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RESEARCH ARTICLE

Farmer's Perception on Climatic Factors and Social-economic Characteristics in the Agricultural Sector of Gujarat

Ajay K. Singh[1*] **Shah Nawaz Ashraf**[2] **Sandeep Kumar Sharma**[1]

1. School of Liberal Arts and Management, DIT University, Dehradun, Uttarakhand, 248009, India
2. Entrepreneur Academy, Mohammed VI Polytechnic University, Ben Guerir, 43150, Morocco

Abstract: This study investigated the implication of various factors, including climatic conditions, social-economic variables, agricultural inputs, technological development, institutional support, and adaptation strategies in the agricultural sector of Gujarat. A confirmatory factor analysis (CFA) was used to analyse the farm-level data from 240 randomly selected farmers across eight districts. The study found that farm income per hectare is influenced by climate adaptation strategies, appropriate technology, annual income, education level, family size, fertilizer application, farm income from cash crops, financial support from the government, and access to credit. The study recommends the use of appropriate technology and adaptation strategies to mitigate the negative impact of climate change, as well as increase farmers' access to credit, diversify crops, and encourage technological development in the agricultural sector. In addition, agricultural extension and development agencies should train farmers regularly to improve their understanding of climate adaptation practices and other inputs.

Keywords: Agricultural sector; Appropriate technology; Climate change; Farm income; Adaptation strategies

1. Introduction

Climatic factors, geographical location and ecosystem services have a significant contribution to increasing the farmer's choice to cultivate a particular crop [1-7]. For instance, wheat, mustard and gram crops need minimum temperature during sowing time, and high temperature during harvesting time. Sugarcane crop needs different climatic conditions at various stages of production [8]. Rice crop needs high temperature and an abundance of water during sowing time; moderate temperature and high rainfall during plant growth; and high temperature, minimal

*Corresponding Author:
Ajay K. Singh,
School of Liberal Arts and Management, DIT University, Dehradun, Uttarakhand, 248009, India;
Email: a.k.seeku@gmail.com; kumar.ajay_3@yahoo.com

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precipitation and no rainfall during harvesting time [9]. The growth and production of other crops like groundnut, sesame, soybean, cotton, sorghum, millet, etc. also depend on different climatic conditions [9]. Agricultural production activities, therefore, primarily depend on climatic factors [8,9]. Whereas, high variability in climatic factors in various seasons may reduce the productivity of crops [2,3,9-12]. Extreme climatic events such as drought, floods, cyclones and heat waves may also produce a negative impact on the agricultural production system [13,14]. Findings of previous literature have concluded that climatic factors are fluctuating due to the rising quantity of GHGs emissions in the atmosphere [3,9,15]. Moreover, ecosystem services such as water and land resources are useful inputs for agricultural production activities. While, the quantity of ecosystem services is declining due to rising population, urbanization, industrialization, infrastructural development, production activities of industries and agriculture and climate change [1,3,14]. Also, the excessive use of pesticides and fertilizer in the agricultural sector also reduces soil fertility, quality of water and air [9,16].

It is stated earlier that agricultural production and its allied activities are adversely affected due to climate change and ecosystem services. Therefore, the sector needs technological advancement, appropriate technology, climate adaptation strategy (CAS) and institutional support to reduce the vulnerability of crops due to climate change [3,5,6,12,17,18]. Technological advancement and appropriate technology will bring significant changes in this sector to cope with climate change [1,5,6,9]. Adaptation strategy is a practice or action which reduces or mitigates the negative consequences of any event in a production process. It can be divided into two categories i.e., autonomous and planned adaptation. Autonomous adaptation is an involuntary and regular incidence that creates a capacity to adjust to climate change impact in a system without taking any action. Planned adaptations strategy is associated with farmers' practices in a system to reduce the negative impacts of human and natural activities in it [19]. Mitigation means all human interventions which abate greenhouse gas emissions from various sources [6,9]. Institutional support also helps to increase the farmer's understanding to apply different practices to reduce the uncertainty of climate change impacts on crop production [20]. Public policies, adaptation practices and climate action policies support to reduction the negative consequences of climate change in the agricultural sector [4,5,14,19,21].

India is a developing and highly agricultural-intensive country. Thus, the agricultural sector has a greater contribution to sustaining the social-economic development of a farming community in India. As India is located at low latitudes, therefore, its agricultural sector is highly vulnerable due to climate change [9,14,15,22,23]. In India, numerous studies have examined the climate change impact on agricultural production, food-grain yield and commercial crops, agricultural productivity and agricultural GDP at district, state and national levels [1,2,8-10,16,24-33]. Previous findings reported that yield, production and cropped area of cash crops decline due to climate change in India. Accordingly, climate change produces a negative impact on sustainable food security (SFS), livelihood security, the income of farmers, rural development and environmental factors and sustainable agricultural development (SAD) in India [12,34,35]. SFS is a state in which the agricultural sector meets the food security of all people to ensure their physical and mental health, and provide fodder to all livestock as sustaining the quality and quantity of ecosystem services [35]. At present India's population is around 1.37 billion and its population is projected to be 1.53 billion by the year 2030 [9]. Hence, India would be required to produce 70% more food grains to meet the food security of future generations [36]. Moreover, high population growth, industrialization, urbanization and labour migration would increase the extensive burden on natural and capital resources, and the agricultural sector in India [9]. Most developing countries including India would be unable to maintain irrigation systems and ecosystem services which further hamper sustainable agricultural development [37,38].

India, therefore, needs to protect ecosystem services by using technological advancement, appropriate technology and CAS in the agriculture sector [5,6,10,16]. The use of new technologies, scientific techniques, climate resilient technologies and appropriate technology will reduce the negative impact of climate change [3,5,39-41]. CAS would be useful to reduce the risk, and increase the economic capacity of farmers to manage the climate change impact on the agricultural sector. Education level, access to information, electricity for irrigation, agricultural subsidies, water and land management practices, farm income, training, social capital, agroforestry, bio-diversification, and communication are also detected as the most CAS influencing factors [5,12,18]. Changes in planting time, water and nutrient management practices, fertilizer, irrigation management and technology also would work as a CAS [9,13]. Water conservation and management, heat tolerance crops, high yielding of seed, change in cropping pattern, mixed cropping pattern, crop diversification, tree planting, late sowing of seed and application of green fertilizer can be used as CAS [3,16,19,25]. Crop rotation, drip irrigation, local farming techniques, green technologies and green fertilizer are the various practices of CAS [42].

In addition to the above, agricultural technologies would be positive to increase crop productivity and reduce the negative consequences of socio-economic activities on natural resources; decreases the use of water, fertilizer and pesticides in farming; reduce chemicals in the rivers and groundwater [3,5,6,41,43]. It can be used for ploughing, planting seeds in soil, watering, irrigation, and fertilizer and others [6,44]. Subsequently, technological development and agricultural technologies have a positive and significant impact on the growth of the agricultural sector in India [5,6,44,45]. Applications of traditional technologies have also provided numerous benefits in agricultural activities in India [46-50]. Furthermore, appropriate technology will bring several alternatives to increase the sustainability of ecosystem services as its practices in production activities will abate the GHGs emission in the atmosphere [5,6]. Appropriate technology may be conducive to maintaining economic, social and environmental conditions of available resources [6,51]. The use of appropriate technology in the agricultural sector is helpful to increase the productivity, efficiency and profitability of farmers [5,6,39]. Appropriate technology is a new technology or idea or knowledge or knowledge-know-how which reduces the negative impact of social and economic development on the environment [5,6]. Most specifically, appropriate technology and technological development will improve land pattern and management, recovery of surplus land, maintain the cropping pattern in various crop seasons, a technique of farming, marketing facilities, seed germination and seed viability, soil quality and fertility, and land productivity in the agricultural sector [5,6,39,52-54].

Agricultural production activities depend upon different types of indicators such as climatic factors, ecosystem services, technological advancement, appropriate technology, Agri industries, irrigated area, physical assets, farm management practices, government policies, credit accessibility, geographical location, institutional support and others. Therefore, it is indispensable to assess the most valuable factors which enhance the growth of the agricultural sector. Hence, there is a requirement to apply a confirmatory factor analysis (CFA) to examine the contribution of the above-mentioned indicators to mitigate the adverse impact of climate change in the agricultural sector. Moreover, few studies could observe the significance of mentioned variables in farming activities using CFA. Hence, it is essential to examine the role of highlighted indicators to mitigate the negative impact of climate change in the agricultural sector. Accordingly, this study achieved the answer to the following research questions:

- What is the significance of climatic and non-climatic factors, & climate adaptation strategies (CAS) in the agricultural sector?
- How social-economic factors, agricultural inputs, technological advancement, and institutional supports related activities can be used as CAS in the agricultural sector?

This present study realized the following objective:

- To examine the latent variables in five different categories of variables (i.e., climate change, social-economic, agricultural input, technological change and appropriate technology, and institutional support and CAS) in the agricultural sector using a confirmatory factor analysis (CFA).

2. Research Methods and Materials

2.1 Study Area

Gujarat is located on the western coast of India and it is bounded by the Arabian sea in the west and southwest. Figure 1 shows the geographical and administrative location of Gujarat. The state touches the international border of Pakistan; and Rajasthan, Madhya Pradesh and Maharashtra states and the Dadra, Diu and Nager Haveli union territories of India. Geographically, the state is located at a latitude and longitude of 23.00 north and 72.00 east, respectively. The state has a 1,659-kilometre coastline which is the largest among the other Indian states. It occupied a total 196,244 square kilometer geographical area that has a significant share of forest area, grazing land and arable land total geographical area of Gujarat. The state is located in a peninsular region which can be divided into four sub-regions. Administratively, the state has 33 districts that have high diversity in agricultural, industrial and service sector, and social-economic activities of the population. Gujarat is a highly industrialized state and it has appropriate start-ups and entrepreneurship ecosystem among the Indian states [55]. It has a dominant position in the production of many industrial goods such as diamonds, petrochemical, medical devices, medical engineering goods and services, drugs, dairy products, etc. The state also has a significant share of the agricultural sector in India's gross domestic product. The agricultural and its allied sector meet the requirement of raw materials for agro-industrial development in Gujarat. Sugarcane, mustard, groundnut, soybean, cotton, potato, rice, sorghum, wheat and maize are the major crops of this state [6]. Gujarat is a climate-sensitive state due to its geographical location, and it has high diversity in ecosystem services, availability of natural resources, demographical change and social-economic development of farmers. Climate change has a diverse negative impact on the livelihood security of farmers in Gujarat [5,6,35,56]. Therefore, this state was considered a study area for the proposed research.

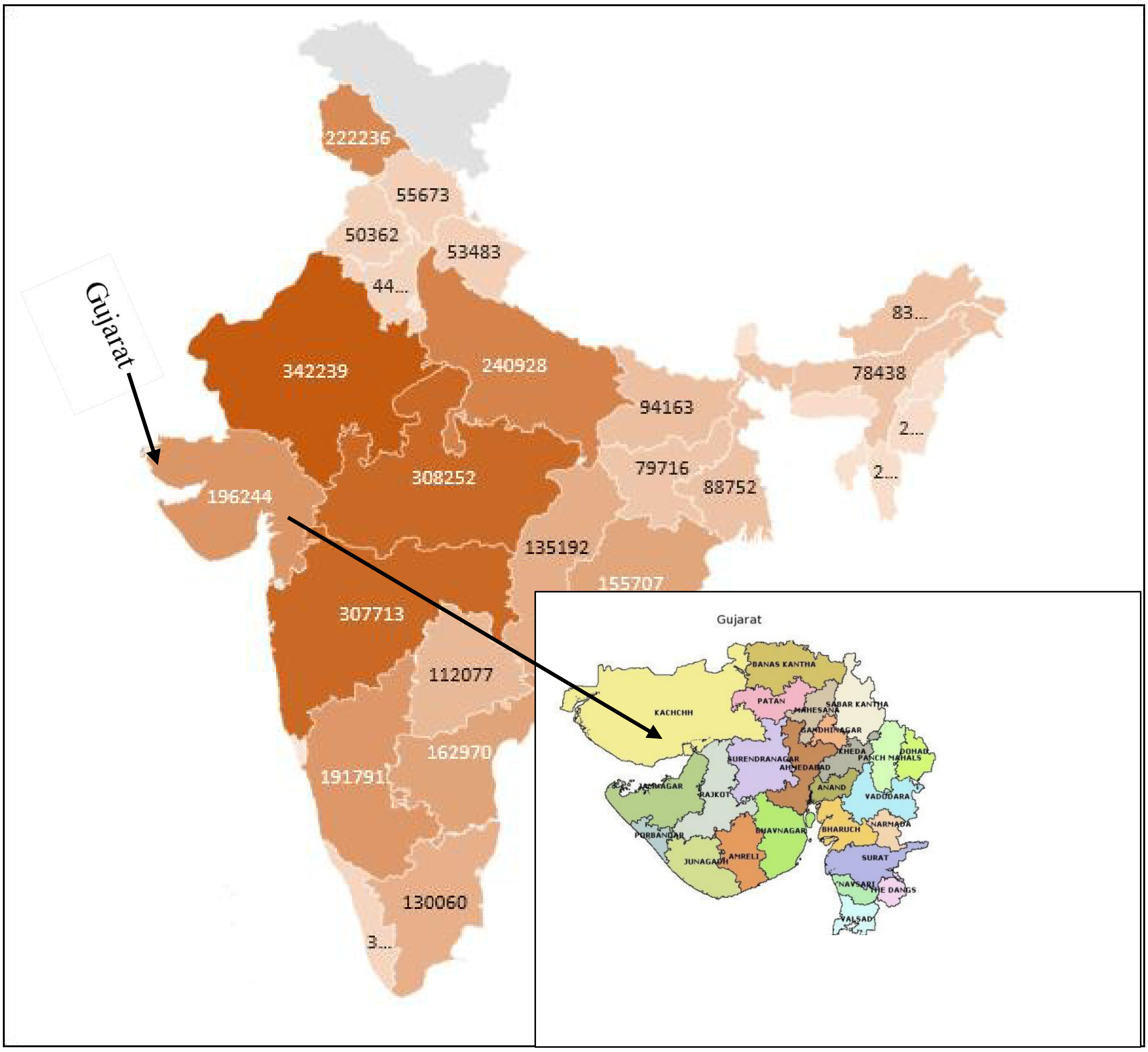

Figure 1. Geographical location of Gujarat.

Source: Author's formation.

2.2 Collection of Primary Data

A total of 8 districts out of 33 (i.e., Anand, Banas Kantha, Bharuch, Bhavnagar, Junagadh, Kheda, Surat, and Vadodara) were selected based on their contribution to the agricultural sector (Figure 2). These districts collectively contribute around 46% of agricultural labour, 36% of agricultural district domestic product, 36.6% of gross cropped area, 31% of net area sown and 44% gross irrigated area of Gujarat. Also, these districts have a high share in arable land, agricultural workforce, cropping intensity, irrigated area, and cropped area under food-grain and cash crops in Gujarat. These districts are highly vulnerable due to climate change as compared to other districts of Gujarat [14,35]. Two blocks from each district were chosen purposively, and 16 blocks were considered for a field visit. One village from each block was selected randomly. Thus, 16 villages were considered in this study. Subsequently, 15 farmers from each village were identified randomly for a personal interview. Hence, 240 farmers were interviewed.

The personal interview of selected respondents was conducted from 1st October 2019 to 31st December 2019. A well structural questionnaire survey was conducted for the personal interview of selected farmers. The questionnaire was filled up by the research team during the personal interview of farmers. The questionnaire was divided into four broad sections. The 1st section includes the information associated with the social-economic structure of farmers, gender, age, family size, annual income, educational level and income-generating occupations. The 2nd section includes information on the gross cropped area, irrigated and non-irrigated area, production of all crops, number of livestock and agricultural inputs. The 3rd section comprises information on the cost of technologies, appropriate technology, financial support from the government and credit accessibility from banks, farmer's association with Agri-entrepreneurs, skill supports, farmer's adaptation strategy and agricultural development agencies. The 4th section contains open-ended questions on various aspects such as government policies, marketing, and pricing of products, etc. of the agricultural sector. Qualitative and quantitative information was collected from the farmers to achieve the specific objectives of the study.

2.3 Collection of Secondary Data

Information related to climatic factors such as actual annual average evapotranspiration, annual average maximum temperature, annual average minimum temperature, annual average precipitation and annual actual rainfall were derived from the India Meteorological Department (IMD), Ministry of Earth Sciences (Government of India) and official website of International Crops Research Institute for the Semi-Arid Tropics. The statistics of mentioned climatic factors were used during 1991-2015. Since the statistics were available in time series. Hence, the coefficient of variation (CV) in mentioned climatic variables was included in the statistical analysis. The farm harvest price of each crop was taken from the annual report (2019-2020) of farm harvest prices of principal crops in India published by the Directorate of Economics and Statistics, Department of Agriculture, Cooperation and Farmers Welfare, Ministry of Agricultural and Farmers Welfare, GoI, New Delhi.

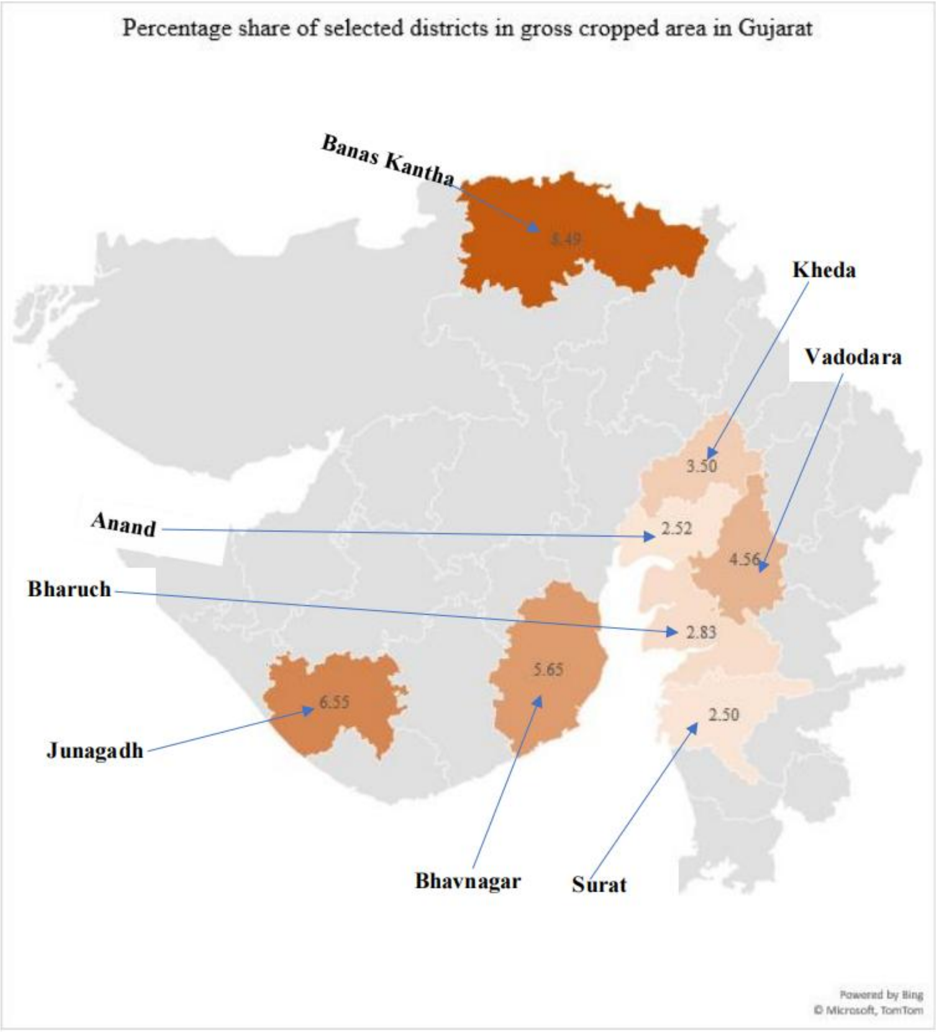

Figure 2. Location of districts.

Source: District wise statistics of CMIE (2019-2020).

2.4 Data Analysis

Analysis of Qualitative and Quantitative Data

CFA is a statistical technique that identifies the latent and constructed variables in production activities [57]. The technique is helpful to describe the role of climatic and non-climatic factors in the agricultural sector [57-60]. It makes the group of indicators into constructs or factors and observes the interrelationship among them [38,61]. Hadrich and Olson [58] examined the correlation coefficients between farm size and farm performance, and the role of latent variables in farm performance in the USA using a CFA. Hosseini and Eghtedari [59] detected the factors affecting the development of nanotechnology in the agricultural sector of Iran using CFA. Karakas et al. [62] have determined the factors which were useful to increase the farmer's knowledge and skills regarding bureaucratic procedures using CFA. Syan et al. [63] applied the CFA technique to examine the farmer's intention to adopt sustainable agriculture practices in Punjab (India). Narmilan et al. [41] used CFA to estimate the relationship between factors with regard to precision agricultural techniques and farmers' adoption capacity in Sri Lanka. Pakmehr et al. [60] used CFA to determine the factors affecting farmers' adaptation to climate change-induced water pressure in Iran. Laurett et al. [38] examined the SAD-affecting factors in Brazil using exploratory factor analysis. Singh et al. [64] also applied PCA to examine the performance of indicators associated with sustainable livelihood security in Indian states. This study also used the CFA technique to inspect the performance of climatic and non-climatic factors in the agricultural sector.

Rationality of Confirmatory Factor Analysis (CFA)

The authors of this study collected information on numerous factors which were essential for the growth of the agricultural sector. These variables have diverse contributions to the agricultural production system. Therefore, this study used CFA to identify the latent variables which cannot be observable [63]. A latent variable can be decided as per its variance and covariance in the set of variables. For this, CFA helps to reduce the dimensionality of a set of variables and further it may be useful to develop a mathematical model for different statistical and empirical analyses. If the variance of a variable in a specific category of factors is less than 40%, then the variable can be dropped from the statistical analysis [57]. The estimate infers that the variable has an insignificant contribution among the set of variables. In the agricultural sector, there are many variables that can be used as dependent and independent variables. Therefore, it is expected that the contribution of some variables may be latent in farming activities. Hence, CFA was used to examine the latent variables among the selected set of variables.

Validity of CFA Results

Cronbach's alpha score was estimated to check the reliability of the scale coefficient of individual and group factors [59,65]. If the statistical value of Cronbach's alpha score is less than 0.50, then undertaken variables cannot consider for CFA. Furthermore, Kaiser-Meyer Olkin (KMO) test was also used to check the perfection of the sample and consistency of CFA [38]. If the KMO value is detected as more than 0.5, the sample has adequacy for CFA [57]. Finally, the Chi^2 value was also considered to check the viability of CFA.

Description of Variables Included for CFA

This study applies the CFA technique to observe the latent and construct factors in the agricultural sector. Therefore, 31 factors in five categories: (i) Climate change, (ii) Social-economic, (iii) Agricultural input, (iv) Technological development and appropriate technology, and (v) Institutional support and CAS-related variables were used (Table 1). Previous studies have used climatic and non-climatic factors to observe the impact of climate change in the agricultural sector [1,2,8,16,22,32]. Few studies have considered only climatic factors to assess the impact of climatic factors on production, yield and cropped area of foodgrain and cash crops [26,28]. As district-level information on climatic factors was available during 1991-2015. Since, the coefficient of variation in climatic factors measures their long-term variability [1,5]. Thus, the coefficient of variation (CV) in a particular climatic factor captures its integrated influence in the agricultural sector. Therefore, CV in climatic factors was considered to examine the significance of climatic factors in the agricultural sector. Kumar et al. [15]; Singh et al. [66] also used CV in climatic factors to observe the climate change impact on sugarcane production in Indian states. A farmer's social-economic profile also plays a significant role to increase farm income [67]. Thus, gender, age, family size, education level, main occupation, annual income, family size and a number of livestock were also included in the statistical analysis of this study [3,12,68-71]. Here, education level was used to capture the influence of technical skills, and livestock was used to analyze the impact of physical assets of farmers in the agricultural sector.

Table 1. Summary of the variables.

Category	Variables	Symbol	Unit
Climate change related variables	CV in actual annual average evapotranspiration	*cvaaea*	mm
	CV in annual average maximum temperature	*cvaamaxtem*	°C
	CV in annual average minimum temperature	*cvaamintem*	°C
	CV in annual average precipitation	*cvaapre*	mm
	CV in annual actual rainfall	*cvaarf*	mm
Social-economic related variables	Gender (Male = 1; Female = 0)	*genres*	Number
	Farmer's age	*ageres*	Years
	Family size	*famsizres*	Number
	Types of family (Joint = 1; Single = 0)	*typfamres*	Number
	Farmer's education level (years spent in school)	*edulevres*	Years
	Farmer's main occupation (Farming = 1; Farming and others = 0)	*maioccres*	Number
	Farmer's annual income	*annincfam*	Rs.
	Number of livestock (Cow, goat, buffalo)	*nlf*	Number
Agricultural input related variables	Farm income/Ha.	*fiph*	Rs./Ha.
	Gross cropped area	*tagla*	Ha.
	Irrigated area	*irrare*	Ha.
	Non-irrigated area	*nonirrare*	Ha.
	Crop diversification index	*cdi*	%
	Use of agricultural labour/Ha.	*ualph*	Number/Ha.
	Farm income from cash crops farming/Ha.	*ficcph*	Rs./Ha.
	Fertilizer application/Ha.	*faph*	Kg./Ha.
Technological development and appropriate technology related variables	Cost of technology/Ha.	*cotepeha*	Rs./Ha.
	Economic viability of technology (Yes = 1; No = 0)	*ecoviatec*	Number
	Social viability of technology (Yes = 1; No = 0)	*socviatec*	Number
	Environmental viability of technology (Yes = 1; No = 0)	*envviatec*	Number
	Appropriate technology (Yes = 1; No = 0)	*apptec*	Number
Institutional support and climate adaptation strategies related variables	Financial problem of farmers (Yes = 1; No = 0)	*finpro*	Number
	Financial support from government and credit accessibility from banks (Yes = 1; No = 0)	*finsupgov*	Number
	Farmer's association with various stakeholders (i.e., Agri-entrepreneurs, agricultural universities, agricultural extension offices, coo-operative societies, Agri industries) (Yes = 1; No = 0)	*farassstahol*	Number
	Skill and technical support from technology developers (Yes = 1; No = 0)	*skitecsupfar*	Number
	Farmer's adaptation strategy to climate change (Yes = 1; No = 0)	*adstfa*	Number

Source: Author's compilation based on primary and secondary data.

Agricultural output was valued as the monetary value of food grain and cash crops which were cultivated by farmers during the survey year. The monetary value of each crop was estimated as per farm harvest price. Aggregate economic values of all crops were considered as gross agricultural production. Accordingly, per hectare farm income was assessed as a ratio of gross agricultural production with the gross cropped area. While, per hectare farm income from cash crops was also estimated separately. Gross cropped area, irrigated and non-irrigated area, use of agricultural labour per hectare, farm income from cash crops farming, fertilizer application per hectare, number of livestock and crop diversification index (CDI) were considered as agricultural inputs [4,5,22,45]. Cash crop farming is also useful to increase farmers' income and economic capacity [1]. Subsequently, farmers can apply various inputs to get a better return in the cultivation of crops in the next season. Crop diversification measures how many crops can be cultivated in a specific area in a year. Agricultural production and income of farmers are to be increased as crop diversification increases. Moreover, crop diversification is also a vital driver to familiarizing the climate change impact on cultivation [5,2,72,73]. Hence, CDI was used to examine the influence of crop diversification on per hectare farm income. While, the crop diversification index (CDI) was estimated as:

$$(CDI)_i = \sum_{i=1}^{n} (CA)^2 \quad (1)$$

Here, CDI is the crop diversification index of i^{th} farmers; *CA* is the cropped area of a crop (in percentage) under 1 to n^{th} crops during the survey year in Equation (1).

Any agricultural technology may have multiple practices in the agricultural sector. Therefore, the impact of technological change in the agricultural sector cannot be observed easily. Prior researchers used the time trend factor, new varieties of seeds and crop diversification as proxy variables to capture the impact of technological development in the agricultural sector [1,12,42,45,74]. Irrigation facilities, fertilizer and high-yielding verities of seeds also reflect the overall technological development in farming activities. In this study, the cost of technology/hectare was used to capture the impact of technological development on farm income. This study assumes that technological development needs more financial resources to bear the cost of the latest technology. Further, it also accepts that if the cost of technology increases then it infers the technological development in the agricultural sector. Cost of technology is the gross amount which is paid by farmers to bear the cost of tractors and another mechanical devices during various stages of crop production, i.e., land preparation, seed planting, electricity or fuel charge for irrigation and harvesting. Accordingly, the cost of technology/hectare was used to examine the significance of technological development in the agricultural sector. Ashraf and Singh [6] also used a similar variable to capture the impact of technological development on the farm income of the agricultural sector.

Appropriate technology ensures the economic, social and environmental viability of the resources in the production process [5,6,39,40,51]. Most studies claimed that an appropriate technology maintains sustainability in the economic, environmental and social aspects [6]. In the context of the agricultural sector, technology can be appropriate when it meets said aspects. The economic aspect of technology is concerned with purchasing power of farmers and the social aspect of technology is associated with its acceptability and usability by farmers. Economically viable technology also provides a better return to the farmers. The environmental viability of technology helps to ensure the protection of ecosystem services (i.e., soil fertility, and air and water quality) and natural resources. This aspect of technology is useful to reduce GHG emissions from the production sector and it may be highly conducive to reducing more existence of climate change. Hence, the measurement of appropriate technology is not easy [5,6]. Also, the scientific research community could not provide a universally acceptable indicator and develop a model to examine the impact of appropriate technology in the agricultural sector. Therefore, existing researchers could not assess the influence of appropriate technology on the production, yield, and growth of the agricultural sector. Though, previous studies used different variables such as time trend factor, cost of technology, fertilizer intensity, tractor, ICT, transplant technique, etc. to perceive the significance of appropriate technology and technological development in this sector [39,45]. Accordingly, it was difficult to observe the viability of appropriate technology and its components. The authors of this study used some proxy questions to include the farmer's view on appropriate technology and its other aspects. For instance, whether applied technologies are economically feasible for you or not (if yes then 1 otherwise 0)? whether applied technologies are socially acceptable to you or not (if yes then 1 otherwise 0)? whether applied technologies are environmentally sound or not (if yes then 1 otherwise 0)? Henceforth, in this study, farmers' judgments on economic, social and environmental aspects of appropriate technology were used as proxy variables. In CFA, it uses binary data for mentioned aspects of appropriate technology in mentioned ways [5].

Financial restrictions of farmers, financial support from the government and credit accessibility from banks, farmer's association with different institutions (i.e., Agri-entrepreneurs, agricultural universities, agricultural extension offices, agricultural cooperative societies, Agri industries), skill and technical support from technology developers' industries, and farmer's CAS were used as institutional support related variables in CFA. Agricultural extension offices and developmental institutions provide training and technical support to the farmers to increase their understanding of various climate adaptation strategies and new technologies in the agricultural sector [5,6,12,63,75].

3. Main Results

3.1 Statistical Summary of the Variables

Table 2 shows the statistical properties (i.e., minimum, maximum, mean, standard deviation and skewness) of climatic and non-climatic factors. The values of standard deviation (SD) of most variables (except *ageres*, *anninc-fam*, *fiph*, *ficcph*, *faph*, *cotepeha*, *edulevres*, *tagla*, *irrare*, *ualph*, *famsizres*, *cdi* and *nlf*) were appeared less than 1. Thus, these factors have an insignificant diversity in the sample. The statistical value of skewness describes the normality of the respective factor. The skewness values of most factors (excluding *cvaapre*, *cvaarf*, *genres*, *nlf*, *ficcph*, *faph*, *socviatec* and *fiph*) appeared between –1 to + 1. Thus, these factors were found in normal form. Moreover, Cronbach's Alpha score measures the internal viability of individual variable. The Cronbach's Alpha (α) score of a variable also measures its internal viability for further consideration in CFA [57]. Cronbach's α score for all factors was found more than 0.70. Hence, the estimates infer that undertaken variables have internal consistency to apply CFA.

3.2 Results Based on CFA

The eigenvalues, proportion share and cumulative contribution of all factors were estimated through simple factor analysis, principal-component factors analysis, iterated principal-factor analysis and maximum likelihood factor analysis. As principal-component factor analysis produces better results as compared to other forms of CFA. In the CFA method, the significance of a factor in the group of factors was observed based on eigenvalue, percentage variance and cumulative variance. Thereupon, factor loading and the uniqueness value of a specific variable explain their aggregate variation in the group of variables. This study used five categories of variables to examine latent and construct variables. The CFA results for climate change, social-economic, agricultural input, technological development and appropriate technology,

Table 2. Descriptive statistics of factors.

Variables	Min	Max	Mean	SD	Skewness	Cronbach's α score
cvaaea	0.081	0.221	0.145	0.051	0.351	0.7614
cvaamaxtem	0.011	0.012	0.012	0.002	0.592	0.7608
cvaamintem	0.021	0.021	0.023	0.003	–0.043	0.7643
cvaapre	0.241	0.391	0.291	0.041	1.124	0.7630
cvaarf	0.340	0.481	0.382	0.043	1.990	0.7803
genres	0.001	1.002	0.981	0.142	–6.712	0.7643
ageres	22.001	65.002	39.982	10.644	0.331	0.7524
famsizres	2.00	12.001	5.831	1.831	0.801	0.7515
typfamres	0.00	1.001	0.631	0.48	–0.55	0.7407
edulevres	7.00	17.00	12.59	3.09	–0.11	0.7338
maioccres	0.00	1.00	0.65	0.48	–0.65	0.7575
annincfam	140000	912000	531692	159320	–0.021	0.7535
nlf	5.00	34.00	12.40	4.17	1.40	0.7483
fiph	10821	23420	12053	1757	3.68	0.7668
tagla	1.00	25.00	9.27	5.57	0.67	0.7507
irrare	0.50	20.00	6.16	4.12	0.88	0.7527
nonirrare	0.00	10.00	3.15	2.00	0.79	0.7529
cdi	2.00	8.00	6.00	1.43	–0.55	0.7649
ualph	40.00	78.00	54.24	6.37	0.39	0.7693
ficcph	7214.17	9816.00	7865.46	597.24	1.48	0.7707
faph	102.00	435.00	167.38	50.58	2.59	0.7623
cotepeha	1765.00	2986.00	2536.39	287.22	–0.68	0.7674
ecoviatec	0.00	1.00	0.64	0.48	–0.59	0.7454
socviatec	0.00	1.00	0.89	0.31	–2.52	0.7619
envviatec	0.00	1.00	0.63	0.48	–0.55	0.7431
apptec	0.00	1.00	0.72	0.30	–0.51	0.7358
finpro	0.00	1.00	0.69	0.46	–0.83	0.7567
finsupgov	0.00	1.00	0.44	0.50	0.25	0.7640
farassstahol	0.00	1.00	0.51	0.50	–0.05	0.7644
skitecsupfar	0.00	1.00	0.32	0.47	0.77	0.7717
adstfa	0.00	1.00	0.46	0.50	0.15	0.7351

Source: Author's estimation using primary and secondary data.

and institutional support and CAS-related variables are given in Table 3, Table 4, Table 5, Table 6 and Table 7, respectively. The KMO values of most variables (except, a few) were observed more than 0.5 and the overall KMO value was reported more than 0.72. Also, the Chi^2 value was found statistically significant at a 1% significance level in each category. Thus, estimates infer that all factors have consistency for the application of CFA. In the category of climate change-related variables, the first 3 factors were found retained factors that contribute 87.83% variation among the five different climatic factors (Table 3). The variation in an individual factor loaded onto 3 retained factors (i.e., *factor*1, *factor*2 …, *factor*3) and the uniqueness of each factor in farm income/hectare detect the category of latent variables. If the value of a factor loaded is less than 0.40, then the factor cannot be used in the statistical explanation [57,75]. The estimates reveal that *cvaaea*, *cvaamaxtem*, *cvaamintem*, *cvaapre*, and *cvaarf* have high loaded on *factor*1. Hence, actual annual average evapotranspiration, annual average maximum temperature, annual average minimum temperature, annual average precipitation and annual actual rainfall appeared as latent variables in the category of climate change-related variables.

For the social-economic related variables, CFA results infer that the first 3 factors seemed retained variables. These first 3 factors have a 60.10% variation in the 8 social-economic related variables (Table 4). As per the factor loading and uniqueness, *agrees, famsizres*, *typfamres*, *edulevres* and *nlf* have highly loaded on *factor*1. Therefore, the farmer's age, family size, type of family, education level and number of livestock seemed latent variables in the category of social-economic variables.

In the category of agricultural inputs related-variables, the first 3 *factors* were detected as retained factors (Table 5). The first 3 *factors* have a 72.5% variation among the 7 variables in this category of variables. The results also suggested that gross cropped area, irrigated area, crop diversification and fertilizer application were found latent variables in the category of agricultural input-related variables.

Appropriate technology and its other components have highly loaded on *factor*1 (Table 6). Thus, these variables were found latent variables in the category of technological change and appropriate technology related variables. While, the cost of technology has highly loaded on *factor*2. Cost of technology, therefore, was also found as a hidden variable for *factor*2.

As the eigenvalue and proportion share of individual factors, the first 3 *factors* were reported retained factors and these variables have 65.10% variation among the 5 factors in the category of institutional support and CAS-related variables (Table 7). The estimates infer that government financial support, farmers' association with different stakeholders, skilled and technical support for farmers and CAS have highly loaded on *factor*1. Hence, these variables were observed as latent variables in this category of variables.

Table 3. Proportion of factors, factors loading and unique variances in climatic factors.

Eigenvalue and proportion of factors						
Number of obs.	240		Number of params		15	
Retained factors	3		Chi^2		1271.20*	
Factor	*Factor*1	*Factor*2	*Factor*3	*Factor*4	*Factor*5	*Factor*6
Eigenvalue	2.8221	1.4432	1.0043	0.47505	0.24555	0.0099
Difference	1.3789	0.4389	0.52925	0.2295	0.23569	.
Proportion	0.4703	0.2405	0.1674	0.0792	0.0409	0.0016
Cumulative	0.4703	0.7109	0.8783	0.9574	0.9984	1
Factor loadings (pattern matrix) and unique variances						
Variable	*Factor*1	*Factor*2	*Factor*3	Uniqueness	*KMO* Value	
fiph	0.0757	0.0298	0.9952	0.0030	0.3234	
cvaaea	0.6750	0.6250	0.0487	0.1514	0.6960	
cvaamaxtem	0.9470	–0.2733	–0.0280	0.0278	0.4087	
cvaamintem	0.7376	–0.6019	0.0009	0.0937	0.3263	
cvaapre	0.4589	0.7785	–0.0921	0.1750	0.2578	
cvaarf	0.8422	–0.0933	–0.0476	0.2796	0.3985	

Source: Author's estimation using primary and secondary data.

*: show that Chi^2 value is statistically significant at 1% significance level.

Table 4. Proportion of factors, factors loading and unique variances in social-economic related variables.

Eigenvalue and proportion of factors									
Number of obs.	240		Number of params			24			
Retained factors	3		*Chi*^{2}			708.33*			
Factor	*Factor*1	*Factor*2	*Factor*3	*Factor*4	*Factor*5	*Factor*6	*Factor*7	*Factor*8	*Factor*9
Eigenvalue	3.092	1.261	1.057	0.945	0.921	0.761	0.589	0.254	0.122
Difference	1.832	0.204	0.112	0.024	0.160	0.172	0.335	0.131	.
Proportion	0.344	0.140	0.117	0.105	0.102	0.0845	0.065	0.028	0.014
Cumulative	0.344	0.484	0.601	0.706	0.808	0.893	0.958	0.986	1.000
Factor loadings (pattern matrix) and unique variances									
Variable	*Factor*1	*Factor*2	*Factor*3	Uniqueness	*KMO* Value				
fiph	–0.056	0.4837	–0.270	0.6901	0.5759				
genres	0.2998	0.4328	–0.203	0.6816	0.6023				
ageres	0.5178	–0.185	–0.510	0.4378	0.7304				
famsizres	0.7837	0.3793	0.1331	0.2242	0.6237				
typfamres	0.7836	–0.155	0.0827	0.3553	0.7476				
edulevres	–0.823	0.2842	0.0977	0.2332	0.6942				
maioccres	0.285	–0.278	0.7126	0.3336	0.7002				
annincfam	–0.314	0.5749	0.3421	0.4543	0.6714				
nlf	–0.804	–0.385	–0.155	0.1806	0.6258				

Source: Author's estimation using primary.

*: show that *Chi*^{2} value is statistically significant at 1% significance level.

Table 5. Proportion of factors, factors loading and unique variances in in agricultural inputs related variables.

Number of obs.	**240**		**Number of params**		**21**			
Retained factors	3		*Chi*^{2}		1529.94*			
Factor	*Factor*1	*Factor*2	*Factor*3	*Factor*4	*Factor*5	*Factor*6	*Factor*7	*Factor*8
Eigenvalue	3.070	1.722	1.004	0.866	0.695	0.350	0.288	0.005
Difference	1.348	0.718	0.138	0.170	0.346	0.061	0.284	.
Proportion	0.384	0.215	0.126	0.108	0.087	0.044	0.036	0.001
Cumulative	0.384	0.599	0.725	0.833	0.920	0.963	0.999	1.000
Factor loadings (pattern matrix) and unique variances								
Variable	*Factor*1	*Factor*2	*Factor*3	Uniqueness	*KMO* Value			
fiph	–0.092	0.915	0.091	0.147	0.5051			
tagla	0.966	0.101	–0.015	0.056	0.4980			
irrare	0.913	0.102	–0.007	0.157	0.4669			
nonirrare	0.851	0.059	–0.005	0.272	0.4284			
cdi	0.427	–0.080	0.177	0.780	0.9448			
ualph	–0.019	–0.082	0.981	0.030	0.1017			
ficcph	–0.077	0.917	0.011	0.153	0.5035			
faph	0.618	–0.088	–0.036	0.609	0.8100			

Source: Author's estimation using primary data.

*: show that *Chi*^{2} value is statistically significant at 1% significance level.

Table 6. Proportion of factors, factors loading and unique variances in technological development and appropriate technology related variables.

Number of obs.	**240**		**Number of params**		**11**	
Retained factors	2		*Chi*^{2}		4607.75*	
Factor	*Factor*1	*Factor*2	*Factor*3	*Factor*4	*Factor*5	*Factor*6
Eigenvalue	2.451	1.159	0.996	0.918	0.477	0
Difference	1.292	0.163	0.077	0.441	0.477	.
Proportion	0.408	0.193	0.166	0.153	0.080	0
Cumulative	0.408	0.602	0.768	0.921	1.000	1
Factor loadings (pattern matrix) and unique variances						
Variable	*Factor*1	*Factor*2	Uniqueness	KMO Value		
fiph	0.1880	–0.4966	0.7180	0.8867		
cotepeha	–0.1853	0.4202	0.7891	0.6819		
ecoviatec	0.6622	–0.4557	0.3538	0.1695		
socviatec	0.4683	0.7181	0.2651	0.1013		
envviatec	0.8589	0.0939	0.2535	0.2394		
apptec	0.9927	0.0565	0.0114	0.3225		

Source: Author's estimation using primary data.

*: show that *Chi*^{2} value is statistically significant at 1% significance level.

Table 7. Proportion of factors, factors loading and unique variances in institutional support and CAS related variables.

Number of obs.	**240**		**Number of params**		**15**	
Retained factors	3		*Chi*^{2}		101.57*	
Factor	*Factor*1	*Factor*2	*Factor*3	*Factor*4	*Factor*5	*Factor*6
Eigenvalue	1.586	1.310	1.009	0.917	0.677	0.500
Difference	0.277	0.300	0.092	0.240	0.177	.
Proportion	0.264	0.218	0.168	0.153	0.113	0.083
Cumulative	0.264	0.483	0.651	0.804	0.917	1.000
Factor loadings (pattern matrix) and unique variances						
Variable	*Factor*1	*Factor*2	*Factor*3		Uniqueness	KMO Value
fiph	0.214	0.3195	0.8651		0.1037	0.4627
finpro	–0.2867	0.7604	0.1311		0.3224	0.4488
finsupgov	0.7983	0.1583	–0.2062		0.2951	0.5042
farassstahol	0.4452	–0.1179	0.0245		0.7873	0.6882
skitecsupfar	0.6013	0.5667	–0.2841		0.2365	0.4713
adstfa	0.5111	–0.5186	0.3463		0.3499	0.5606

Source: Author's estimation using primary data.

*: show that *Chi*^{2} value is statistically significant at 1% significance level.

4. Discussion on Findings

The results based on CFA indicate that climatic factors, social-economic variables, CAS and institutional support have an important contribution to the agricultural sector. However, the roles of different categories of variables were found to differ in the cultivation. Social-economic factors such as the farmer's age, family size, type of family, education level and the number of livestock can be applied as CAS in the cultivation. Gross cropped area, irrigated area, crop diversification and application of fertilizer are reported as vital agricultural inputs. These variables may be worked as CAS in the cultivation. The government's financial, skilled and technical support by agricultural development agencies may be helpful for the farmer to increase their intention toward CAS. Thus, most social-economic and institutional support-related variables work as CAS in the cultivation.

Evapotranspiration, maximum temperature, minimum temperature, precipitation and rainfall were reported as hidden variables in the group of climatic factors (Table 3). As these variables cannot be controlled by farmers, thus, climatic factors can be considered exogenous variables in the agricultural production system. Here, it can be argued that climatic factors work as crucial inputs during various phases, i.e., sowing, growing and harvesting time of a crop [1,9,16,20]. The plant growth of a crop can tolerate the impact of certain climatic factors up to a certain extent. Subsequently, there is expected a non-linear and hilly-shaped relationship between land productivity and climatic factors [14]. Thus, the production of most crops may decline due to high variability in climatic factors. Accordingly, farm income per hectare may be declined due to changes in climatic factors. The mentioned results are consistent with previous studies like Singh et al. [5]; Angom et al. [14]; Singh and Issac [35]; Singh et al. [75] have also reported the negative impact of climatic factors in the agricultural and its associated activities in Gujarat. Therefore, at present agricultural production activities are in a vulnerable position due to climate change. Therefore, there is indispensable to apply CAS to mitigate the negative impact of climate change in the agricultural sector.

Farmer's age, family size, education level, annual income and livestock seemed as latent variables in the category of the social-economic profile of farmers (Table 4). Hence, the estimates demonstrated that productivity and production of crops may be increased as the social-economic status of farmers improves. Previous studies also reported significant implications of mentioned variables in farming activities [5,12,19,68,73]. Age, family size and education level of farmers have a substantial role in farming activities. Educated farmers have more skills to apply various CAS, inputs and farm practices in the cultivation to increase yield. Farm management practices and productivity are to be improved as the involvement of experienced farmers increase in the cultivation. The result of the study also found a significant role of farmers' age in cultivation. Most family members of the farming community generally engaged in agricultural production activities. Hence, land productivity increases up to a certain level as the family size of farmers increases. Otherwise, land productivity may be declined due to the applicability of the law of diminishing returns in the agricultural sector [1,16]. Farmers can use various inputs like new seeds, fertilizer, pesticides and technology as their annual income increases. Moreover, literate and experienced farmers use different techniques of cultivation to increase farm income [16]. Availability of physical assets (i.e., number of livestock) also helps farmers to apply various CAS. The mentioned findings are similar to existing studies like Singh et al. [5]; Mitra et al. [12]; Basu [19]; Dhanya and Ramachandran [68]; Singh [73]. Briefly, the farmer's family size, education level, annual income, family type and livestock seemed useful to mitigate the climate change impact on farming activities.

Gross cropped area, agricultural labour, irrigated area, crop diversification and fertilizer were noticed as latent variables in the group of agricultural inputs (Table 6). Therefore, these variables appeared as significant inputs for the agricultural sector. Earlier studies like Ashraf and Singh [5]; Kumar [9]; Kumar et al. [16]; Chandio et al. [22]; Ashraf and Singh [45]; Singh [73] have also noticed a positive impact of mentioned inputs in the agricultural sector. Thereafter, income from cash crops farming also showed a positive impact on farm income. Income from cash crops farming is necessary to increase the economic capacity of the farmers for purchasing new technologies, new varieties of seed, irrigation resources, green fertilizers and other inputs in cultivation. Hence, income from cash crop farming may be beneficial for farmers to apply a climate adaptation approach to avoid the risk of climate change in the agricultural sector. Cash crop farming may be favorable to creating an agri-entrepreneurial ecosystem. Farmers, therefore, should grow cash crops to get a better return and increase CAS.

All components of appropriate technology appeared as latent variables in the group of technological development and appropriate technology-associated variables (Table 7). The estimates can be defensible that the application of agricultural technologies is helpful to increase productivity and production of crops [6,13,44,46,50]. Cropping patterns and crop diversification also improve as the use of technology increases in cultivation. Moreover, the application of appropriate technology helps to save water, and human resources, germination of seeds, seed fertility and increase plant growth. The use of appropriate technology may also reduce the fertilizer and pesticides, and waste materials in the cultivation. Land management practices also improve as the application of technology increases in the agricultural sector. Furthermore, the use of appropriate technology enhances soil quality and fertility, water and air quality, and other ecosystem services [5]. Subsequently, the use of appropriate technology would increase sustainable agricultural development. The CFA results of this study proposed that appropriate technology and its dimensions have a positive impact on the farming activities. The mentioned findings are consistent with previous studies [5,45].

Financial support from the government, farmer's association with stakeholders, skill and technical support from technology developers and adaptation practices seemed as latent variables among the institutional support and CAS-associated variables. The abovementioned findings are consistent with Naidu et al. [48]. The government should provide subsidies on seeds, fertilizer, pesticides, electric engines and irrigation sprinkler machines to the farmers. The government also announced the minimum support price (MSP) of food-grain and cash crops before their sowing time. MSP will motivate the farmers to grow a crop that provides them with better benefits. Moreover, credit accessibility for farmers would also increase their purchasing power to buy different inputs (i.e., seed, fertilizer, pesticides, etc.) during the sowing time of crops. Appropriate credit accessibility for the farming community would also enhance the production and productivity of crops. Kumar et al. [16] also found that credit accessibility was a vital driver to increasing agricultural productivity in Indian states. Agricultural development agencies, agricultural cooperative societies, technology developers' agencies, and research institutions and agricultural universities should provide training and organize various programs for farmers to increase their awareness of new varieties of seeds, fertilizer, technology and scientific methods of cultivation. Therefore, institutional support has a positive involvement to increase farm income [5,47]. It is consistently accepted that climate change is highly responsible to reduce the farm income and productivity of food-grain and crops in India [1,8-10,15,22,23,25-29,32,36,59]. Therefore, CAS may be effective to mitigate the climate change impact in the Indian agricultural sector. Previous studies like Singh et al. [5]; Mitra et al. [12]; Angom et al. [14]; Dhanya et al. [68]; Singh [73] have also observed a positive and significant role of CAS in the Indian agricultural sector.

5. Conclusions and Recommendations

The prime aim of this study was to examine the implication of climatic factors, social-economic variables, agricultural inputs, technological advancement and appropriate technology and institutional support and climate adaptation strategy in the agricultural sector of Gujarat using CFA. The CFA was run on 31 factors which were divided into five different categories. Farm income per hectare was treated as a dependent variable in every group of variables. Subsequently, this study could find latent variables in each category of a variable. These variables can be used as a CAS by farmers to mitigate the adverse impact of climate change.

The results based on CFA, demonstrate that the coefficient of variation in annual actual evapotranspiration, annual average maximum temperature, annual average minimum temperature, annual actual precipitation and annual actual rainfall have a significant influence on farm income per hectare. In the category of social-economic variables, the farmer's age, family size, type of family, education level and a number of livestock have a vital contribution to increasing farm income per hectare. Gross cropped area, irrigated area, crop diversification and fertilizer application seemed important agricultural inputs. Farm income was also significantly linked with technological development and appropriate technology. The government financial support, farmer's association with different stakeholders, skilled and technical support for farmers and CAS were also found vital determinants to increasing farm income.

The study suggests policy recommendations such as improving soil and seed quality, adopting green fertilizers, implementing appropriate farm management practices, and utilizing irrigation methods to mitigate the negative impact of climate change on agriculture. Further, the study recommends that future researchers consider the factors that have minimal negative effects on the environment and ecosystem services. Additionally, future studies could investigate the categorization of appropriate technologies and develop universally accepted indicators to determine which technologies are most suitable for the agricultural sector. Finally, replicating this study with larger samples from different states in India could yield more robust findings.

Author Contributions

The proposal for this article was prepared by Dr. Ajay K. Singh and Shah Nawaz Ashraf. Dr. Shah Nawaz Ashraf collected primary data from the selected respondents through field surveys. Dr. Sandeep Kumar Sharma collected the secondary data from various sources. Dr. Ajay Kumar Singh completed the formulation of empirical models and statistical inferences. Review of literature was undertaken by Dr. Sandeep Kumar Sharma and Shah Nawaz Ashraf. The final draft of this article was written by all authors jointly.

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Data Availability

The data presented in this study are available on request from the corresponding author.

Conflict of Interest

The authors declare no conflict of interest.

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