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Review

A systematic review on Asian's farmers' adaptation practices towards climate change

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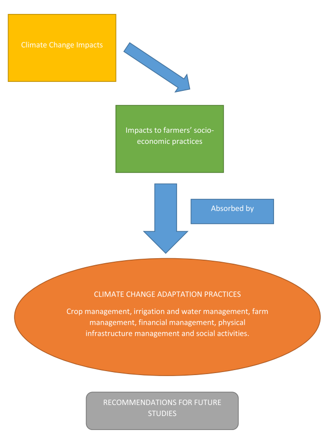
HIGHLIGHTS

- Climate change in Asia is affecting farmers' socio-economic practices.
- Few systematic reviews have been carried out on the social impacts of climate change among farmers in Asia.
- Six themes on climate change adaptation among Asian farmers.

GRAPHICAL ABSTRACT



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ABSTRACT

Climate change in Asia is affecting farmers' daily routines. Much of the focus surrounding climate change has targeted the economic and environmental repercussions on farming. Few systematic reviews have been carried out on the social impacts of climate change among farmers in Asia. The present article set out to analyse the existing literature on Asian farmers' adaptation practices towards the impacts of climate change. Guided by the PRISMA Statement (Preferred Reporting Items for Systematic reviews and Meta-Analyses) review method, a systematic review of the Scopus and Web of Science databases identified 38 related studies. Further review of these articles resulted in six main themes – crop management, irrigation and water management, farm management, financial management, physical infrastructure management and social activities. These six themes further produced a total of 35 sub-themes. Several recommendations are highlighted related to conducting more qualitative studies, to have specific and a standard systematic review method for guide research synthesis in context of climate change adaptation and to practice complimentary searching techniques such as citation tracking, reference searching, snowballing and contacting experts.

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Contents

1. Introduction

Climate change is forecasted to worsen across the Asian region. Rising temperature is strongest over the continental interiors of Asia (Mannig et al., 2018; Dimri et al., 2018). In a period of 105 years (1990 to 2005) precipitation increased significantly in northern and central Asia but declined in parts of southern Asia (Hijioka et al., 2014). Climate change is proven to affect water resource scarcity as the unstable climate variability and more rapid melting of glaciers increased risk of extinction for many plant and animal species (Gampe et al., 2016; DeNicola et al., 2015) while the increasing sea level rise is proven to affect the coastal ecosystems (Perera et al., 2018; Phillips, 2018). While the impact of severe climate change on the environment continues to be recorded, climate change's impact on human beings is more severe, particularly among those who rely on environmental and climactic stability such as Asian farmers (Arouri et al., 2015). IPCC report in 2014 stressed on regional differences within Asia in the impacts of change on food production. Projected sea level rise expose the Asian coastal community to the risk of flooding (Hanson et al., 2011). Furthermore, climate change will impede sustainable development of some Asia countries due to its formidable impacts on the natural resources and the environment related to rapid urbanization, industrialization, and economic development (Hijioka et al., 2014; Chan et al., 2018).

As climate change impacts on the environment worsen, adaptation is seen as the best remedy (Shaffril et al., 2017). Adaptation, according to the International Union for Conservation of Nature (2010, p. 5), is defined as "the ability to respond to challenges through learning, managing risk and impacts, developing new knowledge and devising effective approaches." Within the scope of this review, the terms of climate change, climate and weather, climate variability, extreme events, weather and natural variation are used interchangeably. Weather refers to day-to-day state of the atmosphere, and its short-term variation in minutes to weeks while climate refers to average of weather over a period of time, usually in 30 years (Planton, 2013). Climate variability can be understood as variations in the mean state and other statistics of the climate on all spatial and temporal scales beyond that of individual weather events while extreme events refers to rare event at a particular place and time of year and it yields an average or total that is itself extreme (e.g., drought or flood) (Planton, 2013). Natural variation on the other hand can be understood as the variation in climate parameters resulted by nonhuman forces while weather variation refers to variation in to day-to-day state of the atmosphere (Guido et al., 2013).

1.1. Towards a systematic review framework on Asian's farmers' adaptation practices towards climate change

A systematic review is an examination of a clearly formulated question that uses systematic and explicit methods to identify, select and critically appraise relevant research and to collect and analyse data from studies that are included in the review. Statistical methods may or may not be used to analyse and summarize the results of the included studies (Higgins et al., 2011). Via a systematic review, authors' claims of rigor in their research can be justified, allowing for the identification of gaps and needed directions for future research.

Despite abundance of studies on farmers' climate change adaptation, efforts to systematically review these studies are still lacking. This article attempts to fill the gap in understanding, and identifies and characterizes the climate change adaptation pattern among Asian farmers. Reports on adaptation in the peer reviewed literature are used as a proxy of adaptation, underscoring that this study provides a general and baseline overview of adaptation in the region. The work fills an important gap in the literature, with most systematic review examining the adaptation efforts on non-agriculture community (Bonjean Stanton et al., 2016; Babatunde et al., 2017; Bofferding and Kloser, 2013), or focused on other regions (Hurlimann et al., 2018; Epule et al., 2017; Makuvaro et al., 2018; Tessema et al., 2018; Li et al., 2017). This study is important as so far there are lack of studies that provide a holistic baseline on the status of climate change adaptation among farmers in the Asian Region. Prior to this study, systematic review articles on Asian farmers' adaptation practices, is not strong in a sense that it doesn't provide detail on the review procedures employed (e.g., databases searched, articles excluded, search terms used) which eventually make it difficult for future scholars to replicate the study, validate the interpretation, or examine the comprehensiveness (Greenhalgh and Peacock, 2005). Additionally, this study is vital because Asian region is expected to continue experience climate change stresses (droughts, floods and winds) (Hijioka et al., 2014) that calls for urgent adaptation actions to enhance resilience (Savacool et al., 2012); therefore, details on where the peer review literature has so far focused provide the opportunity in understanding on where the emphasis is and where attention needs to be placed.

To construct a relevant systematic review, the current article was guided by the main research question – how do Asian farmers adapt to the impact of climate change? The main focus of the study was on human adaptation practices. A special focus was given to Asian farmers as this group is most affected by the changing climate due to their higher reliance on nature stability for conducting their socio-economic practices (Shaffril et al., 2017; Islam and Hasan, 2016). Although they are considered as an agriculture community, fishermen and those involved in aquaculture activities were not included in this review as the nature of their activities are significantly different from those in inland farming.

This study attempts to analysis the existing literature on Asian farmers' adaptation practices towards climate change. This section explains the purpose of conducting a systematic review while the second section details out the methodology section and the PRISMA Statement (Preferred Reporting Items Systematic Reviews and Meta-Analysis) approach used. The third section systematically reviews and synthesizes the scientific literature to identify, select and appraise relevant research on Asian farmers' adaptation towards climate change. The last section identifies future research priorities.

2. Methodology

In this section the method used to retrieve articles related to climate change adaptation among Asian farmers is discussed. The reviewers used the method called PRISMA, which includes resources (Scopus and Web of Science) used to run the systematic review, eligibility and exclusion criteria, steps of the review process (identification, screening, eligibility) and data abstraction and analysis.

2.1. PRISMA

The review was guided by the PRISMA Statement (Preferred Reporting Items for Systematic reviews and Meta-Analyses). PRISMA is often utilized within the environmental management field. According to Sierra-Correa and Cantera Kintz (2015), it offers three unique advantages which are 1) defining clear research questions that permits a systematic research, 2) it identifies inclusion and exclusion criteria and 3) it attempts to examine large database of scientific literature in a defined time. The PRISMA Statement allows for rigorous search of terms related to Asian farmers' response to climate change and its impact and coded information in future environmental management reviews. The methodology can be used for monitoring Asian farmers' practices in adapting towards worsening climate change.

2.2. Resources

The review relied on two main journal databases – Scopus and Web of Science (WoS). WoS is a robust database consisting of >33,000 journals with coverage of over 256 disciplines including subjects related to environmental studies, interdisciplinary social sciences, social issues and development and planning. It includes over 100 years of comprehensive back file and citation data, established by Clarivate Analytics and ranks them by three separate measures: citations, papers, and citations per-paper. Scopus is the second database used in the review. It is one of the largest abstract and citation databases of peer-reviewed literature with >22,800 journals from 5000 publishers worldwide. Scopus consists of diverse subject areas such as environmental sciences, social science and agriculture and biological sciences.

2.3. Eligibility and exclusion criteria

Several eligibility and exclusion criterion are determined. First with regard to literature type, only article journal with empirical data are selected which means review article, book series, book, chapter in book and conference proceeding are all excluded. Second, in order to avoid any confusion and difficulty in translating, the searching efforts excluded the non-English publication and focused only on articles published in English. Thirdly, with regard to timeline, a period of 12 years are selected (between 2007 and 2018), an adequate period of time to see the evolution of research and related publications. As the review process focused on adaptation practices towards climate change, articles indexed in social science based indexes are selected, which means, articles published in a hard science index (Science Citation Indexed Expanded) are excluded. Lastly, in line with its objective which focuses on Asian farmers, only articles focused in Asian territories are selected (see Table 1).

2.4. Systematic review process

Four stages were involved in the systematic review process. The review process was performed on December 2017. The first phase identified keywords used for the search process. Relying on previous studies and thesaurus, keywords similar and related to climate change, adaptation and farming community were used (Table 2). At this stage, after careful screening, two duplicated articles were removed.

The second stage was screening. At this stage, out of 350 articles eligible to be reviewed, a total of 268 articles were removed. The third stage is eligibility, where the full articles were accessed. After careful examination, a total of 44 articles were excluded as some did not focus on inland farming communities, were not empirical articles, did not focus on adaptation practices or did not focus on Asian countries and territories. The last stage of review resulted in a total of 38 articles that were used for the qualitative analysis (see Fig. 1).

2.5. Data abstraction and analysis

The remaining articles were assessed and analysed. Efforts were concentrated on specific studies that responded to the formulated questions. The data were extracted by reading through the abstracts first, then the full articles (in-depth) to identify appropriate themes and sub-themes. Qualitative analysis was performed using content analysis to identify themes related to Asian farmers' adaptation practices. The authors then organized sub-themes around the themes established by typology.

3. Results

The review resulted in six main themes and 35 sub-themes related to adaptation practices. The six main themes are crop management (five sub-themes), irrigation and water management (six sub-themes), farm management (seven sub-themes), income management (six sub-themes), physical infrastructure management (four sub-themes), and social activities (seven sub-themes) (Table 3 and Fig. 2). The results provided a comprehensive analysis of the current adaptation practices practiced by Asian farming communities.

A total of eight studies focused on Bangladeshi farmers' adaptation practices (Islam and Nursey-Bray, 2017; Abdur Rashid Sarker et al., 2013; Alauddin and Sarker, 2014; Alam et al., 2017; Kabir et al., 2017; Rahman and Alam, 2016; Alam et al., 2016; Mallick et al., 2017), eight studies concentrated on adaptation practices among farmers in China

Table 1
The inclusion and exclusion criteria.

Criterion	Eligibility	Exclusion
Literature type	Journal (research articles)	Journals (systematic review), book series, book, chapter in book, conference proceeding
Language	English	Non-English
Time line	Between 2007 and 2018	<2007
Indexes	Social Science Citation Index, Emerging Sources Citation Index, Art and Humanities Index (Web of Science)	Science Citation Indexed Expanded (Web of Science)
Countries and territories	Asian countries	Non-Asian countries

Table 2
The search string used for the systematic review process.

Databases	Keywords used
Scopus	TITLE-ABS-KEY (("Climat* chang*" OR "Climat* risk* OR " climat* AND variabilit* " OR " climat* AND extrem* " OR " climate AND variability* OR "climat* uncertaint*" OR "global warming*" OR "temperature ris*" OR "sea level ris*" OR "el-nino" OR "la-nina") AND ("Adapt* abilit*" OR "adapt* strateg*" OR "adapt* capacit*" OR "adapt* capabilit*" OR "adapt* strength*" OR "adapt* potential*" OR "adopt* abilit*" OR "adopt* capacity*" OR "adopt* capabilit*" OR "Adopt* potential*" OR adopt* AND strategy*)) AND (farmer*)
Web of Science	TS = (("Climate-chang*" OR "Climat-risk*" OR "climate-variabilit*" OR "climate- extrem*" OR "climate- variabilit*" OR "climate-uncertaint*" OR "global-warming*" OR "temperature-ris*" OR "sea-level- ris*" OR "el-nino" OR "la-nina") AND ("Adaptation-abilit*" OR "adaptation-strateg*" OR "adaptation- capacit*" OR "adaptation- capabilit*" OR "adaptation- strength*" OR "adaptation -potential*" OR "adoption- abilit*" OR "adoption-capacity*" OR "adoption- capabilit*" OR "Adoption- potential*" OR "adoption -strategy*") AND (farmer*)

(Yin et al., 2016; Yang et al., 2015; Jianjun et al., 2015; Lei et al., 2014; Lei et al., 2016; Yang et al., 2016; Chen et al., 2014; Hou et al., 2012), six studies focused on farmers' adaptation practices in India (Nambi et al., 2015; Bahinipati and Venkatachalam, 2015; Kakumanu et al., 2016; Tripathi and Mishra, 2017; Singh et al., 2017; Pandey et al., 2018), three studies focused on Iranian farmers' adaptation practices (Keshavarz et al., 2014; Keshavarz et al., 2017; Allahyari et al., 2016), three studies concentrated on Vietnamese farmers (Mishra and Pede, 2017; Simelton et al., 2015; Le Dang et al., 2014), two studies focused on Thai farmers' adaptation practices (Arunrat et al., 2017; Bastakoti et al., 2014), two studies concentrated on adaptation practices among farmers in Pakistan (Rahut and Ali, 2017; Ashraf et al., 2014) and two studies focused on farmers' adaptation practices in Nepal (Joshi et al., 2017; Gautam and Andersen, 2017). Furthermore, one study focused on Sri Lankan farmers (Esham and Garforth, 2013), one study conducted by Masud et al. (2017) concentrated on Malaysian farmers, Gomez (2015) focused on farmers' adaptation practices in the Philippines, Choudri et al. (2013) concentrated on adaptation practices among farmers in Oman.

Furthermore, three studies applied a qualitative approach while another eight studies employed a mixed methods (qualitative + quantitative) approach. The remaining studies (27) used quantitative analytic methods. Regarding years published, one article was published in 2018, 13 articles were published in 2017, seven studies were published in 2016, six studies were published in 2015, seven studies were published in 2014, three studies were published in 2013 and one study was published in 2012.

3.1. Climate change adaptation practices among farmers in Asian countries

This section concentrates on the main adaptation practices practiced by farmers in Asian countries such as crop management, irrigation and

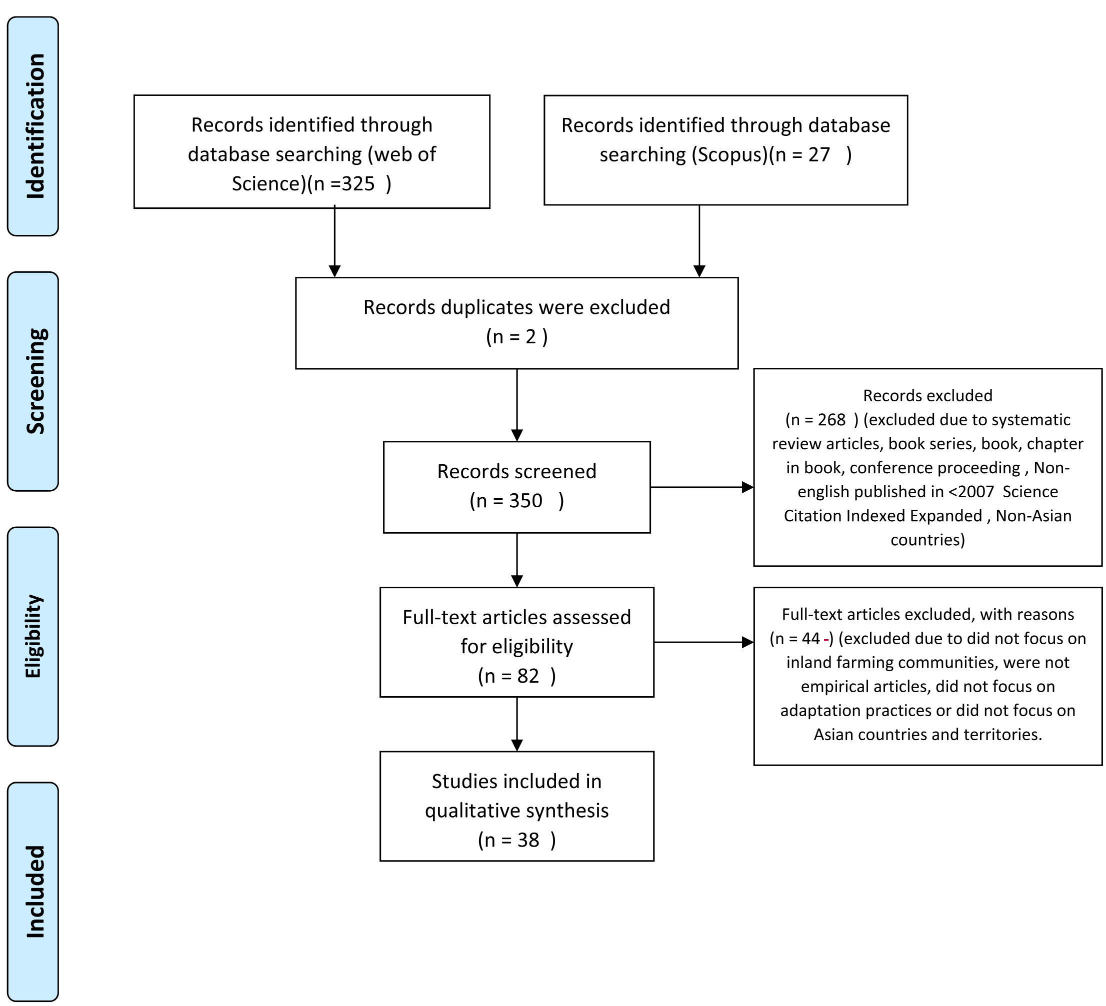

Fig. 1. The flow diagram of the study.
(Adapted from Moher et al., 2009.)

Table 3
The findings.

Authors/countries	Main study design	Crop management						Irrigation and water management					Farm management							Financial management						Physical infrastructure management				Social activities						
		RP	CL	FZ	IV	RC	OT	IS	EX	WP	CW	OT	TP	AF	HG	I	IF	SC	LL	NF	LN	SV	LV	HE	OT	UT	UG	BI	OT	RA	IS	CE	TR	TK	MG	BT
Masud et al. (2017) – Malaysia	QN	√		√				√				√																								
Keshavarz et al. (2014) – Iran	QN			√	√				√										√	√																
Islam and Nursey-Bray (2017) – Bangladesh	MM					√																				√				√			√			
Yin et al. (2016) – China	QN					√		√		√								√																		
Esham and Garforth (2013) – Sri Lanka	MM	√				√		√			√																							√		
Abdur Rashid Sarker et al. (2013) – Bangladesh	QN	√			√	√		√						√							√	√	√													
Kakumanu et al. (2016) – India	QN	√				√		√															√			√							√			
Pandey et al. (2018) – India	QN			√	√						√	√																					√			
Gomez (2015) – Philippines	QN					√		√	√				√																		√					
Alauddin and Sarker (2014) – Bangladesh	QN	√			√	√		√																												
Alam et al. (2017) – Bangladesh	QN	√			√	√							√		√					√			√											√	√	
Choudri et al. (2013) – Oman	QL	√			√			√									√	√	√	√																
Bastakoti et al. (2014) – Thailand and Vietnam	MM	√		√		√		√	√	√				√					√		√		√			√	√					√				
Rahut and Ali (2017) - Pakistan	QN	√			√															√			√													
Ashraf et al. (2014) – Pakistan	QN			√		√			√			√								√			√	√	√										√	
Yang et al. (2015) – China	QN				√			√	√								√		√																	
Nambi et al. (2015) _ India	QN			√	√			√	√							√				√												√				
Joshi et al. (2017) – Nepal	QN								√		√							√																		
Arunrat et al. (2017) – Thailand	QN	√	√		√	√			√																											
Le Dang et al. (2014)- Vietnam	QN	√	√													√																		√	√	
Jianjun et al. (2015) – China	QN				√	√										√										√		√								
Kabir et al. (2017) – Bangladesh	MM	√			√	√			√	√								√		√			√			√										
Rahman and Alam (2016) – Bangladesh	MM	√		√		√		√	√					√			√		√	√			√				√	√								
Lei et al. (2014) – China	QN					√																														
Lei et al. (2016) – China	QN				√	√																														
Alam et al. (2016) – Bangladesh	QN	√				√							√		√					√															√	
Tripathi and Mishra (2017) – India	QL				√	√			√	√				√					√	√																
Yang et al. (2016) – China	QN																		√																	
Keshavarz et al. (2017) – Iran	QN										√							√		√					√											
Mallick et al. (2017) – Bangladesh	MM																				√	√	√		√			√	√						√	
Gautam and Andersen (2017) – Nepal	MM																			√	√															√
Mishra and Pede (2017) - Vietnam	QN				√	√										√					√	√	√													
Singh et al. (2017) – India	QL				√	√								√						√		√														√
Chen et al. (2014) – China	QN	√				√			√	√						√																				
Hou et al. (2012) – China	QN																√			√			√													
Simelton et al. (2015) – Vietnam	MM												√	√																						
Allahyari et al. (2016) – Iran	QN	√		√	√	√		√								√							√													
Bahinipati and Venkatachalam (2015) – India	QN				√	√												√																		

Crop management	Water management	Farm management	Income management	Physical infrastructure management	Social and ritual activities
RP = Rescheduling Planting IV = Improved crops/seeds (including short duration crops, seeds) CL = Changing farming location/relocate their accommodation RC = Diversify/Mixed/Change/Intercropping/Rotating/multiple crops FZ = Using organic fertilizer/fertilizer/bio-retilizer/insecticides/pesticides	IS = Irrigation system WP = water pumps/pipes CW = Conserving water resources RW = Reduce water consumption RT = Rainwater harvesting technique EX = extending, maintaining or reserving water supplies	SC = Soil conservation I = Insurance HG = Homestead Gardening AF = Agro-Forestry/Organic Farming TP = Tree planting IF = Indoor Farming LL = Levelling land/reducing farm land	NF = off-farm income generating activities, additional income generating activities LN = taking loans SV = rely on savings LV = Livestock possession/Fishing activities HE = Reduce household expenditure	UT = use of farming related technology UG = Upgrade farm related infrastructure BI = Building/improved infrastructure OT = others	TK = Traditional/local knowledge/Rituals CE = Community events/associations MG = Migration RA = Raising awareness and motivational activities TR = Training IS = Information shared/received BT = Barter, food/seed/resources exchange

QN = Quantitative; QL = Qualitative; MM = Mix Method.

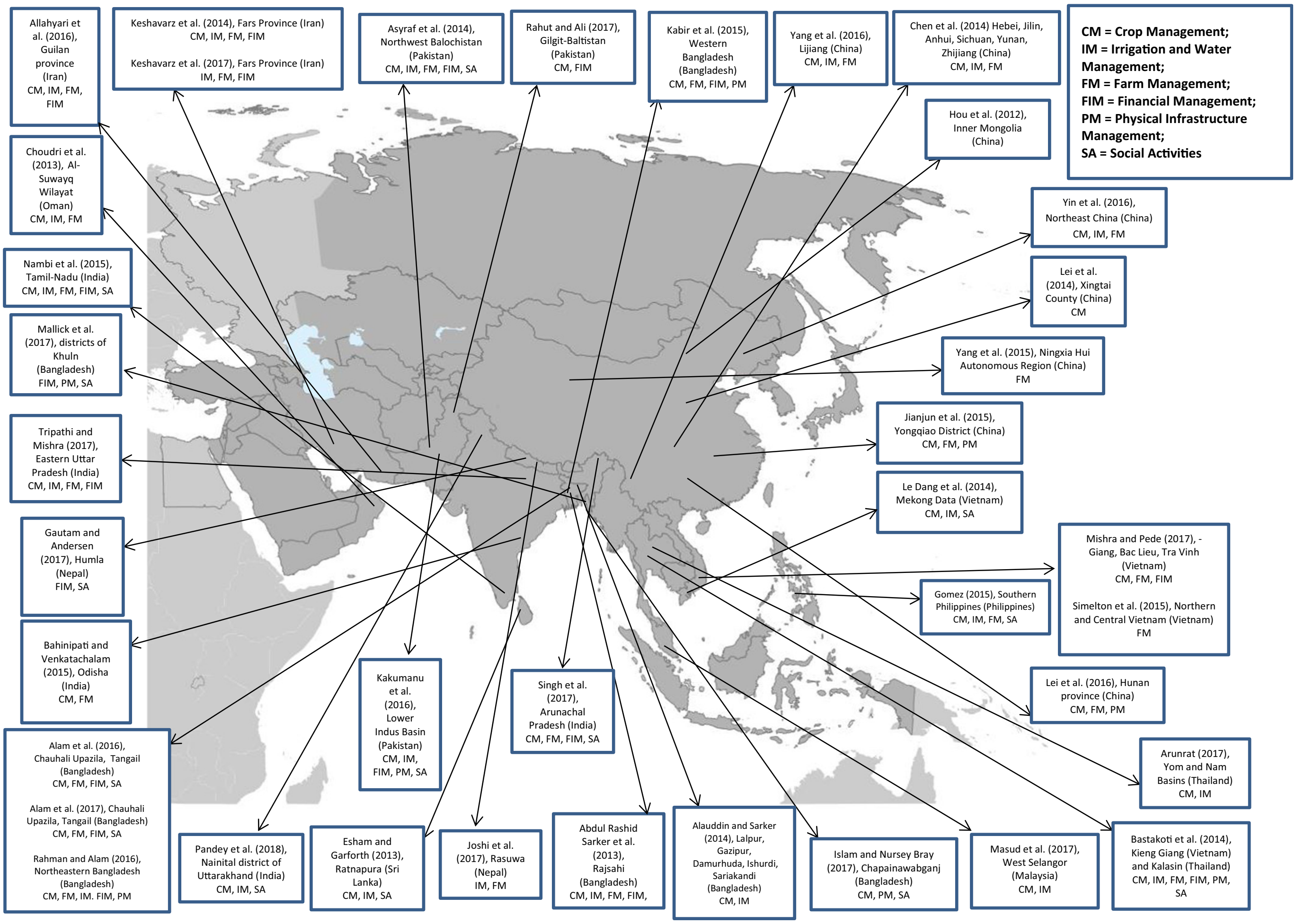

Fig. 2. Climate change affected areas of selected studies.

water management, farm management, financial management, physical infrastructure management and social activities.

3.1.1. Crop management

A total of 31 out of 38 studies focused on crop management to cope with climate change impacts. The most common crop management practices are diversifying crops (23 studies) while 18 studies found that farmers relied on improved varieties as a way to adapt to climate change impacts. A total of 16 studies made use of rescheduled planting calendars while eight studies used fertilizer or insecticides/pesticides as a strategy. Arunrat et al. (2017) and Le Dang et al. (2014) found that farmers have changed farming locations as a way to cope with climate change impacts (Table 3).

Crop diversification (Diversify/Mixed/Change/Intercropping/Rotating/Multiple crops) is one of the adaptation measures taken by Asian farmers as different crops might react differently to climate change impacts (Yin et al., 2016; Kakumanu et al., 2016). In Pakistan and Bangladesh for example, multiyear persistent drought, change in temperature and rainfall patterns has caused 60–80% reduction of crop areas with a productivity loss of around 50%. To practice mixed cropping or inter-cropping is seen as one of the solutions as it enables them to grow more than one crop in the same field simultaneously and minimize the risks associated with productivity and income loss (Ashraf et al., 2014; Rahman and Alam, 2016). In Village of Beidian, an area prone to flooding in northern China, farmers have replaced their main crops of apples and corn to coarse cereals. In Southern China, farmers have diversified their crops whereby a 30% reduction in paddy area was replaced by dry-land crops such as cotton and coarse cereals, which are more tolerant to drought (Lei et al., 2014; Lei et al., 2016). In India, due to the loo - a strong, hot and dry summer afternoon wind from the west which blows over the western Indo-Gangetic Plain region of North India, their sugarcane industry is affected. In response to this, farmers are gradually changing their crops from sugarcane to peppermint as it offers more profit and is easy to market (Tripathi and Mishra, 2017). In Thailand, the increased mean annual temperature and declining average annual rainfall has resulted in more frequent droughts over the past 20 years and this resulted in reduction of rice (between 4 and 14%). As a response to this, Bastakoti et al. (2014) found that after harvested the rice, Thai farmers plant other crops such as cassava, bean, tobacco, and corn. This strategy helps them generate extra income and reduce the risk of loss from failure of one particular crop. Nonetheless, not all of them afford to diversify their cropping pattern, especially when it comes to include cash crops, due to inadequate resources to purchase the required inputs such as fertilizers. Nevertheless, some farmers have opted the increased use of input in adapting to climate change as it maintains productivity level in adverse conditions.

Using improved varieties is another adaptation strategy practiced by Asian farmers. In Iran, China and India, farmers use early maturity rice, short duration, high yield and more drought or flood resistant crops (Allahyari et al., 2016; Keshavarz et al., 2014; Yang et al., 2015; Jianjun et al., 2015; Pandey et al., 2018; Tripathi and Mishra, 2017). In Bangladesh, farmers have opted for a modern rice called Swarma as it is more drought and pest tolerant, while a short duration variety called BBR128 is being used instead of long duration varieties (BBR129 and hybrid) (Kabir et al., 2017). Rescheduling is also an adaptive practice to reduce the risks of crops damaged due to climate change and uncertainty. In Bangladesh, most of the Bangladeshi farmers take advantage of the wet-season rainfall and growing crops during the reduced stress season (no drought/storm) (Alam et al., 2017; Kabir et al., 2017). The planting calendar for maize, for example, has moved up from mid-January to Mid-December as it helps them reduce irrigation costs, and seeds are less affected by cold injury and thus produce better yields (Kabir et al., 2017). In Oman, farmers have tried to cultivate their crops before the onset of the rainy season with the help of drip irrigation (Choudri et al., 2013). In Vietnam, in the dry season, farmers have delayed rice plantation to avoid salinity intrusion into the fields (Bastakoti et al., 2014).

In some Asian countries, farmers have used fertilizer, insecticides and pesticides as a response to climate change. Keshavarz et al. (2014) in his study discovered that Iranian farmers decided to decrease fertilizer use, claiming that it has negative impacts on their soil. Farmers in Malaysia and Thailand used organic fertilizer as they are more environmental friendly while at the same time rehabilitates poor soils, restores organic matter content and bring such soils back into productivity (Masud et al., 2017; Bastakoti et al., 2014). Rahman and Alam (2016) also found that Bangladeshi farmers sprayed organic (cow dung, oil cake and compost) and inorganic fertilizers (NPK) in attempts to produce a better yield. Allahyari et al. (2016), Rahman and Alam (2016) and Pandey et al. (2018) reported that farmers in Iran, Bangladesh and India also used pesticides and insecticides to combat pest and insect attacks, and are aware that it is harmful to the environment. Nambi et al. (2015), on the other hand, claimed that farmers in Tamil Nadu, India used bio-fertilizer to overcome the problem of decreasing soil fertility and to increase their rice harvest. Some studies have concluded that farmers are changing their farming locations in order to absorb the climate change impacts. Due to flood, Arunrat et al. (2017) found Thai farmers in the Chao Phraya Basins transferred their production to another site to overcome pest attacks while drought has geared them to seek water resources for planting. To reduce the risk of shelter loss, farmers in the Mekong Delta in Vietnam relocated their accommodations as a response to extreme weather events such as annual flooding (Le Dang et al., 2014).

3.1.2. Irrigation and water management

Irrigation and water management features often in the studies on Asian farmers' adaptation strategies. A total of 23 articles reported that farmers practiced irrigation and water management as a way to adapt to climate change. Under this theme, six sub-themes emerged, namely, using natural resources for irrigation, water conservation, micro irrigation, supplementary irrigation, irrigation in general and other water management approaches. Twelve studies indicated that Asian farmers relied on natural resources for their irrigation purposes while another seven studies reported that Asian farmers conserved water resources in response to extreme drought seasons. Supplementary irrigation was another technique mentioned in five studies while two studies stated that farmers used micro irrigation. Three studies merely mentioned irrigation in general without referring to specific irrigation techniques while the other three studies emphasized levelling land, livestock reduction and tree branch trimming as effective methods to conserve water (Table 3).

Several studies stated that farmers relied on natural resources for irrigating their plants by making use of water pumps, tube wells, canals (including smaller field level canals), channels and drainage to transfer water to crops (Keshavarz et al., 2014; Yin et al., 2016; Gomez, 2015; Kabir et al., 2017; Tripathi and Mishra, 2017; Bastakoti et al., 2014; Chen et al., 2014; Rahman and Alam, 2016; Allahyari et al., 2016). In Iran, for example, severe drought reduces the water availability and this effect their agricultural productivity – for example, production of rainfed wheat and barley were dropped by 34–75%. In response to this, the Iranian farmers re-excavated rivers, qanats, and canals and dug their own irrigation wells as well as deepened existing wells (Keshavarz et al., 2014). In Thailand, due to the increase of mean annual temperature by 0.85 C and declining average annual rainfall farmers has relied on small farm ponds, groundwater and surface ponds for irrigation purposes, nevertheless, not all farmers can rely on such strategy due to unsuitability of land. In China, due to less precipitation and more frequent drought condition, farmers were found to construct wells, excavate channels, and update pump equipment to improve water supply reliability and water delivery efficiency. They also invested in maintaining canals to reduce canal water leakage and water delivery losses (Chen et al., 2014).

Farmers in India, Thailand, Pakistan, China, Iran, Nepal and Bangladesh conserved water resources for use during water shortages (Pandey et al., 2018; Bastakoti et al., 2014; Ashraf et al., 2014; Yang et al., 2015; Nambi et al., 2015; Joshi et al., 2017; Rahman and Alam, 2016; Keshavarz et al., 2017; Chen et al., 2014). Rainwater harvesting such as storage tanks, in-ground storage, retention pond or well are popular water storing technique in Vietnam (Bastakoti et al., 2014), India (Nambi et al., 2015), and Nepal (Joshi et al., 2017). In the Ningxia Hui Autonomous Region (NX region) of Northwestern China, in responding to reduction of approximately 32.3% of the total crop area due to droughts, they opted for water storing as they dig the cellar to store more water for their crops. In North-Eastern Bangladesh, farmers have used big plastic drums and cement rings as reservoirs for water storage, and water is also collected from water pumps, ponds or deep wells (Rahman and Alam, 2016). Studies by Yang et al. (2015) and Nambi et al. (2015) have shown that farmers in The Ningxia Hui Autonomous Region (NX region) of Northwestern China, and Tamil Nadu, India, often opt for micro-irrigation, an advanced irrigation technique that allows for lower pressure irrigation for plants.

Farmers in China, Bangladesh, Sri Lanka and India have used supplemental irrigation (Yin et al., 2016; Esham and Garforth, 2013; Abdur Rashid Sarker et al., 2013; Kakumanu et al., 2016; Alauddin and Sarker, 2014). While studies by Gomez (2015), Jianjun et al. (2015) and Choudri et al. (2013) indicated the use of irrigation in general without referring to any specific irrigation technique. Asian farmers practiced unique ways to response to climate change. In Malaysia for example, farmers were found to farm their plants near water resources as the nearby water sources can save a lot of costs and facilitate crops irrigation (Masud et al., 2017). As significant amount of irrigation water is lost during its application at the farm due to poor farm designing and unevenness of the fields, The Iranian farmers level their land as it enables water to be distributed uniformly into their farms thus resulting in more efficient water usage (Keshavarz et al., 2014). In India, farmers have reduced livestock rearing as such activity involve huge volumes of water consumption. Meanwhile, in Pakistan, farmers have been reported to trim their tree branches as trees with fewer branches consume less water.

3.1.3. Farm management

A total of 25 studies reported farm management as one of the adaptation measures taken by Asian farmers. Under this theme, a total of six sub-themes emerged, namely, soil conservation, insurance schemes, tree planting, agro-forestry/organic farming, in-house farming, and other farm management practices. Seven studies focused on soil conservation, and six studies looked into agricultural-related insurance. Tree planting was mentioned by five studies and agro-forestry/organic farming was also mentioned by five studies. Two studies focused on in-house farming while the other two studies concentrated on homestead gardening. Five studies mentioned other farm management practices (Table 3).

Soil erosion can be resulted by increased rainfall amounts and intensities, while higher temperatures increase decomposition and mineralisation of the organic matter in the soil, reducing organic carbon content. In response to this, soil conservation is seen as an important adaptation strategy (Yin et al., 2016; Choudri et al., 2013; Bahinipati and Venkatachalam, 2015; Keshavarz et al., 2017). In Nepal and North

Eastern Bangladesh, farmers practice mulching technique as it increases the soil quality by reducing erosion and leaching of soil nutrients, it increases soil moisture content and fertility (organic fertilizer), and it shelters the soil from rising temperatures (Joshi et al., 2017; Choudri et al., 2013; Rahman and Alam, 2016). In Western Bangladesh, farmers rely on jute biomass, which enhances soil fertility for future harvesting seasons (Kabir et al., 2017). Protecting their farms with insurance is another adaptation response by many Asian farmers. In Tamil Nadu, India for example, crop-insurance is an adaptation measure taken to lessen the burden of losses that occur due to climate variability (Nambi et al., 2015). Farmers in Mekong Data have bought insurance, as a certain amount of damage (i.e. death, property loss and crop failure) caused by extreme events can be covered (Le Dang et al., 2014). Nevertheless, traditional insurance suffers from high information asymmetry and transaction costs, hence, weather index are introduced for the farmers. The weather index is different from the traditional insurance in the sense that indemnification is not triggered by damage to the crop, but by the level of a meteorological index, which is itself correlated to crop yield. Such weather index are popular among farmers in Vietnam, China and Iran (Le Dang et al., 2014; Mishra and Pede, 2017; Allahyari et al., 2016; Jianjun et al., 2015; Chen et al., 2014).

Asian farmers are threatened by rainfall and climate variability and tree planting is another adaptation measure taken by them. In Bangladesh and the Philippines, tree planting enables effective use of remaining lands, supplying needed nutrients and providing extra income to the farmers (Gomez, 2015; Alam et al., 2017; Alam et al., 2016). In Vietnam and Bangladesh, farmers plant more trees, as the trees have shorter recovery periods after most natural disasters and provide extra protection against landslides (Simelton et al., 2015; Rahman and Alam, 2016). Agro forestry or organic farming was one of the adaptation strategies practiced by farmers (Abdur Rashid Sarker et al., 2013; Bastakoti et al., 2014; Tripathi and Mishra, 2017; Singh et al., 2017; Simelton et al., 2015). Planting more nitrogen-fixing trees for example, produce drought-resilient crops due to improvements in soil nutrients and water infiltration, especially in degraded land (Le Dang et al., 2014). Such strategy however, requires a wide area of land which means it is unsuitable for the land-less farmers. Bastakoti et al. (2014) found that Thai farmers opted for organic farming as it can improve soil fertility and productivity, and conserves moisture, making their farming products more durable to climate change while reducing weather risks.

In-house farming features often in the studies on Asian farmers' adaptation strategy. In Oman maximum daily temperatures rise to above 48.8 C during the summer months and as the agriculture in the area rely heavily on the groundwater and the rainfall, any significant change in the air temperature can result in changing climatic conditions and subsequent shifts in agriculture pattern. As a response to this phenomenon, farmers in Oman plant their crops in greenhouses. In China, housing livestock is another common practice that protects the animals from poor health in the event of strong winds and dust storms (Choudri et al., 2013; Hou et al., 2012). Although the temperature can be higher in a poorly ventilated housing structures, a more significant problem with the warming climate, an improved ventilation can overcome heat stress while fans can be used to improve air flow and sprinklers or misters can be used to improve evaporative cooling. Asian farmers have been shown to practice several other adaptation measures including Bangladeshi farmers' practices of homestead gardening - a small scale agricultural production method which sustains food and nutritional supply, ensure farmers empowerment and strengthen their resilience against climate change (Alam et al., 2016; Alam et al., 2017). Vietnamese farmers have relied on technical measures to deal with climate change impacts. For example, they often test the salinity levels of water and soil, use lime to reduce salinity, and reclaim land (Bastakoti et al., 2014). In the Ningxia Hui Autonomous Region (NX region) of North-western China, grassland degradation resulting in decreased grassland-bearing capacity and force the Chinese farmers shift grazing to barn feeding in captivity. In the North-eastern Bangladesh on the other hand, the Tripura and Garo communities use bamboo to shield their seedlings and saplings, and at the same time use bamboo sticks to protect their crops from windbreaks whereby more than one bamboo stick was used in a circular way to keep the seedlings and saplings upright (Yang et al., 2015; Rahman and Alam, 2016). Farmers in China have been found to reduce the overall amount of cultivated land (Yang et al., 2015; Yang et al., 2016), while in Iran, a large farm enables farmers to do multiple cropping and integrate their livestock component, which is vital under dry land conditions (Keshavarz et al., 2014).

3.1.4. Financial management

Some studies reported on the financial management practices of Asian farmers in relation to climate change adaptation. Six sub-themes emerged under this theme including non-farm activities (14 studies), relying on livestock/fish rearing (11 studies), making loans (5 studies), spending savings (3 studies), reducing household expenditures (2 studies) and selling off belongings (2 studies) (Table 3).

Due to the impact of climate change such as the increase of mean annual temperature, declining average annual rainfall and extreme events such as severe drought and annual flooding, the overall productivity of Asian farmers has declined. They have been forced to rely on non-farm activities to generate extra income (Keshavarz et al., 2014; Alam et al., 2017; Choudri et al., 2013; Rahut and Ali, 2017; Ashraf et al., 2014; Nambi et al., 2015; Kabir et al., 2017; Rahman and Alam, 2016; Alam et al., 2016; Tripathi and Mishra, 2017; Keshavarz et al., 2017; Gautam and Andersen, 2017; Singh et al., 2017; Hou et al., 2012). Among the popular non-farm activities are small businesses, for example, they open a grocery store that sells daily items to locals (Keshavarz et al., 2014; Rahman and Alam, 2016; Alam et al., 2017; Ashraf et al., 2014; Kabir et al., 2017), Labor (Keshavarz et al., 2014; Ashraf et al., 2014; Kabir et al., 2017), transportation-related activities – they had taken up driving license as their occupation as a response to diminishing employment in agriculture (Alam et al., 2017; Ashraf et al., 2014; Gautam and Andersen, 2017), making and selling handicrafts such as tribal cloths, bamboo and rattan-based handicrafts manufacture (Rahman and Alam, 2016; Singh et al., 2017), tourism-related activities such as eco-tourism, eco-lodge and eco-guiding (Ashraf et al., 2014; Rahman and Alam, 2016) and others such as construction, nursery production, sales, security and local commercial alcohol production (Ashraf et al., 2014; Rahman and Alam, 2016; Tripathi and Mishra, 2017).

Farmers also try to increase their income by getting involved in livestock or fish-rearing activities. Such activities minimize the risk associated with productivity and income loss due to climate change impacts (Rahut and Ali, 2017; Rahman and Alam, 2016). In India and Bangladesh for example, farmers were found to react to climate change by rearing livestock, which allows them to have liquid (Abdur Rashid Sarker et al., 2013; Kakumanu et al., 2016). During extreme events, farmers in Iran, Vietnam, Pakistan and China, trade their livestock to earn extra money (Keshavarz et al., 2014; Mishra and Pede, 2017; Ashraf et al., 2014; Hou et al., 2012). Nevertheless such technique might result in what Wilson (2014) call as lock-in effects. A scenario where a vicious cycles created in which households opt to short-term ad-hoc adaptation measures, Turning to this kind of option in response to the adverse impacts of climate change forces households further into the poverty trap, making it difficult for households to get out of such lock-ins. Thai farmers have small farm ponds to irrigate their farms during dry season, it allows them to culture fish, which can offer extra nutrients or even income (Bastakoti et al., 2014). In Western Bangladesh, >60% rear cattle and goats to earn extra money. They usually buy young cattle or goats at lower prices and after 1 or 2 years, they will sell them back during peak time (Ramadhan) to obtain a higher selling price (Kabir et al., 2017).

Although loans intensify their indebtedness and dependency, Asian farmers still take loans from several sources (Gautam and Andersen, 2017; Bastakoti et al., 2014). In Bangladesh for example, farmers have taken loans from rural usury lenders and relatives, while others, especially in Western Bangladesh, take loans from NGO's and other sources even though the repayment scheme is strict (Abdur Rashid Sarker et al., 2013; Mallick et al., 2017). In Vietnam, farmers usually take loans from banks (Mishra and Pede, 2017). While farmers with enough will live off their own savings (Mishra and Pede, 2017; Mallick et al., 2017). Other measures related to financial management include reducing household expenditures. Pakistani farmers, for example, try to reduce their expenditures on health, clothing, children's education, house maintenance and social events, while in Iran, farmers opt to use cheaper and less nutritious foods (Ashraf et al., 2014; Keshavarz et al., 2017). Farmers like those in the South-western Coastal Regions of Bangladesh and Pakistan sell their belongings (e.g. jewellery, agriculture tools, household utensil) to survive during extreme seasons (Ashraf et al., 2014; Mallick et al., 2017).

3.1.5. Physical infrastructure management

A total of four sub-themes emerged under physical infrastructure management theme namely use of farming related technology (5 studies), upgrade farm related infrastructure (2 studies), building/improved infrastructure (2 studies) and other physical infrastructure management practice (1 study) (Table 3).

Asian farmers have turned to advanced technologies to adapt to climate change (Kakumanu et al., 2016; Jianjun et al., 2015; Bastakoti et al., 2014). Bangladeshi farmers have embraced alternate wet and dry technology, while others use technology to reduce the risks of crop failure (Islam and Nursey-Bray, 2017; Kabir et al., 2017). Furthermore, climate change impacts affect public infrastructure, in term of communication for example, sea level rise increases flooding of equipment and corrosion from salt water while rising temperature increased road material degradation, resulting in increased road maintenance. Farmers have addressed these climate change impacts by upgrading their physical infrastructures such as rural roads, communication and transportation systems. Having better road conditions, communication and transport systems enable farmers to seek or receive assistance faster from the related agencies when extreme events occur (Bastakoti et al., 2014; Rahman and Alam, 2016). Building new infrastructure or improving the existing one is another adaptation measure taken. In Northeastern Bangladesh, Tripura farmers constructed terraces within the slopes of the denuded hills to grow crops as it prevents the upper soil nutrients from being washed away. To prepare against landslides, protection walls made from bricks, cement and iron rods were constructed around their houses and locality to provide effective protection for houses and farms whereby they have received financial and technical support from local NGOs to implement the strategy (Rahman and Alam, 2016). Farmers have also been found to change their house and staircase patterns. The Khasia community in Northeastern Bangladesh for example, have converted their houses into tin-shed and semi-pucca buildings (partially brick-built) to withstand adverse climatic effects such as flash flood and landslide. They also improved their staircase designs by making them curved instead of straight (Rahman and Alam, 2016). Meanwhile, in the Southwestern coastal region of Bangladesh a majority of farmers strengthened their houses via roof reconstruction by using the Golpata type of roof. Furthermore, a majority have reconstructed their walls by using bamboo and wood rather than mud. They also have reduced the risks caused by extreme weather by tying-up their roofs to trees (Mallick et al., 2017).

3.1.6. Social activities

A total of 13 studies found that Asian farmers rely on social activities related to traditional/local knowledge/rituals, community events/associations, migration, raising awareness and motivational activities, attending training, information sharing and barter system for food, seed, or other resources (Table 3). Among the most common social adaptations to climate change is migration. In Bangladesh, for those without land, migration is their main adaptation choice while Pakistanis farmers and their families migrate to seek off-farm employment that helps them survive during drought episodes (Alam et al., 2017; Alam et al., 2016; Ashraf et al., 2014). Mallick et al. (2017) added that in the Southwestern Coastal Region of Bangladesh, about 34% of the households reported that at least one of their family members left the village to migrate to other places. Vietnamese farmers, on the other hand, migrate from high vulnerability to lower vulnerability areas to reduce the effects of climate change (Le Dang et al., 2014). Their decision to migrate is influenced by push and pull factors. Push factors such as cyclone-induced losses and damages, low agricultural income, agricultural unemployment and underemployment influenced the movement decision (Sanfo et al., 2016). As farmers loss their crops, especially the landless, pull factors such as opportunity to diversify income at the nearby cities play a major role in their migration decision (Rai, 2018). Moreover, unlike to their current areas, availability of push factors such as accessibility to community services, involvement with micro-credit institutions, availability to loans, and opportunity to diversity pattern at the other places, were also important in deciding migration (Alam et al., 2017; Alam et al., 2016; Ashraf et al., 2014). Mallick et al. (2017). Traditional knowledge helps Bangladeshi farmers to reschedule their planting while Sri Lankan farmers practice religion-spiritual rituals to ask their deities to cause rainfall in the dry months and to enhance growth endurance of crops (Alam et al., 2017; Esham and Garforth, 2013). In Thailand (Chao Phraya Basins), farmers rely on local knowledge to prepare against weather shifts, for example, when they see ants carrying eggs it denotes precipitation and possible rain is imminent (Arunrat et al., 2017). In Nepal, farmers practice a traditional system known as 'Balighare', in which they provide different services, mainly labor, to the high-caste households in exchange for food grain (Gautam and Andersen, 2017). In the Adi community in the eastern Indian Himalayas, the barter system for agriculture products is frequently practiced, the swaps, allow farmers to diversify their food sources and at the same time bolstering their relationships with others in their communities. (Singh et al., 2017).

Islam and Nursey-Bray (2017) highlighted the importance of training, advice, information, motivation and awareness activities about climate change impacts for farmers. Attending community events provides opportunities for farmers to exchange resources or information, which can strengthen their climate change adaptation practices. Thai farmers, for example, conduct a farmers' annual fair where they exchange information and agricultural resources (e.g. seed) (Bastakoti et al., 2014). Involvement in farmers associations, women's self-help groups and seed banks through community-based efforts provide opportunities to involve in community's environmental services (e.g. water conservation and harvesting, drought proofing, flood control) and this have improved the availability and conserving the natural resources (Nambi et al., 2015). Consequently, such effort assists farmers in Tamil Nadu India decrease their level of vulnerability. Farmers in Bangladesh and India attend related training (e.g. technology usage related) that aim to strengthen their knowledge, skills, raise their awareness and stimulate appropriate response to the climate change impacts (Islam and Nursey-Bray, 2017; Kakumanu et al., 2016).

4. Discussion

This study has attempted to systematically analyse the existing literature on Asian farmers' adaptation practices to climate change. Climate change is a global challenge and adaptation measures must be practiced to minimize its impacts and capture possible opportunities. A rigorous review sourced from two databases have resulted in 38 articles related to Asian farmers' adaptation practices. The results indicate that Asian farmers have engaged in a diversity of practices. Within the scope of this review, six themes and 35 sub-themes emerged. Crop management, irrigation and water management, farm management and financial management are four main adaptation measures practiced by Asian farmers while other adaptation strategies were physical infrastructure management and being involved in social activities.

Asian farmers are diverse in their adaptation practices and one of it is crop diversification. Multiyear persistent drought and rising temperature destroying portions of crops across the Asian continent, causing a ripple effect on the price of food and affecting the communities while flood and unstable rainfall patterns have delayed the planting of many crops, and may also impact the types of crops that can be planted (Pak-Uthai and Faysse, 2018). These types of storms and flood events are projected to increase in the future. In response towards these extreme weathers and events, Asian farmers practiced mixed cropping, inter cropping, using advanced and upgraded crops. This strategy helped them to overcome the problems of productivity loss while at the same time generate extra income and reduce the risk of loss from failure of one particular crop (Li et al., 2018). Furthermore, as the climate change is forecasted to effect agriculture formidably, and many rural farm households may be unable to meet basic needs, farmers rely on alternative livelihood to survive (Martin and Lorenzen, 2016; Gautam and Andersen, 2017). They moderate their livelihoods accordingly, by engaging in several non-farming activities related to small business, transportation-related business, labor, and security-related activities. Their decision to join non-agriculture activities are influenced by several drivers namely (i) better relative returns, (ii) inadequate farm output, (iii) a need for non-farm cash sources to pay for farm inputs, and (iv) risky returns to farming (Martin and Lorenzen, 2016). By having alternative livelihood, more options are available for responding to climate-induced changes through a better income, a diversity of resources, increase agricultural production by smoothing capital constraints, reducing the level of sensitivity to climate change and also to better cope with environmental stresses than those who derive most of their income from a sole source (Hoang et al., 2014; Gautam and Andersen, 2017) Asian farmers opt for either the traditional or advanced irrigation system. The advance irrigation system instead of accelerating farmers' agricultural processes, able to assists farmers in their adaptation strategy. Drawing on study by Yin et al. (2016) for example, to mitigate the negative effects of drought, the adoption of irrigation maize yield an increase of 419–435 kg/ha. Yin et al. (2016) in their study also confirmed that farmers with advance irrigation system have a better chance to adapt to climate change impacts as it ensures the efficiency of water usage and improving the quality and quantity of their productivity. Farmers still rely on the traditional irrigation system. Availability of natural resources enables the farmers to practice the old ways of irrigating their crops. The availability of water from rivers, wells, rainwater and efforts on constructing canals and digging drainage systems allows the construction of natural irrigation system (Varela-Ortega et al., 2016).

As rising temperature, precipitation and sea level rise damage or reduce the service quality, improving physical infrastructure is another adaptation measure taken by Asian farmers. Upgrading their transportation and communication systems are among the focus while building new infrastructure or improving the existing one (e.g. protection walls made from bricks, cement and iron rods) is another adaptation measure taken (Bastakoti et al., 2014; Rahman and Alam, 2016). This strategy provides protection for farmers against the hazardous effects of climate change and reduces the risk of injury or loss of life. In addition, a good transport and communications system can reinforce the adaptation strategy, whereby aid to be sought or delivered, can be accelerated (Shaffril et al., 2013). Things to be considered in this kind of adaptation strategy is the infrastructure capability to withstanding the shock and stressor of climate change in a long term period and frequent upgraded, replaced, or preserved, anticipating the effects of climate change continues to be critical to these infrastructures longevity (The Fourth Regional Plan, 2016). Furthermore, although scientific solutions seem to be effective in coping with climate change, social activities related to community events/association, raising awareness and motivational activities, training and information sharing have been proven to play operative roles in adaptation. Such activities provide farmers with opportunities to raise awareness, exchange views and local knowledge about climate change. These awareness, views and knowledge can guide people on how to respond to climate change, while at the same time informing them on the best ways to preserve their land and natural resources, and to pass them on to future generations. Hence, the communities will have better adaptation strategies today and in the future (The World Bank, 2018).

For many Asian farmers, living in the modern world does not mean that their local and traditional knowledge have been forgotten, they still make use of traditional approaches with considerable success. Scholars have turned their attention to examine the ways in which local and traditional knowledge on environment can be used to construct a better climate change adaptation, including monitoring the impacts of climate change, carbon abatement initiatives, and the development of local strategies (Audefroy and Sanchez, 2017). Local and traditional knowledge plays a pivotal role in mediating farmers' understandings of climate change and how these beliefs may influence future decision-making related to climate change adaptation at a local level (Leonard et al., 2013). In Thailand (Chao Phraya Basins) for example, local farmers know that when they see ants carrying eggs, it denotes that precipitation is imminent while Sri Lankan farmers practice *kekulama*, a traditional direct seeding technique used to minimize water usage. These knowledges offer valuable insights, complementing scientific data with chronological and landscape-specific precision, which is important for authenticating climate models and assessing climate change scenarios developed by scientists at a much broader spatial and temporal scale.

To put into place the different adaptation practices, Asian farmers need social support. The review shows that family members, colleagues, NGO, and private and government agencies have helped farmers to prepare for climate change threats. Having supportive relationships assists them to prepare against climate-related catastrophes and accelerates recovery and long-term adaptation (Neef et al., 2018; Tiwari et al., 2011). NGOs, banks and donors can play their role in helping farmers to diversify their socio-economic practices through activities related to poultry and livestock rearing, fish farming, nursery production, eco-lodge and eco-guiding, tribal cloth making, bamboo and rattan-based handicrafts manufacturing, sewing, and setting-up grocery and tourist shops (Mallick et al., 2017). People with stronger, more informed and more effective networks are found to have reciprocal connections of interactions, increased levels of trust and access to information that are exchanged for mutual benefits (Paul et al., 2016). Consequently, in the context of climate change threats, trust and reciprocal relationship influence community's confidence that they can rely on others for resource sharing, conflict resolution, and sustained cooperation which may results in wider opportunities for adaptation (Adger, 2003).

It is important to mention that some adaptation practices were unsuitable for the farmers. Taking loans, for example, offer short term relief, however, farmers are bound to a strict repayment schedule that can intensify their indebtedness and dependency. In certain cases, farmers took loan from uncertified lenders, the debt cycle escalates and the loan recovery processes may be unrespecting the human rights and place pressure on the farmers. These are often unethically aggressive in nature, even bordering on the criminal (Rao et al., 2017).Chemical usage is another ineffective adaptation measure. As temperature rise it results in frequent pest and diseases attacks, Asian farmers are forced to spray an extra amount of pesticide and insecticide, although they know it's being harmful to the environment. Such practice, according to Antwi-Agyei et al. (2018) lead to a problem called 'shifting vulnerability'. Uncontrolled use of agro-chemicals for example, can then leach into nearby water bodies, compromising their use for human consumption. A lack of water predisposes them to diseases and weaken their adaptation ability, hence, increasing their overall vulnerability. Although selling livestock generate extra income for farmers, nevertheless, Wilson (2014) expressed concern on this technique and relate it to lock-in effects. A scenario where a vicious cycles created in which farmers prefer the short-term adaptation strategy and consequently forces farmers further into the poverty trap, making it difficult for them to get out of such lock-ins. Not every farmers able to diversify their cropping pattern, especially when it comes to include cash crops, due to their financial limitation and inadequate supports from the concern parties (Bastakoti et al., 2014).As tree planting requires a wide area, the land-less farmers are not able to practice such strategy while reliance on pond or well digging and groundwater surface are depending on the suitability of the land (Le Dang et al., 2014).

5. Future direction

There remains much that is unknown about how Asian farmers adapt to climate change. Accordingly, several areas of research need to be given attention. First, most current articles in this review are fully quantitative in nature (27), eight studies relied on a mixed methods approach, while the remaining studies (3) were fully qualitative in nature. Future studies should consider using more qualitative designs. A qualitative perspective offers in-depth analysis and detailed explanations on farmers' adaptation methods along with farmers' perspectives and decision-making about adaptation practices. Berrang-Ford et al. (2015) noted that more explicit and detailed reporting of analysis methods for qualitative reviews can result in an improved transparency and increased ability to critically assess the rigor of review methods while at the same time reflects new and diverse systematic methods to research synthesis.

Despite the suitability of PRISMA (a standard systematic review guidelines usually used in health science writing) for this environment management field (Sierra-Correa and Cantera Kintz (2015), within the specific context of climate change adaptation however, it requires more standard systematic review method for guide research synthesis (Berrang-Ford et al., 2015). Up to date, standard approaches are still lacking and it results in a limited penetration and use of systematic approaches in adaptation research. To fill this gap, there is a room for developing a standard guideline to support searching efforts on evidence-based reviews for adaptation practices. A work by Berrang-Ford et al. (2015) who introduced three main components and seven sub-components in their Proposed Components of a Systematic Review in Adaptation Research should be a good basis to further develop a more detail and complete systematic review guideline.

As for future studies focusing on a systematic review of climate change adaptation, their review efforts should consists of important points such as

1. Research questions which drives to the review's objective
2. Methodology
   - Conceptual approach used to guide their review effort
   - Resources – justification and description of the databases used for the articles and other publications searching
   - Inclusion and Exclusion Criteria - explaining the selection criteria used to find suitable articles in systematic review process
   - Systematic Review Process
     a. Identification – description of the keywords used to retrieve articles from the database
     b. Screening – Explaining the exclusion some articles that not me the criteria set in the exclusion level.
     c. Eligibility – Selected articles will be reviewed thoroughly and any articles that do not meet the criteria will be
3. Analysis and presentation of results
   - Description of methods for analysis

Most of the studies rely on electronic keyword searches as this technique is acknowledged as the best searching method for a systematic review, however, there are several complimentary techniques that can be considered in researchers' searching efforts (Wohlin, 2014; Tsafnat et al., 2014). Among techniques that can be considered is citation tracking (Wright et al., 2014). It refers to efforts to identify related articles based on those papers citing the paper being studied. This technique allows researcher to follow research leads both forwards and backwards in time. Furthermore, the search results can be enriched as it might detect additional publications that cannot be identified via standard database searches due to vocabulary constrained of a search strategy or bibliographic record (Wright et al., 2014).

Reference searching is another technique where the searching effort is by examining the reference lists in the selected articles for other articles. Horsley et al. (2011) further noted that in a situation where researchers face challenges in finding related information, examining the reference lists potentially might reduce the risk of missing relevant information. Snowballing is another technique that can be divided into two types – forward snowballing and backward snowballing and are similar to citation tracking and reference searching. It must be noted that the main disadvantage of citation tracking, references searching and snowballing system is that it can get out of control, retrieving more articles than it is feasible to appraise manually (Tsafnat et al., 2014). Contacting experts is another searching technique that should be considered especially if the specialist literature is not clearly defined (Gotzsche, 2012).

6. Conclusion

This systematic review has highlighted the importance of adaptation strategy towards climate change among Asian farmers. Within the Asian context, changes such as rising temperature, unstable rainfall pattern, hot and dry summer afternoon wind and extreme events such frequent drought and annual flood erode the soil, reduce the water supply and at the same time affect farmers' productivity in terms of its quality and quantity. In response towards this, farmers have practiced several adaptation strategies. Based on the systematic reviews performed, authors have identified six adaptation patterns namely crop management, irrigation and water management, farm management, financial management, physical infrastructure management and social activities. These adaptation strategies were further extended to 35 sub-themes.

The review suggests several recommendations for future studies. First, more qualitative studies are needed as it offers in-depth analysis and detailed explanations on farmers' adaptation methods along with farmers' perspectives and decision-making about adaptation practices. Second, to have specific and a standard systematic review method for guide research synthesis in context of climate change adaptation and thirdly to practice complimentary searching techniques such as citation tracking, reference searching, snowballing and contacting experts.

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