries

Region	Countries where studies were reported	Smallholder (No./%)	Pastoral (No./%)	Agro-pastoral (No./%)	Overall (No./%)
East Africa	Ethiopia, Kenya, Uganda, Tanzania	9 (52.9)	7 (70)	5 (55.6)	21 (58.3)
West Africa	Burkina Faso, Ghana, Ivory Coast, Nigeria	7 (41.2)	0	2 (22.2)	9 (25)
Central Africa	Cameron	0 (0)	0	1 (11.1)	1 (2.8)
Southern Africa	Zimbabwe, South Africa, Botswana, Malawi	1 (5.9)	3 (30)	1 (11.1)	5 (13.9)
<i>Total</i>		<i>17 (100)</i>	<i>10 (100)</i>	<i>9 (100)</i>	<i>36 (100)</i>

Table IV.
Climate change adaptation strategies implemented by pastoral farmers

Adaptation strategies	No. mention (n = 11)	(%)
Purchase and provide supplementary feed(fodder, crop-residues, concentrate)	8	72.7
Herd destocking	8	72.7
Diversify livestock species/types	6	54.5
Change herd composition/shifting to camel/small ruminants/ poultry/beekeeping	6	54.5
Herd mobility/migration	6	54.5
Enclosure/controlled grazing/rotational grazing	4	36.4
Diversify livelihood/engage in off-farm activities (labor, charcoal/firewood selling, petty trade)	4	36.4
Crop farming and related management strategies	4	36.4
Diversify fodder crops/planting drought tolerant fodder trees	3	27.3
Depending on aid (government, NGOs)/remittance	3	27.3
Water harvesting and water management	3	27.3
Animal treatment/prophylaxis including vaccination	2	18.2
Risk sharing (social insurance, borrowing from relatives/neighbors, sending children to relatives)	2	18.2
Watering animals from borehole/pond meant for human consumption	2	18.2
Herd splitting	2	18.2
Conservation of animal feed	2	18.2
Provision of shade for animals	1	9.1
Irrigation farming	1	9.1
Reducing food intake	1	9.1

The adaptation strategies exercised by agro-pastoral communities were crop diversification (growing different varieties of food and cash crops) and diversifying, changing or supplementing livestock feed, followed by changing the cropping calendar (changing planting and harvesting dates) and mixed crop–livestock farming (Table V). The predominant adaptation strategy implemented by smallholder farmers was crop diversification/planting varieties of crops, followed by adopting drought-tolerant crops, planting early maturing crops and changing the cropping calendar (Table VI).

3.6 Determinant factors of climate change adaptation

In the pastoral production systems, five out of 11 studies investigated several determinant factors, but the remaining six focused only on few determinant factors. In agro-pastoral production systems, seven of the studies investigated several determinant factors. Except one study that focused on three determinant factors, the remaining studies (16) investigated several determinant factors.

In the pastoral production systems, household income/capital (72.7 per cent), access to information (63.6 per cent) and institutional/government support (54.5 per cent) were prioritized as the top three major determinant factors that influence the adaptation of pastoral/livestock producing communities to CCA (Table VII). Whereas, in the agro-pastoral communities, access to information (70), household income/capital (60), age of household head (50) and land/livestock ownership (50) were identified as the major determinant factors (Table VIII). Household income/capital (47.1 per cent), land ownership (47.1 per cent), access to information (47.1 per cent), farm size (47.1 per cent), household size (41.2 per cent) and

Adaptation Strategies	No. mention ($n = 10$)	(%)
Crop diversification (growing different varieties of food and cash crops, etc.)	7	70
Diversifying, changing or supplementing livestock feed	7	70
Changing cropping calendar/changing planting and harvesting dates	6	60
Mixed crop–livestock farming	6	60
Herd Destocking	5	50
Livestock rearing/farming (herd diversification)	4	40
Engage in off-farm activities (labor, charcoal/firewood selling, petty trade)	4	40
Using improved crop and livestock varieties	4	40
Herd mobility/migration	4	40
Using drought resistant crop varieties along high yield crops	3	30
Soil and water conservation	3	30
Changing fertilizer type and application	3	30
Depending on aid (government, family, NGOs)/remittance	2	20
Planting trees	2	20
Preserving/managing pasture and storing animal feed	2	20
Water harvesting and water management	2	20
Treatment/vaccination of animals	2	20
Shift from cattle to shoat/camel production	2	20
Adopting modern farming techniques	1	10
Provision of shade/shelter for animals	1	10
Irrigation farming	1	10
Involving in fish farming	1	10
Praying to god	1	10
Graze livestock in protected areas/government land	1	10
Vegetable gardening during dry season	1	10

Table V.
Climate change
adaptation strategies
implemented by
agro-pastoral
farmers

Table VI.
Climate change
adaptation strategies
implemented by
smallholder farmers

Climate change adaptation strategies implemented by farmers	No. mention (<i>n</i> = 14)	(%)
Crop diversification/planting varieties of crops	12	85.7
Adoption of drought tolerant/resistant crops	10	71.4
Planting early maturing crops	10	71.4
Changing cropping calendar/planting dates	10	71.4
Tree planting/agro-forestry	9	64.3
Integrated crop–livestock farming	8	57.1
Started non-farm activities	8	57.1
Using new land management practices	8	57.1
Soil and water conservation practices	8	57.1
Started growing new crops/improved crops	7	50.0
Supplementary irrigation	7	50.0
Seasonal/temporary migration	6	42.9
Herd destocking (reducing livestock numbers by selling)	6	42.9
Diversification of livestock types and varieties	6	42.9
Dependence on Institutional/government support	4	28.6
Diversify food habit/change in consumption pattern (wild foods, etc.)	4	28.6
Fertilizer and manure application/intensive use of agricultural inputs	4	28.6
Remittance/receiving assistance from family and friends	3	21.4
Crop–livestock insurance	3	21.4
Bought additional food	2	14.3
Reduce food consumption	2	14.3
Land renting	2	14.3
Maintenance of grain reserves	2	14.3
Planting flood and heat tolerant varieties	2	14.3
Taking credit or loan	1	7.1
Storage of crop residues as an emergency feed	1	7.1
Rain water harvesting	1	7.1
Change livestock species composition/from cattle to shoats or camel	1	7.1
Purchase supplementary animal feed	1	7.1
Grow fodder crops on soil and water conservation (SWC) structures	1	7.1

access to extension service (41.2 per cent) were indicated as the major determinant factors of CCA in the smallholder production systems (Table IX).

4. Discussion

Actions to minimize further impacts of CC are essential. Still, even if significant actions are taken, it is clear that adaptation to the existing level of CC is critical. Particularly in developing countries, where the impacts of CC are severely felt by pastoral and agro-pastoral communities and smallholder farmers, adaptation should be considered as a core element of climate policy and research (Ford *et al.*, 2013). However, these adaptation practices/strategies are influenced by various factors.

Though there are limited systematic reviews in CC-related research, their power in answering a specific research question has been proved (Ford *et al.*, 2011; Khan *et al.*, 2001; Lea *et al.*, 2015). This has also been justified in this systematic review where the major factors that influence the adaptation strategies of pastoral and agro-pastoral communities and smallholder farmers in SSA were clearly identified.

Majority of the research works on determinant factors of CCA used quantitative, qualitative or mixed-methods analysis. Majority of the studies in pastoral (Chingala *et al.*, 2017; Mengistu and Haji, 2015; Tilahun *et al.*, 2017; Zampaligré *et al.*, 2014), agro-pastoral (Balama *et al.*, 2013; Bryan *et al.*, 2013; Kgosikoma *et al.*, 2018; Kima *et al.*, 2015;

Table VII.
Determinant factors
of CCA by pastoral
farmers

Determinant factors of CCA	No. of mention ($n = 11$)	(%)
Household income/capital	8	72.7
Access to information	7	63.6
Institutional/government support	6	54.5
Access to extension/veterinary services	5	45.5
Access to market/distance to market	5	45.5
Education level of household head	5	45.5
Household size	4	36.4
Gender of household head	4	36.4
Livestock holding/size	4	36.4
Age of household head	3	27.3
Access to credit	3	27.3
Agro-ecological zone	2	18.2
Farming experience	1	9.1
Access to training	1	9.1

Table VIII.
Determinant factors
of CCA by agro-
pastoral farmers

Determinant factors of CCA	No. of mention ($n = 10$)	(%)
Access to information (weather forecast)	7	70
Household income/capital	6	60
Age of household head	5	50
Land/livestock ownership	5	50
Access to extension services	4	40
Institutional/government support	4	40
Household size	4	40
Gender of household head	4	40
Education level of household head	4	40
Access to market/distance to market	3	30
Access to credit	3	30
Access to training	2	20
Farmers' knowledge of adaptation strategies	2	20
Agro-ecological zone	1	10
Farming experience	1	10

Mengistu and Haji, 2015; Serkalem *et al.*, 2014; Zampaligré *et al.*, 2014; Silvestri *et al.*, 2012) and smallholder farmers (Ajao *et al.*, 2011; Alemayehu and Bewket, 2017; Belay *et al.*, 2017; Comoé and Siegrist, 2015; De Jalón *et al.*, 2015; Gedefaw *et al.*, 2018; Legesse *et al.*, 2013; Mabe *et al.*, 2014; Misganaw *et al.*, 2014; Mudombi-Rusinamhodzi *et al.*, 2012; Nabikolo *et al.*, 2012; Osumanu *et al.*, 2017; Ozor *et al.*, 2010; Yila and Resurreccion, 2013) used logistic/logit regression models (binary/ordered/multinomial) to evaluate the determinant factors of CCA. This highlights that the various kinds of logistic regression models are widely implemented in assessing the determinant factors of CCA research studies. This is owing to its advantage in mathematical simplicity to give meaningful results. There are no assumptions of normality of independent variables and equal variance within each group in logistic regression (Gedefaw *et al.*, 2018; Tesfahunegn *et al.*, 2016). Particularly, binary logistic regression models are useful to predict discrete outcome of dichotomous dependent variables from independent variables that may be continuous, discrete and/or dichotomous (Tefahunegn *et al.*, 2016).

Table IX.
Determinant factors
of CCA by
smallholder farmers

Determinant factors of CCA	No. mention (<i>n</i> = 17)	(%)
Income of household (farm and/or non-farm)	8	47.1
Land ownership	8	47.1
Access to information on climate change	8	47.1
Farm size	8	47.1
Household size	7	41.2
Access to extension service	7	41.2
Education level of household head	6	35.3
Gender of household head	5	29.4
Farming experience	5	29.4
Age of household head	4	23.5
Agro-ecological zone	4	23.5
Access to market/distance to market	4	23.5
Livestock ownership/size	4	23.5
Access to credit	4	23.5
Agricultural mechanization/farm inputs	4	23.5
Religion/social network	4	23.5
Perception on annual rainfall amount	3	17.6
Perceived soil fertility status	2	11.8
Support from government/NGOs	2	11.8
Access to training	2	11.8
Perceived occurrence of new pests and weeds	1	5.9
Access to water/adequate water	1	5.9
Access to phone/radio/TV	1	5.9
Household's experience to extreme events (drought, flood)	1	5.9
Marital status	1	5.9
Possession of bicycle	1	5.9
Trust	1	5.9
Out-migration of labor	1	5.9

It has been clearly observed that the adaptation strategies in pastoral, agro-pastoral and smallholder farmers are different considering the variation in the production systems. The predominant adaptation strategies in pastoral communities in the region are supplementary feeding and herd destocking, followed by livestock species diversification, changing herd composition and herd mobility. Whereas, in the agro-pastoral production systems, crop diversification, and diversifying or supplementary feeding, followed by changing cropping calendar and mixed crop–livestock farming, were the major adaptation strategies. In smallholder farming communities, crop diversification, adoption of drought tolerant crops, planting early maturing crops, changing cropping calendar and tree planting/agro-forestry practices were considered as the major adaptation strategies. This highlights that there is no “one-fits-all” adaptation strategy for the different production systems. It has also been indicated that to take advantage of the continuous improvements in climate knowledge for developing applications in agriculture, climate information at any spatial or temporal scale needs to be communicated in terms of its consequences on agricultural production. This type of information is much more likely to influence decision-making at different levels (farmers, advisors, rural insurance/rural credit organizations, agribusinesses, planning agencies) (Baethgen *et al.*, 2003; Holzkämper, 2017).

Likewise, the determinant factors of CCA also vary between the different production systems. However, household income/capital and access to information were considered the most important determinant factors in all the three production systems. It has been

demonstrated that household income (farm and/or non-farm) significantly increases the likelihood of adapting to CC impacts (Ajao *et al.*, 2011; Chingala *et al.*, 2017; Kgosikoma *et al.*, 2018; Mabe *et al.*, 2014).

Farmers that have access to information on CC (temperature and rainfall) have a significant and positive impact on the likelihood of adapting to CC. Majority of the studies in different production systems have indicated that access to information is one of the major determinant factors of CC coping and adaptation strategies (Ajao *et al.*, 2011; Alemayehu and Bewket, 2017; Feleke *et al.*, 2016; Gedefaw *et al.*, 2018; Mabe *et al.*, 2014).

In addition to the above common determinant factors across the production systems, government support, access to extension/veterinary services and access/distance to market were the determinant factors in pastoral production systems. Pastoralists who get support from the government or local institutions, have access to veterinary services and access to market or travel short distances to reach market have better adaptation capacity than their counterparts (Feleke *et al.*, 2016; Hassan and Nhemachena, 2008; Kirkbride, 2008; Opiyo *et al.*, 2016). Whenever there is better access to veterinary service delivery and extension support, pastoralists use these services to protect their animals from emerging and re-emerging diseases that are associated with the changing climate (Ayal *et al.*, 2018). In addition, better access to markets gives the households an opportunity to purchase inputs and sell their goods (Opiyo *et al.*, 2016).

In agro-pastoral production systems, land/livestock ownership, access to extension service and household age were also found to be important determinants of CCA. Land/livestock ownership plays a pivotal role for agro-pastoral farmers to take adaptation measures (Kima *et al.*, 2015; Mengistu and Haji, 2015; Serkalem *et al.*, 2014). Farmers who get access to agricultural or livestock extension services have a higher probability of taking adaptation measures (Bryan *et al.*, 2013; Serkalem *et al.*, 2014; Silvestri *et al.*, 2012). As the age of the household head increases, experience of the farmer in local weather forecasting also increases, which in turn supports for making proper decision (Kgosikoma *et al.*, 2018; Kima *et al.*, 2015; Serkalem *et al.*, 2014).

In the case of smallholder farmers, land ownership, farm size, access to extension service and household size were the other most important determinant factors identified. Land ownership and the size of the farm were indicated by several investigators to encourage farmers to take CCA measures such as soil and water conservation and irrigation (Alemayehu and Bewket, 2017; Belay *et al.*, 2017; Misganaw *et al.*, 2014; Nabikolo *et al.*, 2012; Yila and Resurreccion, 2013; Mutabazi *et al.*, 2015). The provision of extension services also plays a significant role in influencing the decision of farmers on CCA measures. Extension service is an important source of information on CC impacts and adaptation strategies and various land management practices. There is a higher likelihood of taking adaptation measures when farmers have access to extension services (Alemayehu and Bewket, 2017; Nabikolo *et al.*, 2012; Ozor *et al.*, 2010; Yila and Resurreccion, 2013).

5. Conclusion

Though systematic review methodologies are well developed in the health sciences, there are also developments in the climate context. However, there is still a need for further improvements in methodological aspects that are specific to climate research. The nonspecific results in the search databases make the review challenging.

With all its challenges, this systematic review highlighted that majority of the studies related to pastoral and agro-pastoral farming communities are focused in Eastern Africa. The logistic regression models were the widely used approaches to assess determinant factors of CCA. It was also observed that there was variation in the adaptation measures

taken among the different production systems. Similarly, the determinant factors of CCA also vary according to the production systems. However, household income, access to information and access to extension services were consistent in all the production systems. Thus, it is important to consider the production system while designing adaptation strategies. Giving due emphasis for the availability of climate-related information for farmers and strengthening the agricultural and veterinary extension services could play a paramount role in building the capacity of farmers to take adaptation measures against the changing climate.

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