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Review

Climate Change Adaptation Influences and Barriers Impacting the Asian Agricultural Industry

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Abstract: There has been an increasing interest among scholars regarding the impacts of climate change on agriculture and possible adaptation strategies for farmers. Little attention has been paid, however, to reviewing adaptation initiatives amongst farmers in Asia. This article fills this knowledge gap by examining the current literature on Asian farmers' perception of climate change, their adaptation strategies, key factors influencing their choices, and the barriers to change. A systematic quantitative literature review is undertaken of 48 papers taken from a range of sources. The review indicates that farmers' perceptions of climate change have been consistent with the scientific data. It further identifies farmers' adaptation strategies with regards to soil conservation, water management and land use changes. The review shows numerous factors influencing, and barriers impacting, farmers' ability to adapt. Influencing factors were analysed and categorised into five groups: cognitive, demographic, social-economic, resources, and institutional. Barriers hampering their adaptive capacity were identified as: a lack of access to information, a lack of access to extension services, limited awareness and knowledge, and limited financial options. The review finishes with some recommendations for future research.

Keywords: adaptation; climate change; agriculture; land management; technology; farming strategies; farmers

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1. Introduction

The agricultural sector has already been significantly impacted by climate change, and the situation will get worse in the future. In many countries, rising sea levels have encroached on land and increasing precipitation rates have led to the spread of floodplains, resulting in the reduction of existing croplands [1]. Increasing temperatures have had a negative impact on crop production and yield from a national [2,3] to a global scale [4]. In the next few decades, warming trends are likely to continue to reduce production yields, unless there is effective adaptation [5,6]. In addition, crop failures will increase due to rainfall variability [7] as well as extreme heat and water stress [8]. Even high precipitation can make harvesting difficult and reduce crop quality [2]. Generally, these impacts of climate change on agricultural industries will continue and be long term and highly detrimental [3]. Further, these impacts are exacerbated by the pressures of increasing population and urbanisation that threaten food security.

Adaptation that builds resilience for agricultural systems should therefore be a policy priority. According to the Intergovernmental Panel on Climate Change (IPCC) [9], adaptation involves adjusting to current or anticipated climate change and its consequences in order to minimise harm or to exploit advantageous possibilities. Agricultural adaptation is crucial as it relies heavily on the climate and some farmers have already started to employ a range of strategies.

Given the importance of adaptation at the farm level, and the key role of the farmers, there has been considerable research into these issues, but many studies are limited in their scope. Existing reviews of the literature mainly discuss farmers' adaptation practices [10], farmers' perceptions of climate change [11–13], or factors influencing farmers' adaptation [14]. Barriers influencing farmers' adaptation were also reviewed in Dang, Li, Nuberg and Bruwer [14] and Karki, Burton and Mackey [12], but these were limited. There was only one review conducted by Juana, Kahaka and Okurut [13] that embraced all these factors but in a non-systematic and limited way. Further, among these reviews, only Sharrfil et al. [10] focussed on adaptation by Asian farmers. This systematic literature review fills the knowledge gap and offers a new, more systematic review of the literature.

The focus of this review is to study the use and management of land for agriculture in the face of climate change, specifically, the land used for growing crops. Agricultural land use and management is considered at the farm level to explore how farmers perceive climate impacts, how they use their agricultural land for growing crops to adapt to the changing climate, and key enablers and barriers to their adaptation. In order to achieve the objectives of the research, this systematic literature review addressed the following questions:

(1) What climate change impacts have been perceived?
(2) How do farmers adapt to climate change impacts?
(3) What are the factors influencing and what are the barriers inhibiting adaptation by farmers?

The next section describes the methodology used to conduct this systematic review and the research questions being addressed. Section 3 identifies the results that address the research questions. Section 4 discusses and evaluates the findings. Finally, Section 5 summarises the results and discussion, suggesting options for further research.

2. Materials and Methods

This literature review was conducted according to the systematic quantitative approach outlined by Pickering and Byrne [15] and Pickering, et al. [16]. This approach helps improve consistency and methodological transparency in identifying, selecting, and synthesising scientific literature [17]. By comprehensively assessing the existing literature, research boundaries and limitations are located, and gaps that provide space for future research are therefore identified [15]. A process labelled Preferred Items for Systematic Review Recommendations (PRISMA) [18] was used that involves several steps (Figure 1). First, relevant research questions, databases, and appropriate search keywords need to be identified according to the objective of the review. The next step involves searching the databases and assessing the collected papers. The captured articles were evaluated, and those articles that were irrelevant or duplicates were then excluded. The last step comprised the content analysis, with the most relevant papers chosen for further analysis and synthesis. These steps are described in more detail in the following sections.

2.1. Databases and Search Criteria

Scopus, Science Direct, and Google Scholar were the three databases selected to search for relevant papers. The databases were searched for articles dating from 2011 to 2020. All papers that are not in English were excluded, and only peer-reviewed papers were chosen. The key terms used to search for appropriate papers were: "agriculture" AND "climate change adaptation" AND "barriers" OR "social factors" OR "economic factors" OR "factors" AND "influencing farmers". The search field was limited to social science disciplines, and the area of study was limited to Asian countries. Endnote software and Microsoft Excel were used as assistant tools for recording relevant data.

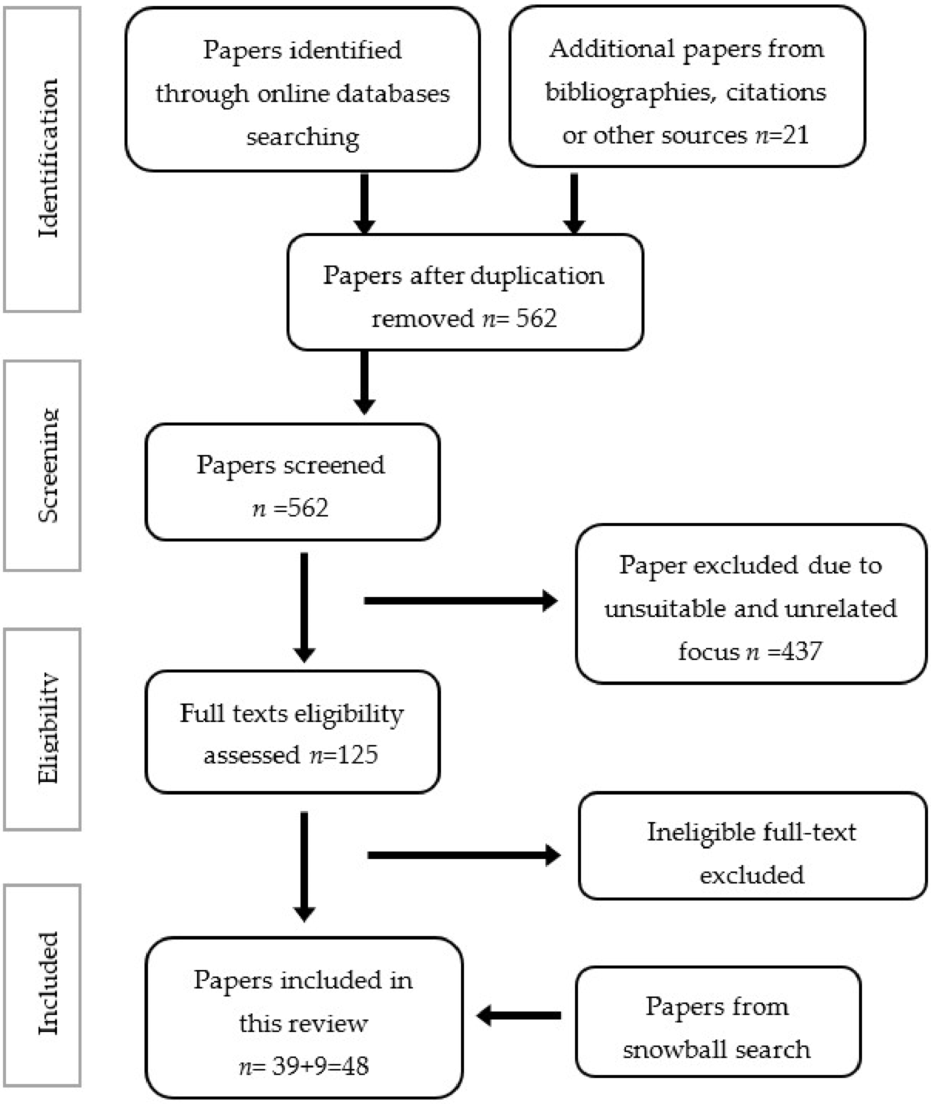

Figure 1. Systematic review process.

2.2. Database Search and Selection Methods

By using these terms and criteria, the database search resulted in 334 articles from Scopus and 219 articles from Science Direct. In addition, twenty-one new papers were found from bibliographies or citations of the papers that bring the total number of articles to 574 (including duplicates). The process of assessing and evaluating articles was accomplished by using the Preferred Items for Systematic Review Recommendations (PRISMA) method [18], which consists of four steps: identification, screening, eligibility, and inclusion (Figure 1). After the first step, twelve papers were excluded as duplicates. After the titles and abstracts were scanned to identify if the papers were related to the scope of the research, the number of papers in the sample was reduced to 125. The full texts were then assessed according to the research objectives and after this step, 39 papers met the criteria and were put through the full review. During the assessment process, 9 additional papers were identified through a snowball search, which increased the number of papers selected to 48.

3. Results

Forty-eight identified papers were analysed conferring to three following topics: (1) perceived impacts of climate change, (2) climate change adaptation strategies, (3) factors influencing farmers' adaptation, and (4) barriers to climate change adaptation.

Figure 2 illustrates the chronological trend of reviewed articles based on their year of publication. Although there is a small decline from 2017 to 2019, there is a general upward trend in publications over 10 years. No papers were published in 2011 and 2012, but there was a peak of 13 articles eight years later, in 2020. Notably, in recent years from 2016 to 2020, approximately 79% of all reviewed papers were published.

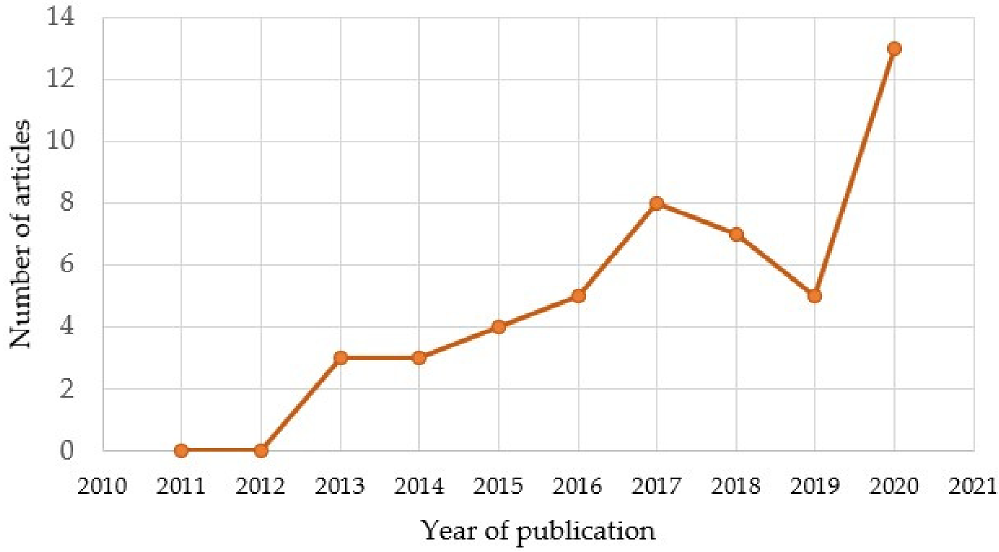

Figure 2. The chronological distribution of reviewed papers.

The geographical distribution of reviewed articles is demonstrated in Figure 3 based on their location of study. Almost all investigations were conducted in less developed countries of Asia, particularly in South Asia (Afghanistan, Bangladesh, Indian, Nepal, Pakistan, and Sri Lanka) with 31 papers, accounting for 65%. In which, the majority of articles have focused on Bangladesh, India, Nepal, and Pakistan (7 papers each). The number of studies located in South East Asia (Cambodia, Indonesia, Malaysia, Myanmar, Thailand, and Vietnam) was 11, accounting for about 22%. Vietnam is the country that nearly half of the papers have focused on in the South East Asia region; however, five out of 48, accounting for 10%, is a very modest number.

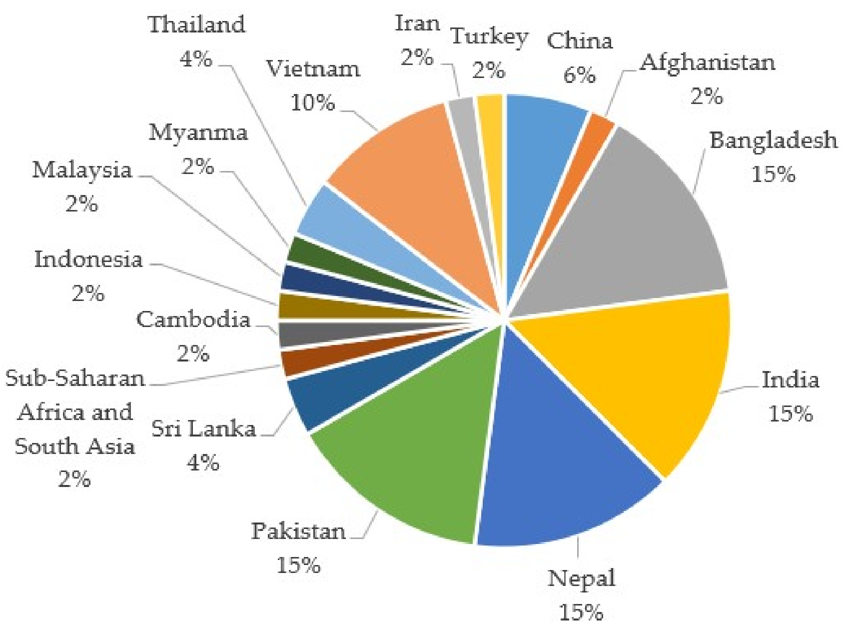

Figure 3. The geographical distribution of reviewed papers.

Three-quarters of the papers (n = 36) used quantitative methods, only one paper (2%) used qualitative research methods, and 11 papers (roughly 23%) used mixed methods. There are 11 publications (approximately 23%) that included a review of the literature in their methods. The range of methods used included qualitative analysis, exploratory factor analysis, multiple regression analysis, multivariate probit model, multinomial logit model, binary model, Heckman two-stage models, descriptive statistics, and several other methods.

3.1. Perceived Impacts of Climate Change

Climate change and its impacts have been observed across the study locations. Changes in precipitation patterns and atmospheric temperatures are the most frequently perceived by farmers in Asia. Twenty-eight papers show that farmers have perceived a trend of increasing temperature, and 29 papers reported observed changes in precipitation. Among these 29 papers, 23 papers show a decline while two papers show an increased in rainfall [19,20]. In some places, changes in rainfall have described as more erratic [21], unpredictable [22], and untimely [23,24]. Among 22 papers that provided records of climate data, 21 show that farmers' perceptions of climate change have been consistent with the observed scientific data. The exception was in research conducted by Phuong [25], where farmers in central Vietnam perceived a slight increase in temperature and a decrease of rainfall, while the climate records show that both have decreased in the dry seasons but increased in rainy season. In addition, common climate change impacts identified were frequent drought (19 papers), and floods (10 papers). Farmers in some places have encountered other impacts, such as cyclones [26,27] heatwaves [28], dry spells [29], cold spells [28,30], and land erosion [22,31,32]. These climate impacts are presented in Figure 4.

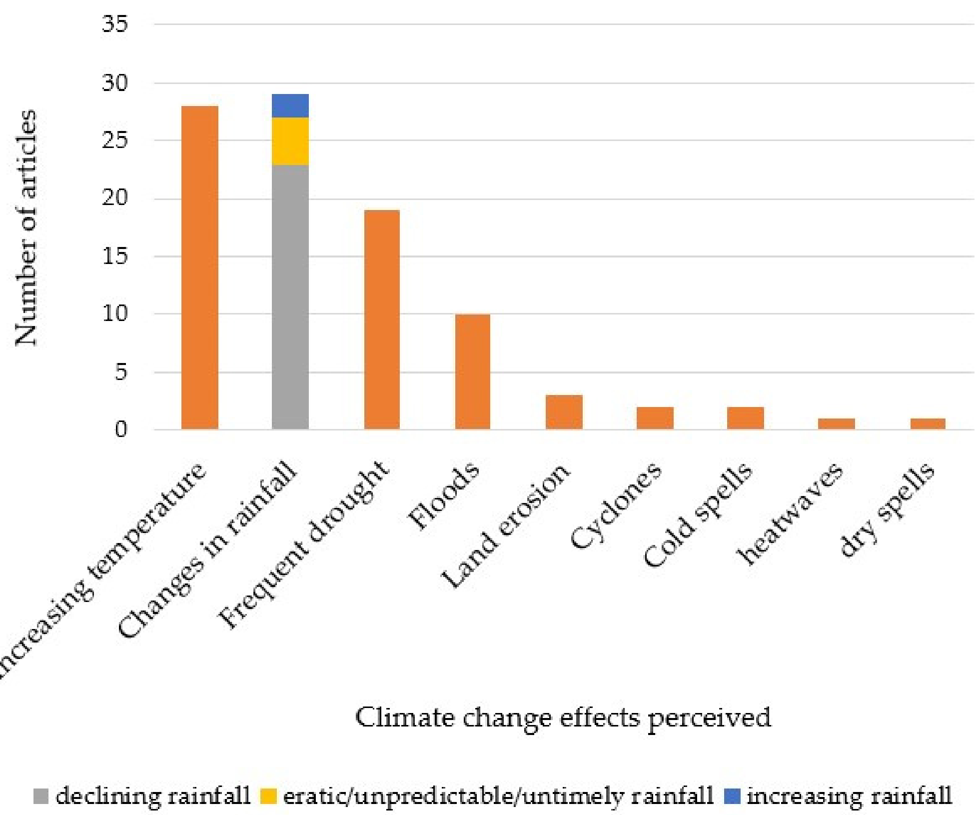

Figure 4. Farmers' perceptions of climate change effects.

The most common impacts on crops that farmers have experienced are changes in yields, pest and disease attacks, and farming activities. Farmers reported a decline in the productions of their crops [19,22,25,27,33] and crop failures [34–36]. Many farmers reported that the infestation of insects and diseases have been escalating due to excessive changes in temperatures and rainfall [19,25,37,38]. In addition, farmers have perceived changing sowing and growing seasons due to climatic variability [19,37].

3.2. Climate Change Adaptation Strategies

The results of identified papers demonstrated that farmers have employed different forms of technologies to adjust their land use options and land management practices to climate change. This review focuses on the main adaptation technologies, including soil management, water management, crop management, and land use option changes.

3.2.1. Soil Management

To reduce soil degradation and decomposition resulting from higher temperatures and rainfall variability, Asian farmers have used a different technique to conserve soil structure and to maintain soil moisture. Using mulch is a common method practised by farmers in Nepal [21,38,39] and Myanmar [34]. Some farmers in Sri Lanka use crop residues as mulch to reduce soil moisture loss [29] or use residues as fertilisers [22]. Five papers mentioned minimising ploughing and reducing tillage as soil conservation strategies [21,23,38,40]. However, farmers in a rain-fed region of Pakistan used deep ploughing during the rainy season as a critical farming practice to improve soil moisture [41]. In Pakistan, farmers planted bamboo to reduce soil erosion or planted shade trees to protect crops from increasing temperatures [19,31,42]. In some places, farmers employed land levelling to prevent the loss of moisture [40] and elevated the land [28] or made stone embankments to protect their land from erosion caused by flooding [31].

3.2.2. Water Management

When adapting to increasing temperatures and drought, farmers can use a variety of water practices. Eight papers reported that farmers have to provide supplementary irrigation or increase the amount of irrigation during drought periods [28,29,36,42–46]. Harvesting rainwater to use during the dry season is an essential method used in Sri Lanka [29], India [35], and Nepal [21,38,39]. However, only a small number of farmers are able to employ these strategies due to the lack of financial resources to build a harvesting system [29,39] and due to the lack of knowledge and information about the strategies [38]. To cope with water scarcity, some farmers in Bangladesh, India, and Pakistan seek alternative water sources by increasing their use of groundwater [19,33,44]. Common ways that farmers use to store harvested water are digging wells [47], and pond construction [21,45]. Pump irrigation is reported to be used in India [48] and Bangladesh [49] by very few farmers due to the high cost of pumping machine.

The use of advanced water management technologies was reported in five papers. Improved irrigation methods are used by farmers in Nepal [50] and Malaysia [20]. Drip irrigation is used by farmers in Nepal with support from organisations [21]. Efficient water management and water-saving technologies are employed by farmers in Vietnam [51] and Bangladesh [30], but by very few farmers.

3.2.3. Land Use Option Changes and Crop Management

Changes in land use options and crop management were adopted widely and considered to be effective strategies to respond to changing climate conditions. Adjusting the farming calendar was identified in 29 articles. Four reported that there are few farmers changing sowing or planting dates [23,30,36,52], while the others claim that this is the main adaptive strategy and widely used. Khanal, Wilson, Hoang and Lee [50]; Huong, Bo and Fahad [51]; and Abid, Scheffran, Schneider and Ashfaq [42], for example, suggest that a larger number of farmers prefer to practice this method because it is simple to implement and it requires less input cost. Crop diversification was mentioned in nine papers. It is an effective strategy for farmers in Indonesia to minimise losses incurred by the failure of a single crop due to severe weather [47]. In central Vietnam, it is a crucial adaptive strategy due to its various advantages, including low input cost and a large source of income [25]. Farmers in Bangladesh add cereal crops to their cropping system to avoid fallowing their farmland in the dry season [32]. Changing crop types was discussed in seven papers. Farmers in Nepal adopt this strategy to minimise the adverse impact of climate change and earn more income [21,28]. Changing crop type is an effective practice adopted by farmers in Pakistan to deal with pest infestation, water shortage, and extreme weather events [19].

Changing crop varieties and adopting modern improved varieties are largely employed by farmers in Asian countries with 29 papers mentioning this adaptation. Changing crop varieties are claimed to be the most important practice adopted by farmers in Pakistan [42], Bangladesh [32], India [48], and Sri Lanka [29]. Nevertheless, very few farmers can afford to change their crop varieties due to access to credit [51,53]. Adopting modern improved varieties was identified as an important strategy employed by farmers to maintain their yield production. For example, farmers in Pakistan changed to heat-tolerant varieties to cope with extreme temperatures or use genetically modified varieties to minimise the impact of pest attack. Farmers in Vietnam use drought-tolerant sweet potato varieties to overcome freshwater shortage [25]. While this is a valuable measure for improving land-use efficiency in the face of climate change, it requires technical and information assistance and financial support for farmers. This is confirmed in the research conducted by Omerkhil, et al. [54] and Khanal and Wilson [38].

Changes in land use options, including changing the location of farming, changing farming area, fallowing, and renting land, are also practised by farmers across Asian countries to adapt to climate change conditions. Changing the planting location of crops was identified in six papers. Farmers adopt this strategy to respond to irrigation water shortage, to avoid reductions of grain quality yield, and to limit infestations of diseases and insects [23,45]. Reducing cultivation area was found in four papers. This practice is among the most common strategy used by farmers to cope with water scarcity [55,56]. Renting out the land was identified in seven papers. This practice is adopted by farmers in China [56], India [27,48], and Pakistan [19,41,42,46]. Abandoning farming is less used as a strategy, being identified in only two papers. However, the number of farmers abandoning farming to seek urban job opportunities in Yunnan Province, China has been increasing [56].

3.3. Factors Influencing Adaptation to Climate Change

Farmers' adaptation to climate change has been influenced by various factors that were categorised into four groups (Table 1).

Table 1. Key influencing factors and barriers affecting farmers' adaptation.

Influencing Factors and Affecting Barriers	Number of Publications
Cognitive factors	
Farmers' perception	20
Efficacy belief	7
Demographic factors	
Age	14
Gender	12
Household size	10
Social-economic factors	
Farm size	23
Incomes	22
Non-land assets	14
Education	28
Membership of a group or organisation	5
Social networks between farmers	5
Experience	19

Table 1. *Cont.*

Influencing Factors and Affecting Barriers	Number of Publications
Resources and Institutional factors	
Access to information	10
Access to extension services	13
Access to basic infrastructure	7
Land tenure	11
Attend education/training program	7
Lack of access to information	10
Lack of access to extension services	6
Lack of knowledge	7
Lack of access to finance	10

3.3.1. Cognitive Factors

A total of 20 papers focused on farmers' perception of climate change and its impacts as a determining factor affecting their adaptation. The findings show that the level of adaptation is significantly influenced by climate change perception and risk perception. In particular, when farmers consider climate change is affecting their livelihoods or they believe that climate variability poses real threats, they are likely to adopt different measures to adapt [26,29,36]. How they perceive climate change or climate risks affects their intention to undertake adaptation [28,57]. In contrast, people who do not perceive climate change as a potential threat to their farming do not make any attempt to adapt [58]. Importantly, farmers who exhibit wishful thinking, denial of climate change risk, and fatalism are unlikely to attempt to adapt [57].

Seven articles discussed the belief in the efficacy of changes in land management practices as an important determinant influencing farmers' adaptation. Truelove, et al. [59] claim that efficacy belief is the strongest factor influencing farmers' behavioural intentions. The more farmers believe that adaptation can minimise the negative impacts of climate change on their agriculture, the more likely they are to employ adaptation strategies [23,29,38] or to have an intention to adapt [28,57]. However, the fear of change hinders farmers' adaptation [58]. Thus, it is critical to understand how farmers recognise and perceive climate change and perceive the effectiveness of measures in order to help them improve their adaptation strategies.

3.3.2. Demographic Factors

Fourteen papers discussed the age of farmers as something affecting their adaptive decisions. Results of research conducted by [36] and Masud, Azam, Mohiuddin, Banna, Akhtar, Alam and Begum [20] suggest that an increase in the age of farmers impacts their adaptation practices positively. The older farmers are considered to have a better knowledge of local practices, have witnessed more climatic impacts, and are expected to be more adaptive than young farmers. Five other studies claim that older farmers use their experience to adapt better. For example, older farmers manage their land more effectively in combating to floods [49]. They employ a variety of better adaptation strategies than younger farmers during drought seasons [27]. In addition, because older farmers are more aware of dangerous climatic situations and know how to deal better with bad climatic conditions, their choices of adaptation are more production-focussed [53,60].

In contrast, the other four papers state that aging farmers are less likely to adapt or to employ new adaptive strategies. They are less likely to adopt changes to plant protection and management or to diversify their farms due to their illiteracy [31]. The older they are, the fewer strategies they adopt [52,56]. In particular, older farmers are more comfortable with traditional practices, hesitate to change their behaviour, and are not willing to apply modern farming techniques or advanced technologies. They may, for example, prefer adopting crop diversification to minimum tillage strategies [40], while younger farmers are found to be more likely to adopt adaptation practices than their counterparts [38,50,55]. Young farmers may have more access to climate information; they are more innovative, and they show more interest in adopting advanced technology and new techniques. For example, they may adjust sowing time, use drought-tolerant varieties, and shift to new crops [24].

Regarding gender, 12 papers discuss the differences between male and female farmers in adapting to climate change. Research conducted by Joshi, Ji and Joshi [39] and Oo, Van Huylenbroeck and Speelman [34] claim that female farmers are less willing to adapt, while men are more likely to undertake adaptation and adopt more strategies [24,26,45]. In addition, men and women are very different in selecting adaptation approaches. Women tend to choose to adopt traditional strategies, such as changing cropping patterns [27], changing crop varieties [61], and making stone pitched contour bunds [62]. In contrast, men practice more innovative and technological strategies to manage their land. These strategies include irrigation [49,53], information and communication technologies [62], sharecropping [49], and planting non-rice and short duration rice crops [62].

Household size plays a role in adaptation. Among 10 papers mentioning household size as a factor affecting farmers' adaptation, almost all articles present a positive relationship between household size and adaptation, though two articles show the reverse. On the one hand, the larger size of the household is a driver for the adoption and implementation of various adaptive strategies [24,45,52,62], as well as the application of new technology [42]. Families with larger households are more able to accomplish labour-consuming strategies to adapt. For example, they are likely to employ adaptive strategies such as deep lowing, crop diversification, soil bund making [41], and crop pattern change [27].

Farmers' adaptive behaviours are significantly influenced by their farming experiences. Among 48 identified articles, there are 19 papers discussing farming experience and climate-damage experience as influencing factors in decisions. Results from research conducted by Esfandiari, Khalilabad, Boshrabadi and Mehrjerdi [55]; Masud, Azam, Mohiuddin, Banna, Akhtar, Alam and Begum [20]; and Oo, Van Huylenbroeck and Speelman [34] suggest that the number of years of farming experience plays a determining role in adaptation. Naz, Doneys and Saqib [49] claim that the more experienced farmers are, the more they manage their land effectively and are likely to adapt. Farming experience significantly influences farmers' probabilities of adapting to cope with climate change as more experienced farmers are more aware of past climate events [42,44,45,51,60]. Further, farmers who are more experienced regarding previous climate damage are better prepared [23,38,40,44,63]. The knowledge learnt over the years enables them to make effective decisions to reduce risks to their farms [41]. They also have a higher probability of monitoring weather forecasts than those with less experience [61].

3.3.3. Social-Economic Factors

Twenty-three papers have shown the important role of farm size in adaptation. Among these, 18 have reported the positive relation between farm area and the employment of adaptation strategies. Larger farm size households are more likely to adopt different strategies [20,23,32,35,37–40,45,50,51,53,61]. They have more capacity to invest in high-cost strategies [24] and tend to respond earlier [30]. Farm size also has a significant and positive influence on the choices of farmers [42,63].

However, five other papers claim that farmers with less land are more likely to adapt [31,34,52,55,60]. The reason is that small farm holders have less capacity to bear risk, so they adopt diversification strategies to minimise loss, while large farm-sized families already have the capacity to diversify their crops [31,60]. Due to the more significant investment requirement, farmers with less land tend to adopt modern technological measures, while farmers with large farms prefer to adopt traditional methods [34,52].

Incomes play an important part in determining the resilience of farmers. Among six papers mentioning general household income, only one states that higher household income decreases the chance of adapting [37], while five others claim that households with higher incomes are more likely to adopt multiple adaptive strategies [24,44,46,55,60]. The on-farm incomes of households were identified in 11 papers and off-farm incomes identified in five papers as significant influences on adaptation measures related to investments and innovations. According to Masud, Azam, Mohiuddin, Banna, Akhtar, Alam and Begum [20], farm income has considerable impacts on farmers' adaptation practices. High farm income enhances the possibility of selecting soil management strategies, such as minimised soil tillage [63] or land clearing without slashing and burning [47]. Farmers with high agricultural incomes are able to deal with the risk of various adaptation options. They are more likely to change cropping patterns, adjust the farming calendar, and invest in different crop varieties [25,45,47,53,55,63,64]. Higher farm incomes also enable farmers to improve their irrigation [35,53,63]. Income from other sources also increases the adaptive capacity of farmers [34,36,38,39,51].

Fourteen papers indicated that owning non-land assets have positive effects on farmers' adaptation. Possessing livestock increases farmers adaptive capacity [30,65] and the numbers of adaptive measures adopted [46]. Households that own tub better facilities have more capabilities of farming adjustment [24,42,48]. Possessing a tractor also has a strong influence on farmers' adaptation as it helps farmers with deep ploughing, crop diversification, and the transportation of manure [41]. Having more assets increases farmers' employment of various adaptation strategies [26,31]. It also enables farmers to adopt high-cost and advanced technology-related measures such as adopting improved varieties [66], shifting to new crops, adjusting growing schedule [24,54], using information and communication technology, adopting irrigation, diversifying crops, and adopting soil and water management [62]. In addition, it affects farmers' selections of adaptation practices, for instance, the choice of crop varieties [53].

The level of education is an essential factor relating to the capacity of farmers to adapt to climate change and is mentioned by 28 papers. Education is a factor that significantly underpins farmers' decisions to adapt [30,33]. Farmers with higher levels of education have a greater probability and ability to adapt to climate change [20,23,33,36,38,42,45,51,52]. They are more flexible in deciding on land management practices and more aware of the benefits of these practices, and so use land more efficiently by employing different adaptation strategies [28,35,44,46,55]. Because educated farmers are more aware of obtaining and using information, they usually make better adaptation choices [41,49,60,61]. They are more aware of climate change and agricultural innovations, so they are more interested in adopting scientific techniques and advanced technologies in land management practices [24,39,54,63]. If these farmers are the heads of households, they can positively and significantly influence the adaptation ability of other family members [39,53]. In contrast, farmers who have lower education levels must rely on their neighbours in choosing adaptation methods [31].

Only five papers identified membership of a group or organisation as a contributing factor to the adaptation. Participation in a group enhances the likelihood of making changes in farming practices [26,66] and increases the number of adaptive strategies employed [24]. It is also found to be a crucial factor affecting farmer's choices of adopting crop diversification, the use of stress-tolerant varieties [40], and clearing land without slashing and burning [47]. In addition, farmers in social organisations are able to exchange information on climate change and adaptation strategies [65], and access support from NGOs [26,65].

Social networks between farmers that influence farmers' adaptive capacity were identified in five articles. All of them indicated a significantly positive relationship between social networks and adaptation. Farmers are more likely to adopt adaptation measures that they learn through their neighbours and friends [29,33]. Frequent communication with their peers encourages farmers to use more innovative strategies, such as minimum tillage and irrigation improvements [40,63]. Cooperation between farmers is very important as this can enhance collective actions that help to improve the adaptation capacity of farm households [19].

3.3.4. Resources and Institutional Factors

Access to information on climate change is identified as a factor that can increase farmers' adaptive capacity. A total of ten papers show the positive correlation between access to information and the probability of adaptation to climate change. Farmers who obtain more information on climate change are more likely to adapt [23,38,50]. Access to timely weather information urges farmers to improve irrigation to conserve water [35,51]. Adopting climate smart adaptation strategies significantly increases amongst farmers who have access to information about agricultural technologies and practices [40]. Farmers who receive information on climate change and on adaptation from trusted sources are more likely to adapt and use more strategies [34,35,42,45,51,66]. A case in point is that obtaining information on weather forecasting increases the likelihood of adopting adjustments to the farming calendar [51,66], improving crop varieties, and other land management practices [66].

Thirteen papers identified the ability to access extension services as a key contributing factor to farmers' adaptation. Farmers' adaptation probability is significantly impacted by their contact with extension services [23,36,38,52]. This contact also increases the number of adaptation practices employed [24,40]. Farmers' selections of adaptation options were found to be significantly influenced by how they access extension services [31,34,42,44,60,62]. Farmers who access extension services practice irrigation strategies much more than those who do not [62]. A wide range of strategies is adopted that includes adjusting planting calendars, changing sowing methods, growing improved varieties, and increasing the use of good agricultural practices recommended by public organisations [34]. Moreover, in research conducted by Singh [35], extension services in the form of credit, as well as information on climate and crop insurance, were identified as a factors influencing farmers' selections of adaptation strategies. However, access to extension services was found to increase only the likelihood of adopting water management [51] and variegation of crops [31] while decreasing the probability of adopting other strategies. The reason mentioned is that the role of extension officers is insufficient.

Access to basic infrastructures such as irrigation and electricity was identified in seven papers. These reveal that access to irrigation and electricity positively influences farmers' adaptive capacity and choices. Biggs, Tompkins, Allen, Moon and Allen [65] found farmers with more access to irrigation are more likely to adapt. More access to irrigation increases the employment of crop pattern changes [31] or increases the use of irrigation [43]. Farmers who have more access to electricity increase usage of surface water irrigation [44] and groundwater irrigation [30] to cope with water scarcity. In addition, greater access to electricity enables farmers to diversify crops and change land use options [44] and to switch to planting short duration and climate resistant varieties [30,44].

Discussions of the key role of land tenure status were found in 11 papers. Only one paper states that land renters are more likely to adapt to climate change [42] while almost all of them (10 papers) identified that the rights of farmers regarding land certainly affect farmers' possibilities and decisions of adaptation. Land access increases the farmers' probability of adaptation significantly [49]. In comparison with tenants, landowners adopt more adaptation strategies [24,51]. It is easier for farmers to make choices regarding adaptation strategies when they own the land [44,45,60]. There is a higher likelihood to adopt crop diversification as they have a higher risk-bearing capacity [40,44,60]. In addition, the literature suggests that land tenure status encourages farmers to invest more in their land and adopt new technologies. For example, they are more likely to apply farming structure diversification [31], soil bund-making [41], laser land levelling [40], and climate stress-tolerant varieties [40,53]. Only one paper states that land renters are more likely to adapt to climate change [42]. The reason is the tenants have to pay rent, so they are more concerned about their farm income.

Only seven articles identified attending an education or training program on climate change and adaptation as a contributing factor. The willingness of farmers to change their agricultural practices is positively improved when engaging in training [26,55,61,64].

Farmers' choices to adapt are significantly impacted by what they learn from training programs. For instance, attending a training program on climate smart adaptation encourages farmers to adopt crop diversification, laser land levelling, and minimum tillage [40]. Changing rice varieties, using irrigation systems and adjusting the farming calendar, are significantly practiced by farmers who participate in training courses on rice growing [45]. Especially, female farmers are more able to and likely to adapt to flood risks when engaging in training [49].

3.4. Major Barriers to Climate Change Adaptation

Asian farmers have faced a number of constraints that affect their adaptation. They are categorised as the four main groups below (Table 1).

3.4.1. Lack of Access to Information

A lack of access to information is a prominent factor hindering farmers' adaptive capacity. A lack of information on climate change, climate risks, and the weather forecast was identified as a major barrier in ten papers [19–21,25,29–31,45,46,53]. In research conducted by Karki, Burton and Mackey [21], farmers in Nepal could not make better decisions about crop choice due to a lack of weather information and climate change. They do not even have a clear understanding of what climate change is. A lack of reliable information on climate change provided by their government was identified in research conducted by Esham and Garforth [29]. Therefore, farmers have to rely on their traditional knowledge and own experience to predict weather changes and patterns. Furthermore, a lack of access to information about adaptation methods was identified in five papers. This limitation significantly prevents farmers from adjusting to their farming practices [25,36,42,53,58].

3.4.2. Lack of Access to Extension Services

A lack of access to extension services was identified in six papers. Limited access to agricultural extension officers is a critical impediment to farmers' adaptation as farmers are unable to learn modern farming methods [29]. Moreover, a lack of extension services deprives farmers of obtaining valued adaptation information [22] and technical knowledge [46]. Therefore, this impacts their decision-making in terms of adopting adaptive strategies. In addition, farmers must rely on themselves or their community when there is an ineffective extension service [19,31].

3.4.3. Lack of Knowledge

Limited knowledge was found as a constraint to farmers' adaptation in seven articles. Adapting to climate abnormalities has become challenging due to farmers' limited knowledge [21]. This lack of knowledge on adaptation measures is identified in studies conducted by Alauddin and Sarker [30]; Sarker, Alam and Gow [53]; and Arunrat, Wang, Pumijumnong, Sereenonchai and Cai [45]. This barrier obstructs a number of farmers from employing any adaptation strategies. In addition, possessing inadequate technical knowledge restricts farmers from adopting advanced adaptation methods to improve their farming practice [19,29]. Female farmers especially have to rely on their male counterparts, who possess knowledge in farming practices, which prevents them from successfully adapting [49].

3.4.4. Lack of Access to Finance

Ten papers identified financial limitations as a restricting factor for adaptation. All papers cited financial constraints or the availability of financial assistance as the major barrier [19–21,29–31,42,46,53,58]. For instance, due to a lack of funds, farmers are highly reliant on crop diversification [58]. Additionally, they are unable to invest in new seed varieties, adopt crop management, or employ water conservation strategies [29]. Despite the availability of financial services, farmers in some places such as Pakistan hardly use them because of high interest rates [42].

4. Discussion

This review indicates that farmers in Asian countries are already dealing with adverse climate change impacts. They perceive an increase in temperature and changes in precipitation. These results support the observations in the reviews of Juana, Kahaka and Okurut [13]; Foguesatto, Artuzo, Talamini and Machado [11]; and Karki, Burton and Mackey [12]. Regarding the consistency between perceived climate change impacts and scientific data, this review identified that meteorological records support Asian farmer's perceptions. These findings of this review are in line with the results of Juana, Kahaka and Okurut [13], and Karki, Burton and Mackey [12]. However, they diverge from the observation in the review of Foguesatto, Artuzo, Talamini and Machado [11], who found that farmers' perception of rainfall, on the whole, does not correspond with actual records. It is clear that warming trends, increasing temperature extremes, and changing precipitation trends across most of the Asian region have not only been observed over the past century [67] but are also projected to continue through the 21st century [68]. Without adaptation, climate change and its effects are projected to cause further reductions in crops, threatening food security [67,68]. Thus, appropriate adaptation strategies regarding agricultural land use options and land management should be taken to minimise the negative impacts of these conditions on agricultural production and productivity. As the effectiveness of adaptive management can be successfully achieved through collective actions [9], local knowledge and experiences should be included in the development of adaptation policies.

Farmers in Asia have been employing a variety of adaptation techniques in soil conservation, water management, and crop management, and they have changed their land use options to manage the impacts of climate change. These strategies are also mentioned by Shaffril, Krauss and Samsuddin [10]. In addition, this review reveals that very few farmers can adopt advanced technology-related strategies that require financial support, and technical knowledge and information assistance. Meanwhile, Shaffril, Krauss and Samsuddin [10] found that farmers have difficulty adopting cropping pattern practices as they are unable to purchase the necessary inputs due to financial hardship.

This review suggests that farmer's adaptation responses are influenced by various factors. Some of these factors may be varied in different contexts, for example, the differences in adaptation between ages and genders. The review also identified numerous barriers that hamper farmers' adaptive ability. Those influencing factors and barriers have correlated relationships. The prominent themes that emerge from these factors and barriers are farmers' perceptions, land tenure, education and training, financial resources, and information and agricultural extension. These results partly support the findings in the review of Dang, Li, Nuberg and Bruwer [14], who stated that agricultural extension, credit, land, and improved technologies are the factors that have the most significant effects.

It can be seen that farmers need better long-term and location-specific support from the government to address these aspects. First, the perceptions and judgments of farmers are crucial components in the determination of the immediate and ultimate consequences of climate change [69]. Human behaviour is influenced by subjective images of the environment as well as attitudes, goals, feelings, and beliefs [70]. Therefore, farmers' adaptation of production practices is affected by their perceptions and expectations of climate change [69]. Adaptation to climate change involves two steps: the first step requires farmers to perceive a change in climate, the second step is to adapt [71]. Thus, when designing adaptation programmes, it is critical to understand how farmers recognise and perceive climate change and perceive the effectiveness of adaptation measures to help them improve their adaptation strategies.

Second, land tenure security is positively associated with the probability of taking up sustainable land management practices [72]. Hence, it is crucial to secure farmers' land ownerships to strengthen their long-term investment. Additionally, encouraging the flexibility of land use is an effective way to support agricultural land users in adapting to climate change [73].

Third, education and training enhance farmers' understanding of climate change and adaptive measures. Higher formal education gives farmers the ability to access information about climate change and adaptation options [74]. In addition, a lack of education is a major barrier to the adoption of new technology [75]. Further, education and training programmes change farmers' perceptions [76,77]. They boost farmers' likelihood of, and ability to, adapt as they provide farmers with information about adaptation measures as well as skills of implementing these measures [45]. Therefore, education and training are valuable assets for farmers to improve their adaptation capacity.

Fourth, the availability of financial resources has a significant impact in determining the resilience level of farmers' adaptation. The review suggested that the availability of financial resources increases farmers' investment capability, especially on improved technologies that require high costs. When facing financial hardship, their priority is not adaptation to climate change but family expenditures [78]. Further, farmers could pay more attention to the adaptation to climate change if they were relieved of economic limitations such as spending money for buying fertilizer [29].

Fifth, the literature shows that farmers can access information in various ways. However, Weber [79] argues that people pay attention to climate information and incorporate it into their actions and decisions if the information comes from a trusted source. With better access to information such as the resilience of crops and cultivation techniques, farmers can increase their agricultural production and improve their vulnerable situation [80]. Thus, agricultural extension services need to be improved to make them easier for farmers to approach.

5. Conclusions and Further Research Recommendations

This review identified an inadequate combination of quantitative and qualitative research in the existing literature. While quantitative research presents meaningful facts and figures, qualitative methods offer opportunities to obtain in-depth understandings of farmers' experiences and thoughts. Therefore, the authors suggest that mixed-method approaches should be given more attention in the future research to achieve comprehensive explanations on farmers' adaptation to climate change.

In addition, what is clear from this review is that the ability to improve farmers' adaptation is dependent on a complex number of supporting factors and barriers. While the socio-economic factors remain important, there is a need to increase research of the policy aspects. Further, the authors suggest that a systems thinking approach can assist potential research in conceptualising and acting towards the integration of economic, social, and political issues in improving farmers' adaptation capacity.

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