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A literature review on examining individual commitment of farmers Toward resilient farming: adoption and determinants of resilient Agricultural practice in the face of climate change

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ABSTRACT

The present paper aims to study the impact of climate change on agriculture and the individual commitment of farmers to adopt resilient farming practices to fight climate change. Climate change can be defined as "long-term shifts in temperature and rainfall over a long period." (United Nations,2023). This change can be natural or through man-made activity. Climate change has various implications. One such implication of climate change is on Agriculture. The potential way through which climate change impacts agriculture is by affecting crop production, livestock, and overall food security. Resilientn agricultural practice is an important practice that ensures food security and sustainable food systems in developing countries. The practice regulates the balance between producing food, managing natural resources, dealing with uncertainty, and providing a livelihood base for the rural population. The term specifies the role of public, private, and civic entities in combating climate change. Reviews of literature were analyzed on the topic. The results of the study included tables and figures from an existing study on resilient farming practices.

Keywords: Climate Change, Agriculture, Resilient Farming

Introduction

DEFINITION OF CLIMATE CHANGE

Climate change can be defined as "long-term shifts in temperature and rainfall over a long period." (United Nations,2023). This change can be natural or through man-made activity. Climate change has various implications. One such implication of climate change is on Agriculture. The potential way through which climate change impacts agriculture is by affecting crop production, livestock, and overall food security.

DEFINITION OF AGRICULTURE:

Agriculture can be defined as "the science, art, or practice of cultivating the soil, producing crops, and raising livestock and in varying degrees the preparation and marketing of these products." (Merriam-Webster,2023).

IMPACTS OF CLIMATE CHANGE ON THE CULTIVATION OF SOIL:

Although climate change is a gradual process that results in gradual changes in precipitation and rainfall over a long period causes significant effects on the various properties of soil, especially the fertility of the

soil. Changes in the moisture content of soil and increase in the soil temperature and levels of CO2 mainly cause these effects (NSW, 2023).

WAYS IN WHICH CLIMATE CHANGE IMPACTS SOIL FORMATION:

Following are the various ways in which climate change can affect soil formation

- **Erosion and loss of topsoil:**

Increased precipitation and extreme weather events such as heavy rainfall and storms can lead to soil erosion. Intense precipitation can wash away topsoil, which contains important organic matter and nutrients necessary for plant growth. This erosion depletes the fertility of the soil and impacts the productivity of agriculture.

- **Desertification and Aridification:**

Climate change contributes to the expansion of arid and semi-arid areas, causing desertification. Rising temperatures, changing rainfall patterns, and increased evaporation rates can reduce the levels of soil moisture, leading to soil dryness and increased vulnerability to soil erosion. These changes can degrade soil quality, decrease vegetation cover and reduce soil fertility.

- **Alteration of soil micro-organisms:**

Changes in temperature and moisture conditions can affect soil micro- organisms activity and composition. Microorganisms are vital in nutrient cycling, decomposing organic matter, and maintaining soil structure. Heat stress and moisture fluctuations can impact microbial communities, potentially altering nutrient availability and nutrient cycling processes

- **Changes in nutrient availability:**

Climate change can influence the mobility and availability of nutrients within the soil. Increased rainfall results in leaching, where nutrients are washed out of the root zone and become less accessible to plants. Similarly, in regions that are dry reduced precipitation can limit the breakdown and release of nutrients from organic matter, leading to nutrient deficiencies.

- **Soil Acidification:**

Changes in temperature and rainfall patterns can influence soil pH levels. Rising temperature and increased carbon dioxide concentrations can accelerate organic matter decomposition, which can release acidic compounds into the soil, causing soil acidification.

- **Permafrost thawing:**

In cold regions, climate change can lead to the thawing of permafrost, which is permanently frozen soil. Permafrost thawing can disrupt soil structure and stability, causing subsidence,sinkholes, and changes in

hydrology. It can also release trapped organic matter, potentially leading to increased greenhouse gas emissions, particularly carbon dioxide, and methane.

- **Salinization and Soil Degradation:**

Rising temperatures and changing precipitation patterns can alter water availability and evaporation rates, contributing to soil salinization. Increased evaporation can result in concentrated salt levels in the soil, inhibiting plant growth and degrading soil quality. Additionally, saltwater intrusion from rising levels can affect coastal soils, making them less suitable for agriculture.Although, these are the various impacts of climate change on soil formation, there maybe variations in these impacts depend on local conditions and geographical regions.

IMPACT OF CLIMATE CHANGE ON LIVESTOCK (FEEDIPEDIA, 2016)

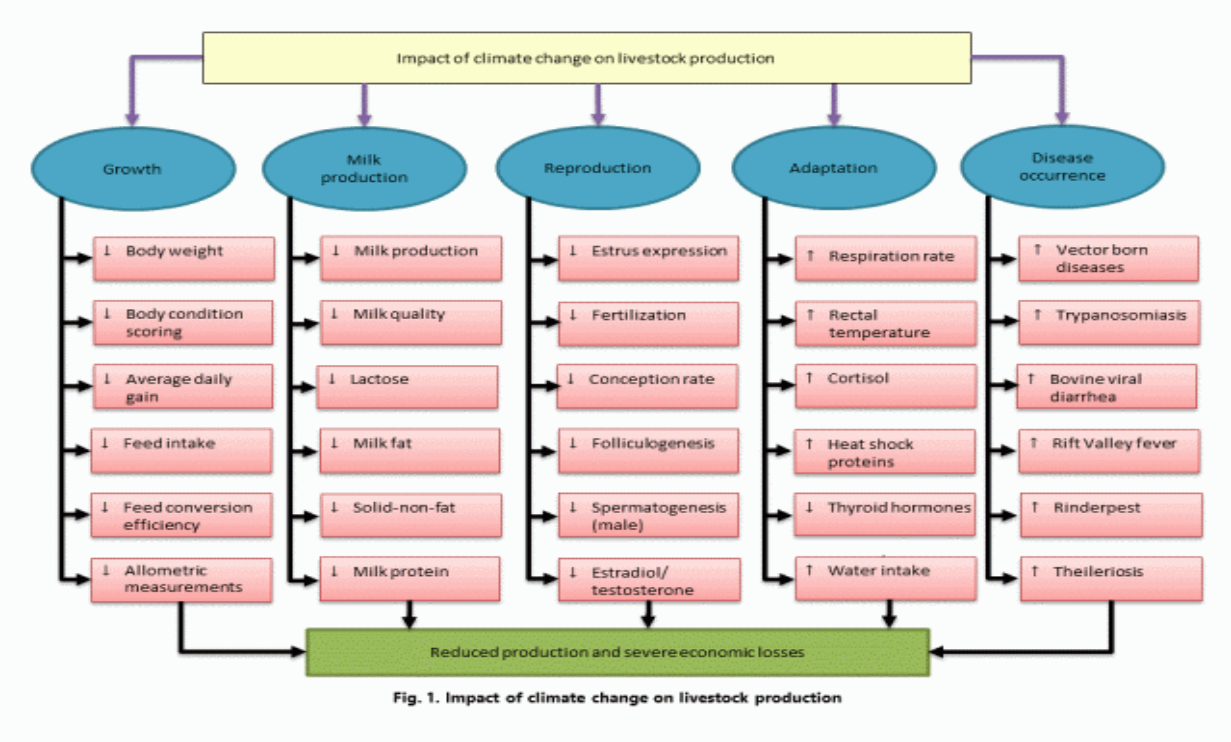

Fig. 1. Impact of climate change on livestock production

IMPACT OF CLIMATE CHANGE ON FOOD SECURITY:

According to a report by the Agriculture and Food Security Organization of the United Nations in 2015, climate change is found to play a major role in limiting the efforts of the nation against hunger and malnutrition. A report by the Intergovernmental Panel on Climate Change has stressed that climate change can contribute to an increase in cases of hunger and malnutrition in the most vulnerable countries and populations. IPCC AR 5 identified four out of eight important risks caused by climate change which can have direct consequences on food security, namely,

- Loss of rural livelihoods and income
- Loss of marine and coastal ecosystems and livelihood
- Loss of terrestrial and inland water ecosystems and livelihood
- Food insecurity and breakdown of food systems

The report has mentioned that the earliest and most affected by climate change are the most vulnerable countries and populations. In addition, to the above-mentioned impacts climate change can also affect the

trade flows, and food markets, lead to instability prices, and cause new risks to human health. The report concluded that earlier interventions are necessary in mitigating climate change.

IMPACT OF CLIMATE CHANGE ON WATER SCARCITY FOR AGRICULTURE:

Following are the various ways in which climate change can contribute to water scarcity for agriculture:

- **CHANGES IN PRECIPITATION PATTERNS:**

Climate change alters precipitation patterns, leading to changes in the timing, intensity, and distribution of rainfall. Some regions may experience more frequent and intense rainfall events, resulting in increased runoff and soil erosion. Simultaneously other areas may face reduced rainfall and prolonged droughts. Both scenarios can disrupt water availability for agriculture, making it challenging to meet crop water requirements.

- **INCREASED EVAPORATION AND TRANSPIRATION:**

Rising temperatures associated with climate change can enhance evaporation rates and plant transpiration, increasing the water demand. This leads to faster drying of soils and increased water requirements for crops, potentially leading to water stress and inadequate irrigation capacity.

- **MELTING GLACIERS AND SNOWPACK REDUCTION:**

In regions dependent on meltwater from glaciers and snowpack for irrigation and water supply, climate change-induced melting can impact water availability during critical growing seasons, affecting crop productivity and water security.

- **CHANGE IS RUNOFF AND WATERSHED DYNAMICS:**

Climate change can alter the timing and amount of surface water runoff, affecting water availability and downstream irrigation. Changes in precipitation patterns, such as intense rainfall events can result in increased runoff, leading to flash floods and reduced infiltration into the soil. This can limit the recharge of groundwater aquifers that are vital sources of irrigation water.

- **SALTWATER INTRUSION AND SEA LEVEL RISE:**

Climate change-induced sea level rise can increase the risk of saltwater intrusion into coastal areas. Saltwater can contaminate freshwater sources, including groundwater making them unsuitable for irrigation and leading to soil salinization. This reduces available water supplies for agriculture and decreases the productivity of affected coastal regions.

- **INCREASED WATER DEMAND AND COMPETITION:**

Climate change impacts, such as changing rainfall patterns, droughts, and temperature fluctuations can lead to increased demand for water resources across different sectors.This heightened competition for water resources which can strain agricultural water supplies as other sectors, such as households, industry, and ecosystems, also require access to limited water resources.

NEED FOR RESILIENT FARMING:

Resilient agricultural practice is an important practice that ensures food security and sustainable food system in developing countries. The practice regulates the balance between producing food, managing natural resources, dealing with uncertainty, and providing a livelihood base for the rural population. The term specifies the role of public, private, and civic entities in combating climate change (Barbara, 2019)

THEORY OF INDIVIDUAL COMMITMENT:

MARS THEORY OF INDIVIDUAL COMMITMENT:

According to the MARS model, individual behavior is the result of four major Components, namely, individual motivation, abilities, role perception, and situational Factors.

MOTIVATION:

An individual motive to engage in a particular behavior is determined by his/her direction, intensity, and persistence in voluntary behaviour. The model suggests that individuals have a clear sense of what they want and the quality and quantity of their efforts.

ABILITY:

Ability is the function of two major components, namely,Natural aptitudes and learned capabilities. Both these components determine an individual's ability to complete a task. While aptitudes are natural, learned capabilities refer to knowledge and skills an individual has acquired over time.

Competencies refer to characteristics that result in superior performance in individuals. Competencies refer to the personal traits of an individual such as knowledge, skills, aptitudes, personality, self-concept, and values.

ROLE PERCEPTIONS:

Role perceptions refer to the ability of an individual to Understand what roles are assigned or expected of them.

Need for the Study

The present paper is a literature review that is conducted to analyze two different concepts- the impact of climate change on agriculture and the individual commitment of farmers to mitigate climate change. Examining the impact of climate change on agriculture may involve understanding how farmer respond psychologically to environmental changes. The understanding psychological factors enables the researchers to identify effective strategies, barriers, and facilitators of behavior change in the agricultural sector, contributing to the development of evidence-based policies and interventions. The study also highlights the need for resilient farming practices to fight climate change.

Review of Literature

STUDIES RELATED TO THE IMPACT OF CLIMATE CHANGE ON SOIL FORMATION:

A study was conducted to examine the impact of climate change and human influence on soil erosion within the Kagera Basin of the East African Highlands by Chaodong Li, Zhanbin Li, et.al. (2021). The researchers conducted a grey relation analysis to understand qualitative assessment of the influence of climate change and human activities on soil erosion. The study's results revealed that 90.32% of the Kagera Basin perceived climate change as having a greater influence on soil erosion than human influence, while the remaining 9.68% perceived human beings to be playing an important role in soil erosion. Further, the researchers found that there is a very low level of soil erosion within the Kagera Basin of the East African Highlands. The range land and farmland were found to have a major loss in soil followed by forest, wetland , and built-up areas.

A study was conducted to assess the impact of climate change on soil microbial community by Srikanth Mekala and Srilatha Polepongu (2019). The researchers analyzed the impact of various factors related to climate change such as elevated CO_2, drought, and temperature on the beneficial plant community. The

researchers realized through their study that there can be variations in the responses of different microbial communities to climate factors. The results of their study revealed that there was a positive influence of the elevated levels of CO2 on the abundance of arbuscular and ectomycorrhizal fungi than plant-growth-promoting bacteria and endophytic fungi. The researchers also found that plant-growth-promoting organisms showed varied responses to a rise in temperature. Also, it was found that plants in areas of drought were more affected by Plant-growth-promoting organisms.

A study was conducted on the industrial contaminants accumulated in Arctic permafros by Moritz Langer, Thomas Schneider von Demling, et.al (2022). The researchers have found that potentially hazardous substances are stored in 4500 industrial sites in the Arctic permafrost regions. They have identified 13000 and 20000 contaminated sites related to industrial sites. The researchers conclude from their study that the contamination and mobilization of substances will increase due to climate change in the future. The study recommends that to prevent environmental hazards reliable and long-term planning strategies for industrial and contaminated sites are required.

IMPACT OF CLIMATE CHANGE ON FOOD SECURITY:

A literature review was conducted on the impact of climate change on food and Nutritional security by Tais de Moura, Maira Lopes, et al. (2022). The study was conducted in Pub Med using the descriptors "climate change and food security" as the headline. The researchers selected papers related to the topic in Portuguese, Spanish, and English languages. The results of the study revealed that the major impact of climate change was access to production, nutritional quality, and volatility of food prices. Further, the results highlighted mitigation and adaptation strategies to the effects of climate change on food and nutrition services in countries with poverty and inequality.

IMPACT OF CLIMATE CHANGE ON WATER SCARCITY:

A study was conducted on global water scarcity in the future and the potential solutions to handle water scarcity by Chunyang He, Zhifeng Liu, et al. (2021). The study quantified global water scarcity in 2016 and 2050 under four socio-economic and climate change scene and analyzed the potential solutions. The study's results revealed that water scarcity in the global population is likely to increase from 933 million in 2016 to 1.693 to 2.373 billion people in 2050, with India being the most affected country. Further, the results revealed that the number of cities likely to face water scarcity will increase from 193 to 193-284, including 10-20 megacities. The study recommends infrastructure investment by guarding the potentially significant environmental trade-offs related to water scarcity.

STUDIES RELATED TO INDIVIDUAL COMMITMENT TOWARDS CLIMATE CHANGE:

A literature review was conducted on the adoption of climate-resilient crops by small-scale producers in low and middle-income countries by Maricelis, Kevin, et al. (2020). The researchers used PRISMA-P to analyze various literature related to the topic. The study examined the conditions that led to the adoption of climate-resilient crops over 30 years in low and middle-income countries. They conducted a descriptive analysis of 202 papers. The results of the analysis revealed that small-scale producers adopted climate-resilient crops to cope with abiotic stresses such as drought, heat, salinity, and flooding. Further, the study revealed that the most important determinants for the adoption of climate-resilient crops were the availability and

effectiveness of the extension services and outreach followed by the education levels of the heads of the households, farmers' access to inputs especially seeds and fertilizers, and the socio-economic status of farming families. The study also found that an analysis of 53% of studies found that social differences such as sex, age, marital status, and ethnicity affected the adoption of climate-resilient crops.

Research Methodology

AIM OF THE STUDY:

The study was conducted for the following two purposes-

1. To study the impact of climate change on agriculture and
2. To study the individual commitment of farmers in adopting resilient farming practices to fight climate change.

TOOLS USED FOR THE STUDY:

The study analyzed various literatures related to the above topic.

Results

This section analyses the tables and figures of a review on individual commitment of farmers in adopting climate-resilient farming practices.

Table 1 shows the adoption of climate-resilient crops as part of broader climate-resilient strategies:

Types of responses to papers Climate change	Percentage list the response	Examples of specific activities associated with each response to climate change
New variety Planted	24%	Introduction of a new variety of an existing crop to the farmer
Modified Planting Activities	32%	Change in planting date, plant diversification, crop rotation

		and intercropping.
Irrigation Water Management	32%	Water conservation strategies, Irrigation, micro-irrigation, Water harvesting and improving Drainage
Seeking off Farm work or migration	5%	Outmigration, seeking off the farm employment and diversification of activities beyond the farm
Storage and Infrastructure Development	5%	Crop storage development and Improvement, community sharing and road building
Use of fertilizers and Pesticides	16%	Use of fertilizers, including manure and pesticides, and change in use of fertilizers, compost manure and green manure.
Planting trees	12%	Planting shade trees and agroforestry.

From the above table, it can be inferred that a percentage of 24% of the papers listed the introduction of a new variety of plants to the farmer as an example of the specific activities associated with the type of response titled “new varieties planted”. About 32% of papers mentioned changes in planting date, plant diversification, crop rotation, and Intercropping is an example of the specific activities associated with the type of response titled “Modified Planting Activities”. 32% of papers mentioned Water conservation strategies, Irrigation, micro-irrigation, water harvesting, and improving drainage as examples of the specific activities associated with the type of response titled “Irrigation and water

management". About 5% of papers mentioned out-migration, seeking off-farm employment, and diversification of activities beyond the farm as examples of specific activities associated with the type of response titled "seeking off-farm work or migration". 5% of papers mentioned crop storage development and improvement, community sharing and road building as examples of specific activities associated with the type of response titled "Storage and Infrastructure Development". 16% of papers mentioned the Use of fertilizers, including manure and pesticides, and change in the use of fertilizers, compost nature, and green manure as examples of specific activities associated with the type of response titled "Use of fertilizers and pesticides". 12% of papers mentioned Planting Forest trees and agroforestry as examples of specific activities associated with the type of response titled "Planting trees".

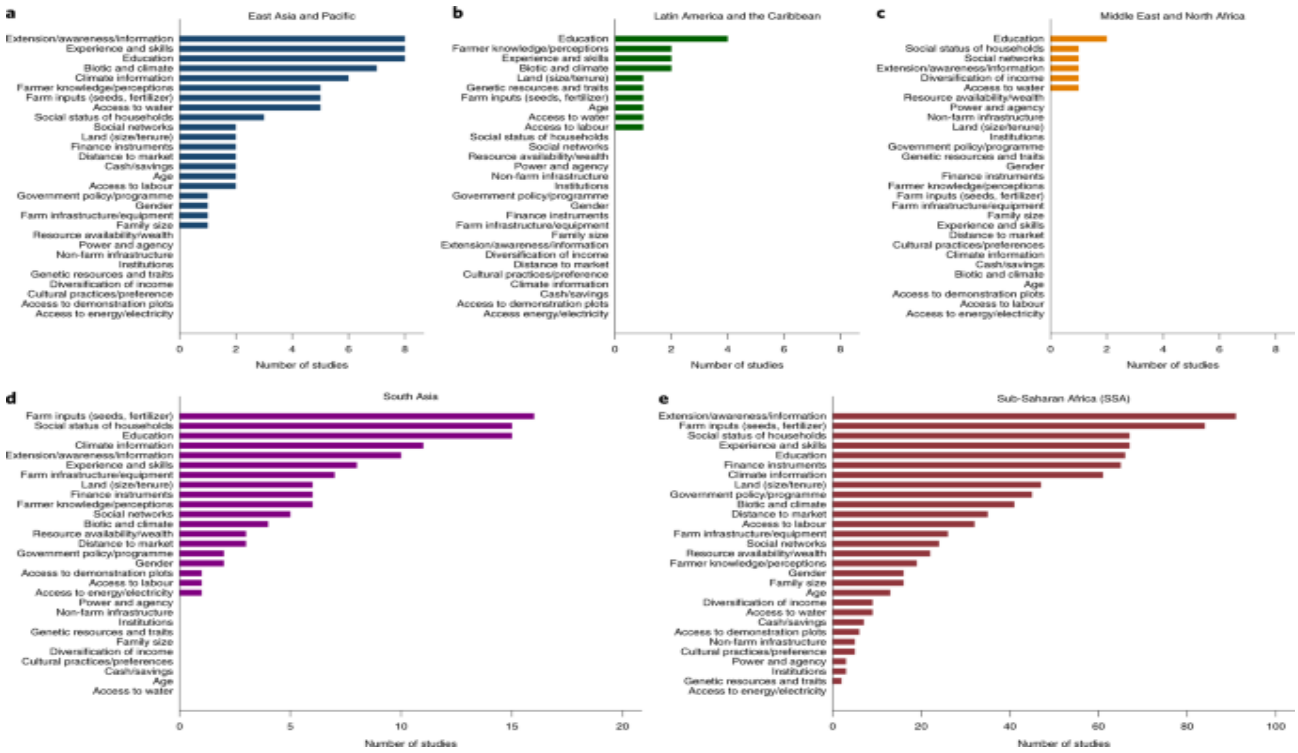

Fig. 2: Relevance of social, environmental, and economic determinants of adoption of climate-resilient crops by region.

TABLE 2 SHOWS THE SEED FACTORS ASSOCIATED WITH CLIMATE-RESILIENT CROPS AND CROP VARIETIES

EMERGENT THEMES ABOUT SEED	SUMMARY OF THE EVIDENCE
ACCESS	Access to seed or the ability to afford seed was a principal barrier for small-scale farmers' adoption of climate-resilient varieties.

Several papers mentioned that cost was even more challenging for women and farmers with fewer assets, smaller parcels of land , or lower economic status. At least four papers suggested seed subsidies as a strategy to improve access to seed.

AVAILABILITY

Availability, or the ability to acquire seed on time, in the quantity needed, and within reasonable proximity, was a determination of adoption related to seed. Community seed banks also enhanced the availability of seeds.

SOCIAL NETWORKS

Participation in social networks that enable the exchange of seeds was a climate-resilient strategy for farmers. Participation in social networks, which included community seed banks, seed organizations, farmer groups, and intra-village or neighbor networks improved the adoption of seed, and these social networks also increased the spread of speed that was distributed as a part of development projects. Conversely, one paper reported that seed did not spread beyond the immediate beneficiaries of the project. Another report stressed the importance of reciprocity within strong social networks as important for maintaining access to seed and several others recommend supporting social networks to strengthen seed systems. According to three papers, community seed banks strengthened social networks for the exchange provided landraces for participatory crop improvement, and increased availability of seed. Integration of informal and formal seed system elements is important because most of the seeds planted by small farmers are uncertified and sourced through informal seed system channels or social networks. Social networks also have an important role in enhancing farmers' access to information.

INFORMATION	Farmers lacked information about varieties, adaptation, and attributes, or did not know where to acquire seed. Extension services, seed companies, seed suppliers, and seed traders were a source of information about seeds, and in some cases increased use of seed and other management practices. In a few cases, there was evidence that access to extension services positively influenced the use of certified seed, and in another, the authors suggested that extension services positively influenced the use of certified seed, and in another, the authors suggested that extension services could help farmers become aware of different adaptive strategies and help in the distribution of seed of improved varieties.
GENDER	Few papers explicitly linked gender and seed. Improved seed was more difficult to acquire for female-headed households and women were less likely to use improved seeds or have access to extension services; small, affordable seed packs were suggested as a potential solution.
STRATEGY	Improved or hybrid seed and exchanging seed with other villages were considered to be climate-resilience strategies for farmers.
POLICY	A few papers discussed agricultural policies related to seeds, arguing that policies should enable the seed sector to provide suitable varieties and aim to increase the availability of funds for seed distribution research and access to improved seed, and one paper indicated that government policies restrict farmers' options for obtaining their

	preferred seed.
EXPERIENCE	One paper indicated that farmers' experience had a positive effect on the adoption of new seeds, whereas another indicated the opposite.
SEED OR VARIETY ATTRIBUTES	Four papers reported on concerns related to the attributes of hybrid seed varieties and their adaptation to the environment, suitability for storage, flour-to-grain ratio, and other processing issues. One study found that farmers favor composite varieties and local landraces under conditions of abiotic stress.
SEED SOVEREIGNTY	One paper discussed issues related to seed sovereignty, reporting that farmers wanted a say in where seeds came from and were resistant to the use of transgenic crops. They expressed a belief that seed industries are appropriating a resource that belongs to humanity. Autonomy is highly valued by these communities, and local varieties are valued in part for their contribution to maintaining independence from commercial hybrid sources.

From the above table, it can be inferred that, on the emergent theme of access, the summary of evidence states, Access to seed or the ability to afford seed was a principal barrier for small-scale farmers' adoption of climate-resilient varieties. Several papers mentioned that cost was even more challenging for women and farmers with fewer assets, smaller parcels of land, or lower economic status. At least four papers suggested seed subsidies as a strategy to improve access to seed. On the emergent theme of availability, the summary of evidencementions that availability, or the ability to acquire seed on time, in the quantity needed, and within reasonable proximity, was a determination of adoption related to seed. Community seed banks also enhanced theavailability of seeds. On the emergent theme of social networks, the summary of the evidence mentionsthat Participation in social networks that enable the exchange of seeds was a climate-resilient strategy for farmers. Participation in social networks, which included community seed banks, seed organizations, farmergroups, and intra-village or neighbor networks improved the adoption of seed, and these social networks also increased the spread of speed that was distributed as a part of development projects. Conversely, one paper reported that seed did not spread beyond the immediate beneficiaries of the project. Another report stressed the importance of reciprocity within strong social networks as important for maintaining access to seed and several others recommend supporting social networks to strengthen seed systems. According to threepapers, community seed banks strengthened social networks for the exchange provided landraces for participatory crop improvement, and increased availability of seed. Integration of informal

and formal seed system elements is important because most of the seeds planted by small farmers are uncertified and sourced through informal seed system channels or social networks. Social networks also have an important role in enhancing farmers' access to information. On the emergent theme of Information, Farmers lacked information about varieties, adaptation, and attributes, or did not know where to acquire seed. Extension services, seed companies, seed suppliers, and seed traders were a source of information about seeds, and in some cases increased the use of seed and other management practices. In a few cases, there was evidence that access to extension services positively influenced the use of certified seed, and in another, the authors suggested that extension services positively influenced the use of certified seed, and in another, the authors suggested that extension services could help farmers become aware of different adaptive strategies and help in the distribution of seed of improved varieties. On the emergent theme of gender,Few papers explicitly linked gender and seed. The improved seed was more difficult to acquire for female-headed households and women were less likely to use improved seeds or have access to extension services; small, affordable seed packs were suggested as a potential solution. On the emergent theme of strategy,the summary of evidence mentions that Improved or hybrid seed and exchanging seed with other villages were considered to be climate-resilience strategies for farmers. On the emergent theme of policy, thesummary of evidence mentions that a few papers discussed agricultural policies related to seeds, arguingthat policies should enable the seed sector to provide suitable varieties and aim to increase the availability of funds for seed distribution research and access to improved seed, and one paper indicated thatgovernment policies restrict farmers' options for obtaining their preferred seed. On the emergent theme of experience, according to the summary of evidence, one paper indicated that farmers' experience had a positive effect on the adoption of new seeds, whereas another indicated the opposite. On the emergenttheme of seed or variety attributes, according to the summary of the evidence, four papers reported on concerns related to the attributes of hybrid seed varieties and their adaptation to the environment, suitabilityfor storage, flour-to-grain ratio, and other processing issues. One study found that farmers favor composite varieties and local landraces under conditions of abiotic stress. On the emergent theme of seed sovereignty,according to the summary of evidence, One paper discussed issues related to seed sovereignty, reporting thatfarmers wanted a say in where seeds came from and were resistant to the use of transgenic crops. They expressed a belief that seed industries are appropriating a resource that belongs to humanity. Autonomy is highly valued by these communities and local varieties are valued in part for their contribution to maintaining independence from commercial hybrid sources.

Fig. 1: Summary of determinants of adoption of climate-resilient crops and crop varieties by farmers

The inner ring outlines the five broad categories to which the 29 social and economic factors are mapped. The outer ring shows the factors within each broad category that were most frequently mentioned across the included studies. The relative area occupied by categories indicates their relevance.

Summary

The present study was conducted to study the impact of climate change on agriculture and the impact of individual commitment of farmers in adopting resilient farming practices to fight climate change. Thefirst chapter of the paper briefly presents a definition of climate change and agriculture. The various impacts of climate change on agriculture are briefly outlined. This Chapter also gives a short descriptionof resilient farming. In the second chapter, the researcher analyses reviews related to theimpacts of climate change on agriculture concerning three domains, namely, soil erosion, foodsecurity, and water scarcity, and a review related to resilient farming. The Third Chapter of the paperanalyses the aim of the study, the tools used for the study, and the results of the review on resilientfarming practices mentioned in the paper.

Conclusions

From the analysis of the literature in Chapter 2, it can be concluded that climate change has profoundimpacts on aspects of agriculture such as soil erosion, water scarcity, and food scarcity. The fertilityof the soil is determined by its moisture. Changes in climatic conditions make it difficult tocultivate various seasonal crops for the farmers. Apart from the above-mentioned impact, climatechange also influences the scarcity of food in many countries serving as a major driver of hungerand starvation, especially, in developing countries like India. Also, irregular patterns of rainfallcontribute to the scarcity of water for cultivation. The study concludes by discussing the resultsof a review on climate-resilient practice.

Limitations

A major limitation of the study is it is not based on empirical data. The researcher concluded the study by analyzing existing sources of literature. Hence, the findings of the study cannot be generalized.

Scope for further research

An extension of the study can be carried out in the future by collecting data concerning various demographic factors such as region of residence (Urban/ Rural), age of farmers, educational background and socio-economic status.

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