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A. T. M. Sanaul Haque

Lalit Kumar

Navjot Bhullar
Edith Cowan University

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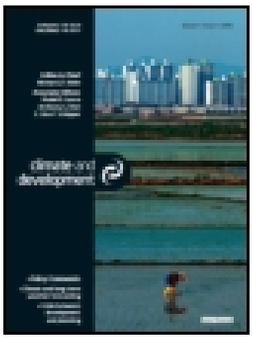

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REVIEW ARTICLE

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Gendered perceptions of climate change and agricultural adaptation practices: a systematic review

A. T. M. Sanaul Haque [a,b], Lalit Kumar [c] and Navjot Bhullar [d,e]

[a]School of Environmental and Rural Sciences, University of New England, Armidale, Australia; [b]Department of Agricultural Extension and Rural Development, Faculty of Agriculture, Patuakhali Science and Technology University, Patuakhali, Bangladesh; [c]GIS and Remote Sensing, EastCoast Geospatial Consultants, Bonnells Bay, Australia; [d]School of Psychology, University of New England, Armidale, Australia; [e]Discipline of Psychology, Edith Cowan University, Joondalup, Australia

ABSTRACT

The present systematic review was undertaken to obtain a detailed understanding of how climate change perceptions and adaptation differ globally by gender and different intersections among the farmers. Findings from 41 studies selected following Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) protocol, mostly from Africa and Asia, suggest that climate change perceptions and adaptation are highly contextual and considerably varied by gender and different intersections. Existing gender role, farmers' age, education, knowledge, marital status, intra-household power structure, religion, social status and ethnicity were intersecting with gender and climate change perception and adaptation. Apart from gender and intersectionality, access to resources, social network and local institutions are found to be important correlates of adaptation strategies by farmers. While agriculture being feminized, mere technological changes are not conclusive to climate change adaptation rather socio-cultural, structural and political changes in inevitable. Female farmers were tend to be more concerned and fatalistic about climate change which reminds us the urgency of culturally appropriate climate change communication to obtain informed decision regarding climate change. Future climate change research could be more gender transformative by exploring the existing inequalities lying in different intersections of gender rather than highlighting binary gender differences only.

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Gender; climate change; farming; intersectionality; feminist political ecology; rural development

1. Introduction

Changes in temperature, rainfall, sea-level rise and extreme events, such as floods, droughts and heat waves severely impact agriculture in any form and ecosystem of land, freshwater and coastal habitat (Howden et al., 2007; IPCC, 2018). While climate change impacts agriculture severely, they are felt disproportionately by the farmers, as resource poor, subsistence farmers and women are the most impacted by climatic changes (Goh, 2012; Morton, 2007; Nelson et al., 2014). Impacts of climate change are unlikely to be gender neutral (A. Singh et al., 2010) and women, in particular, experience more negative impacts of climate change due to social and cultural norms related to gender roles, lower socio-economic status, and lack of access to, and control of, assets (Denton, 2002; Goh, 2012; Skinner, 2011).

As there is no 'silver bullet' for mitigating the negative impacts of climate change yet (Pinkse & Kolk, 2010), adaptation is the best possible strategy to minimize the impact of climate change (IPCC, 2014). Under moderate climate change scenario, some of the potential agricultural adaptation strategies are capable of minimizing the climatic risks (Howden et al., 2007). Adaptation to climate change in agriculture seems to be influenced by the farmers' perceptions of climate change (Bryant et al., 2000). In farming communities, men and women have different roles and responsibilities, which make them experience climate change differently. Differences in climate change experience along with existing gender inequality often worsen the adaptive capacity of women, and the way they decide about adaptation strategies (Mehar et al., 2016). This clearly indicates that, while perception is shaping adaptation, it varies by gender of the farmers.

The role of women in agriculture is ever increasing and male outmigration in the face of climate change is making more women engaging with agriculture sector, which is ironically described as 'feminization of agrarian distress' (Pattnaik et al., 2017). While economically active population in agriculture is decreasing globally, female share in agricultural labour force has increased gradually in the developing countries (FAO, 2011). On the other hand, a large number of studies conclude that their productivity in terms of crop yield is consistently lower than that of men (Huynh & Resurreccion, 2014; Sachs, 2013). Thus, with the increasing number of women in agriculture amidst the changing climate, it is of importance to explore the gender differences in perceptions of climate

CONTACT A. T. M. Sanaul Haque ahaque2@myune.edu.au; sanaulext@pstu.ac.bd School of Environmental and Rural Sciences, University of New England, Room No 222, Building-W55, Elm Avenue, Armidale 2351, Australia

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change in farming communities and how men and women farmers differ in selecting adaptation strategies.

Recent progress in climate change research has given a sharp rise in number of studies with farmers' perception and adaptation. In such perspective, it was an utmost priority to conduct a systematic review on how climate change perception and adaptation vary by gender and intersectionality. Previous systematic reviews and meta-analysis on climate change were conducted by Shaffril et al. (2018), Salehi et al. (2019), van Valkengoed and Steg (2019), Karki et al. (2020) and Pearse (2017) based on different objectives; they were either regional, gender neutral, focusing non-farming communities or not exploring the gendered differences in perception and adaptation.

This study considered approaches from feminist political ecology to explore the current issues in gender and climate change in agriculture. This systematic review contributes by identifying the gendered differences in climate change perception and adaptation of the farmers and how intersectionality makes a difference. The present review aims to answer three specific questions: (1) what are the domains and indicators used to measure famers' perceptions and adaptation to climate change? (2) what are the differences in climate change perceptions and adaptation of the farmers by gender and other intersections? and (3) what are the research gaps in gendered climate change perceptions and adaptation?

The next section of the present study illustrates the detail about the eligibility criteria, selection of the studies, extraction and analysis of data to explore the results.

2. Methodology

This study followed the formal systematic review process strictly which differs from usual literature reviews by their explicit, predefined methodology which adds transparency and reproducibility (Berrang-Ford et al., 2015; Gough et al., 2012). This systematic review follows the main points from the 27 checklists proposed by the PRISMA protocol – a widely used method in systematic reviews (Moher et al., 2009).

2.1. Eligibility criteria

Peer-reviewed journal articles from two electronic databases – 'Web of Science (core collection)' and 'Scopus' – those discussing gender disaggregated perception and/or adaptation to climate change in agriculture around the globe published from 1 January 2005 to 18 April 2019 and written in English were considered for this systematic review. The details of eligibility and exclusion criteria can be seen in supplementary material.

2.2. Search strategy

A search string was developed for the two selected electronic databases. The main keywords were 'gender', 'climate change', 'perception', 'adaptation' and 'agriculture'. To get articles containing all possible variants of a keyword, wildcards and truncations (asterisk and question mark) were used wherever possible. Boolean operator 'OR' was used to yield maximum possible studies with keywords and operator 'AND' was used to narrow down the search to those papers which were discussing all the keywords. To search articles in advance search mode, field tags 'TS=' and 'TITLE-ABS-KEY' were used before the search string in the database of 'Web of Science' and 'Scopus', respectively. The complete search string can be seen in supplementary material.

2.3. Study selection

The search was performed on 18 April 2019 and the articles were selected in four stages. Primary search with the search string was further refined by year of publication (2005–2019) and article only (keeping peer-reviewed published journal articles only). The refined search yielded a total of 1519 articles. After careful screening, 293 articles were eligible for the study and after full-text reading 252 studies were discarded by predefined eligibility and exclusion criteria. As a result, 41 studies were finally included for this systematic review process. Forward snowballing of the selected 41 papers yielded one paper matched with the inclusion criteria. The detail selection process can be seen in Figure 1.

2.4. Data extraction and analysis

First, descriptive data were collected from the selected 41 studies. Apart from descriptive data, qualitative data on gender role, access to and control over resources, sources of climate change information, social network, intersectionality, indicators and gendered differences in perception, and adaptation strategies and gendered differences were also extracted by full-text reading. A gender mainstreaming score was tabulated for each article adapted from Bunce and Ford (2015). Gender mainstreaming score was measured by the presence or absence of gender sensitive, gender responsive and gender transformative approaches in the articles. A total of eight questions (see supplementary materials) were framed to judge gender mainstreaming score of a study under review where a score of one (1) was assigned against each question addressing the approach and zero (0) for not addressing. Thus, gender mainstreaming score of a paper could range from 0 to 8. Individual gender mainstreaming score for each study can be seen in Table S3 as supplementary materials. Based on the score against the questions, each study was further classified as gender sensitive (2 out of 3), gender responsive (2 out of 3) and gender transformative (2 out of 2) which can be seen in Table S3 as supplementary materials. Due to space limitations, we have to put a good portion of extracted data as supplementary materials. A year-wise average gender mainstreaming score was obtained from dividing the total gender mainstreaming score of paper published in a respective year by the numbers of paper published in that particular year.

3. Results

A total of 41 studies were included for this systematic review. From the 41 papers included in this study, 35 papers (Table 2) investigated gendered adaptation strategies and 16 papers (Table 1) examined gendered climate change perception of the farmers (numbers are not mutually exclusive as some

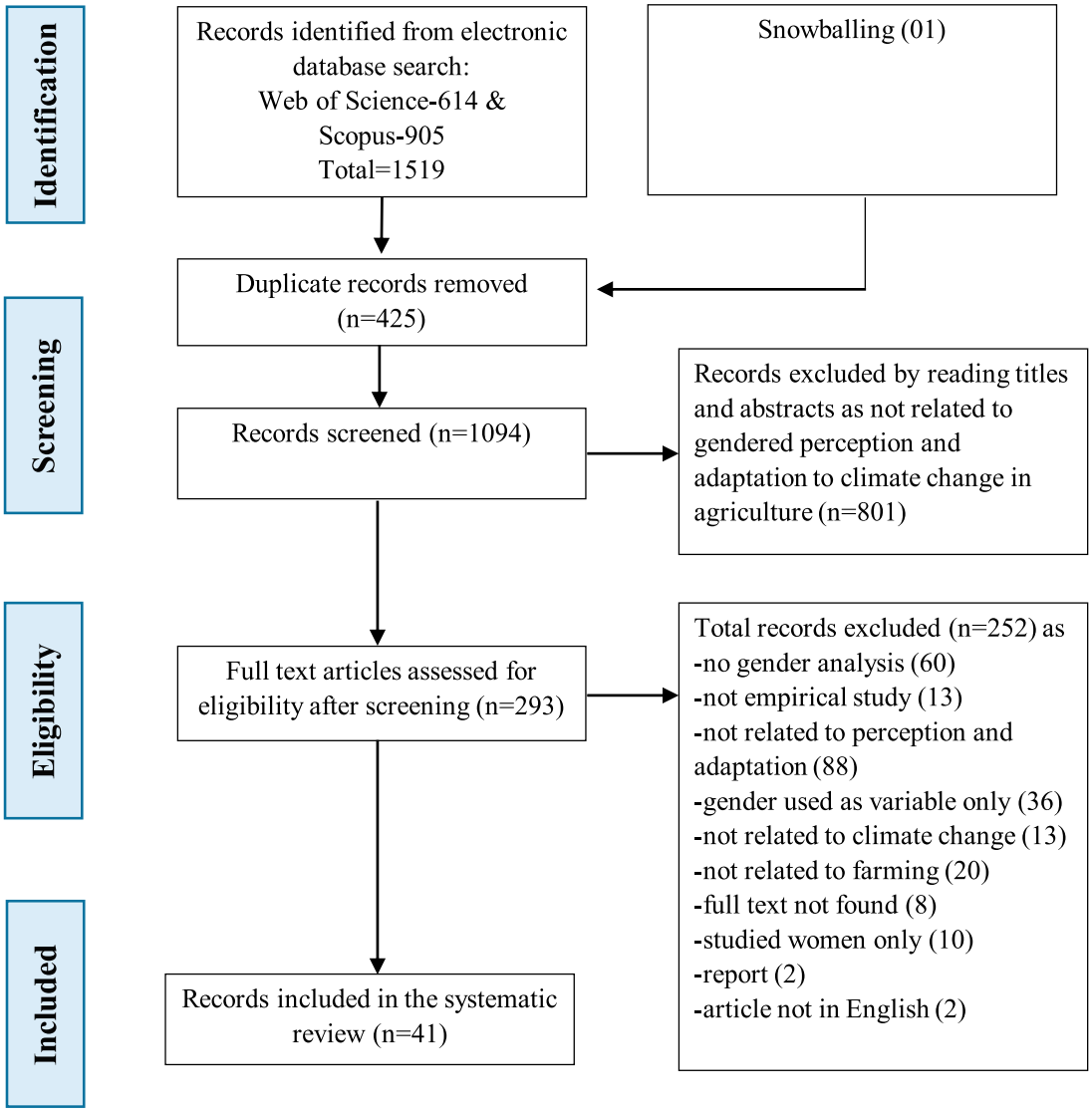

Figure 1. PRISMA flow chart showing the selection procedures of the studies.

studies have investigated both perception and adaptation). Most of the studies ($n = 26$) were from Africa, 13 were from Asia, one from both Africa and Asia, and only one was from North America. A detail of geographical distribution of the studies can be seen in Figure 2.

Considering the coastal area proposed by Nicholls and Small (2002) as the area within 100 m of sea level and 100 km of the shoreline, 26 studies were from non-coastal highland, 11 were from non-coastal plain land and only 4 were from coastal areas. Further details about the characteristics of each of the 41 selected studies are provided in supplementary materials.

3.1. Descriptive results

Nearly half of the studies (44%) used mixed method approach, 32% of studies used qualitative and the other 24% of studies followed quantitative method. Out of the 41 studies, 21 studies followed a theoretical framework (e.g. sustainable livelihood framework, entitlement theory, asset-based vulnerability and adaptation, means-end chain approach, grounded theory approach and feminist political ecology) and within these 20% of the studies followed feminist political ecology/economy. Average gender mainstreaming score was 5.88 out of highest possible score of 8 and from which we can say gender engagement of the selected 41 studies was above average. Year-wise distribution of studies and their gender mainstreaming score can be seen in Figure 3. When we tried to examine the gender engagement level, it was found that out of 41 studies 7 were gender sensitive, 19 studies were gender responsive and only 15 were gender transformative (see Table S3, supplementary materials).

The number of studies with gender disaggregated climate change perception and adaptation seemed to have increased after 2015. Considering the type of agriculture involved, 54% of the studies were conducted with crop farmers, while 24% with mixed farmers (crop and livestock), 12% with fish farmers and 10% with pastoralists.

Word cloud of selected 41 studies (Figure 4) shows the focus and emphasis area of those papers. The word cloud suggested that perception is an under researched area compared to adaptation and intersectionality is one of the least

Table 1. Domains and indicators used in perception measurement and gendered difference in perception.

	First author (year) location	Study design	Perceived meteorological changes				Perceived causes of climate change				Perceived impacts of climate change							Gendered difference in perception
			CT	CR	US	EE	GW	RS	HA	EC	AP	DC	IP	WQ	DF	CC	CF	
1.	Mnimbo et al. (2016) Tanzania	MM	•			•	•		•		•							Y
2.	Limuwa and Synnevåg (2018) Malawi	MM	•		•	•												N
3.	Luo et al. (2016) China	QN				•			•	•	•							Y
4.	Mwongera et al. (2017) Tanzania and Uganda	MM	•	•	•						•				•			Y
5.	Haq and Ahmed (2017) Bangladesh	MM	•	•			•	•	•									Y
6.	Ngigi et al. (2017) Kenya	QL	•	•	•	•												Y
7.	Jin et al. (2015) China	QN	•	•								•						N
8.	Wrigley-Asante et al. (2017) Ghana	QL	•	•	•	•					•							Y
9.	Yila and Resurreccion (2014) Nigeria	MM					•		•	•	•		•	•	•		•	Y
10.	Su (2017) China	MM			•	•			•	•								Y
11.	Dah-gbeto and Villamor (2016) Benin	QN	•	•								•						N
12.	Sánchez-Cortés (201) Mexico	QN	•	•	•				•	•						•		Y
13.	Ampaire et al. (2017) Uganda	QL	•	•	•	•			•		•		•	•	•	•		Y
14.	Kerr et al. (2018) Malawi	MM					•	•	•									Y
15.	Arku (2013) Ghana	MM	•		•				•									N
16.	Singh et al. (2017) India	MM	•	•	•	•					•		•		•	•	•	Y

QL = Qualitative;
QN = Quantitative;
MM = Mixed method

CT = Changes in temperature
CR = Changes in rainfall
US = Unpredictable seasons
EE = Extreme Climatic events are more frequent

GW = God's will
RS = Results of sinful activities
HA = Human activities
EC = Environmental changes

AP = Affects agricultural production/productivity
DC = Damages crops
IP = Increased insect-pests infestation
WQ = Water quality/availability decreased
DF = Damages forest
CC = Change in cropping
CF = Change in food security and health

Y = Yes
N = No

researched issue which is even absent in the cloud due to low frequency (47 times against 1379 times of the word gender).

While both gender and intersectionality are stressed upon by the feminist scholars, only 14 studies were found exploring intersectionality and surprisingly only 7 studies had used the word in text. Researches in climate change perception and adaptation in agriculture started using the word intersectionality from the year 2014. Highest number (six) of paper was published from the journal *Climate and Development* of which four papers used the intersectionality approach.

3.2. Domains, indicators and gendered differences of climate change perception in agriculture

Findings revealed that a small number of studies ($n = 16$) were exploring farmers' gendered perception of climate change in agriculture (see Table 1). These studies used 'yes-no response', 'Likert scale' and 'open-ended questions' as instruments for measuring climate change perception. Careful examination yielded three domains of perception that were measured by these studies, namely, perceived meteorological changes, perceived causes of climate change and perceived impacts of climate change.

3.2.1. Perceived meteorological changes

Climate change perception is mostly measured based on meteorological changes. Changes in temperature, changes in rainfall, unpredictable seasonal changes and more frequent extreme events came out as broad indicators used by the studies in measuring perceived meteorological changes (Table 1). Some of the studies revealed that men and women had more or less similar perception of climate change (Arku, 2013; Dah-gbeto & Villamor, 2016; Mnimbo et al., 2016; Yila & Resurreccion, 2014). Interestingly, some studies reported that women were a bit more concerned about climate change than men (Ampaire et al., 2017; Dah-gbeto & Villamor, 2016; Haq & Ahmed, 2017; Jin et al., 2015; Ngigi et al., 2017; Su et al., 2017) with an evidence of opposite findings too (Luo et al., 2016; Sánchez-Cortés & Chavero, 2011). At the same time, there were considerable gendered differences in the perception of meteorological changes among the studies. Changes in temperature were usually perceived more by women than men (Ampaire et al., 2017; Haq & Ahmed, 2017).

3.2.2. Perceived causes of climate change

Perceived causes of climate change were measured broadly by four indicators: climate change is the result of God's will, climate change was the result of our sinful activities, result of human activities and environmental changes (Table 1). Men and women had different perceptions on causes of climate change. Most of the studies found that women were usually more fatalistic than men about climate change. More women than men perceived climatic change as God's will and results of our sinful acts (Haq & Ahmed, 2017; Mnimbo et al., 2016;

Table 2. Domains and indicators used in gender disaggregated adaptation measurement.

First author (year) location	Study design	Technical						Livelihood			Financial				Structural			Managerial											Socio-cultural					Migration/ relocation		
		CV	CB	DA	IT	UI	MC	AL	DI	AA	CR	SA	SR	CI	WH	RS	PS	CP	MP	IR	SC	AT	MF	CA	IF	FM	HS	IL	HF	FH	SP	GR	FS	ED	TR	SM	PM
Afriyie et al. (2018) Ghana	QL	•							•		•	•			•	•	•	•				•		•				•		•	•			•	•		
Limuwa and Synnevåg (2018) Malawi	MM							•	•		•		•										•							•					•		
Naz et al. (2018) Bangladesh	MM	•		•				•	•		•							•		•	•	•															
Nyasimi et al. (2017) Tanzania	MM	•																•				•		•	•	•											
Sugden et al. (2014) Nepal and India	MM						•	•		•								•			•																•
Ibnouf (2011) Sudan	MM	•							•						•			•				•	•														
Koyenikan and Anozie (2017) Nigeria	QN	•			•	•	•										•	•	•	•		•		•		•										
Tongruksawattana and Wainaina (2019) Kenya	QN				•						•	•						•	•											•							
Mwongera et al. (2017) Tanzania and Uganda	MM	•	•		•													•	•	•		•		•													
Assan et al. (2018) Ghana	MM	•						•	•		•	•	•						•	•		•		•					•								
Chah et al. (2018) Nigeria	QN	•			•	•										•	•		•							•										
Mehar (2016) India	QN	•		•							•		•					•	•			•				•											
Ngigi et al. (2018) Kenya	QL	•																•						•													
Jin et al. (2015) China	QN	•		•	•									•						•																
Rao (2019) Kenya	MM							•	•														•	•			•									•	
Venkatasubramanian and Ramnarain (2018) India	QL										•	•															•									•	
Codjoe et al. (2012) Ghana	QL	•		•	•	•								•	•		•			•				•													
Ngigi et al. (2017) Kenya	MM	•	•	•											•		•	•		•			•	•	•		•	•									
Jin et al. (2015) China	QN	•		•	•									•						•																
Wrigley-Asante et al. (2017) Ghana	QL	•													•		•			•		•	•	•		•											
Yila (2014) Nigeria	MM	•		•					•			•						•			•			•											•	•	
Tesfamariam and Hurlbert (2017) Eritrea	QL							•	•			•	•																•								
Smucker and Wangui (2016) Tanzania	QL	•	•					•					•							•		•		•	•	•								•		•	
Wangui and Smucker (2018) Tanzania	QL		•					•												•			•		•									•	•		
Su (2017) China	MM							•	•				•		•			•		•			•														
	QL							•	•			•						•				•														•	

(*Continued*)

Table 2. Continued.

First author (year) location	Study design	Technical						Livelihood			Financial				Structural			Managerial												Socio-cultural					Migration/ relocation		
		CV	CB	DA	IT	UI	MC	AL	DI	AA	CR	SA	SR	CI	WH	RS	PS	CP	MP	IR	SC	AT	MF	CA	IF	FM	HS	IL	HF	FH	SP	GR	FS	ED	TR	SM	PM
Chandra et al. (2017) Philippines	QN	•			•																	•	•	•		•		•							•	
Djoudi and Brockhaus (2011) Mali	QL							•	•															•							•			•		•
Arku (2013) Ghana	MM							•	•						•					•			•													
Singh et al. (2017) India	MM			•					•														•						•								
Kumasi et al. (2019) Ghana	MM	•		•					•						•	•	•	•	•	•		•		•	•	•	•								•		•
Ravera et al. (2016) India	MM	•		•		•			•									•		•			•	•		•				•	•	•			•		•
Jost et al. (2016) Uganda, Ghana & Bangladesh	QL	•	•	•	•										•			•		•		•	•	•		•							•	•			
Birhanu et al. (2017) Ethiopia	QL							•	•			•					•							•	•						•				•		
Hossain and Zaman (2018) Bangladesh	QN	•			•	•					•	•					•	•					•	•													

QL = Qualitative
QN = Quantitative
MM = Mixed method

CV = Change of crop varieties
CB = Change of animal breeds
DA = Diversification of agriculture
IT = Improved agricultural technology
UI = Use of climate and agricultural information
MC = Mechanization

AL = Alternative livelihood
DI = Diversity in income
AA = Abandon agriculture

CR = Credit /borrowing
SA = Selling assets
SR = Savings and remittance utilization
CI = Crop insurance

WH = Rainwater harvesting
RS = Reinforcing structures
PS = Preventive structures

CP = Change in cropping pattern/rotation /agroforestry/mixed cropping/ intercropping
MP = Modern agricultural practices
IR = Use of irrigation
SC = Sharecropping
AT = Adjustment of time
MF = Mixed farming
CA = Conservative agriculture
IF = Improved feed and treatment
FM = Use of fertilizer and manure
HS = Change in herd size and composition
IL = Increase land under cultivation
HF = Hunting wild food

FH = Food habit change
SP = Sharing productive assets
GR = Change in gender role
FS = Change in farming system
ED = Education programme

TR = Temporary relocation /mobile herding
SM = Seasonal migration
PM = Permanent migration

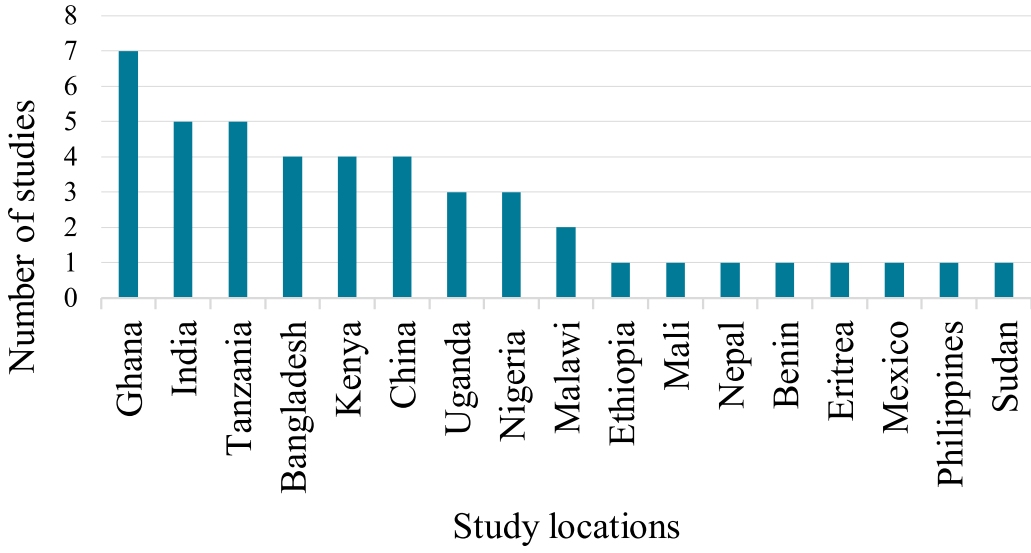

Figure 2. Geographical distribution of studies in the review.

Yila & Resurreccion, 2014). One of the causes for possessing such belief by women may be due to the fact that they are less informed about climate change than men (Kerr et al., 2018; Mnimbo et al., 2016). Women in China claimed human activities were responsible for climate change, while men blamed environmental changes (Su et al., 2017). In Ghana and Malawi, deforestation followed by overpopulation was the most cited causes of climate change by both men and women (Arku, 2013; Kerr et al., 2018) but more men mentioned it in Bangladesh (Haq & Ahmed, 2017).

3.2.3. Perceived impacts of climate change

Six broad indicators were used in measuring the perceived impact of climate change (Table 1). There was a strong difference between male and female farmers in perception of climate change impacts on crop production (Mwongera et al., 2017) and fish catches (Limuwa & Synnevåg, 2018). Women in China reported greater impacts such as flood effect and flood prevention, while men reported greater flood occurrence perception (Luo et al., 2016). More female farmers over male were concerned about future crop loss, less crop productivity (Jin et al., 2015; Yila & Resurreccion, 2014), loss of vegetation and salt-water intrusion (Ampaire et al., 2017) and standing crop damage by strong winds (Dah-gbeto & Villamor, 2016).

3.3. Gender role and perceptions of climate change in farmers

Three studies out of 16 discussing gender and climate change perception reported that gender role shapes climate change perception differently in men and women. In a study conducted in India, almost all effects of climate change were perceived differently by men and women, such as women were less likely to be certain about the change in wild animal hunting in the forest, increased disease of livestock, and increase in ineffective tiller in wetland rice as these were performed by men. On the contrary, other effect of climate change, such as availability of forest food plants, less horticultural production, unavailability and less productivity of medicinal plants, was best perceived by women as they were responsible for these tasks (R. K. Singh et al., 2017). In Ghana, women farmers from two different tribes perceived less food production than their male counterparts and securing food supply was women's job in those tribes (Wrigley-Asante et al., 2017). Again, women from Uganda noticed some climatic changes more intensively than men, such as prolonged drought, salty water and transformation of wetlands to fuel wood cultivation ground, while men noticed decrease in soil fertility more than women (Ampaire et al., 2017). This difference of perception indicates women's gender roles regarding water and fuel wood collection and men's roles on crop production. The above findings suggest that gender roles within the same gender vary geographically but perception of climate change between men and women in the same location may vary due to their different gender role. Thus, these findings clearly indicate the existing gender roles of male and female farmers lead to differences in climate change perception. Similarly, Terry (2009) argued how perception about climatic changes differs by gender role. Even after living in the same household, men and women reported different changes about climate in the area which was due to their difference in gender role (Kristjanson et al., 2017).

3.4. Gender and intersectionality in shaping climate change perceptions

Climate change perceptions are not homogenous between men and women and may also differ across different intersections acting upon gender. Farmers' age, education, social status and ethnicity were found intersecting with gender and climate change perception. In Ghana, climate change perception differed within and between the tribes (Wrigley-Asante et al., 2017). Farmers' climate change perception also varied by their age. Older farmers were more certain than young about drought, change of rainfall and short winter in India (R. K. Singh et al., 2017) and in Mexico older farmers had

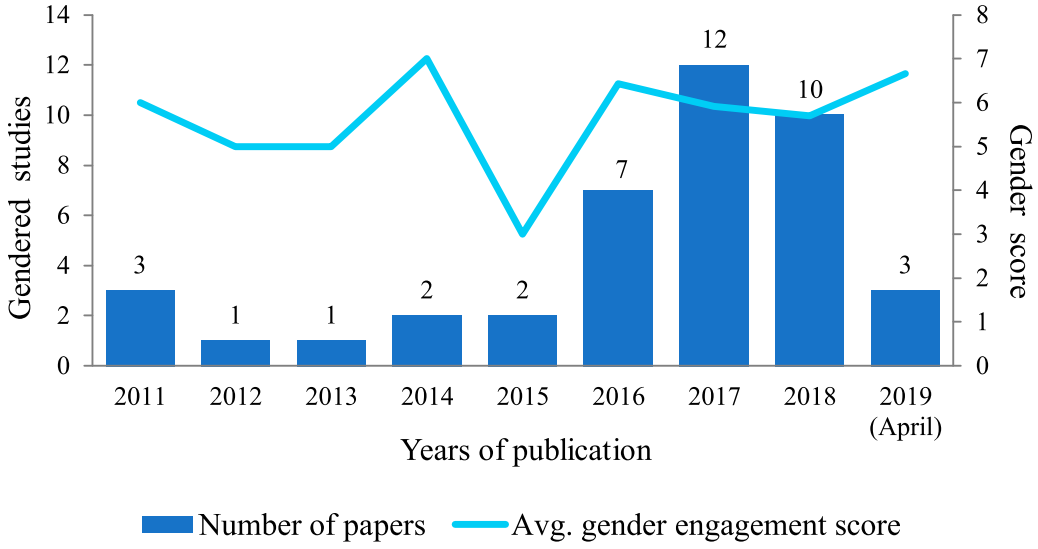

Figure 3. Progress of studies by year and gender mainstreaming score.

better perception about climate change than the young ones (Sánchez-Cortés & Chavero, 2011). Poor farmers compared to wealthier farmers in India felt that weather was less predictable and rainy season had shortened (R. K. Singh et al., 2017). Apart from intersections, a striking finding was revealed by Jin et al. (2015) and Ngigi et al. (2017) where they found climate change perception and risk perception influenced adaptation behaviour in farmers, especially women. Similarly, Arbuckle et al. (2013) confirmed that farmers who were concerned about climate change adapt better than others.

3.5. Domains, strategies and gendered differences in climate change adaptation of the farmers

Thirty-five from the 41 studies included in the review discussed farmers' gendered adaptation strategies to climate change in agriculture (Table 2). Seven distinct domains of adaptation were identified from these studies, namely, technical, financial, structural, managerial, socio-cultural, livelihood and migration. Among these domains of adaptation, technical and managerial adaptations were mostly adopted strategies by the farmers. All the studies exploring adaptation found gendered difference in the adopted strategies.

3.5.1. Technical adaptation

Technical adaptation strategies yielded six broad strategies (Table 2). Twenty-seven among the 35 studies discussing gendered adaptation examined technical adaptation strategies. Change of crop varieties, diversification of agriculture and improved agricultural technology were the most considered technical adaptation strategies in these studies.

Both men and women adopted diverse adaptation strategies. Adoption of improved crop varieties was highly contextual and differed by study locations. Some studies reported that more women than men adopted improved crop varieties (Dahgbeto & Villamor, 2016; Jin et al., 2015; Ngigi et al., 2017; Nyasimi et al., 2017), while others found men outnumbered women in adopting newer varieties (Jost et al., 2016; Ravera et al., 2016; Yila & Resurreccion, 2014). Gendered difference in technical adaptation is multifaceted and motivation behind adopting new varieties fluctuated by gender. Men in Kenya mentioned requirement of little rain as a motivation for changing variety, while women identified fast maturity (Ngigi et al., 2018). Improved livestock breed was adopted differently by men and women in Africa. Women from Tanzanian highland preferred improved livestock breed as most important adaptation practice, while men from Ugandan highland and Tanzania opted for the same (Mwongera et al., 2017; Wangui & Smucker, 2018). Adoption of diverse agriculture varied by gender and place. In Bangladesh, women were found to adopt diverse agriculture more than men (Hossain & Zaman, 2018; Naz et al., 2018), while in Ghana men were adopting more diverse agriculture than women (Jost et al., 2016; Kumasi et al., 2019).

3.5.2. Financial adaptation

Financial adaptation resulted in four broad strategies (Table 2). Seventeen studies examined financial adaptation, and among the strategies, selling assets and taking credit was most preferred financial adaptation.

Selling assets in the face of climate change gives temporary relief to the farm families. In Ghana and Kenya, men preferred selling assets (e.g. livestock) to cope with drought but women chose borrowing from neighbours (Assan et al., 2018; Tongruksawattana & Wainaina, 2019). Women in extreme cases were found even selling their wedding ornaments (Tesfamariam & Hurlbert, 2017).

Financial adaptation strategies may even vary from climatic events or impacts and gender. As for example, in Kenya, more male-headed households sold assets during drought but in case of increased pest infestation, more female-headed households sold their assets to adapt (Tongruksawattana & Wainaina, 2019). In case of taking loans, in Bangladesh and Malawi women got involved in saving scheme, depended more on savings (though earned and saved less) and took loan more often than men for starting micro enterprises (Hossain & Zaman,

Figure 4. Word cloud of the included papers represents the level of emphasis in particular research areas.

2018; Limuwa & Synnevåg, 2018; Naz et al., 2018) while in India, more men than women took loan, borrowed from neighbours and utilized savings (Mehar et al., 2016).

3.5.3. Structural adaptation

Farmers build or modify different structures to adapt to different climatic situations. Findings from the 35 adaptation studies identified three broad structural adaptation strategies (Table 2).

Structural adaptation strategies were mostly the role of men. Preventive structures such as raising land, house reinforcement, micro-irrigation and construction of community drains were done by men as adaptation to floods (Afriyie et al., 2018; Codjoe et al., 2012; Jost et al., 2016). Women were found adopting different structural adaptation strategies. Water harvesting, pen reinforcement, digging wells and boreholes, building water tanks and construction of trenches to control bushfire were some of the adaptation strategies adopted by more women than men (Arku, 2013; Chah et al., 2018; Codjoe et al., 2012; Kumasi et al., 2019; Su et al., 2017). Water harvesting in Sudan had increased labour for women as they had to collect water from Baobab tree and by building *Hafier*-a earthen pit to trap water (Ibnouf, 2011).

3.5.4. Managerial adaptation

Managerial adaptation was mostly used strategies by the farmers irrespective of gender. Almost all of the studies except one had considered managerial adaptation. Twelve broad adaptation strategies were considered by the studies (Table 2).

Management practices adopted by the farmers varied greatly by gender of the farmers. In Tanzania, women mentioned change in cropping, and use of fertilizers as important climate smart agriculture (CSA), while men opted for conservative agriculture, improved feed and composting (Nyasimi et al., 2017). Opposite to this finding, women from Tanzania and tribal women of Ghana were more conservative in using natural resources than men (Smucker & Wangui, 2016; Wrigley-Asante et al., 2017). In Ghana, fishermen scored rearing fish in pond and lakes as the most important adaptation strategy for adapting to drought and women mentioned about seasonal forecast and post-harvest technology (Codjoe et al., 2012). Changing herd size and composition is another

important adaptation for pastoralist and livestock farmers. In Kenya, while husbands looked for limiting number of livestock and diversifying livestock feeds, wives diversified livestock portfolios through rearing of small ruminants and non-ruminant livestock during extreme climatic events (Birhanu et al., 2017; Ngigi et al., 2017).

It was evident from the studies that single enterprise was not going to add much advantage in adapting to climate change. In Malawi, males were prevalent in practising fishing and agriculture together (Limuwa & Synnevåg, 2018). Besides the mixed farming, risk aversion by adopting management practices has become a tendency for some farmers. In Bangladesh, India and Nepal both, men and women found lending land to sharecroppers as the most important strategy (Naz et al., 2018; Sugden et al., 2014). Similarly, in Benin, women wanted to sell livestock earlier than men during food shortage caused by drought (Dah-gbeto & Villamor, 2016).

3.5.5. Socio-cultural adaptation

Apart from widely adopted managerial and technical adaptation strategies, some of the changes were also noticed which were socio-cultural in nature. Change in food habit, gender role, farming systems, sharing productive assets and gaining education were the major socio-cultural strategies identified from the studies. Eight studies discussed about gendered socio-cultural adaptation (Table 2).

Change of food habit in harsh climatic conditions is a usual practice among farmers. In Ghana and Eritrea, women were found reducing consumption of number and amount of meals and using wild plant to make traditional food to fight against drought (Kumasi et al., 2019; Tesfamariam & Hurlbert, 2017), while in India, more men ate less or changed food habit than women (Mehar et al., 2016; Ravera et al., 2016).

Education is a critical asset for informed adaptation. Educating children was found more effective by women than men at household level (Smucker & Wangui, 2016) and at community level (Wangui & Smucker, 2018) in Tanzania. Again, sending children to school and teaching swimming in school was preferred by the farmers in Ghana (Afriyie et al., 2018).

A striking finding reflects change in gender role and responsibilities in agriculture and beyond as a result of adaptation. In Mali, agriculture was mainly men's job, which had transformed to small-scale livestock rearing and added as a new role to play for women while men left agriculture and preferred migration or sharecropping due to changing climatic conditions (Djoudi & Brockhaus, 2011).

3.5.6. Livelihood adaptation

Agriculture alone is not sufficient to support farmers, especially the smallholders, to adapt to climatic changes. In such scenarios, farmers try to diversify income from non-farm income and alternate livelihood strategies. Twenty studies were found exploring livelihood adaptation strategies (Table 2). Diversifying income through temporary non-farm activities could be seen as critical adaptation against climate change. While both men and women preferred diversifying income through non-farm activities (Afriyie et al., 2018), they varied by gender as in Malawi, men opted for fisheries and agriculture-related initiatives, while women were more interested in petty business initiatives (Limuwa & Synnevåg, 2018).

Who adapts more is debated by the findings of the researches as studies from India and Bangladesh claimed more men than women diversifying income (Hossain & Zaman, 2018; Mehar et al., 2016), while another study by Naz et al. (2018) from Bangladesh reported that more women were found adapting diversification of income compared to men. Apart from agriculture, women start a small business to meet the family needs (Arku, 2013; Chandra et al., 2017; Limuwa & Synnevåg, 2018; Naz et al., 2018; Wrigley-Asante et al., 2017). Again, other than small business, women were involved in many non-farm activities in climate affected period, such as non-agricultural labour, house-help, cleaning sales assistant (Chandra et al., 2017), charcoal production (Djoudi & Brockhaus, 2011) and hired labour in food processing (Arku, 2013).

Accordingly, men had some exclusive alternative income diversifying activities, such as fishing, crab-fattening, herding, collecting Nipa palm leaves (locally known as *golpata*), wax and honey, selling labour and pulling non-motorized three wheelers in Bangladesh (Hossain & Zaman, 2018), and carpentry, blacksmithing or masonry, and hired labour in Ghana (Arku, 2013). At times, farmers abruptly changed their livelihood to adapt to climate change. In Mali, men changed their livelihood to pastoralism, while women took small-scale sedentary livestock management in homestead and forest-based livelihood (Djoudi & Brockhaus, 2011).

3.5.7. Migration as adaptation

Migration is debated for considering as an adaptation option. Black et al. (2011) considered adaptation as an opportunity to new employment which may sometimes fail due do inappropriate policy. Gemenne and Blocher (2017) advocate for careful consideration of migration and advised to portray both positives and negatives of migration as adaptation. Repeated climatic events coupled with low or no income from agriculture and lack of locally available off-farm income-generating activities can push farmers back to the wall and the farmers may seek migration. We considered migration as adaptation as fourteen studies were found discussing migration (Table 2).

It is well known that migrant farmers are usually men rather than women. Mostly adult men (Assan et al., 2018; Dah-gbeto & Villamor, 2016; Djoudi & Brockhaus, 2011; Ibnouf, 2011; Rao, 2019; Sugden et al., 2014) and rarely younger men (Afriyie et al., 2018; Wrigley-Asante et al., 2017), younger women (Afriyie et al., 2018; Chandra et al., 2017) and widows (Chandra et al., 2017) were reported to migrate elsewhere for non-farm jobs.

Seasonal or temporary migration is another option for farmers. In pastoralist community, shifting or relocation is very common, but it varies by location. In Kenya, men followed a traditional shifting pattern from one pasture to another during drought (Rao, 2019). In Malawi, more women than men adopted circular migration between the fishing areas to allow fishes to regrow (Limuwa & Synnevåg, 2018), while in Ghana, both men and women preferred shifting farm area to a neighbouring higher land (Afriyie et al., 2018).

Though we consider migration as an adaptation strategy, it has both positive and negative impact on women who are left alone on the farm. Large-scale migration in some parts of Nepal and India created shortage of agricultural labour, giving birth to female-headed households (FHHs) (Sugden et al., 2014) and women's workload is increased (Dah-gbeto & Villamor, 2016). On the other side, women got empowered and started business with the remittance from the migrant farmers (Sugden et al., 2014).

3.6. Effectiveness of adaptation strategies

In climate change adaptation studies, we often miss to measure effectiveness of adaptation strategies (Owen, 2020). Effectiveness of adaptation can be measured either based on evidence or by perceived effectiveness from the adopters. We could not measure any of these methods as only three studies attempted to measure perceived effectiveness and no study found measuring evidence-based effectiveness. Thus to get an idea about effectiveness, this section categorized all the identified adaptation strategies from 35 studies discussing adaptation following the five types of effectiveness proposed by Owen (2020) as seen in Table 3.

From Table 3, we can see the strategies that reduce climatic risk, enhance social wellbeing and strengthen institutions were mentioned in lesser number of studies compared to those adaptations that increases financial resources. That means farmers adopted short-term strategies targeting financial benefits while they did not consider climate resilient and gender transformative strategies to a satisfactory extent which require more institutional support.

3.7. Relationship of gender role, access to resources, social network and intersectionality with climate change adaptation

While doing gender research, looking into the gender roles, access to resources, social network and intersectionality are some prime considerations as prescribed by feminist scholars (Djoudi et al., 2016; Kaijser & Kronsell, 2014; Sultana, 2014). The following sections will discuss how these issues are intervening in climate change adaptation.

3.7.1. Gender role and adaptation

Eighteen out of the 41 articles in this review process studied gender role in agriculture and out of these 18 articles 13 were from Africa and rest are from Asia. Again, out of these 18 only 7 studies, mainly from Africa revealed that gender role and responsibilities shaped differences in adaptation strategies. As for example, while adopting diversified livelihood, young men in Ghana chose charcoal business which requires an intensive labour and hence it was men's task but women took petty business which is usually less labour demanding (Afriyie et al., 2018). In Bangladesh, Benin, Ghana, Nigeria, Sudan and Uganda men earned cash income or grew commercial crops for adapting, while women grew food crops or did the post-harvest activities and contributed more to household food security in the time of seasonal food shortage or drought (Dah-gbeto & Villamor, 2016; Ibnouf, 2011; Jost et al., 2016; Yila & Resurreccion, 2014).

Similarly, while fishermen in Ghana chose fishing and house reinforcement to withstand flood, fisherwomen opted for post-harvest processing of fish (Codjoe et al., 2012). Again, in Tanzania, men preferred livestock breed improvement, herding and treating livestock diseases and these are considered as men's job, while women preferred buying fodder, educating children and temporary employment, which are women's existing gender role (Wangui & Smucker, 2018). All the findings discussed in this section support that existing gender role and responsibilities is determining the choice of adaptation strategies in changing climate.

3.7.2. Gendered access to resources and adaptation

Though 26 out of 41 studies explored access to and control over resources, a few of them explored adaptation and access to resources. The remaining 15 studies did not discuss about gendered access to resources. How inequality in accessing

Table 3. Effectiveness of adaptation strategies reviewed and actions required to adopt.

Types of effectiveness	Adaptation strategies included	Number of studies discussed ($n = 41$)	Gendered action required to adopt
Reduce risk and vulnerability	Rainwater harvesting, reinforcing structures, preventive structures, use of climate and agricultural information, educational programme	16	Access to and ownership of resources, access to institutions, decision-making ability, involvement of public and private institutions guided by gendered policy
Enhance social wellbeing	Sharecropping, sharing productive assets	6	Access to and ownership of resources, access to social institutions, decision-making ability
Improve environment	Change of crop varieties, change of animal breeds, diversification of agriculture, improved agricultural technology, conservative agriculture	28	Access to and ownership of resources, access to institutions, decision-making ability, involvement of public and private institutions guided by gendered policy
Increase economic resources	Mechanization, alternative livelihood, diversity in income, credit/borrowing, selling assets, savings and remittance utilization, crop insurance, change in cropping pattern/ agroforestry, modern agricultural practices, use of irrigation, adjustment of time, mixed farming, improved feed and treatment, use of fertilizer and manure, change in herd size and composition, increase land under cultivation, hunting wild food, change in food habit, migration/ relocation	36	Access to and ownership of resources, access to institutions, decision-making ability
Strengthen institutions	Change in farming system, change in gender role	3	Gender transformative institutions performing under gender transformative policy

resources made difference in adaptation is discussed mostly in some of the studies from Africa. It is clear from the studies that women have been restricted in access to productive resources in many ways. In Sudan, while both men and women adopted petty business as a strategy to adapt with drought, women went door to door on foot while men with the help of camels as women lack entitlement in camels (Ibnouf, 2011). Men had more involvement in resource-based adaptation like fertilizing, manuring and irrigating than women in Ghana (Wrigley-Asante et al., 2017). Another study from Ghana mentioned that, among the adoption strategies, women had highest adoption in changing planting and harvesting dates though they rated it as one of the least effective strategies and lowest adoption rate was in adopting irrigation (Assan et al., 2018), which indicates women had difficulties in adopting strategies that require inputs and materials. In Nigeria, avoiding indiscriminate bush burning was found irrelevant adaptation strategy by the women while water use and conservation by men might be due to the difference in ownership of land and access to water between men and women (Koyenikan & Anozie, 2017). The worst case was found in a tribe from drought-prone Eritrea where women were not culturally allowed to plough land whereas traditionally more men from that area joined military services which creates labour crisis for farm women (Tesfamariam & Hurlbert, 2017). In most of the studies, women were found to adopt mostly the managerial adaptation rather than technical adaptation which indicates unequal access to resources by women in agriculture.

Restricted access to resources is sometimes found in both gender as Mehar et al. (2016) reported Indian farmers, irrespective of gender, seek non-farm activities rather than specific cropping strategies due to lack of capital. Similarly, Assan et al. (2018) found both men and women heavily rely on nature rather than capital for adaptation. As access to resources is linked to poverty, it is found confronting by both genders, especially in the smallholders.

3.7.3. Intersectionality and adaptation

Age, education, marital status, religion, ethnicity and class were explored as intersections of gender by half of the reviewed studies. Selection of adaptation strategies greatly varied by gender along with different intersections. In Ghana, younger men and older women preferred most to grow submergence tolerant crop, while older men and younger women preferred avoiding growing crops near river banks (Afriyie et al., 2018). Medium and large farmers from Nepal and India adopted mechanization, and marginal farmers even could not afford irrigation, as a result they looked for off-farm work (Sugden et al., 2014). In Kenya, women from poor, FHHs, and food-insecure households adjusted farm practices more than their counterparts, while adapting to drought (Tongruksawattana & Wainaina, 2019). Again, large herd size affects women as they have to work longer hours to maintain large herds. Similarly, Wangui and Smucker (2018) and R. K. Singh et al. (2017) also found that rich farmers had higher adaptive capacity and adapt more cash crops than the poor farmers, especially the women who are mostly nature dependent. Lower cast and less educated women in India were secluded from assets and adopted reactive adaptation strategies, like working as a labour, while higher cast women with higher education and wealth were able to renegotiate gender roles and adopted some proactive strategies which reduced vulnerability (Ravera et al., 2016).

In India, religious belief helped to form a milk market based on large animals like cows and buffalos, while in drought smallholders find it difficult to buy feed and fodder for large ruminants (Venkatasubramanian & Ramnarain, 2018). Again it burdens women's workload as taking care of large and sedentary animal generally done by them, while small ruminants are grazed by men in pasture.

Abandonment leads women to adapt in the worst way; which is better to say marginalization rather than adaptation. In Philippines, FHHs adapt the worst way; they go hungry with child, and socio-political exclusion along with climate change compel them to prostitution (Chandra et al., 2017). The worst is, women being abandoned by husband are forced to get involved in transactional sex for money to adapt with drought-affected period (Rao, 2019).

3.7.4. Gendered access to social network and adaptation

Social network and role of institution in adaptation were least examined in the studies. Only 18% of the studies explored social network and very few of them explored the relation with adaptation. In Sudan, women used social network more than men and they learned Indigenous Technological Knowledge (ITK), and got input from the network (Ibnouf, 2011). Women were found to have poorer social network, mostly localized, and related to food security and family issues while men had more institutional network, predominantly external, and crop production oriented (Mwongera et al., 2017; R. K. Singh et al., 2017; Sugden et al., 2014). Cultural practices were seen to be restricting access to social network as in Bangladesh, *purdah* (veil) in some conservative societies restricts women to connect with social network like NGOs (Hossain & Zaman, 2018). On the other hand, it was also reported that both gender reported limited access to social networks such as in Ghana social institutions for both men and women were limited to informal one, such as kinship and friendship mainly and rarely found to have formal microcredit groups (Afriyie et al., 2018).

3.8. Research gaps in climate change perceptions and adaptation research with farmers

Farmers' perceptions of climate change refer to about how they feel the meteorological changes, which may or may not be in line with the meteorological data. Though a good number of studies (Asare-Nuamah & Botchway, 2019; Ayanlade et al., 2017; Hasan & Kumar, 2020; Mkonda et al., 2018; Simelton et al., 2013) have compared farmers perception with meteorological data, those are not gender disaggregated. So, gendered perception of climate change needs to be verified separately with meteorological data in the future. Determinants of gendered perception of climate change are a less researched area and hence future research can explore the determinants

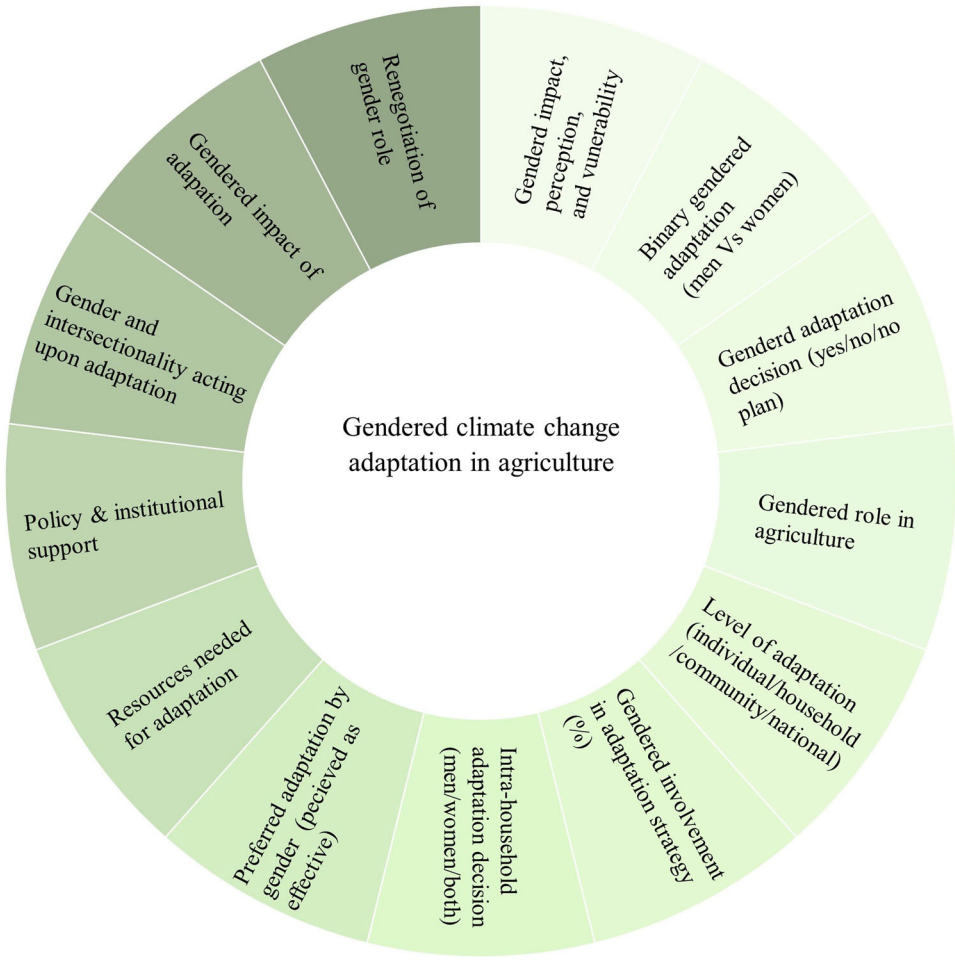

Figure 5. Gendered adaptation research wheel showing existing research priorities and research gaps in climate change adaptation.

leading to differences in perception. More research could explore the role of gendered perceptions and adaptation related to climate change and factors affecting them.

To understand the gender dimensions of climate change adaptation fully, we need a deeper understanding of gender and intersectionality along with other priority research areas in gendered adaptation. The priority research areas in gendered adaptation can be seen in Figure 5.

The lighter coloured fields denote the well-researched areas and the darker the colours, the lesser the areas are studied. Considering the smaller number of studies addressing the issues, future research on famers' gendered perception and adaptation in climate change have ample scope to incorporate feminist political ecology approach in the research to address the power and position of men and women, not only as farmers but also as human beings.

Future research could examine climate change knowledge and communication, role of local and national institutions in gendered adaptation, motivation behind the selecting adaptation strategy, change of gender role and responsibilities in the face of climate change, gendered impact of adaptation, intra-household adaptation decision making, role of social network in gendered adaptation, how gender is addressed in policy and implementation, and gender and intersectionality. Effectiveness of adaptation practices is another important yet less research area and hence more research should come up with this issue.

4. Discussion

The present research systematically analysed and synthesized the existing literature on gendered perceptions of climate change and adaptation practices in the farming communities across the globe. The systematic search yielded 41 papers, mostly from the developing countries of Africa and Asia may be due to higher participation of women in agriculture in Africa (62%) and Asia (57%) against North America (1%) and Europe (4%) (FAO, 2011). In the following sections, we discuss the key findings of the present review and future policy suggestions.

4.1. Gender and climate change perceptions of farmers

Considering the involvement of women in agriculture, gendered perceptions of climate change bear importance in selecting appropriate adaptation. Climate change perceptions are contextual and vary considerably between gender and different intersections. Women were more concerned and fatalistic about climate change than men. This difference may have been contributed by lack of access to climate change information and

education as most of the studies found women farmers were less educated than men. Apart from experience and gender role, climate change perceptions are formed by climate change knowledge and education (Kabir et al., 2016). Though climate change communication seems to be well established in developed countries (Chadwick, 2017), it is still to go a long way in the developing world. So, culturally appropriate climate change communication and integration of climate change awareness in curricula can form perception in line with scientific body of knowledge and hence would foster appropriate adaptation (Nursey-Bray et al., 2012).

4.2. Gender and adaptation to climate change in farming communities

Diverse adaptation strategies were adopted by both men and women though women were clearly lacking behind in adapting climate change than men. Adaptation strategies were highly contextual and location specific. Choice of adaptation even varied by same gender in a given location. Most of the adaptation strategies were governed by the existing gender roles. Some adaptations even burdened gender role and responsibilities which in turn increased women labour and time expenditure (Djoudi & Brockhaus, 2011). Men mostly adapted technical strategies, agronomic practices which increased economic benefit while women adapted mostly the managerial adaptation strategies for maintaining household food security. This difference indicates prevalence of unequal access to resources and capital between men and women while it is crucial for adaptation. Moreover, entitlement, intra-household power structure, different intersections (age, education, class, ethnicity, religion and marital status), lack of gender-balanced policy and implementation also play adversely to adaptation of women in agriculture.

Male outmigration, searching for alternate livelihoods, nonprofitability in agriculture, and gender role of women to assure food security adds more women in agriculture. While more women are entering 'men's job' area as farm operator or labourer, designing women-friendly technology is still least emphasized. Absence of males either by outmigration or abandonment, has both positive and negative effects on women's space. Women, mostly in female-headed households with access to resources can be empowered even after male outmigration. The situation becomes worse for women from conflicted areas when women have been abandoned by husband, lack of social capital and access to resources. In the worst case, women abandon agriculture or compelled to be involved in transactional sex, leaving health and welfare at risk (Rao, 2019).

Agriculture alone is not going to sustain livelihood in a changing climate due to low productivity and demand for off-farm income. While women mainly opted for handicrafts, petty business, and collecting and selling firewood, men worked as non-farm labour, migrated to cities and abroad, and went for fishing and hunting. Earning off-farm income is not a panacea in changing climate as it has some negative consequences. In Australia, drought-affected farmers, stricken by poverty, demanded for more off-farm labour from women and children which in the long run affects both productivity and sustainability of agricultural production (Alston, 2011).

Diversity is a key to sustainability in a changing climate. The greater the diversity in crops or fish catches, in using technology or gears, in income-generating ways (off-farm incomes), the greater the adaptive capacity to climate change (Quiros et al., 2018). Again, diversification of livelihood is challenged by culture, access to resources and lack of skill which cannot be addressed locally by the farmers irrespective of gender. Structural changes are necessary to address long-term development issues like climate change. Structural changes through knowledge, power, values and politics in the community and national level are the key to maintaining diversity and sustainability in a changing climate (Scoones, 2009).

Institutions play an important role in climate change adaptation. Women adapt less than men due to unequal access to informal and formal institutions. Extension services providers are still largely gender blind (Ngigi et al., 2017). Female farmers have limited access to extension services as some countries with conservative societies, male agents are reluctant to work with female farmers (Martini et al., 2017). It is observed in Tanzania that female farmers being advised by female agents have higher adoption than the female farmers supervised by male agents (Lahai et al., 1999). So, with 15% female extension agents worldwide (FAO, 2009), we cannot expect inclusive extension services for female farmers. Moreover, restricted mobility limits women social capital. Men's adaptation choice is influenced by political discourse as they are politically more connected than women. Women, having less political contact, are more vulnerable than men due to less acceptance as farmer, less social contact, and less access to instruments and support services. Institutionalizing gender at all levels of decision-making processes may help the institutions to shift from gender blind to gender responsive (Mackay et al., 2010). Changes in values, culture and politics may help reducing gender inequality by institutions.

Effectiveness of adaptation strategies is a great concern in a changing climate. It is evident that adaptation strategies adopted by the farmers are benefitting them financially while adaptation strategies that reduce climatic risk (water harvesting or use of climate information) or that are gender transformative (change in gender role) were less reported. As most of these adopted strategies are autonomous, it indicates less involvement of formal institutions in planned adaptations which could be the most needed gender transformative action in developing countries. Most of the adaptation strategies address the practical gender needs of the farmers which may not change power and position of women in the long term. As for example, adopting agro-chemicals to boost up production in drought will benefit men, not women, as access to fertilizer is male dominated. Structural changes are needed to uphold women's position in agriculture. By adapting to climate change, new gender role is evolved which in turns gives farmers a new identity. With this new role and identity, redistribution of resources is crucial to adapt with.

4.3. Closing the research gaps

In spite of having greater contribution of women in agriculture in the developing countries and increasing trend of climate

change research, number of researches engaging gender seriously is not increasing. Most of the studies yet to recognize the need of gender-transformative approaches in climate change and agriculture. Almost all the studies explored autonomous adaptation rather than planned adaptation and institutional efforts required. Agricultural adaptation being more attached to social science dimensions, is yet to get more interdisciplinary research combining researchers from physical and social sciences (Davidson, 2016). However, lack of feminist research methods on gender and climate change issues are a big challenge for progressing this highly interdisciplinary area of research. More interdisciplinary and action research will help to understand the gender issues in agriculture and climate change. Linkage between academia and service providers under gender transformative policy will yield more gender transformative studies in agriculture and climate change.

5. Conclusion

This systematic review has attempted to answer the questions of how climate change perceptions and adaptation differ by gender in agriculture across the countries worldwide. Climate change perception is highly contextual, varies by gender and intersections, and perception of climate change guides adaptation behaviour, especially among women. Regionally appropriate climate change communication is a must in developing countries to develop scientific perception among the farmers. Both men and women adapt to diverse adaptation strategies and these vary mostly by existing gender roles. While new gender role is evolving by adapting to climate change, women's workload is piling up, no significant strategic change is noticed in household, regional and national adaptation strategies. Most of the adaptation strategies adopted by the farmers are autonomous and benefit them financially rather than reducing climatic risks. Role of formal institutions in planned adaptation is nearly absent, at least at farm level. Gender transformative policies are needed in the service providing formal institutions for guiding farmers adopting more gender-inclusive planned adaptation that may bring climate resilience in agriculture. In spite of repeated calls by the academics from feminist political ecology to consider gender beyond dichotomy, still intersectionality is understudied. This study reminds us climate change adaptation is not limited to technological adoption, it is deeply rooted in social, cultural and political arena. Adaptation being multifaceted in nature, technological changes alone is not enough to bring agricultural sustainability under a changing climate. Future research could be interdisciplinary for taking climate change perception and adaptation research beyond mere agricultural practices and for introducing the gender and power relations that interacting upon agriculture. Socio-cultural change, changes in power and position between men and women, and political will together can reinforce adaptation to climatic changes in agriculture.

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Notes on contributors

A. T. M. Sanaul Haque is an Associate Professor working in the Department of Agricultural Extension and Rural Development at Patuakhali Science and Technology University, Bangladesh. After graduating from Bangladesh Agricultural University in B. Sc. Ag. (Hons.), he obtained MS degree in Agricultural Extension Education from the same university. He participated an intensive training programme on gender in agriculture held in India. He has published 12 peer-reviewed journal articles focusing on agriculture, rural development, gender issues and sustainable agriculture in coastal ecosystem. He is currently a PhD fellow in Ecosystem Management in the University of New England, Australia.

Lalit Kumar is a Professor in Spatial Modelling, specialising in GIS and Remote Sensing applications in agriculture, environment and climate change related impacts. Professor Kumar has over 25 years' experience in the application of satellite and environmental data layers for broad-scale environmental monitoring, change detection, land use change and its impacts, above-ground biomass estimation, pasture quality assessment, and impacts of climate change on invasive species and biodiversity. He has published extensively in international peer-reviewed journals, with over 300 journal articles, and more than 150 conference papers and technical reports. His work has been cited over 15000 times.

Navjot Bhullar is a Research Professor of Psychology and behavioural scientist with expertise in the areas of community and environmental psychology. She has extensive experience in conducting psychological research assessing community attitudes, perceptions and behaviour change related to environmental and social issues, and investigating environmental influences on mental health and wellbeing. She has published in high-impact peer-reviewed journals, with over 80 research articles, and her work has been cited over 7500 times.

ORCID

A. T. M. Sanaul Haque http://orcid.org/0000-0003-2700-0724
Lalit Kumar http://orcid.org/0000-0002-9205-756X
Navjot Bhullar http://orcid.org/0000-0002-1616-6094

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