

CHAPTER I

INTRODUCTION

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1.1 Introduction

The term "vulnerability" is used in a variety of disciplines, and because these disciplines have distinct goals and levels of expertise, there can be significant discrepancies in how different disciplines define and explain vulnerability. Vulnerability in the agricultural system refers to the interaction of climatic exposure, sensitivity, and adaptation capacity. The function of climatic exposure, sensitivity, and adaptive capacity within the system, as well as the degree to which the agricultural system is exposed to or unable to cope with the detrimental consequences of climatic variability, are thus the definition of agricultural vulnerability. (McCarthy et al. 2001). Exposure is the extent and characteristics of a system exposed to severe climatic variability; Sensitivity is the degree to which a system is influenced by climate-related elements, including both positive and negative effects; The ability of a natural or artificial system to profit and prevent loss when it is subjected to current or anticipated climatic disturbances and their effects is known as adaptive capacity. (IPCC, 2001).

Various sectors industry, tourism, and health etc are becoming vulnerable due to climate change and its variability in India (Mitra et al. 2008). Climate change and variability most affect the agricultural sector since they are the main factors influencing agricultural productivity. (Patnaik et al., 2005). The distribution and amount of rainfall have become extremely unpredictable, which directly affects on the agricultural sector and natural resources, both of which are essential to the country's economy (Smit and Wandel, 2006). Climate variability, such as droughts and floods, has been shown to destroy agriculture and crop production, which has a detrimental effect on people's health, their capacity to support themselves, and the country's food security. (Pathak et al. 2012). The risk of climate-dependent crop production has increased due to human-induced environmental changes, and prolonged monsoon drought spells, rising temperatures, and unexpectedly strong winter rains have seriously harmed people across the nation who depends heavily on agriculture. (Sehgal et al. 2013). It has been demonstrated that in various agroclimatic zones of India, rising average temperatures, altered rainfall patterns, an increase in the frequency of extreme weather events like severe droughts and floods, and shifting agricultural seasons have all been observed. (Kumar and Gautam, 2014). The probable effects of rising global mean surface temperature include temperature increases, unequal rainfall, decreased irrigation water, and extreme weather events. These signs show that India's climate is already changing and having an influence. (IPCC 2014). Since over 80% of Indian farmers are marginal (cultivating up to 1 hectare of land) and small (cultivating 1-2 hectares of land) with limited coping skills, the effects of climate change and unpredictability on agriculture are extremely difficult to deal with (Prasad et al. 2015). Because of their strong reliance on agriculture, rural populations are especially exposed to climate variability in this scenario. Additionally, the agricultural sector in India is diversified, heterogeneous, and unorganised. 51% of the country's

net cultivated area are rain fed (NRAA, 2022), and the sector is vulnerable to the stresses brought on by changing and unpredictable weather patterns. (Medat et al. 2016).

The challenges to Indian agriculture include declining per capita land availability, deteriorating land quality, stagnating net planted area, and increasing climate variability and change (Rao et al. 2016). So, the climatic variability and change is causing adverse effects on agriculture and it has a major threat to farming community particularly small and marginal farmers (Mhlongo and Managa, 2016). Therefore the Smart Agriculture Practices (SAPs) could be an alternative for food and sustainable livelihood to cope up with the agricultural vulnerability and helpful in mitigating the adverse effects of climate change and variability (Reddy and Dixit, 2017). But, it is a big challenge to develop innovative technologies to improve rural livelihoods, environment conservation and ensuring adoption of smart techniques. The term "Smart Agriculture Practises" (SAPs) refers to those methods that boost farmers' income and productivity while reducing greenhouse gas emissions and strengthening the resilience and capacity of food systems and agriculture to adapt to or mitigate the negative effects of climate change. (Lan et al. 2018). Smart Agriculture Practices (SAPs) include zero tillage, use of paddy transplanter, use of seed drill, drip and sprinkler irrigation, vermicompost, Integrated Farming System (IFS), mixed agriculture, use of mulching, bio-flock fishing and paddy cum fishing, crop insurance, Soil Health Card (SHC), Krishnan Credit Card (KCC) etc.

1.2 Statement of the Problem

The agricultural sector in India accounts for over 60.05% of the country's total land area and is essential to the country's food, nutrition, and livelihood security (World Bank Report, 2021). Since cultivators and agricultural labourers make up the majority of the district's workforce i.e. 32.3% and 34.7% respectively and agriculture is the foundation of the Koch Bihar district's economy (District Census Handbook, Koch Bihar, 2011). Marginal holdings of less than one hectare accounted for 1,28,277 hectares (46.69 percent of total area) in 2000–01; by 2005–06, that number had risen to 1,32,758 hectares (48.46 percent of total area). Between 2000–01 and 2005–06, the area covered by medium-sized properties, with an average size of 4 hectares to less than 10 hectares, fell dramatically from 8,805 hectares to 2,094 hectares (District Statistical Hand Book, Koch Bihar, 2010-11). Major obstacles related to agricultural marketing system include inadequate infrastructure and marketing channels, lengthy middlemen, a lack of timely and reliable market information, etc. affect the agricultural sector of Koch Bihar district (Bhowmik, 2012). The agricultural activity primarily depends on weather and climatic conditions and any variation of its pattern create vulnerability to this sector. The vulnerability of agriculture leads to low level of production, increase input cost, low net profit etc (Sharma, 2021). The vulnerability ranks of Koch Bihar district is 54 among the 161 districts in the Indo-Gangetic Plains (Sehgal et al.2013). The decision-makers need to address the vulnerability of agriculture as for different regions it is important as the resources are limited and they should plan various Smart Agricultural Practices (SAPs) based on vulnerability assessment, because

through maximizing the adaptive capacity SAPs, it is possible to reduced the agricultural vulnerability (Sehgal et al. 2013).

Thus, there is an urgent need for the adoption of Smart Agricultural Practices (SAPs) to enhance the production and productivity through sustainable use of natural resources, reduced the input cost, increase in the net profit, and generation of employment. For the solution of the problems related to agricultural vulnerability, a detailed study and research work about vulnerability of agriculture and adoption of Smart Agricultural Practices (SAPs), is very crucial (Reddy and Dixit, 2017). Keeping in view these problems, the present study entitled “Vulnerability of Agriculture and Introduction of Smart Agricultural Practices (SAPs): An Assessment in Koch Bihar District, West Bengal” has been taken.

1.3 Literature Review

R. Singh et al. (2008) in their paper “Multidimensional Impact Assessment of Zero Tillage Technology” reported that adopters were more likely to transition to zero tillage technology than non-adopters and had a more positive attitude. When it came to zero tillage technology, the adopters were reasonably knowledgeable. The adopters expressed pleasure with the time, money, yield, and timely planting savings. The farmers also stated that they are unable to buy new equipment and inputs because of a lack of funds. The degree of adoption could be raised via government initiatives and educational initiatives.

The vulnerability of South African farmers to climate change and variability was assessed by G. A. Gbetibouo and C. Ringler (2009) in their paper "Mapping South African Farming Sector Vulnerability to Climate Change and Variability." They achieved this by creating an index of vulnerability and comparing vulnerability indicators among the nine provinces in the nation. They have determined nineteen environmental and socioeconomic indicators that correspond to the exposure, sensitivity, and adaptive capacity—the three facets of vulnerability. The study's findings demonstrate that areas most susceptible to climatic unpredictability and change also possess a greater capacity for adaptation. Furthermore, social and economic growth are inextricably related to sensitivity to climate fluctuation and change. Additionally, they said that the variations in risk among provinces should prompt policymakers to create regionally appropriate policies and deal with climate change locally.

S. Chowdhury. and P. Roy (2009) in their paper “Participatory Constraint Analysis Regarding the Adoption of IPM Technologies in Pointed Gourd Cultivation: An Empirical Study” reported about some problems regarding adoption of pest management technology such as, economic threshold limit (ETL) which was ranked first followed by the lack of Knowledge of the respondents about the Integrated pest management (IPM) techniques which was third and lack of training of the respondents on the proper use of pesticides which was ranked fourth. He also stated that most of the farmers adopted the medium level of the production technology.

S. Bairagi et al. (2010) in their paper “Climate Risk Management Strategies and Food Security: Evidence from Cambodian Rice Farmers” revealed that there was significant gap

between awareness and adoption of integrated pest management (IPM) practices for different crops among farmers. In case of paddy cultivation, farmer's awareness about the different recommended practices was 20 to 100 percent, however in case of adoption it was 0 to 60 percent for different IPM practices. They also conclude that majority of the farmers were found in the range of high level of knowledge about organic farming practices.

Based on research conducted by R.P. Sahu et al. (2010), the majority of farmers (46.70%) have a good degree of understanding regarding organic farming practises. The usage of HaNPV (43.34%), Tricho cards (41.12%), bio-pesticides (38.88%), and NADEP compost (37.77%) are among the organic farming practises where there are significant knowledge gaps. The report also notes that in order for farmers to understand the fundamentals of organic farming and how to apply it, they must be well informed about the use of such practises.

M. A. Mo et al. (2011) in their paper Analysis of Adoption of Improved Maize Varieties among Farmers in Kwara State, Nigeria concentrated on examining the socioeconomic elements that affect farmers' adoption of improved maize varieties. Their study's main goals were to list the new varieties of maize that are available in the study area, identify information sources about these varieties, assess farmers' awareness of improved varieties, ascertain the impact of farmers' socioeconomic characteristics on farmers' adoption of improved varieties, and pinpoint issues that farmers face when adopting new varieties of maize. Regression analysis results indicated that factors influencing the adoption of better maize varieties were household size, education level, interaction with extension agents, availability of credit, and yield of the improved varieties. The main obstacles found were the high cost of manpower, the high cost of fertiliser, the lack of capital, the inability to communicate with extension agents, and the shortage of a market for produce.

A. K. M. N. Islam et al. (2013) in their paper Vulnerability to Climate Change: Adaptation Strategies and Layers of Resilience-Quantifying Vulnerability to Climate Change in Bangladesh described both regional and ecological vulnerability to climate change throughout the country. Two methodologies were used in this study: the IPCC method (2007) and the Patnaik & Narayanan method (2005). These techniques involved the selection of a collection of indications that define the three elements of vulnerability-exposure, sensitivity, and adaptive capacity-taking into account their respective roles and contributions to the vulnerability. This study set out to assess the country's various ecological zones and regions with regard to their susceptibility to climate change. The country is becoming more vulnerable to natural disasters, according to this paper, because of inadequate agricultural infrastructure, a shortage of resources, a lack of job opportunities, challenges related to geography and demography, economic regression, and rising climatic exposure and variability. They came to the conclusion at the end of the investigation that most of the regions were extremely vulnerable to climate change. Additionally, they suggest that in order to improve these areas' capacity to withstand the effects, resources including money, technology, and development initiatives should be given top attention.

B.C. Yadav et al. (2013) in their paper Adoption of Improved Production Technology of Mandarin in Rajasthan, India: A review described technologies like soil and soil preparation, varieties, propagation, plantation, hoeing and weeding management, irrigation management, intercropping, manure and fertilizers training and pruning, plant protection measures which improved the production of citrus fruits. They also stated about some constraints such as small land holding, undulated land, threat from wild and stray animal, poor quality of water, lack of technical knowhow, unsuitable soil for orchard, long vegetative period, high cost of insecticide and pesticides, storage and marketing constraints, lack of proper marketing system, high fluctuation in market prices about mandarin production in the study area.

The farming sector is most sensitive to climate change because of its strong reliance on weather and climate, according to D. Sridevi et al. (2014) in their work, "Climate Change Vulnerability in Agriculture Sector: Indexing and Mapping of Four Southern Indian States." Millions of Indians depend on agriculture, food security, and rural livelihoods, all of which are severely impacted by climate change. Of the more than one billion people living in India, around 68% work in agriculture either directly or indirectly. This industry is especially susceptible to the current climate's fluctuations. This article aims to map and analyse the climate change vulnerability in several districts of Andhra Pradesh, Karnataka, Tamil Nadu, and Kerala, four states in south India. To calculate the composite vulnerability index, they used five different sources of vulnerability indicators: sociodemographic, climatic, agricultural, occupational, and common property resource vulnerabilities. According to the composite vulnerability index, the most vulnerable districts in Andhra Pradesh, Karnataka, Tamil Nadu, and Kerala were Adilabad, Chamarajanagar, Thiruvarur, and Kasaragod; the least vulnerable districts were Hyderabad, Belgaum, Thoothukkudi, and Kottayam.

M.O. Akinnagbe and J.I. Irohibe (2014) in their paper Agricultural Adaptation Strategies to Climate Change Impacts in Africa: A review detail the agricultural adaptation tactics used by farmers in different African countries to mitigate the effects of climate change. Farmers frequently employed drought-resistant crop varieties, crop diversification, altered planting dates and cropping patterns, efficient irrigation techniques, afforestation, and agroforestry, as well as appropriate tillage techniques to preserve soil moisture. They concluded by saying that increasing and enhancing human capital at all levels through outreach initiatives, education, and extension services will increase capacity to adapt to the effects of climate change.

In their paper "Climate-Smart Agriculture Global Research Agenda; Scientific Basis for Action," S.L. Kerri et al. (2014) found that despite a changing climate and fewer opportunities for agricultural expansion on new lands, climate-smart agriculture (CSA) addresses the challenges of meeting the growing demand for food, fuel, and fibre. The goals of CSA are to reduce trade-offs and generate natural capital by sustaining and improving the resilience and productivity of agricultural and natural ecosystem processes, as well as to contribute to economic development, poverty reduction, and food security. The 2013 Global Science Conference on CSA highlighted agendas for multidisciplinary research and science-based action, which are

summarised here under three themes: Farm and food system, Landscape and regional concerns, and Institutional and policy factors.

Farmers encounter difficulties in determining how to increase farm output, according to J.M. Kavoi et al.'s 2014 article, "Challenges Faced by Small Land Holder Farmer Regarding Decision Making in Innovative Agricultural Development: An Empirical Analysis from Kenya." The analysis of farmers' operating circumstances was crucial, and it also became clear that farmers needed accurate information to make well-informed decisions about farming. As a result, development partners should provide sufficient information about available technologies and innovations, with the exception of those that take advantage of current public-private partnership (PPP) meetings to promote technologies and innovations with broad utilisation options. put plans in place to assess the conditions of farmers and to support new ideas and technology that will boost agricultural output and enhance food security.

G. Teneja et al. (2014) "Farmer's Preferences for Climate-Smart Agriculture: An Assessment in the Indo-Gangetic Plain" described various types of climate-smart Agriculture (CSA) practices are preferred by farmer's in Eastern & western Indo-Gangetic plain. In this particular setting, the most favoured interventions in the Eastern Indo-Gangetic plain were determined to be laser land levelling, crop insurance, and weather advisory services. However, in the western Indo-Gangetic plain, farmers favoured crop insurance, zero tillage, irrigation scheduling, and laser land levelling (LLL). However, this report also reveals that in order to really implement the recommended Climate-Smart technologies and other interventions on a large scale, financing availability and capacity building for both technology promoters and users would be necessary.

Farmers' options for adapting to climate change and the determinants influencing their decisions were evaluated by G. Hadgu et al. (2015) in their work "Farmers Climate Change Adaptation Options and Their Determinants in Tigray Region, North Ethiopia." In this study, adaption options were evaluated using descriptive statistics, and factors, such as household decisions, were identified using the multinomial logit model (MNL). In this paper it was revealed that farmers used change in crop variety, soil and water conservation practices, crop diversification, and change in planting date and irrigation practices as climate change adaptation options. They had also showed that education level, age, sex of the household head, farm income, access to extension services, access to credit, access to climate information and agro ecological setting were the most important determinant factors that affect significantly the choice of farmers to climate change adaptations.

"Opportunities and Challenges for Climate-Smart Agriculture," authored by D. Harijono and A. Desa (2015), two dimensions have been examined: the macro and the micro. The macro aspect will include international initiatives and legislation, and the micro aspect will detail particular methods and tools for implementing climate-smart agriculture (CSA). Macroeconomically speaking, the goal of the global alliance's activities is to help corporations, governments, scientists, farmers, and civil society achieve better food and nutrition security by

assisting in the mitigation of climate change and the efficient management of natural resources. Knowledge, investment, and an enabling environment are the first areas of action. The application of engineering analytical methods and aeronautical technology to support increased crop yields will be explained and illustrated in the micro aspect. In order to give insight into their setting and benefits, the macro and micro parts of CSA have been developed to the point where policies, smart farming techniques, techniques derived from space technology, and related ones may be defined.

K. Kant et al. (2015) –“Constraints Perceived by the Dairy Farmers in Adapting to Changing Climate in Western Dry Region of India” described about the challenges dairy farmers in the study area had in adjusting to the changing environment, as well as the recommendations they made for overcoming the obstacles to climate mitigation. The article highlighted several important obstacles, including but not limited to repeat breeding, a limited comprehension of the implications of climate change, high feed costs, and the lack of government legislation about weather information. Organising an awareness campaign about climate issues, planting drought-resistant grasses on pasture land, providing high-quality bulls, and offering animal health services at a nominal cost are the main recommendations made by the respondents in this paper.

A. Amin et al. (2015) –“Climate Smart Agriculture: An Approach for Sustainable Food Security” described numbers of strategies for achieving the goals of agriculture with a sensible climate. For an energy-smart food system, for instance, the utilisation of integrated renewable energy technology for farming such as wind mills, solar panels, pyrolysis units, and bioenergy-operated water pumps is essential. In order to prevent warm weather that is harmful to grain filling, farmers can plant wheat quickly after harvesting rice or cotton thanks to resource-conserving technologies (RCTs) like zero tillage. Another more effective CSA tactic is the introduction of recently created cultivars that are resistant to heat, drought, and salinity. In their research, they also make recommendations regarding computer-aided crop simulation models that can help determine the potential impact of climatic variation on agricultural yields in the future.

K. Yussif et al. (2015) –“Constraints to Farmers Willingness to Pay for Private Irrigation Delivery in Nandom, Ghana –revealed that majority of farmers in the Nandom district are ready to pay for private irrigation provision because of irrigation is governments duty (46.2%); Financial constraints (30.8%); Unacceptable terms / Conditions (15.4%). However, they are some key challenges that might hinder their will to pay. The most important ones being financial constraint; followed by lack of ready market for output, crop pest and disease, unstable output price, costly private services, inadequate supply of complementary inputs and lack of credit services.

A. D. Nciizah and I.C. Wakindiki (2015) in their article “Climate Smart Agriculture: Achievement and Prospects in Africa” described about the principles of Climate Smart Agriculture (CSA) and the achievements attained under this CSA practices in South Africa. They also stated about some possible challenges and prospects of CSA practices. At last they suggest

some possible remarks i.e. (1) Farmers must first invest in learning about a greater diversity of practices and measures. (2) Farmers need to acquire information and management skills. (3) During the transition and learning period, farmers must experiment more, and incur the costs of making mistakes as well as of acquiring new knowledge and information. (4) New technologies often require more labor for overcome the challenges related to adopting CSA practices.

S.J. Vekariya et al. (2016) in their paper Factors Influencing the Adoption of Scientific Animal Husbandry Practices: A Case of Saurashtra in Gujarat stated that the productivity of dairy animals continues to be low in India and they claimed that the major constraints for this low productivity are low level of knowledge and adoption of scientific practices among dairy farmers. In this paper it was also described about some key socio-economic factors (i.e. education, annual income, extension participation, size of landholding, information sources and knowledge.) are responsible for the adoption of scientific animal husbandry practices.

V. K. Sehgal et al. (2017) described in their paper Climate Change and Variability Mapping Vulnerability of Agriculture using Geospatial Technologies that India is especially concerned about climate change and variability since it directly affects agriculture. Additionally, they claimed that rising temperatures, variable rainfall, dwindling irrigation water supplies, an increase in the frequency of extreme weather events, and shifting seasons had a negative impact on the forestry, food security, agriculture, natural resources, economic activity, human health, and infrastructure sectors—all of which have a significant impact on the national economy and way of life of India (IPCC, 2014). People and society need a precise assessment of the ecosystem's vulnerability in order to reduce the potential harm caused by climate change. The susceptibility and adaptation to climate change primarily stem from unpredictability and extremes rather than explicitly altered average conditions. This study demonstrated how district-level data may be gathered, standardised, and reformatted at the indicator level using geospatial technology to create a vulnerability assessment.

J.P. Aryal et al. (2017) in their paper Adoption of Multiple Climate Smart Agricultural Practices in the Gangetic Plains of Bihar, India studied that To maintain Indian agriculture in the face of climate change, it is critical to use climate-smart agricultural practises, or CSAPs. The purpose of this research is to investigate the factors that influence the probability and degree of multiple CSAP adoption in Bihar, India. Additionally, multivariate and ordered probit models are used to analyse the probability and adoption of CSAPs, respectively. This study aimed to demonstrate strong correlations between several CSAPs, suggesting that their adoptions are connected and offering chances to take use of the benefits. The findings indicate that a wide range of factors, including demographics, farm plot features, socioeconomic status, market accessibility, climate hazards, and access to extension services and training, have an impact on the likelihood and intensity of CSAP adoption. Ultimately, this paper offers some insights into the long-running debates on whether farmers adopt CSAPs partially or in a composite manner by using multivariate and Probit models.

R. Raghuvanshi et al. (2017) *“A Study of Farmer’s Awareness about Climate Change and Adaptation Practices in India”* described that An Indian district in the North Himalayan area of Uttarakhand was the site of the study. Researchers discovered that most farmers in this research were aware of climate change, with the majority citing increased temperatures, less predictable rainfall, and decreased agricultural productivity as signs of the phenomenon. Farmers believed that deforestation, population growth, and growing industry were the primary causes of climate change. Furthermore, crop failures, relocation, and flooding were cited by the majority of farmers as the three main effects of climatic unpredictability. Additionally, they propose that the results will aid in creating a roadmap for developing policies and implementing mitigating actions.

M. Nagargade et al. (2017) in their paper *“Climate Smart Agriculture: An Option for Changing Climate Situation”* explain why climate-smart agriculture is necessary. They asserted that while the global population is growing daily, climate change and the depletion of natural resources are endangering agriculture. The changing climate has a detrimental impact on food security, income, agricultural output, and production stability. Thus, in order to meet the requirement for food security and to adapt to a changing climate, agriculture must react to the current circumstances. This report also demonstrated that by 2050, agricultural output will need to increase by 65% in order to meet the demands of a growing population. To address these issues, it is therefore necessary to alter agricultural practises in a more sustainable manner.

Traditional agriculture is an old method for sustainable food production, but it is also an alternative practise for mitigating climate change, according to R. Singh and G. S. Singh's 2017 paper, *“Traditional Agriculture; A Climate-Smart Approach for Sustainable Food Production.”* It was also stated that 15-20 percent of the world's food supply comes from conventional multiple cropping methods. Apart from this, other well-known traditional agricultural methods include integrated crop-animal farming, intercropping, crop rotation, cover crops, traditional organic composting, and agroforestry. These traditional methods are promoted as the standard practises for an agricultural strategy that is climate-smart. Thus, this essay discusses the relationship between agriculture and climate change and advocates traditional agriculture as a climate-smart strategy for the production of sustainable food.

Party T. Samuel et al. (2018): *“Developing Climate-Smart Agriculture to Face Climate Variability in West Africa: Challenges and Lessons Learned”* In their paper, they discussed the opportunities for the development and promotion of climate-smart agriculture (CSA) in West Africa, along with the challenges and lessons learned, with a particular emphasis on the variability of climate change. This research made it clear that West Africa's socioeconomic and physical qualities make it susceptible to climate unpredictability and change. Without the right interventions, the region's efforts to use agriculture as a mainstream means of achieving the sustainable objectives' targets will face significant challenges as long as climate change and variability persist. CSA adoption appears to be a workable plan for both achieving food security and reducing and adjusting to risks associated with climate change. Agroforestry, soil and water

conservation technologies, and climate information services were identified as highly valued and promising choices for climate change adoption and risk management in West Africa, among other CSA practises. The future of CSA in West Africa depends on farming households' and the region's national institutions' ability to comprehend the environmental and socioeconomic issues related to climate change and, as a result, mobilise themselves to create and carry out appropriate policies at the right scales.

"Climate Smart Agriculture towards Triple Win: Adaptation, Mitigation, and Food Security," by Deepika et al. (2018) discussed the CSA programmes' mixed results from the stakeholders involved (insurance plans, irrigation projects, sustainability projects, and diversification projects), as well as the factors that influence acceptance, such as incentives and hurdles. Apart from this, the paper made it abundantly evident that the following parties have been involved in the development, execution, and management of all CSA programmers' activities: government institutions, the state department of agriculture and others, research institutions (KVK), development officers (ADOs and AEOs), extension officers (AEOs and VLWs), farmers associations, self-help groups, input dealers and traders, non-governmental organisations, and Krishak Vikas Associations.

According to A. K. Rohila et al. (2018), "Awareness, Constraints and Prospects of Climate Smart Agricultural Practises," the agricultural community, especially smallholder and marginal farmers, continues to face a serious threat from the current state of climate change, which is having a negative impact on agriculture and is unpredictable. Creating cutting-edge technologies to enhance rural livelihoods, protect the environment, and guarantee their uptake present challenges. In this case, adopting climate-smart agricultural practises may be a better way to deal with the current circumstances and lessen the negative effects of climate change. This study also showed that farmers had a high degree of understanding regarding the ways in which CSAP boosts farm profitability and production. Although the adoption of CSAP was severely hampered by a lack of information about climate change and by inadequate planning and implementation at the district level, the main benefits of CSAP were that they are environmentally benign and can boost income and productivity.

In order to ascertain the factors influencing choice and the impact of CSA on household food security among smallholder farmers in Kenya, B.M. Wekesa et al. (2018) conducted "Effect of Climate-Smart Agricultural Practises on Household Food Security in Smallholder Production Systems: Micro-Level Evidence from Kenya." Four CSA practise components crop management, field management, farm risk reduction, and soil management techniques have been sorted out in this research using PCA analysis. This study discovered that using a larger package that includes all four types of practises has the biggest impact on food security when smallholder farmers embrace CSA. Expectedly, the package's adopters had 25.44% higher household diversity scores (HDDS) and 56.83% higher household food consumption scores (HFCS). This package improves soil nutrient availability for increased productivity while reducing the effects

of climate change. The size of the farm, the value of the productive agricultural assets, and the gender of the head of the household all had a beneficial impact on this adopted package.

According to A. Kishore et al. (2018), "Unfolding Government Policies towards the Development of Climate Smart Agriculture in India," the Indian government allocates 15% of its overall agricultural expenditures to building agricultural resilience to climate variability and change. Under the National Food Security Mission (NFSM), this expense has been covered by conservation agriculture, watershed development, and microirrigation. Rashtriya Krishi Vikas Yojana (RKVY), the National Horticulture Mission (NHM), the National Mission for Sustainable Agriculture (NMSA), crop insurance, neem-coated urea, and weather advisory systems. Furthermore, the Indian government has pledged to devote Rs 838 billion to the advancement of climate-smart agriculture by 2023. Thus, the main purpose of this article is to map the Government of India's agricultural policies and projects that incorporate elements of climate-wise agriculture.

In their paper "Farmer's Own Assessment of Climate Smart Agriculture: Insights from Ma Village in Vietnam," R. Vernooy et al. (2018) detailed how the farmers in that village both men and women were evaluated for the climate-smart methods and practises they had implemented. They largely used firsthand observations to do this. The protection of the environment's health is the only goal mentioned at the collective level. They also presented three outcome indicators that farmers found pleasing, including increased output, better animal health, and cost savings.

The article "Adoption of Dairy Management Practises among the Livestock Owners of Bikaner District of Rajasthan" by P. Godara et al. (2018) discussed the various kinds and degrees of acceptance of livestock management, feeding, breeding, and health-care practises. According to this paper, the majority of owners of dairy cattle (59.17%, 69.16%, 75.83%, and 65.01%) adopted breeding, feeding, management, and health care practises at a medium level. The percentage of sample owners who have adopted general dairy management practises is 71.67%. The adoption indexes for the four main categories of feeding, health care, breeding, and management were found to be 36.00, 32.71, 31.56, and 31.25, respectively, ranking first, second, third, and fourth in this paper. In this study area, dairy management practises were found to have an overall adoption level of 31.99.

S. Diksha et al. (2018) –"Knowledge of farm Women about Improved Animal Husbandry Practices in Saurashtra Region of Gujrat, India". described the knowledge level of farm women about breeding, feeding, management, health care and marketing practices of improved animal husbandry and it was found that majority of the farm women 84%, 75.88%, 70.84%, 75.8% and 81.67% had medium level of knowledge respectively. Knowledge level regarding overall improvement of animal husbandry among farm women was also medium i.e. 65.84%.

In their 2019 paper "Assessing Agricultural Livelihood Vulnerability to Climate Change in Coastal Bangladesh," M.Z. Hoque et al. created an integrated approach and the Agricultural Livelihood Vulnerability Index (ALVI), which made it possible to: (1) map out the hotspots of

vulnerability distribution; (2) identify important factors of spatially heterogeneous vulnerability; and (3) support the planning of adaptation interventions. Using a dependable dataset of 64 indicators that included biophysical, agro-ecological, and socioeconomic variables, a composite index was created to conceptualise vulnerability as a function of exposure, sensitivity, and adaptive capability. Additionally, this study showed that there is geographical variance in the vulnerability of agricultural livelihoods across Bangladesh's coastal districts. The following factors contributed to this vulnerability: land degradation, soil phosphorus, crop production, infant mortality, emergency shelter use, cyclones, droughts, rain-fed agriculture, infant mortality, adoption of agro-technology, and sanitation and housing conditions. They said that by adding several fictitious scenarios to the ALVI Framework for baseline comparison, the integrated method might be helpful for tracking and assessing the success of adaptation interventions.

According to H.S. Kassem et al. (2019), "Climate Change Adaptation in the Delta Nile Region of Egypt: Implications for Agricultural Extension," 51.9% of the farmers at the two target governorates under investigation that is, senior officials from regional governorates and administrators from the ministry of agriculture and land reclamation did not know about the phenomenon of climate change. The most popular adaptation strategies against climate change used by informed respondents were crop rotation, shifting crop patterns, and maximising the use of manure. The findings of a probit model (PM model) research showed that participation in a water user organisation, farm size, diversification of produce, and education level all had an impact on farmers' capacity to adjust to climate change. The study suggested a few extension initiatives to increase public understanding of the predicted consequences of climate change.

In their 2019 study, "Determinants of the Adoption of Climate-Smart Agricultural Practises by Small-Scale Farming Households in King Ceteshwayo District Municipality, South Africa," V.O. Abegunde et al. found that while 17.7% of the sampled farmers are in the high category of CSA users, the majority (56.6%) of the farmers fall into the medium category. The most widely used CSA practises were crop diversity, crop rotation, and the application of organic manure. The study found statistically significant relationships between the level of CSA adoption and the sampled farmers' educational status, farm income, farming experience, size of farmland, contact with agricultural extension, media exposure, agricultural production activity, membership in an agricultural association or group, and perception of the impact of climate change. Aside from these, there was a statistically significant but negative correlation between the CSA level of adoption and off-farm income and farm to house distance.

According to T. Adego et al.'s 2019 paper, "The Impact of Adaptation Practises on Crop Productivity in Northwest Ethiopia: An Endogenous Switching Estimation," the influence of adaptation tactics on crop output in northwest Ethiopia was empirically analysed. They gathered information via key informant interviews, focus groups, and household survey questionnaires. To determine how agricultural yield reacts to climate variability, they also examined time-series climate data. An endogenous switching in crop productivity as a result of adaptation practises is estimated using an empirical model. The model showed that farmers who used adaptation

techniques would have produced less than they would have if they had not, and that farmers who implemented a strategy would have produced more than they would have otherwise. The age of adapters is inversely correlated with them, and for non-adapters, the opposite is true, as this study also demonstrates structural differences.

J.O. Abiola et al. (2019) in their article –Socio-Demographic Structured Constraints of Small Holder Dairy Farmers in Oyo State, Nigeria” tried to establish a relationship between socio-demographic status and constraints of small holder dairy farmers in the study area. From the analysis it was revealed that the major constraint were lack of milking equipment (97.64%), lack of milk preservation (93.82%), high cost of breeder stock (97.64%), and 51.82% of the respondent were not aware of artificial insemination. Except these, inaccessibility to good water was reported by 98.55%; cattle rustling by 93.09% and 70% were not aware of any bio-security measures.

In the article "Climate Smart Agriculture, Productivity and Food Security in India," M. Ghosh (2019) discussed the significance of climate-smart agriculture in the promotion of sustainable agricultural development, guaranteeing food security, and reducing the adverse effects of climate change on agricultural productivity in India. He added that scaling up the CSA practises could significantly contribute to making agriculture more climate-resilient and sustainable, as well as a viable source of income and food security for millions of farmers nationwide. This could be achieved by strengthening agricultural extension services and agricultural finance to achieve smart farming practises by connecting climate finance to traditional agricultural finance. This research also highlighted zero budget natural farming as a climate-resilient agricultural method that can improve food and nutritional security by preserving soil fertility and increasing soil organic matter.

V.K. Gamit et al. (2020) in their paper __Socio-Economic Status and Constraints Confronted by Goat and Goat Farmers in Saurashtra Region“ described about the economic, social and nutritional importance of goat farming in the study area. They had done their work by intensive household survey. They also identified some problems of goat farming i.e. feeding problems, breeding problems, health care problems, marketing problems, lack of knowledge on importance of vaccination deworming and lack of awareness of common disease leads high mortality in flock that is faced by the study area farmers.

1.4 Research Gaps

From a thorough study of literature related to the study some research gaps were identified.

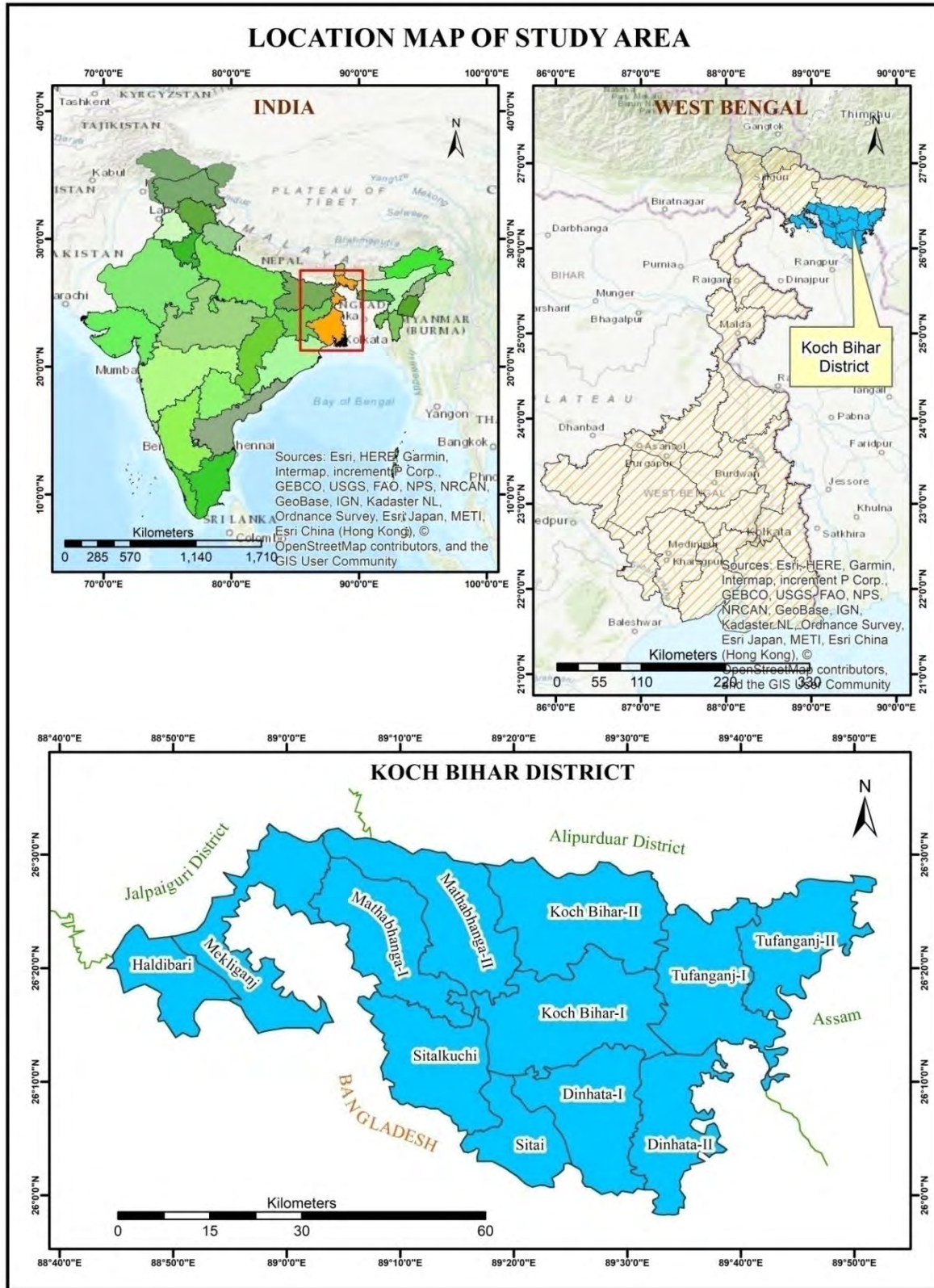
1. Most of the research work related to assessment of agricultural vulnerability due to climatic variability have been done on a global scale at the national or statelevel but no study has been done at a micro level (be it district or Community Development Block level).

2. Many studies have discussed the vulnerability of agriculture, but such studies have not given importance to explore the relationship between adaptive capacities with other components of vulnerability.
3. Vulnerability of agricultural has been analyzed but no studies have been done on how the cultivators would cope-up with the situation by adopting Smart Agricultural Practices.
4. Many research articles have concluded that due to climatic variability, various climate induced adaptation strategies are adopted but in a discontinued manner. There are no works about the factors behind the adoption and discontinuation of climate Smart Agricultural Practices.
5. Some research works have been done on different types of Smart Agricultural Practices but no work related to the problems and future prospects of adopting such practices have been done.

Keeping these research gaps in view, the present study entitled __ Vulnerability of Agriculture and Introduction of Smart Agricultural Practices (Saps): An Assessment in Koch Bihar District, West Bengal.“ has been taken up for study.

1.5 Significance of Study

The economy of the Koch Bihar district is basically agrarian and the agricultural activity practiced by the farmers is becoming vulnerable due to climate variability and climate change. However, some Smart Agricultural Practices (SAPs) are implemented by the Central Government as National Initiative on Climate Resilient Agriculture (NICRA) Project to minimize such challenges in the district but the farmers are facing various problems to adopt and utilize these practices properly. So, the present study is mainly concentrated to assess the spatial variation of agricultural vulnerability; to identify farmers' awareness and the problems regarding adoption of Smart Agricultural Practices (SAPs) at the Community Development Block level of the district. The present study is unique in this regard and the outcome of the present study will surely give some inputs to the planners to implement new programs and project to help the farmer cope up with the vulnerability in agricultural activity in Koch Bihar district.



Map 1.1 Location of the Study Area

1.6 Location of the Study Area

Geographically Koch Bihar district located in the north-eastern part of West Bengal. The latitudinal and longitudinal extensions of the study area are 25°57'57"N to 26°32'58"N and 88°45'28"E to 89°51'50"E respectively. The total geographical area of this district is 338700 ha (3387 sq.km) of which 1146 ha is net sown area and 246491 ha is gross cropped area. There are 4 agricultural sub-divisions which occupies 12 Community Development blocks and 128 Gram Panchayats with 1132 inhabited villages (Census of India, 2011). The northern and eastern part of Koch Bihar district is bounded by Jalpaiguri, Alipurduar district and the Assam state respectively. While the southern, western, south-western parts of the district are bounded by Bangladesh. Koch Bihar district belongs to the Terai-Tista alluvial zone which falls in Eastern Himalayan Agro Climatic Region. The climatic condition of this district is humid to peri-humid with average of 3200 mm annual rainfall and the the average temperature, during summers season remains in between 32°C and 20°C in the month of April to mid of June, while the the average temperature, during winter season remains in between 24°C and 10°C in the end of November and lasting until February (IMD report 2022, Koch Bihar District Unit). Physiographically the district has two zones, active alluvial plain and a recent alluvial plain. Both are formed by Tista River. The soil of the study area falls under Entisol and there are 4 soil series namely Lotafela, Matiarkuthi, Balarampur and Rajpur series (SATSA, Koch Bihar District Unit). The elevation of the study area varies between 30-50 meters above mean sea level. It is essentially a flat region with slight south-eastern slope along which the main rivers namely Tista, Torsa, Kaljani, Gadadhar, Raidhak flow.

1.7 Objectives of the Study

The objectives of the proposed study are as follows:

1. To identify the indicators of vulnerability of agriculture in Koch Bihar district.
2. To assess block wise spatial variation in vulnerability of agricultural within the district.
3. To study block wise Smart Agricultural Practices (SAPs) and its determinants in Koch Bihar district.
4. To study block wise farmers' awareness and adoption level of various Smart Agricultural Practices (SAPs) in the study area.
5. To study the problems faced by the farmers' for adopting Smart Agricultural Practices (SAPs) in the district.
6. To suggest some suggestions for promotion of Smart Agricultural Practices (SAPs) in Koch Bihar district.

1.8 Hypotheses

In order to assess the vulnerability of agricultural and introduction of Smart Agricultural Practices (SAPs) in the study area, the following hypotheses have been considered.

1. There is a block wise spatial variation in vulnerability of agricultural within the district.

2. There is a positive association between Smart Agricultural Practices (SAPs) and its determinants in Koch Bihar district.
3. There is a low level of adoption of various Smart Agricultural Practices (SAPs) in respect of farmers' awareness in the study area.
4. The farmers' are facing various problems related to Smart Agricultural Practices (SAPs) in the district.

1.9 Data Base and Methodology

1.9.1 Data Base: A data base is collection of information that is organized so that it can be easily managed and assessed. The structured schedule for collecting primary data created a helpful data base for the present study. In the present study, the data has been collected from primary and secondary sources.

1.9.1.1 Primary Data: The primary data has been collected by using purposive and random sampling. A schedule has been prepared for the collection of primary data relating to determinants of Smart Agricultural Practices (SAPs), awareness level about Smart Agricultural practices (SAPs), adoption of Smart Agricultural Practices (SAPs), and to get indepth knowledge about the problems and prospects of Smart Agricultural Practices (SAPs). The sample villages are identified during the pilot survey from the 12 CD blocks in which the Smart Agricultural Practices have been run by the Government assistance or by farmer club. During the survey it was observed that paddy tranplanter, thresher, zero tillage practices in maize, mustard cultivation is very significant in the district and has rarely been practiced.

1.9.1.2 Secondary Data: The secondary data has been collected by reviewing various research articles related to the present work. The essential secondary data for monthly maximum temperature, monthly minimum temperature, mean monthly rainfall; net sown area/geographical area, productivity of food grains, average landholding of farmer, population density, organic carbon (C) content of soil; irrigated area, Human Development Index, cropping intensity, livestock density, villages electrified, villages with paved roads have been used for the present research work. The data has been collected from West Bengal District Statistical Hand Book (2015), Koch Bihar Bureau of Economics & Statistics (Government of West Bengal 2017), District Census Handbook (2011), District Gazetteer (2011), District Agricultural Annual Plan 2021, Krishi Vigyan Kendra (KVK) Koch Bihar, Agriculture Development Offices (ADO) of Koch Bihar district, research articles, reports etc.

1.9.2 Sampling Procedure: For the collection of primary data related to this research work, two sampling technique have been adopted namely purposive sampling and random sampling without replacement.

1.9.2.1 Purposive Sampling Technique for Selection of Villages:

Use of paddy transplanter and thresher, zero tillage, Integrated Farming System (IFS) is practiced more or less in all the blocks of the district. Purposive sampling technique has been used to obtain the villages which follow Smart Agricultural Practices (SAPs). During the pilot

survey 36 villages were identified among the 1132 villages of Koch Bihar district on the basis of zero tillage and various types of SAPs i.e. use of paddy transplanter, use of seed drill, drip and sprinkler irrigation, vermicompost, Integrated Farming System (IFS), use of mulching, bio-flock fishing and paddy cum fishing, crop insurance, Soil Health Card (SHC), Krishnan Credit Card (KCC) etc.

1.9.2.2 Random Sampling Technique without Replacement for Selection of Households:

Koch Bihar district has 12 Community Development Blocks and 1132 inhabited villages covering an area of 3387 sq.km. Samples have been taken from the selected 36 villages for the assessment of Smart Agricultural Practices (SAPs). To obtain the primary data at the household level random sampling technique without replacement has been used. For determining the sample size of unknown population, Cochran's formula (1963) was used. $n = \frac{Z^2 P(1-P)}{e^2}$

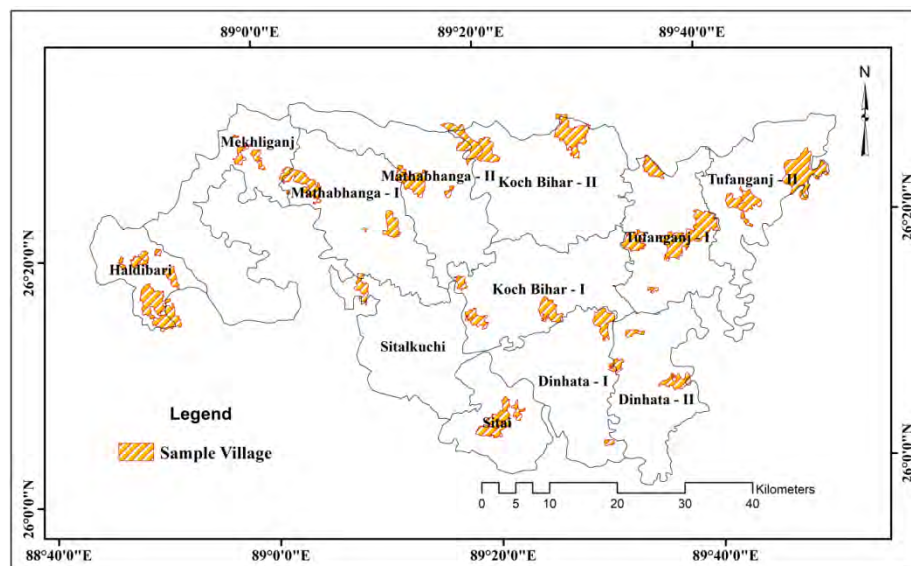
Where: n= number of sample

z = standard normal deviation set at 95% confidence level (e.g. 1.96)

p = percentage picking a choice (e.g. assumed 5%)

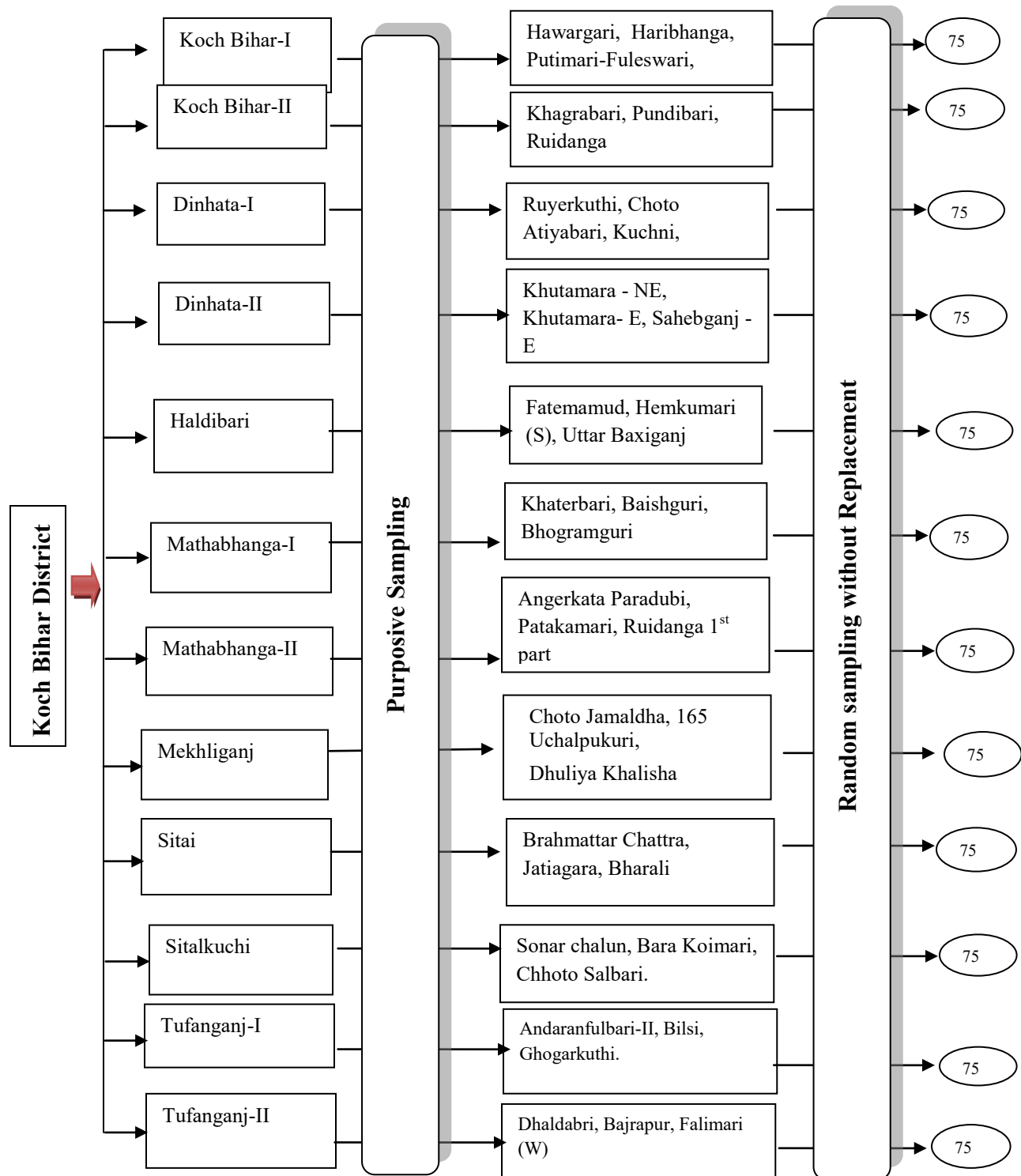
e = Margin of error (e.g. 0.05)

5% (assumed as informed by the Agriculture Development offices) of the total cultivators practicing Smart Agricultural Practices (SAPs) at each block in the district (Reports of Block ADO offices, Koch Bihar, 2019-20). By applying 5% assumed population to the Cochran's formula, it gives the value of 73 as number of samples for each block which has been rounded off to 75. Thus $75 \times 12 = 900$ samples have been taken from the 36 villages. The number of samples at village level has been selected on the basis of how many villages having followed Smart Agricultural Practices (SAPs) in each block.



Map 1.2 Location of the Sample Villages in Koch Bihar District

Sampling procedure for the selection of respondent farmer



Source: Office of the Agriculture Directorate, ATMA Cell 2019-20, and compiled by Researcher.

Figure 1.1 List of Block Wise Sampled Mouza following SAPs in Koch Bihar District, 2019-2020

1.9.3 Construction of Schedule

For assessing the determinants, awareness, adoption level, problems and prospects about Smart Agricultural Practices (SAPs), a structured schedule has been prepared and the data also collected by conducting personal interview with the cultivators.

1.9.4 Methodology: The methodology is the logical validity of the research work. The following research methodologies were adopted for executing the present study.

1.9.4.1 Method of Data Analysis for the Agricultural Vulnerability Assessment:

First the identification of the indicators of agricultural vulnerability and its respective value was done, then the indicator values were normalized according to their respective relationship with vulnerability. The vulnerability indicators have been assigned according to the weights of indicators after standardization of data and ranked by Pair-Wise Comparison Matrix and Analytic Hierarchy Process (AHP). Finally, overall vulnerability index was calculated by assigning a weight value to the major vulnerability indicators i.e. exposure, sensitivity and adaptive capacity in different CD blocks of Koch Bihar district. The identification agricultural vulnerability indicators and its spatial variation in the study area has been assessed by using the following steps.

Step-1

1.9.4.1.1 Calculation of Agricultural Vulnerability Indicators Value: For calculation of the different indicator values the following methods are used

1.9.4.1.1.1 Correlation and Regression: For calculation of changes of maximum and minimum temperature in kharif and rabi season correlation and regression are used.

1.9.4.1.1.2 Standardized Precipitation Index SPI (Z test): The number of standard deviations (SD) from the population mean is called the Z score. The number of SD above or below the population mean is measured. It can be shown on a normal distribution curve and is also referred to as the standard score. The values of Z scores span -3SD to +3SD. The population means exactly match the value of the Z score, which is zero.

$$SPI(Z) = \frac{X - \bar{X}}{\delta}$$

Where, SPI (Z) = Standardized Precipitation Index, X (sample mean) = Rainfall of a particular month of a particular year, \bar{X} (Population mean) = Average rainfall of that particular period (1951 to 2021), δ (Standard deviation) = Standard Deviation of rainfall of the given period.

1.9.4.1.1.3 Population Density: The population density will be calculate using by following formula

$$\text{Population Density} = \frac{\text{Total population}}{\text{Area in sq.km}}$$

1.9.4.1.1.4 Cropping Intensity: The cropping intensity of different blocks of Koch Bihar district is calculated using following formula

$$\text{Crop Intensity} = \frac{\text{Gross cropped area}}{\text{Net sown area}} \times 100$$

1.9.4.1.1.5 Livestock density: Livestock include cow, goat, buffalo, and sheep. Livestock density of different block of Koch Bihar district is calculated using following formula

$$\text{Livestock Density} = \frac{\text{Total number of livestock}}{\text{Area in sq km}}$$

Step-2

1.9.4.1.2 Determination of Vulnerability Coefficient Value: There are two methods to calculate the vulnerability co-efficient value. In case of Positive relationship with vulnerability the highest value assigned is 1 and the other values are divided by the highest value. In case of Negative relationship with vulnerability the lowest value assigned is 1 and the lowest indicator value is divided by the other indicator values.

Step-3

1.9.4.1.3 Determination of Weight Value for Different Indicators

Analytic Hierarchy Process (AHP) and pair-wise comparison matrix have been used for the determination of weight value of vulnerability indicators.

Step-4

1.9.4.1.4 Determination of Overall Vulnerability Index: Finally overall vulnerability index has been calculated by considering the major vulnerability indicators (i.e. exposure, sensitivity and adaptive capacity) of different blocks of Koch Bihar district. The following formula has been applied for determination of overall vulnerability index-

$$\text{Overall Vulnerability index} = (E+S-A)$$

Where, E = Exposure, S = Sensitivity, A = Adaptive capacity.

1.9.4.2 Method of Data Analysis of the Assessment of Smart Agricultural Practices (SAPs):

The present study is carried out in Koch Bihar district of Tariai Testa Agro-Climatic Region. Three villages from each block of Koch Bihar district were purposively selected where there was concentration of pilot project of various smart agricultural practices especially zero tillage. Thus, from 12 CD blocks a total of 36 villages were selected. From each selected village 25 respondents were selected randomly. Thus, total 900 respondents were randomly selected for this study. The assessment of Smart Agricultural Practice (SAPs) was conducted through detailed evaluation of various determinants, awareness level, adoption level, problems and prospects. For the assessment of Smart Agricultural Practices (SAPs) in order to draw meaningful inferences statistical tools such as frequency, percentage, Binary Logistic Regression, Total Weighted Score (TWS), Awareness Index, Adoption Index, Kendall's ω -efficient of concordance, were used.

1.9.4.2.1 Determination of Indicators of Smart Agricultural Practices (SAPs)

1.9.4.2.1.1 Binary Logistic Regression Model: The Logistic Regression Analysis LRA is a useful tool for investigating the implied relationship between a response variable (dependent=Y) and one or more explanatory factors (Independent=X). For the assessment of various determinants of Smart Agricultural practices (SAPs), Binary Logistic Regression test has been used to study block wise Smart Agricultural Practices (SAPs) and its determinants in Koch Bihar district. The independent variables such as age, education, landholding, cropping system, farming system, irrigation facilities, farm power, mass media exposure, extension contact, Economic motivation were taken under consideration and different types of Smart Agricultural Practices were selected as dependent variables. The following formula has been applied for the Logistic Regression model (Peng et al., 2002; James et al., 2013)

$$\ln\left(\frac{\pi}{1-\pi}\right) = \alpha + \beta x$$

The details of measurement of independent and dependent variables selected for the present study are given below

1.9.4.2.1.2 Independent Variables

I. Age

According to the National Institute on Aging's guidance it reflects to the respondent's chronological age at the time of the interview. The respondent was subjected to direct questioning. The respondents were categorized into three age groups such as young upto 35 years, middle 35 to 50 years and old more than 55 years.

II. Gender

The socially constructed traits of men, women, girls, and boys are referred to as gender. In this study gender is divided into two categories i.e. male and female.

III. Family type

Family refers the collection of individuals who are kinship-related to one another. In more detail, kinship is a group of socially accepted links that people have to one another as a result of their relationship through marriage or birth (Firth et al., 1970/2006, p. 3). There are two categories of family type that has been considered for the study i.e. single and joint.

IV. Religion

According to Yinger (1995), religion is "a system of beliefs and practices through which a community of people engages in conflict over the fundamental issues of human existence." So, religion is an organized and integrated system of values, practices, and standards that are based on fundamental societal needs and principles. In this study religion is categorized into three categories i.e. Hindu, Muslim and others.

V. Caste

A caste is a set social group that a person is born into as part of a certain social stratification system. In this study caste is categorized into four category i.e General, Scheduled caste (SC), Scheduled tribe (ST), Other Backward Class-A (OBC-A), and Other Backward Class-B (OBC-B).

VI Education

The level of formal education the respondents had at the time of the interview is used to describe the respondents' educational status in the current study. Illiterate, primary, middle, metric, higher secondary, graduation, and post graduation were the categories used.

VII. Land Holding

Land holding refers to the cultivated land that belongs to the particular respondent. In the present study farmers were categorized into five class i.e marginal landholding farmers (< 1 hectare), small landholding farmers (1 to 2 hectare) and semi medium landholding farmers (2 to 4 hectare) medium landholding farmers (4 to 10 hecare) large landholding farmers (> 10 hectare). (Ministry of Agriculture & Farmers Welfare, Government of India, 2019).

VIII Land Type

According to water availability in all seasons from local surface water level (river, reserver, chara, bill etc) land are categorized into three type i.e low land, middle land and high land.

IX. Extension Contact

Farmers' knowledge, comprehension, and attitudes are often shown to be influenced by the frequency of their interactions with extension workers. Three type of extension conact have been used in this study i.e Krishi Prajukti Sahayak (KPS), Agricultural Technologies Management Agency (ATMA), Agricultural Development Officer (ADO).

X. Mass Media Exposure

It refers to the frequency of use of various mass media by the respondent, including radio, television (TV), mobile phone, internet, newspapers and farm publications. The study's scoring method focused on the respondents' reading habits with regard to the newspapers and farm publications they had access to, as well as listening to radio, television (TV) and youtube voewing behaviors.

XI. Income Source

Incomes refer to the source from where the respondent mainly earns money for their livelihood, whether they earn only from cultivation, or only livestock farming or both. These three categories have been used for the assessment of income source of the respondent.

XII. Income Amount

It refers to the respondent's income less than Rs. 10000 per month, Rs. 10000 to Rs. 15000 per month, Rs. 15000 to 20000 per month and more than Rs. 20000 per month these four categories (M. Rathore.2021) have been used for the assessment of the income of the respondent.

1.9.4.2.1.3 Dependent Variables

A. Soil Test and Soil Health Card (SHC)

A soil test involves measuring the amount of the elements that are available in the sample such as phosphorus, potassium, calcium, magnesium, sodium, sulphur, manganese, copper, zinc and also record them. A Soil Health Card is used to evaluate the state of the soil's health at present and over time in order to identify changes brought on by changes in land use.

B. Use of HYV Seed and Seed Treatment

The idea of seed treatment is using biological or chemical treatments to suppress or control primary insect and disease infestations that are transmitted through soil and seeds and have an impact on crop productivity and agricultural production.

C. Zero Tillage

Zero tillage refers to the method of sowing crop seed with drillers without first preparing the soil or disturbing any existing crop stubbles. Zero tillage not only reduces the cultivation costs but also reduces soil erosion, irrigation needs, weed impact and GHG emission from stubble burning.

D. Mulching

Mulching refers to the application of a covering (such as straw or sawdust plastic) to the ground in order to shield plant roots from heat, cold, or evaporation, prevent soil erosion, suppress weeds or enrich the soil.

E. Sustainable Irrigation

Sustainable irrigation refers to the responsible use of all irrigation-related activities in agriculture in a way that helps meet immediate demands of water for crop by applying less water and generate more profit. The most effective sustainable irrigation methods are drip irrigation, sprinkler irrigation and solar irrigation.

F. e-marketing

E-marketing of agricultural products is a computerised online trading platform for buying and selling of agricultural products by the farmer. It eliminates reliance on vendor, broker for pricing and save time as well as effort in payment received. It can also reduce the impact of time on quality and pricing in order to improve system accessibility. The most important paddy selling e-marketing platform in West Bengal is e-paddy procurement through <https://procurement.wbfood.in/>

G. Intercropping and Crop Rotation

Intercropping is the simultaneous growth of two or more crops with various nutritional needs on the same land in the same season. On the other hand crop rotation refers to a "system of growing different kinds of crops in recurrent succession on the same land in different season or different year.

H. Integrated Farming System (IFS)

This is a sustainable agricultural system that incorporates mutually beneficial production of food crops, cash crops, plantation crops, fish, poultry, livestock, and agro-forest product.

I. Poly House Vegetable and Rain Water Harvesting

Polyhouse farming is the process of growing crops in a controlled environment where the temperature, humidity and fertilisers are all managed by sophisticated machinery. Rainwater harvesting (RWH) is the practise of collecting and storing rainwater instead of allowing it to flow off. Majority of lowland, ponds offers the necessary platform for water collection and use it for irrigation in dry season.

J. Use of Vermicompost

Earthworms are employed in the vermicomposting process to break down organic waste into vermicompost, a humus-like substance. Vermicompost generally has a greater nutrient profile than conventional compost.

K. Plant Protection Measure

Plant protection is the scientific and technical process of controlling pests, diseases, and weeds that harm crops and other plants and can drastically affect farmers' ability to make a living. e.g- Integrated Pest Management (IPM) , Integrated Nutrient Management (INM), Integrated Weed Management (IWM) etc

L. Crop Insurance

Crop insurance protects the farmers from the financial loss of unforeseen risks beyond their control that could result in crop failures. e.g. Pradhan Mantri Fasal Bima Yojana (PMFY),/ PM Krishan Bangla Sashya Bima Yojana (BSB)/ Krishak Bnadhu.

M. Information and Communication Technology (ICTs)

The networks, mobiles, devices, services and applications that facilitate the processing, management and sharing of data, information or knowledge with a particular target group are referred to as Information and Communication Technologies (ICTs) in agriculture. It helps people to share knowledge about agriculture, which helps to increase production and yields.

N. Farm Power Machinery

Farm machinery refers to the mechanical devices which include tractors, harvesters, rotavetors, land leveler, transplanter, thresure etc which are used in farming to save labour.

O. Use of Climate Resilient Crop Variety

Climate-resilient crops are grown with environmental hazards such drought, heat, flooding, salinity and shorter growing seasons, as well as pests linked to changing weather or climatic patterns. Flood resilient paddy variety jalkouri, drought resilience crop e.g. maize, early-maturing crops like mustard 250, are adopted as climate resilient crop variety in the study area.

P. Smart Practices in Animal Husbandry

The daily tasks related to animal husbandry namely feeding, milking, controlling the environment, and reproductive performance when managed by advanced technology is referred as smart practices in animal husbandry. These include feeding hydroponic maize and grass and Artificial insemination for breeding.

1.9.4.2.2 Awareness and Adoption Level

Awareness Index:

Awareness is defined as the perceived knowledge that respondents have concerning practical information about Smart Agricultural Practises (SAP). The responses of farmers were obtained on three-point continuum scale as “not aware” “partially aware” and “fully aware” against each statement and weightage were given as 0, 1, and 2 respectively. Total weighted score was calculated for each statement on the basis of assigned weight. Finally Awareness Index was calculated on the basis of total weighted score of awareness by the following formula

$$\text{Awareness index} = \frac{\text{Obtained Awareness score}}{\text{Maximum Obtainable Awareness score}} \times 100$$

Adoption Index: Adoption is degree of actual use of Smart Agricultural Practices. The responses of farmers was obtained on three-point continuum scale as “not adopt” “partially adopt” and “fully adopt” against each statement and weightage were given as 0, 1, and 2 respectively. Total weighted score was calculated for each statement on the basis of assigned weight. Finally Adoption Index was calculated on the basis of total weighted score of the adoption by the following formula.

$$\text{Adoption index} = \frac{\text{Obtained Adoption score}}{\text{Maximum Obtainable Adoption score}} \times 100$$

A comparison line graph was constructed by the index value of both the awareness and adoption of various Smart Agricultural Practices for represent the awareness and adoption level of Smart Agricultural Practices (SAPs) in different CD blocks of Koch Bihar district

1.9.4.2.3 Kendall's Co-efficient of Concordance (Kendall's W)

The Kendall's Concordance Analysis was performed to determine whether the prioritised problems of different Smart Agriculture Practises were compatible with one another (SAPs). It determines the degree of agreement and disagreement among the responses. The Kendall's Coefficient of Concordance (W) measures how the number of rankers (m) ranks the number of

things or factors (n) agreed with each other. The ratio of the observed variance of the sum of rankings to the maximum variance of the sum of ranks is measured by the W index. The variation in amounts will be at its maximum if the ranks agree exactly (Mattson 1986 and Martey et al 2014). The constraint with the lowest total rank score for each is regarded as the most important, while the one with the highest total rank score is ranked as the least important. The Coefficient of Concordance (W), which gauges how well the ranks agree, is calculated using the total rank score (Edwards 1964, Martey et al. 2014). The coefficient of concordance W formula is then provided as following:

$$W = \frac{12s}{m2n(n2 - 1)}$$

Where;

W= Kendall_s Co-efficient of Concordance

s = Sum of squares of deviations of data points from their sample mean.

m = Number of rankers (farmers) and

n = Number of factors being ranked

W value ranges from 0 to 1. If W is 1, all the respondents have fully agreed, and each respondent has decided the same order to list of concerns. If W is 0, then there is no agreement among the respondents. The values of 0.00 to <0.02 indicate a slight agreement, 0.02 to <0.04 fair agreement, 0.40 to <0.60 moderate agreement, 0.60 to < 0.80 substantial agreement, 0.80 to <1 almost perfect agreement and 1 indicate perfect agreement as suggested by Landis and Koch in 1977.

1.10 Limitation of the Study

This study was conducted to evaluate the agricultural vulnerability and issues about Smart Agricultural Practices in the Koch Bihar district. Such study cannot possibly account for every facet such as, crop productivity, farmer's revenue, and farmer's livelihood. The household survey is a challenging process, and it is not always possible to obtain accurate data, particularly about income, land holding size, property and other factors that are closely related to economic aspect. Beside the farmers' unwillingness to devote the necessary time to the interview during data collection was another issue.

1.11 Conclusion

This chapter deals with the objectives, hypothesis, methodology, location of the study area, the choice and selection of sample size and sample design, and some limitation of the study. Additionally, a brief summary of literature that is either directly or indirectly linked to the study has also been provided in this chapter.

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