Abstract

The agricultural system is crucial for food, nutrition and livelihood security in India and this sector of India occupies almost 43 per cent of India′s total geographical area (Arjun, 2013). The economy of Koch Bihar district is also based on agriculture as the cultivators and agricultural labourers constitute the main work force of this district, they share 32.3% and 34.7% of the total workers respectively (District Census Handbook, Koch Bihar, 2011). The area under marginal holdings with size of less than 1 hectare increased from 1, 28,277 hectares (46.69 per cent of total area) in 2000-01 to 1,32,758 hectares (48.46 per cent of total area) in 2005-06. Reciprocating this, area under medium-sized holdings (having average size of 4 hectares to less than 10 hectares) decreased drastically from 8,805 hectares to 2,094 hectares from 2000-01 to 2005-06. (District Statistical Hand Book, Koch Bihar, 2010-11). Inadequate marketing channels and infrastructure, long intermediation, lack of accurate and timely market information system etc. are also the major challenges to the agricultural marketing system in the district (Bhowmik, 2012). The agricultural activity primarily depends on weather and climatic condition and any variation of its pattern create the vulnerability in 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 for different regions is important as the resources are limited and they also should plan various Smart Agricultural Practices (SAPs) based on vulnerability assessment, because the vulnerability of agriculture is possible to minimize by the adaptive capacity (Sehgal et al. 2013).

So, 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, reduce the input cost, increase the net profit, and generate 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. ‘ Consider six objectives such as (I) To identify the indicators of vulnerability of agriculture in Koch Bihar district. (II) To assess block wise spatial variation in vulnerability of agricultural within the district. (III) To study block wise Smart Agricultural practices (SAPs) and its determinants in Koch Bihar district. (IV) To study block wise farmers' awareness & adoption level of various Smart Agricultural practices (SAPs) in the study area. (V) To study the problems faced by the farmers_for adopting Smart Agricultural practices (SAPs) in the district. (VI) To suggest some suggestions for promotion of Smart Agricultural Practices (SAPs) in Koch Bihar district.

The present study is based on both primary and secondary 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 in depth 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.

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. 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.

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. 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 75×12 = 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.

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.

There are seven chapters in the thesis. The first chapter covers the significance, objective, hypotheses, sampling structure, data sources and methodology of the current study. The physical and socio-economic background of the study area is covered in the second chapter. In this

chapter the agro-climatic location, geology, relief, drainage features, soils, and natural vegetation; climatic factors like rainfall and temperature, different extreme events; land holdings, population density, and KCC holder farmer, status of road connectivity at the block level also described. The third chapter deals with the various indicators and spatial variation of agricultural vulnerability in the study area. The fourth chapter depicted the socio-economic status and different types smart agricultural practices in the study area and also identify the different indicators that determine the adoption of smart agricultural practices (SAPs). The fifth chapter discusses the awareness and adoption level of various smart agricultural practices in different block of the study area. The chapter six addresses the main issues relating to the adoption of smart agricultural practices that makes remedial actions to resolve the issues and implement some new policy for the promotion of such smart technique in the study area in future. The chapter seven described the main findings of the research work as well as some suggestion strategies for the policy maker to development of this sector that will be important to the farming community of Koch Bihar district.

Koch Bihar district belong to Terai-Tista Alluvial Zone which is fall in Eastern Himalayan Agro climatic region. The climatic condition of this district is humid to peri-humid with average 250–300 mm annual rainfall and the summer and winter temperature is in an around 33°C as the highest in the month of May, while the lowest temperature is 7°C in the month of January(SATSA, Koch Bihar District Unit). Physiographically there are two parts in this district, one is active alluvial plain another is recent alluvial plain and both are formed by Tista river. In orderly the soil of this study area is fall under Entisol and there are 4 soil series are found i.e. Lotafela, Matiarkuthi, Balarampur and Rajpur seriers (SATSA, Koch Bihar District Unit). The elevation of the study area varying between 30-50 meters above mean sea level is essentially a flat region with slight South-Eastern slope along which the main rivers (Tista, Torsa, Kaljani, Gadadhar, Raidhak, etc.) flow. Geographically this district located in the north-Easter 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. 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 blocks and 128 Gram Panchayats with 1132 inhabited villages (Census of India, 2011). Politically 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.

Agricultural vulnerability defined as the latent probability of loss and damage of an agricultural system associated with climatic variability and the occurrence of an extreme climatic event, and the susceptibility of any individual or social group to its impacts. So, the vulnerability of agriculture is function of climatic exposure, sensitivity and adaptive capacity within the system and also the degree to which the agricultural system is susceptible to, or unable to cope with the adverse effects of climatic variability. The term exposure describes how much and how

a system is exposed to major climatic variability. Sensitivity is the measure of how much a system is changed or impacted by internal, external, or occasionally both types of disruptions. Adaptive capacity is also defined as the potential or ability of a system, region or community to adjust to the effects or impacts of climate change.

In case of exposure the blocks of Haldibari, Mekhliganj, Mathabhanga-I, Mathabhanga-II, Koch Bihar –I, Koch Bihar-II, Sitalkuchi and parts of Sitai, Dinhata-I, Tufanganj-I shows high to very high composite exposure ranging from 0.524 to 0.868. The higher rate of minimum temperature in kharif and rabi seasons and higher intensity of low and high rainfall in kharif season has resulted in extreme exposure in these blocks. Moderate to low exposure are found in south eastern and eastern parts of the district comprising of Tufanganj-II and Dinhata-II blocks with value ranging from 0.008 to 0.523. The reasons for low exposure in the above mentioned blocks are due to lower rate of change in maximum and minimum temperatures in kharif and rabi seasons and very low to moderate rainfall variability.

In case of sensitivity the central and western parts of the district namely Mathabhanga-I (0.776), Mathabhanga-II (0.755), Sitalkuchi (0.727), Koch Bihar-I (0.755) are very highly sensitive owing to highest percentage of marginal and small farmer, high population density, low organic carbon content. The remeaning blocks Tufanganj-I(0.674), Tufanganj-II(0.667), Dinhata-I(0.687), Dinhata-II(0.689), Koch Bihar –II(0.645), Mekhliganj(0.617), Haldibari (0.406) and Sitai (0.472) have moderate to low sensitivity owing to average net sown area, productivity and low population density. The adaptive capacity in Koch Bihar-II, Dinhata-I, Dihata-II, Tufanganj-I, Haldibari blocks of the district is very low because of lower percentage of irrigated area and cropping intensity.

The adaptive capacity is low in the blocks of Koch Bihar –I and Mathabhanga-II. There is moderate adapative capacity in Sitalkuchi and Tufanganj-II blocks. However Halibari, Mekhliganj, Sitai and Mathabhanga-I blocks shows in higher adaptive capacity comparatively, because More Female work participation in agricultural activity, more Irrigated area, more livestock density and frequently contact with extension services by the farmer.

So the overall agricultural vulnerability (Normalized) very high in the blocks of Tufanganj-II (0.826), Tufanganj-I (0.833), Koch Bihar- II (0.838), Koch Bihar- I (1.00) due to high exposure and sensitivity and lower adaptive capacity. Agricultural vulnerability is high in the blocks of Dinhata-I (0.702) and Dinhata-II (0.743). Moderate agricultural vulnerability is found in Mekhliganj (0.292) and Sitalkuchi (0.458) block. The agricultural vulnerability is low in Sitai (0.00), Haldibari (0.0) and Mathabhanga –I (0.211). Even through these blocks have high exposure and sensitivity they have higher adaptive capacity.

Smart Agriculture Practices (SAPs) are those practices, which increase farmers′ income and agricultural productivity in a sustainable way that build resilience and capacity of agricultural systems to adapt or mitigate the adverse effects of the climatic variability, and also

reduce the greenhouse gases while enhancing national food security. So, Smart Agriculture Practices (SAPs) are the alternative for food and livelihood to cope up with the agricultural vulnerability and helpful in mitigation the adverse effects of climate change and variability.

It is clear from the above study that the adoption of Smart Agricultural Practices are strongly determined by the education, land type, land holding mass media exposure and extension contact that was obviously significant in all blocks of Koch Bihar district. Age group of more than 50 years, female gender, and neuclear family type are slightly negativily associated with Smart Agricultural Practices (SAPs) adoption, but there was no significant association because the regression models were insignificant in those cases.

Findings clearly revealed the most aware as well as adopted SAPs are use of HYV seed, crop rotation and intercropping, Integrated Farming System (IFS), plant protection measure. On the other hand the least aware and adopted SAPs are soil test and use of Soil Health Card, mulching, zero tillage, Information and Communication technologies (ICTs), e-marketing, polyhouse vegetable and rainwater harvesting, crop insurance, smart animal husbandry. From the overall analysis it can be concluded that the awareness level of each smart agricultural practice is higher than the adoption of that respective practice in every block of this district.

From the overall analysis it has been observed that though there are some prospects of Smart Agricultural Practices as it helps to build the agricultural system more resilient to climate change to reduce the production cost and increased yield and give better economic returns to the farmers. But the farmer of the district faces a number of problems in adoption of Smart Agricultural practices (SAPs). The most prominent problem is small and fragmented landholding for adopting integrated farming System (IFS) and different farm power machinery because most of the farmers are marginal and small farmer. The other issues such as scarcity of storage, agro processing unit and cooperative organization at local level, Lack of farm equipments and Inadequate farm inputs, lack of getting proper information and knowledge are also the barrier to adopt smart agricultural practices in the study area.

The economy of the Koch Bihar district is basically agrarian type and the agricultural activity being practiced by the farmers is become vulnerable. However, some Smart Agricultural Practices (SAPs) are implemented by the central Government as National Initiative on Climate Resilient Agriculture (NICRA) project to minimize this challenged in this district but the farmers are facing various problems to adopt and utilize these practices properly. So, the present study is mainly concentrated to identify the indicators of agricultural vulnerability, to assess the variation in vulnerability of agricultural and also to identify farmers` awareness and the problems regarding adoption of Smart Agricultural Practices (SAPs) facing by the farmers in every blocks of this district. The present study is unique in this regard and the outcome of the present study surely give some inputs to the planners to implement new programs and project to cope up from the vulnerability in agricultural activity in Koch Bihar district.