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## Review Article

# Role of Extension Service for Climate Change Adaptation in Agriculture: A Systematic Review for Developing Countries

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**ABSTRACT**

Climate change poses significant challenges all over the world. Developing countries whose economic sector profoundly depends on agriculture are especially vulnerable to climate change. To face climate change impacts, adaptation is found to be one of the most important options. In the case of adaptation to climate change in the agricultural sector, extension service is a crucial actor. Therefore, this study explores the different roles agricultural extension services play in developing countries in climate change adaptation. This article follows a systematic literature review through the process of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). The present study considered only peer Scopus-indexed journals published between 1996 and May 2024. Total (n=113) research articles are found initially based on the nature of the study and keywords. Total (n=68) articles were excluded primarily based on published language, Scopus-indexed research article, repeated article, geographical location, climate change adaptation, and role of extension service as a key focus of the study. Finally, (n=45) papers were taken for analysis. The synthesized result suggests that extension services mainly perform the following roles in climate change adaptation: i) raising awareness of climate change, ii) innovation dissemination, iii) information management, iv) production management, v) implementing policies and programs, vi) capacity development, vii) supply of input, and viii) liaison with existing climate change actors. Additional research should evaluate extension agents' barriers to achieving successful outcomes and their capacity-building needs in developing countries vulnerable to climate change.



## Introduction

Picture yourself in an enclosed room where temperature and toxic gas concentration are gradually increasing, and you are unable to breathe. Our atmosphere resembles this enclosed chamber, where entrapped greenhouse gases (GHGs) are heightening day by day, which also leads our earth's surface temperature to be high (Harris, 1999). According to Ozor & Cynthia (2011) any change in climate, whether due to natural or humanoid reasons, is termed climate change. As result of climate change, our temperature increases more than 1.4 degree Celsius over the last century (IPCC, 2014) and developing countries are the most vulnerable predominantly depending on their agricultural sector for livelihood (Alam et al., 2015). Increased rates of floods, droughts, cyclones, salinity, heatwaves, and changes in the nature of pests make the situation of farmers' worse consequences, and food security is at stake (Bates, 2008).

To maintain food security, developing countries' farmers need to adapt or cope with this situation, as adaptation can mitigate the adverse effects of vulnerability and promote positive outcomes by maintaining crop production (Wheeler et al., 2013; Jones, 2010). Adaptation practices may include the use of resistant varieties, early varieties resulting in early maturing of crops, water harvesting technologies, and so on. From the existing literature (Jones, 2010; Kandji et al., 2007), it is clear that adaptation would be one of the best options to combat climate change impacts, and research, innovation, and effective diffusion of climate change adaptation techniques will shape the future of a country.

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Agricultural extension plays a mediatory role in linking farmers and researchers and can guide research institutions with information on research requirements. The role of extension agents also encompasses the effective dissemination of innovation through closely communicative interventions in helping farmers solve their problems (Leeuwis, 2006). Extension service providers of both govt. and non-govt. Organizations in developing countries are closely connected to rural farmers in innovation dissemination. But, after 2000, when climate change became an alarming issue, the traditional service was transformed into a modern, innovative climate change adaptation service. In developing countries, the role of extension agents in climate change adaptation is explored in many studies (Islam & Nursey-Bray, 2017a; Kabir et al., 2021; Uddin, 2008), but they need to bring under one hat for smoothing further research on it. This gap draws the authors' attention to writing a review article on the role of extension service in climate change adaptation.

The main purpose of this study is to explore extension agents' role in climate change adaptation based on contemporary literature. However, this study concretely aims firstly to arrange similar articles to find them easily for future research. Secondly, the previous studies on climate change adaptation and extension agents' role in different developing countries will be synthesized. Finally, categorize papers based on specific roles of extension agents in climate change adaptation.

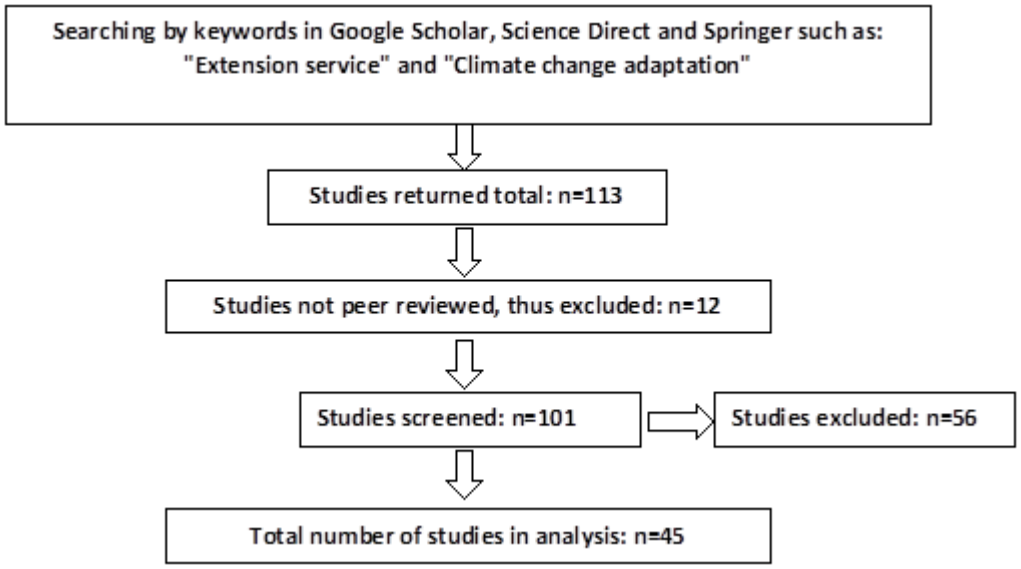


Figure 1. Searching procedure (**Source**: Authors, 2024)

## Review Methodology

### *Review approach*

A systematic literature review, following Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA), is used for this study, which gives a rigorous framework for literature review (Carrera-Rivera et al., 2022; Tranfield et al., 2003; Page et al., 2021). The use of systematic literature review is not new in climate change adaptation research as well as exploring the role of extension agents (Berrang-Ford et al., 2011; Argaw et al., 2023). A systematic literature review allows us to synthesize, analyze, and evaluate scientific literature (Petticrew, 2003; Berrang Ford et al., 2015). This method has several advantages over other literature review methods; specifically, it lets us avoid selection bias in scientific literature (Green et al. 2011). Besides, this approach provides higher transparency, accuracy and consistency by strict inclusion and exclusion methods (Berrang Ford et al., 2015; McDowell et al., 2014).

### *Data collection*

This research considered only peer-reviewed, Scopus-indexed journals published between 1996 and May 2024. To begin searching the literature, authors first finalize their research topics (Cooper et al. 2018). Research databases such as Scopus Index Journals, Elsevier Science Direct, Google Scholar, Springer, and Web of Science were searched using keywords like “Climate change,” “Adaptation,” “Extension service,” “Role of extension,” and “Developing countries.” To maximize the results' coverage, a total of 113 research articles were initially found based on the nature of the study and keywords. Among the searched articles a

total of 68 articles were excluded primarily based on several inclusion and exclusion criteria such as i) published language, ii) peer-reviewed research article, iii) repeated article, iv) geographical location, v) climate change adaptation and role of extension service as the key focus of the study to ensure the robustness of data. Articles that explored the role of extension as a factor of climate change adaptation were also reviewed (Predragovic et al., 2023; Rahman et al., 2018). Besides, we evaluate research papers closely related to this study and provide scope for future research. So, after a review of the title and abstracts, 45 articles were kept for full-text review, followed by analysis. These papers belong solely to the developing country's perspectives on climate change and the role of extension services. However, a flow diagram of the PRISMA method in selecting research articles for this study is shown in Figure 1.

### *Data analysis*

The selected articles (n=45) were downloaded for full-text review and analysis. This set of articles was listed in Microsoft Excel which was then classified into various categories and sub-categories using binary (1=belong to this category, 0=do not) based on thematic arrangement (Rahman et al., 2018). The role of extension agents is sub-categorized by raising awareness of climate change, innovation dissemination, information management, production management, implementing policies and programs, capacity development, supply of input and liaison with existing climate change actors. If one study resembled more than one category, they were recorded separately.

## Results and Discussion

Extension service links the lab and field (De Koff & Broyles, 2019). Extension helps to bring desirable change in human behavior, assist farmers in identifying their problems and finding solutions, and increase crop productivity through human resource development and technology transfer to improve the livelihood of farmers (DAE, 2024; FAO, 1983). Adaptation means to cope with. According to the Global Center for Adaptation (GCA), adaptation to climate change refers to taking necessary steps and coping with the present and projected effects of climate change. As agriculture and food security are the most threatened sectors by adverse impacts of climate change, adaptation to this sector can be the best solution (Berkhout et al., 2006; Islam & Nursey-Bray, 2017b). The role of extension services in supporting farmers in climate change adaptation cannot be denied. Multiple roles played by extension service to adapt to climate change in developing countries namely Bangladesh, India, Nepal, Pakistan, Nigeria, Ghana, Congo, and Central Africa are shown in Figure 2 based on articles by Islam and Nursey-Bray (2017b), SB et al. (2012), Ayanwuyi (2013), Asare-Nuamah et al. (2019), Kassem et al. (2019), Safdar et al. (2014) and Ozor & Cynthia (2011).

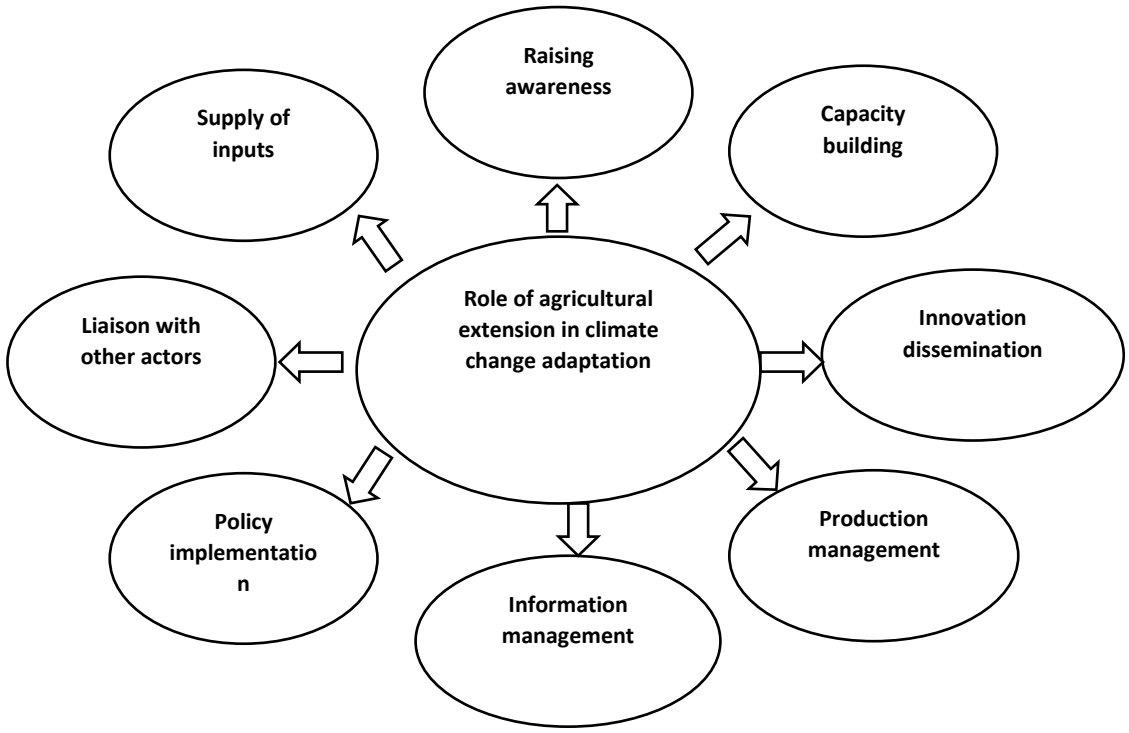


Fig. 2. Roles of agricultural extension service in climate change adaptation in developing countries

**a. Raising awareness on climate change issues:** Increasing awareness of climate change issues can help farmers better adapt to its impacts. Abbasi & Nawaz (2020) found a positive association between climate change adaptation and awareness. In this vein, Afroz et al. (2016) highlighted that awareness, perception, and knowledge of climate change significantly influence people's attitudes to climate change-related actions. The role of extension agents in raising awareness about climate change is well recognized (Mishra et al., 2024). Kassem et al. (2019) showed that extension services can help farmers adapt to climate change by creating awareness. Safdar et al. (2014) also mentioned in their paper that extension agents play multiple roles in adaptation to climate change, awareness in adopting climate-smart technologies positioning first in the list. They utilize ICT tools such as television, leaflets, posters, and radio to raise farmers' awareness about the effects of climate change and adaptation strategies. Ayanwuyi (2013) mentioned that extension agents play a role in climate change adaptation to promote awareness and adoption of new technology through the farmer-to-farmer extension method. Hazrana & Mishra (2024) found that extension service raises awareness of climate change in drought-prone areas of Bangladesh through local cultural music *Gomvira* (a traditional type of music famous in the northern part of Bangladesh) and climate field schools. Exposure to extension services is an important factor influencing climate change-related awareness among farmers (Mashi et al., 2022; Buckland & Campbell, 2021).

**b. Innovation dissemination:** Extension service's role in the information dissemination pathway, especially awareness building and cultivation practice according to climate-smart strategies, are proven (Waaswa et al., 2021). Ayanwuyi (2013) mentioned that extension services played a decisive role in climate change adaptation through innovation dissemination and building resilience. Safdar et al. (2014) illustrated that the dissemination of the latest technology is a major role played by extension services. Asare-Nuamah et al. (2019) mentioned that farmers adopted various innovative technologies, such as no-tillage cultivation, planting sucker multiplication, and so on to enhance production in changing climatic conditions. Extension agents disseminate these innovations. They closely train and stimulate farmers to adopt these innovations. Extension agents play a crucial role in the dissemination of climate-smart agricultural innovations. Therefore, they need to be increasingly trained for successful adaptation to climate change (Olorunfemi et al., 2019).

**c. Climate information management and forecasting:** **A**uthentic, need-based and timely information supply can help farmers to make efficient and effective adaptation strategies that may reduce yield loss (Abbasi & Nawaz, 2020). Seasonal weather information forecasting can help farmers to make the right and timely decisions. If farmers are informed about weather variability through advanced media, communities will be better equipped to face the impacts of climate change. Effective extension services should first assist farmers in this regard. (SB et al., 2012b). Not only this, the extension service conveys field information to researchers to find real-time field solutions like a conveyer belt bridging farmers and researchers (De Koff & Broyles, 2019). Mahamood et. al., (2017) ensures extension agent's role in information management is of two-sided. As, extension agents play an important role in communicating information, they must have the proper education to effectively forecast climate information to farmers (Maponya & Mpandeli, 2013).

**d. Production management:** Agricultural extension has been shown to increase farm productivity and, consequently, economic growth. (Emran et al., 2021; Deressa et al., 2009). Extension provides institutional support to farmers and identifies farmers' needs to support agricultural production in the changed climatic conditions (Maponya & Mpandeli, 2013). Asare-Nuamah et al. (2019) mentioned that extension services help farmers to know about pest and disease control techniques emerging newly as the impact of climate change. The extension helps farmers maintain their production in climate change adaptation by amplifying the use of resistant variety through demonstration, setting up of emergency management unit, dissemination of innovation, and climate-smart technology (Kassem et al., 2019; Safdar et al., 2014). Extension services help farmers by introducing locally suitable climate-smart agricultural management techniques and technologies to adapt to climate variabilities (SB et al., 2012b).

**e. Implementing policies and programs:** Asare-Nuamah et al. (2019) illustrated that farmers of rural communities will be disconnected without extension service. Programs and policies taken by the government for growing climate resilience are only executed through extension agents. Extension officers must be involved in the monitoring and evaluation of agricultural programs (Igodan, 1996). Extension services provide feedback to the government and other interested organizations about climate change impact, farmers' perception, their needs and required climate change adaptation programs (Ayanwuyi, 2013; SB et al., 2012b). In a similar vein, Safdar et al., (2014) also mention that, extension services play a major role in implementing policies and programs taken for climate-vulnerable communities. However, extension services often fail in strengthening vulnerable communities

through government policies due to the institutional tendency to remain in a linear paradigm regarding technology transfer, overdependency on public service, overlooking the intermediary role of extension agents (e. g. negotiating), and the inability of extension personnel to foresee the extension methods (Chowdhury et al., 2013).

**f. Capacity development:** Farmers require a change in knowledge, skill, and resilient capacity to combat climate change impacts, and extension agents help the farmer achieve this (Singh & Grover, 2013). Farmers' educational level has a significant positive effect on climate change adaptation (Abbasi & Nawaz, 2020). Asule et al. (2024) found that training significantly impacts farmers' capacity building, and extension services mainly provide training to farmers. Asare-Nuamah et al. (2019) explored in their study that most farmers were unaware of climate change and had limited adaptation capacity. Extension service, therefore, educates them on climate change and trains them in strategies to adapt to climate change impacts. Ayanwuyi (2013) showed that extension service educates farmers through climate-smart farm practice demonstrations. This study also shows that extension agents build the capacity of farmers to adapt to climate change through setting up emergency management units, farmers' field schools, training and re-training of staff, and educating farmers to build resilience to minimize the negative impacts of climate change and arranging seminar, workshop, field days to sensitize climate change impacts and adaptation strategies. (Ayanwuyi, 2013; Safdar et al., 2014; SB et al., 2012b). Extension services contribute to climate change adaptation by providing farm visits, conducting seminars on climate change issues, demonstrating climate-smart technologies, and featuring agricultural TV shows. (Kassem et al., 2019). Hence, extension agents need to be under continuous training to upgrade their capacity about climate smart agricultural practices (O. D. Olorunfemi et al., 2021).

**g. Supply of inputs:** Supply of input through extension agents significantly improves farm production (Farrington, 1995). Hazrana & Mishra (2024) found a significant positive impact of input subsidy and extension service on rice production in Bangladesh. Agricultural extension and input availability simultaneously produce better results than in isolation in climate change adaptation (Makate et al., 2019). Asare-Nuamah et al. (2019) mentioned that the government sends farm inputs to farmers, which are distributed according to their needs by extension agents. The government takes input supply programs to support climate-vulnerable farm communities to improve their productivity. These programs fail if the right category of targeted farmers is not found, and extension agents identify the right person to help through input supply (Karata, 2024).

**h. Technical advice and liaison role with existing local institutions:** Extension agencies coordinate with other agencies dealing with food, health, education, agrochemicals, and seed (Asare-Nuamah et al., 2019). Extension plays a very crucial role in linking farmers to market, transport, and resources, especially with other public and private entities dealing with climate change adaptation strategies and funding (Mustapha et al.,2012; Mishra et al., 2024; Ferris et al., 2014). Islam & Nursey-Bray (2017c) mentioned that formal institutions like the Department of Agricultural Extension should closely work and collaborate with community-based informal institutions to adapt to climate change.

## Conclusion and Recommendation

This review study explored the roles of extension services in climate change adaptation in developing countries. Reviewing 45 articles results showed that agricultural extension service played eight major roles in improving farm conditions in changing climatic situations. The primary function of extension services is to raise awareness of climate change causes, impacts, and adaptation strategies through various media and direct engagement. Further extension agents disseminate climate-smart agricultural innovations through intensive field-based training, demonstration, and farmer's field school. and develop the capacity of vulnerable farmers. Climate and weather information management by weather forecasting skills of extension service assist farmers in making timely decisions on changing climatic conditions. Due to climate change, many minor pests become major and suddenly collapse farmers' yields. In preventing these complicated sudden loss extension agents can play a significant role by conveying them the right information at the right time to minimize pest population. Moreover, extension agents play an important function in implementing govt. policies and programs taken for climate-vulnerable farm communities. They know better about the real field status, farmers' needs, and necessities. Therefore, they can help in successful program and policy implementation by monitoring, evaluating, and reaching the government to aid or input supply to the real needy farm families. Finally, the extension can bridge climate-vulnerable farmers and other actors working with climate change adaptation to effectively minimize the negative impacts of climate change. Exploring multiple roles of extension service, this research recommends making extension personnel more capable of facing the changing situation of farmers to effectively adapt to climate change. This research concludes with the limitation that more

research is essential for exploring the barriers of extension agents and their capacity-building needs in successful climate-smart extension service delivery in climate-vulnerable developing countries to face the impacts of climate change effectively.

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