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# Assessing the Economic Implications of Climate Change on Agriculture in Punjab in Pakistan: Farmers Perception and Satisfaction

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**Abstract**
Climate factors are pivotal for agriculture productivity and unremittingly climatic change are really harmful for agriculture productivity. Farm level adaptation measures preforms effective role to cope up with climate challenges. This research aims to focus on the farmers' perception and awareness about climate changes and their vulnerable impacts on agriculture productivity. Additionally, this research also explore the farmer's satisfaction on adaptation strategies to handle the climate change in Punjab, Pakistan. The 360 respondents were selected to get the questionnaire based data from the farmers located in Punjab province. The survey is conduct through multi-stage, random, and convenient sampling procedure for face to face interviews. For empirical analysis, this research was applied frequency analysis and Principal Component Analysis (PCA) through factor analysis to account the farmers' perception about climate change and satisfaction on adaptive measures. The results show that younger farmers have more knowledge about climate change and adaptation measures. The empirical results indicates that climate change increases the vulnerability of farmers and reducing the per hectare yield over the time. Variation in temperature, pattern of precipitation, mutable sowing and harvesting time creates alarming situation for agriculture productivity in Punjab, Pakistan. Most of the farmers are not happy with and demanding heat resistant and drought resistant seed varieties. Agriculture extension services are fails to increase the farmer's perception and satisfaction about climate change. The results show that farmer are not satisfied with performance of climate resilient institutions of Punjab, government laws and regulation, public private partnership(PPP), the efforts of Research Institutions and NGOs, initiatives of international organizations, community level interventions and poor climate resilient funds. It is recommended that government, research institutions and climate resilient instructions should focus on to educate the farmers and predict new sowing and harvesting patterns, water technology, introduce the new climate zones and suitable crops for particular zone.
**Keywords:** Climatic Challenges, Agriculture Output, Farmers Perception, Farmers Satisfaction, Principle Component Analysis

## 1. Introduction

Increasing climate variability is threatening extreme events such as droughts and floods, which directly affect agricultural productivity and cause food shortages in the economy. To protect agricultural productivity, it is important to identify successful adaptation measures regarding extreme climate events, policies, and practices. It is important to identify the farmer's perception and satisfaction with climatic vulnerability, adaptation measures, and policy strategies (Dhanya & Ramachandran, 2016). About two-thirds of the people in Pakistan depend on agriculture and other related industries. So, the extreme climate variation is threatening overall economic activity in the economy (Ali, & Erenstein, 2017). Agriculture production in Pakistan is reliant on monsoon rainfall spells all over the semi-arid and arid zones. The agriculture sector is at risk because of the sequential and spatial uncertainties of extreme climate events, temperature variation, and changing rainfall patterns (Tamoffo et al., 2023; Ayanlade et al., 2022). The changing climate affects soil fertility, health, and productivity and increases the chances of livestock mortality. A vulnerable climate causes lower agricultural productivity, including food grains, cereals, fruits, vegetables, and cash crops. The reduction in agricultural productivity has a drastic impact on farmers' incomes. The extreme climate events amplify food insecurity, drinking water shortages, and physical and mental health issues, put pressure on rural-urban migration, and exacerbate debt issues (Ngo et al., 2022). Such issues have negative spillover shocks for all other sectors and regions, which affect economic performance, stability, and economic uncertainty in the economy.

Globally, the demand for water is inextricably linked to climate change and increased greenhouse gas emissions (Zobeidi et al., 2022). Water scarcity produces numerous negative consequences on a socio-ecological system, sustainable living systems, soil infertility, and agriculture productivity (Savari et al., 2022). The world projections for population growth and demand for food consumption indicate that agriculture productivity has to increase by at least 70 percent till 2050 (FAO, 2020). Global warming dilapidated 10 to 50 percent of crop productivity in the South Asian region (IFPRI, 2022). The climate of South Asian countries has a vulnerable impact on agriculture productivity through declining rainfall duration, changing rainfall patterns, increasing temperature, heat waves, switching sowing and harvesting patterns, and floods and droughts. Climate change is one of the biggest challenges influencing people's quality of life and the efficiency of agricultural production. Farmers are the most severely impacted, as they have to make dramatic improvements to cope with climatic changes.

The susceptible impact of climate change can be overcome through a suitable climate policy and early adaptation strategies. Agrarians' climate knowledge and adaptation capacity are fundamental factors that can reduce future agriculture losses. There are two ways of adapting to climate policy, an autonomous adaptation that occurs at the individual level (Pecl et al., 2019) and a societal adaptation that improves through the intervention of policy strategy (Rahman & Hichey, 2019). There is a list of research reports indicated that climate change adaptation in the agriculture sector is mainly influenced through community-level adaptation strategies (Thomas et al., 2007; Dore, 2005; Fahad & Wang, 2020). Farmers' climatic illiteracy creates problems in policy adoption and reduction in climate risk for agriculture output. Farmers' perceptions of climate change and knowledge play a fundamental role in early adaptation, which increases production efficiency (Muralikrishnan et al., 2022; Praveen, & Sharma, 2019).

The farmer's awareness and indemnifications regarding climate adaptation policy reveal that less rainfall, dry spells, and droughts are the foremost concerns and causes of poor agricultural output. Proficient adaptation of climate-resilient tools in the agriculture sector has been incredibly helpful in reducing adverse climate shocks and vulnerable effects (Zobeidi et al., 2022). There are two types of adaptation to climate change. The first is transformational adaptation, which is a process that results in changes to a system's biophysical, social, or economic components (Park et al., 2012). It also involves changing a number of variables that affect how well the system functions. The second is incremental adaptation, which is the creation of behaviors and actions to lessen the negative effects of natural climate change and catastrophic events and to increase their favorable impact as a constant reaction to climate risks in a present structure (Shikuku et al., 2017; Kates et al., 2012). Incremental adaptation has constructive effects on climate risk reduction through small and gradual changes compared to complex decisions. The adaptation measure can be improved through planning, design, and an effective decision-making process (Saleh & Heshmian, 2022). The incremental climate adaptation can be improved through resilient crop varieties, product diversification, intercropping, and variation in cultivated crops (Shaffril et al., 2020).

Agricultural product efficiency is enormously dependent on a suitable climate. In Pakistan, cropping seasons have different ecological requirements; one may require high temperatures with appropriate rainfall, while the other may require a lower temperature. Climate change zones have different vulnerability intensities on different crops (Sultana et al., 2009), which affects the cropping life cycle, crop pests, sowing and harvesting patterns, and droughts in both arid and non-arid zones, which ultimately creates the animal and human diseases. Further, Fahad and Wang (2018) argued that loss of soil fertility, crop disease, water scarcity, and declining crop yields are key determinants of environmental variation in Pakistan. The projection results indicated that rice and wheat crop production losses because of climate change by 2050 are about 19.5 billion dollars from the real GDP of Pakistan; it also creates hyper food inflation, a remarkable decline in private domestic consumption, and an aligned industrial and service sector (Khan et al., 2020). Ali et al. (2021) and Abbas (2020) reveal that ceiling temperature and higher rainfall have a harmful effect on wheat production, and floor temperature with steady-state rainfall has a significantly positive effect on all other crops. Additionally, the adverse climate and mitigation effects can be reduced through drought- and heat-resistant crop varieties, which is helpful in reducing food insecurity and hunger protestation and increasing the economic and social well-being of the society. Environmental variation poses major challenges to all dimensions of the economy to achieve sustainable development; it has extensive effects across the different sectors and ecosystems of agriculture, water, energy, food, forests, and biodiversity (Khan et al., 2016).

In climate change adaptation policy, the farmers are execution representatives, and their adaptive attitude, willingness to opt, knowledge, facilitations, affordability, non-financial and financial factors are important for early adaptation (Praveen, & Sharma, 2019; Yulandari, et al., 2023). A climate adaptation strategy helps to achieve sustainable agriculture and avoid food insecurity (Fadina & Barjolle, 2018; Usman et al., 2021), thereby improving socio-economic resilience among the farmers and sustainable agriculture and economic growth of the economy (Amir et al., 2020). This research seeks to find the answer to the following questions: What is the farmer's prediction regarding climate change? Whether farmers have the knowledge to opt for adaptive strategies? What are the factors affecting agrarian adaptation strategies to climate change? Do the farmers feel satisfied with adaptive measures? To maintain sustainable agriculture, the farmer's perception of climate change and adaptation behavior is a fundamental factor in strengthening their adaptive capacity and satisfaction with climate policy adoption. The aim of this research is to identify farmers' concerns about climate change and factors affecting adaptation strategies. Further, to find the farmer's climate change adaptation knowledge and satisfaction regarding adaptive measures in Punjab, Pakistan.

The threats of climate change can be overcome through adaptation measures, especially by small farmers. The level of green technology in emerging nations is not high enough to help with climate problems and boost agricultural output. Still, farmers' ideas about adaptation strategies need to be changed, especially for those who thought adaptation strategies should include institutional, social, economic, and environmental elements. The prevailing studies are area specific and not considered in the climate policy under consideration. This research found that the existing studies focused on the effectiveness of climate change on agriculture productivity; however, this research is designed to identify the farmers' perceptions of climate policy and satisfaction with adaptation measures. Based on lacking issues in existing research and climatic challenges in Pakistan, this research is designed to investigate the agrarian's perception of environmental challenges. This research aims to examine the farmer's satisfaction with government adaptation actions. This study looks at how climate vulnerability affects agricultural production in the Punjab province of Pakistan and how the government tries to stop production inefficiency. This makes it possible to assess the effects of climate policy (2012) and its implementation on agricultural output. Further, this study investigates the farmers' satisfaction with extension services that promptly inform them of climate problems.

## 2. Literature Review

The adoption of climate change adaptation measures as a means of mitigating the risks is thus garnering more attention. Global change may consequently result in large agricultural losses and jeopardize the security of the world's food supply (Honda et al., 2014; Thornton & Comberti, 2017; Schneider & Asch, 2020). Comoé and Siegrist (2015), Iglesias and Garrote (2015), and Arora (2019) all say that climate change is becoming a serious problem for global development that threatens the future of many industries, especially the agricultural one. Climate change is a change in weather patterns brought on by greenhouse gas emissions, which in turn cause heat to build up in the earth's atmosphere (IPCC, 2019). Increased climate change impacts on the agriculture industry are a result of rising greenhouse gas emissions; these impacts can be either positive or negative depending on factors like geography and other factors (Tripathi and Mishra, 2017).

Adaptations to climate change (Jiang et al., 2017; Dang et al., 2019) are ways to deal with the negative effects of climate-related risks on agricultural activities. Extreme weather and climate events that happen during droughts make it harder to grow crops and make money from them. This makes it harder to tackle the challenges of food insecurity (Trinh et al., 2018; Gomez-Zavaglia et al., 2020). The effects of climate change on agriculture are severe since the industry contributes significantly to economic growth, which creates employment opportunities, the earning of foreign exchange, and the reduction of poverty (Mukasa et al., 2017). The majority of nations have therefore quickly considered adopting several adaptation measures to assure enhanced farm productivity, ensure food security, and improve the livelihood of smallholder farmers, especially in South Africa, which is known as a semi-arid (water-scarce) country (Kibue et al., 2015; Adetoro et al., 2020).

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Climate change and extreme environmental changes also shoddily affect the soil fertility, soil moisture, underground water level, yellow rust, agriculture productivity due to which farmers are shifting from agricultural business to non-agriculture activities. Climate change has adverse social, economic, and environmental impacts that create serious challenges for Pakistan's economy. Climate change is significantly affecting all economic sectors, while agriculture has unique severity issues (Abbas et al., 2022). Extreme climate events cause floods, droughts, evaporation, and water shortage problems in Pakistan. According to Abid et al. (2016), there are a number of farm-level restrictions that make it more difficult for farmers to adapt, which in turn affects how they behave when faced with climate risk. At the farm level, different strategies are used to adapt, such as crop diversification, using new crop types, changing planting dates, changing fertilizers and pesticides, water storage techniques, sowing techniques, and input mix approaches (Abid et al., 2016; Fahad & Wang, 2018). Ali and Erenstein (2017) looked at how farmers choose different ways to adapt, such as planting at different times, planting drought-resistant crops, and planting different kinds of crops.

There is evidence that the reduction in Pakistan's agricultural export trade may be mostly caused by climate change. According to the empirical work, the decline in farm export trade resulting from the negative correlation between exports of agricultural products and CO2 emissions has a direct effect on Pakistan's economy (Khan et al., 2019). According to theoretical and empirical findings, the adoption of clean and green energies and technologies is believed to be the key to reducing pollution in Pakistan. The finding is heterogeneous because, overall, the effects of carbon dioxide emissions on farm export commerce are stronger in the long run. The Pakistani government should consider taking steps to enhance the agriculture industry and enact new regulations to cut carbon dioxide emissions (Ahsan et al., 2020). The long-term coefficients of CO2 emissions, energy use, cultivated area, and labor force all help the production of cereal crops. The data also show that CO2 emissions, cultivated land, and cereal crop yield are all linked in both directions. Energy use causes cereal crop output in a unidirectional manner (Shahbaz & Boz, 2022). The data showed that altering fertilizer was the most popular climate change mitigation approach. Diversification, soil and water conservation, and current input usage techniques explain the technical efficiency gap among farmers, according to stochastic frontier analysis (Abbas et al., 2022).

According to Sohai et al. (2022) and Syed et al. (2022), rain-fed agriculture, which depends on regular weather patterns, provides 60% of Pakistan's food needs directly or indirectly. Climate change has an impact on Pakistani agriculture, and those effects appear to be getting worse every day. Climate change has an impact on Pakistan's wheat, rice, cotton, sugarcane, and maize crops. Constant global warming is altering precipitation patterns, including a change in our monsoon season (Abid et al., 2019). These circumstances have an impact on farm livelihoods, agricultural production, and agribusiness infrastructure, which results in food insecurity and malnutrition in farming communities. In order to provide resilient agricultural practices that ensure family food security, this analysis aims to emphasize the implications of climate change on Pakistan's agricultural industry, current threats, and prospective mitigating measures (Imran et al., 2020). Climate change is crucial in developing nations like Pakistan since it has an impact on people's livelihoods (Dang et al., 2019). There are various obstacles to climate change in this regard, including awareness, strong altruistic ideals, optimistic attitudes, powerful environmental convictions, family businesses, and social conventions (Winn et al., 2011; Hutchinson et al., 2015; Masud et al., 2017; Doluca et al., 2018). Training programs and thorough environmental education are the more effective regulatory frameworks to address the mismatch between the drive for change and resistance. This gap exists between small venture environments and behaviors (Tilley, 1999).

**Table 1: Adaptation Measures by Different Countries to meet Challenges of Climate Change**

| Country | Adaptation | Description |
|---|---|---|
| USA | Preparedness knowledge of climate-related devastations and planning magnitude of activities are base of climate change adaptation. | The results of the entire study showed that California has an enormous ability to handle climate change concerns. California has a high degree of adaptability to new climate change trends. Climate change adaptation is based on knowledge about climate-related devastations, the ability to evaluate such information into accurate management, and the planning of the scope of activities (Moser and Luers, 2008). |
| Scotland | This study helps come up with a way to choose land-based strategies to cut greenhouse gas emissions based on the area. The fundamental criterion was the "complete" mitigation capacity of each measure. | The most successful mitigation strategy that generated the greatest "whole" mitigation output was the forest plantation with Sitka spruces. Many obstacles, including those relating to the economy, society, demography, politics, and institutions, have prevented the region from adopting mitigating measures. Because of this, a measure's acquired mitigation potential may be less than its "full" mitigation potential (Feliciano et al., 2013). |
| China | The rapid expansion of urban transportation systems was the study's primary concern. | The primary contributors to GHG emissions are the rate of motorization and the design of transportation. Policies directing the expansion of the transport infrastructure are urgently needed, particularly in the eastern regions (Hao et al., 2014). |
| Tanzania | The current analysis is focused on the contribution made by regional environmental organisations to Tanzania's efforts to combat climate change. | The study's premise is that conventional farming could be put at risk by adjustments made to address climate change. The complex political system and social justice issues, which hinder adaptation to climate change, were to blame. According to recommendations made by international institutions involved in academia, development, and policy making, a depoliticized hierarchy and technocratic vision can aid in improving adaptation patterns (Smucker et al., 2015). |
| Mexico | Climate change is a major factor in migration, according to studies that concentrated on rural areas as opposed to metropolitan ones. Lack of concentration caused urbanization to become a burden. | Increased precipitation and sowing temperatures throughout the study period were found to have contributed to an increase in global migration. The study demonstrates that mercury, but not precipitation, affects international migration patterns through creating jobs in the agricultural sector. Expanding urbanization can inhibit this type of migration (Nawrotzki et al., 2015). |
| England | The more a topic is stressed, the less attention is paid to climate change, which ought to be a focus of policy. | The policy is built on three things: substantive authority, substantive knowledge, and institutional order. The study was conducted to examine policy adaptation initiatives in England and determine whether or not those initiatives may be used as policy fields (Massey & Huitema, 2016). |
| France | The study demonstrated that transportation networks are essential to both economic and social development, demonstrating their significance for coping with climate change. | The author recommended a thorough examination of all factors (technical or regulatory) that must be changed in order to modify the building of transportation infrastructure and its relationship to current climatic trends. To reduce the future consequences of altered temperature and weather conditions on transportation, a framework for risk assessment must be created (Colin, Palhol, & Leuxe, 2016). |
| Ghana | Adaptation to climate change has changed rural farming, according to a study. | The results of the study demonstrate that rising temperatures caused by climate change and changing weather patterns have had a substantial impact on rural farming communities, which are already dealing with the difficulties of mechanization (Cobbinah & Anane, 2016). |
| USA | According to the study, identifying issues and coming up with workable solutions is a good strategy for evaluating the effects of local climate change. | The results indicate that strategies based on many data sources are needed to assess the effects of climate change in the future. The data also demonstrates that the planning department's plans were more effective in terms of quality. The findings offer crucial understanding for those working to improve climate adaptation strategies and measure them region-by-region (Woodruff & Stults, 2016). |
| Malaysia | The limitations of adaptation and how socioeconomic factors affect adaption measures in Malaysia were discussed in this essay. | The research revealed that underlying characteristics with significant effects on adaption measures include age, educational attainment, farm income, agrarian competence, less frequent access to agricultural extensions, credit availability limits, access to agricultural markets, and farm size (Masud et al., 2017). |
| UK | Storms have been frequent in the UK this winter (2013–2014). This led to a significant flood wave and received extensive media notice. | A study found that the flood and its effects on human health made people more vulnerable to climate change and made them more conscious of the hazards that climate change poses to them personally. Direct exposure to flooding can lead to serious mental illnesses and more support for the government. Moreover, personal climate change adaptations are progressing (Demski et al., 2017). |
| Pakistan | A national and sectoral inventory of Pakistan's green house gas emissions has been developed as part of the study. | According to a thorough analysis of GHG emissions, emissions have increased by 4 percent over the past 20 years and are projected to rise rapidly in order to achieve the country's development objectives. Notwithstanding the fact that they will still be modest relative to global average, per-person emissions (Mir et al., 2017). |
| Korea | In order to test the model's functionality, a demonstration was held at the emissions disaster facility in Seoul, the capital of Korea. | To evaluate the performance and volatility of the technical and economic model The effects of climate change on urban areas were examined using several factors. The model has adaptable managerial features for long-term infrastructure development and administration in metropolitan settings (Kim et al., 2017). |
| China | This research examined at the connection between structural transformation and emissions related to waste. | According to the study, modern, technologically advanced industrial structures can cut polluting emissions, but they can only be used in stringent regulatory environments (Wang et al., 2018). |
| Sweden | The current study brought up the subject of unconventional business practices in Sweden's forestry industry. As a preventative measure, this will result in the planting of new trees that will grow and live for up to 90 years. | According to the study, we need to have regulated adaptation, which should be constrained by national institutions and social systems rather than the system's logical drivers. Techniques for coping with climate change should be based on social and environmental goals. The type of effort necessary to take adaptation measures into consideration is defined by social and environmental factors (Andersson & Keskitalo, 2018). |
| Australia | In this study, urban heat islands (UHI) were highlighted, and their effects on thermal comfort as well as their efficiency and efficacy as green and cool roofs were examined. | This study demonstrated that the initial moisture in the soil for green roofs had no bearing on UHI. As a result, cool roofs and green roofs both increase human thermal comfort by lowering the Universal Thermal Comfort Index for pedestrians and roof surface levels, respectively (Imran et al., 2018). |

**Source: Author's Own**

# 3. Methodology

## 3.1. Factor Analysis

Parallel to the cluster analysis group's related cases, factor analysis involves similar dimensions. This process is used to identify latent variables or constructs that directs for indexing and further analysis. The goal of factor analysis is to condense several independent variables into a small number of dimensions (Ruane et al., 2013; Stedman, 2004). Data can be made simpler via factor analysis, such as through lowering the number of variables in regression models. After extraction, factors are rotated typically alternated. There are various rotation techniques for factors, some of which guarantee that the factors are orthogonal (i.e., uncorrelated), removing the issue of multicollinearity in regression analysis (Gujarati, 2012; McDonald, 1985; Yong & Pearce, 2013). Scale construction is also checked using factor analysis. The components of each dimension in these applications are given up front (Gujarati, 2012). Confirmatory factor analysis is the name given to this type of factor analysis, which is most frequently utilized in relation to structural equation modeling (Engel, et al., 2014; Kim & Mueller, 1978). For instance, if a researcher wants to verify the factor structure of the Big Five personality traits using the Big Five Inventory, a confirmatory factor analysis could be carried out. Indicators can also be created using factor analysis. Just adding up all of the index's components is the most typical technique to build an index. However, some of the index's constituent factors might have more explanatory value than others. A factor analysis could be used to defend removing items to make surveys shorter (Engel et al., 2014; Hassan & Nhemachena, 2008).

In order to create a questionnaire to measure an underlying variable, to understand the structure of a set of variables, and to reduce a data set to a more manageable size while preserving as much of the original information as possible, the factor analysis technique is important (Engel et al., 2014). The factor analysis an also express in mathematical form and factor analysis is working in the basis of VAR model and specify the set of equations in matrix form(Gujarati, 2012). The equation below is used to describing a linear model and further can applied to built the scenario of describing a factor. In this equation there is no intercept, the reason being that the lines intersect at zero(Gujarati, 2012). The *B'*s in the equation represent the factor loadings.

$$Y_i = \beta_1 X_{1i} + \beta_2 X_{2i} + \dots\dots\dots + \beta_n X_{ni} + \varepsilon_i$$

$$Factor_i = \beta_1 Variable_{1i} + \beta_2 Variable_{2i} + \dots\dots\dots + \beta_n Variable_{ni} + \varepsilon_i$$

## 3.2. Factor analysis through Principal Component Analysis (PCA)

The communality estimations utilized in PCA strategies is varying. To put it simply, PCA only divides the original data into a collection of linear variations, whereas factor analysis creates a mathematical model from which factors are estimated. Due to this, only factor analysis can estimate the underlying factors, and the accuracy of these estimates depends on a number of assumptions (Wold, Esbensen, & Geladi, 1987). Determine which linear components are present in the data and how a specific variable may contribute to those components are the main things that principal component analysis is concerned with. Principal component analysis is a method with a strong psychometric foundation, it is theoretically simpler than factor analysis, and it has several features in common with discriminate analysis (Cai et al., 2011; Uddin et al., 2019).

## 3.3. Factor extraction: Eigenvalues and the Scree plot

Not all factors are included in analyses, and the standard for determining whether a factor is statistically significant is up for disagreement. The Eigenvalues associated with vitiate indicate the substantive importance of that factor. Therefore, it is logical that researcher should maintain only factors with large Eigenvalues. Through Eigenvalues the graph is constructed which is known as a Scree plot. It is it looks like a rock face with a pile of debris, or scree, at the bottom. The magnitude of the Eigenvalues explains the relative importance of factor under consideration and also shapes the graph. Imagine drawing a straight line those summaries the vertical portion of the plot and another that summarizes the horizontal portion, then the point of inflexion is the data point at which these two lines meet, at this point, the slope of the line changes considerably.

## 3.4. Data framework

The study is focused on the formers perception about climate change and their satisfaction about adoptive measures in Punjab, Pakistan. The primary questionnaire based data is collected from 36 districts of Punjab and 10 respondents are selected from each district of Punjab. The survey is conduct through multistage sampling and respondents are selected through convenient sampling technique. The districts included in the analysis are Chakwal, Muzaffargarh, Hafizabad, Rawalpindi, Jhelum, Attock, Sargodha, Jhang, Layyah, Khushab, Okara, Mianwali, Sheikhupura, Bahawalpur, Bahawalnagar, Rahim Yar Khan, Sialkot, Gujrat, Narowal, Khanewal, Faisalabad, Mandi Bahuddin, Chiniot, Bhakkar, D.G.Khan, Rajanpur, Multan, Lodhraan, Vehari, T.T.Singh, Gujranwala, Lahore, Kasur, Sahiwal, Pakpattan and Nankana Sahib.

## 3.5. Sampling Framework

In Punjab, there are 5,249,800 agriculture farms and located the 36 districts (Census of agriculture 2016-17). The targeted population is farm manager and we considered the 5,249,800 to farms as agriculture farmer's population. The rationale of unbiased selection of agriculture farms is to get the climatic impact on each farm in all 36 districts of Punjab Pakistan. In order to get the true outcome and farmer's perception and satisfaction about climatic challenges in Punjab, we gave the equal importance and selected the 10 responses from each district. This research adopted snowball sampling technique to collect the data from the respondents. The determined sample size is representative sample from the agriculture farm managers, which is calculated according to the [67] sample calculator. This study took 0.06 percent precision level with 94 percent confidence interval.

$$n = \frac{N}{1 + N(e)^2}$$

Where n is sample size and N is size of population and precision level are denoted by (N) and (e) respectively. Based on study objectives, rigorous literature review has been performed to identify the problem-relevant variables for said study and to finally incorporate those in the form of askable statements in the questionnaire. Keeping in view the study area's specific agro-climatic conditions, we pre-tested our designed questionnaire by conducting pilot survey of 10 percent of total sample size via interviewing one farmer from each district i.e., 36 farmers in total. Contingent-on our field insights we got from interviewing these 36 farmers, we rectified our questionnaire by excluding the irrelevant questions and including the most relevant ones in our questionnaire. Furthermore, we have also interviewed the progressive farmers from targeted communities as well as field experts from local agriculture department to further validate our designed questionnaire. Lastly, the farmers interviewed during the process of pre-testing and the progressive farmers were not been included in our final sample of 360 farmers.

# 4. Empirical Results

## 4.1. Summary Statistics

The results of summary statistics are given in table 3 (See Appendix A), the research instruments includes three demographic factors and, ten factors are demonstrated the farmer satisfaction with climate adaptation policy, while fifteen instruments are addressing the farmers' perceptions about climatic vulnerability. The data is collected based on survey questionnaire from province of Punjab Pakistan and 10 questionnaire were filed through interview from farmers. The data has been collected from small and large farmers of Punjab. The major statistics used to summarize the structure of data are mean, standard deviation, maximum and minimum.

The findings from descriptive statistics show that the respondent average age is 44 years old; this indicates that the majority of the survey is made up of seasoned farmers who are knowledgeable about the farming business and the requirements of suitable weather for agricultural output. The survey is divided into large-scale and small farmers since the average size of a farmer's land holding is 29 acres. The perception of climate change among farmers is examined through 15 questions. All questions have a minimum value of 1 and a maximum value of 5, with the exception of question 4. A maximum score of 4 indicates that no farmer strongly disagrees with the statement that a 'lack of precipitation is seriously affects crops" and that it is a significant contributor to climate change. In a similar vein, 10 questions were posed on the adoption of policies, and the mean values of these questions are typically larger than 3, indicating that farmers have little knowledge of climate change policy and the adoption of policies.

## 4.2. Frequency Statistic Regarding Farmer Perception about Climate Change

The analysis results of frequency graphs are given in Appendix A1. Using frequency statistics, it is determined from the sample size of 360 respondents that 42% of respondents strongly agree that "the agriculture sector is particularly sensitive to climate change." Moreover, 45% of respondents agreed with the assertion, indicating that 87 percent of farmers concur that climate change has made agriculture more susceptible to the current heat wave. Nonetheless, 8% of respondents gave a neutral reaction, and 5% disagreed with the claim that agricultural productivity is vulnerable to climate change. In answer to the question about farmers' perceptions of the vulnerability of the agricultural industry, 24 percent of respondents strongly agreed, 48 percent agreed, and overall 72 percent of farmers in the Punjab region believe that per hectare yield has been declining over the past five years. This is a concerning issue because Pakistan's economy depends heavily on agriculture, which is also greatly impacted by climate change. Despite this, 12 percent of farmers disagreed with the decline in per-hector yield, while 16 percent of respondents were ambivalent. Temperature increases and a lack of precipitation (rainfall) have a significant negative impact on agricultural productivity and generate vulnerable conditions. Around 85% of farmers concur that a rise in temperature and a lack of rain have a significant influence on agricultural output. Farmers are paying close attention to how Pakistan's economy is performing overall as a result of Pakistan's high temperatures and limited rainfall, which negatively affect crop production. The entire economics of the agriculture sector have shifted as a result of altering rainfall patterns. Even the most productive crops did not produce the anticipated outcome. Variety that can withstand drought is necessary.

Temperature variations throughout the day and night are causing inefficiency in the agricultural sector and aggravating the issue of lower output. 60% of farmers concur that low nighttime temperatures pose a significant output issue for agriculture. Nonetheless, 27 percent of people have a neutral opinion about temperature variations at night. The temperature at night also has an impact on the pattern of sowing and harvesting. More than 70% of respondents agreed that the sowing and harvesting times are to blame for Pakistan's agricultural sector's lower productivity, which is a closer response to the question of when to sow and when to harvest. In order to foresee the new sowing and harvesting patterns and new crop varieties, farmers need assistance from the government, policy experts, research institutes, and non-governmental organizations (NGOs). This would help them manage the situation and increase agricultural output. Not only in the manufacturing sector but also in the agricultural sector, new product varieties gain a significant share of the market. The crop varieties in Pakistan's agriculture industry are not effective enough to combat climate change and gain a significant market share in both domestic and foreign markets. According to the response about crop varieties, 55% of farmers are dissatisfied with the current crop varieties and seek climate-defying varieties. While 34% of respondents gave mixed responses regarding the crop varieties now in use, this indicates that farmers are unconcerned about new, climate-resilient crop varieties due to a lack of information about their efficacy.

Agricultural extension services are essential for informing and educating farmers about climatic change, new crop varieties, environmental changes, and use of advanced technologies. According to the farmers' responses, 42 percent of respondents believe that extension services are very responsible for responding to the negative effects of climate change. Even though, 31 percent respondents are unclear about the purpose of extension services and they don't think they have any substantial impact. Nevertheless, 27% of respondents dispute the negative impact of extension services. Vulnerability to climate change of women farmer's is also requested from respondents, 40 percent are agreed and 35 percent are neutral and 25 percent are disagree. Women farmers are also vulnerable to the effects of climate change, and 40% of respondents agree that this is the case. Farmers are currently attempting to implement the field level measure on their own. 48 percent of respondents agree with the adaption measure, 32 percent disagree, and 20 percent are unsure. Generally speaking, farmers are not implementing field-level climate change mitigation strategies.

In Pakistan, the allocation of land is not uniform; a considerable portion of it is farmed, while a smaller portion is farmed by many farmers. A question on the vulnerability of small farmers was also posed to the respondents, and 68 percent of them agreed with the statement, while 19 percent gave a neutral response and

14 percent disagreed. Due to the low number of dams and water storage capacity in Punjab, thousands of acres of planted crops are annually damaged by flood, which results in lower productivity. According to the responses to the question about whether or not extreme events cause numerous problems at the farm, 58 percent of respondents disagree with this assertion. This demonstrates how the issue of decreased agricultural productivity is being brought on by extreme events. Yet, 30% of respondents believe that there is no issue at the farm level as a result of catastrophic events. The soil fertility is also negatively impacted by significant environmental change and climate change. Temperature increases affect the soil's fertility, ability to retain water, and ability to withstand harsh occurrences. Farmers disagreed vehemently with the notion that there would be "no detrimental influence on the fertility of the soil"—61 percent of them were in favor of it. Nonetheless, 27% of respondents agreed with this assertion, and 12% responded neutrally when asked about the detrimental effect on soil fertility. Since the previous two decades, the effects of climate change have significantly reduced agricultural productivity, and more people are turning their backs on farming. Pakistan's economy is based on its agricultural industry. Since a few years ago, farmer migration out of the agricultural sector has significantly decreased productivity and decreased Pakistan's share of global GDP. One question regarding migration from the farming industry was included in the questionnaire. Among the respondents, 54 percent agreed that people are leaving the industry, 26 percent gave a neutral response, and 19 percent disagreed. The government needs to do more to support farmers and provide incentives to keep people in the farming industry.

**4.3. Factor Analysis of Farmer Perception at Field Level**

Factor analysis is used to examine the variance for each factor. The higher the variance of any factor will explains the variability of that factor in data. The most important factors can extract through analyzing the principal components analysis method of extraction. The Principle component analysis highlights the important factors with variance (eigenvalue) greater than a certain value. Similarly, to visually evaluate the eigenvalues on the scree plot can also determine the variance plot.

Factor analysis is an estimating approach used to evaluate the validity of a questionnaire and identify the factors that are most relevant and crucial for use in current and future research. The factor analysis method is additionally used to ensure the accuracy of estimated outcomes. In this case, a correlation matrix is created to look at the specific relationships between the variables. According to statistics, the correlation matrix reveals how strongly or weakly related several instruments are to one another. Also, we use a correlation matrix to find the multicollnearity issue. The findings of the correlation coefficient demonstrate that the calculated variables have only weak association (correlation among most of the estimated variables is less than 20 percent expect few ones). Sowing time factor and harvesting time factor have a strong, positive, 45 percent association. The correlation coefficient between the two variables "increase in temperature is greatly impacting the crops" and "lack of precipitation is seriously affecting crops" is approximately 43%. The correlation coefficient between the statements "there is no adverse effect on the fertility of the soil" and "extreme events are not causing the numerous difficulties at the farm" is also 50%. In addition, a small number of the list's variables have minor but negative correlations with one another. In table Appendix A2, the estimated findings are presented.

**4.4. Principal component analysis (PCA)**

The important part for factor analysis is to *reduce* the large number of variables that describe a complex concept. The factor analysis highlights the few interpretable latent variables that are extremely needed for focus. In addition, the factor analysis point out a smaller number of interpretable and key factors that explain the maximum amount variability in the data. The component analysis is proceeding through orthogonal rotation (varimax) on 15 factors. The estimated value of Kaiser Meyer Olkin (KMO) is 0.595, which is confirmation of the adequacy of sample size and sampling. If estimated value of KMO is greater than 50 percent we consider the acceptable range of sample size for further analysis. (Field, 2012). Calculated value of Bartlett's Test of Sphericity is high and significant; the Bartlett's Test value shows that correlation between variables is sufficiently larger principal component analysis. Initially, the PCA perform and obtain the Eigenvalues for selection factors from the list. The Eigenvalue of 6 components has greater than Kaiser's criterion value and jointly explain the variance by 59.74 percent. The estimates results of total variance are given in table 2.

**Table 2: Total Explained Variance**

| Kaiser-Meyer-Olkin Measure of Sampling Adequacy. | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | .595 | | | | | | | | |
| Bartlett's Test of Sphericity | 619.689 (0.000) | | | | | | | | |
| **Total Variance Explained** | | | | | | | | | |
| Component | Initial Eigenvalues | | | Extraction Sums of Squared Loadings | | | Rotation Sums of Squared Loadings | | |
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 2.201 | 14.674 | 14.674 | 2.201 | 14.674 | 14.674 | 1.802 | 12.012 | 12.012 |
| 2 | 1.900 | 12.667 | 27.340 | 1.900 | 12.667 | 27.340 | 1.720 | 11.468 | 23.480 |
| 3 | 1.464 | 9.763 | 37.103 | 1.464 | 9.763 | 37.103 | 1.578 | 10.523 | 34.003 |
| 4 | 1.302 | 8.682 | 45.786 | 1.302 | 8.682 | 45.786 | 1.339 | 8.927 | 42.931 |
| 5 | 1.090 | 7.268 | 53.053 | 1.090 | 7.268 | 53.053 | 1.316 | 8.770 | 51.701 |
| 6 | 1.004 | 6.694 | 59.748 | 1.004 | 6.694 | 59.748 | 1.207 | 8.047 | 59.748 |
| 7 | .959 | 6.393 | 66.141 | | | | | | |
| 8 | .878 | 5.854 | 71.994 | | | | | | |
| 9 | .856 | 5.709 | 77.704 | | | | | | |
| 10 | .691 | 4.604 | 82.308 | | | | | | |
| 11 | .643 | 4.284 | 86.592 | | | | | | |
| 12 | .593 | 3.954 | 90.547 | | | | | | |
| 13 | .525 | 3.499 | 94.046 | | | | | | |
| 14 | .471 | 3.141 | 97.186 | | | | | | |
| 15 | .422 | 2.814 | 100.000 | | | | | | |
| Extraction Method: Principal Component Analysis. | | | | | | | | | |

Source: Author Calculation

In similar line, the Scree plot is also provides the trending graph of Eigenvalues of selected components like Principal Component Analysis (given in appendix A3). The criterion for selection of components in case of Scree plot is same as the princimpe component analysis the scree plot suggests how much factors due to the way the slope levels off twice. The scree plot also shows the 6 components that are higher than one and slope of graph is twice. The Principal Component Analysis extracted six important factors that are highly valuable from the fifteen variables. The component 4, 6, 3, 1, 5, and 7 are important fundamental for policy aspect. The most important factor is component 4 which is "Farmer's perception about lack of rainfall affecting crops" that needs for policy development and key intention. Similarly the other important factors are 'Farmer's perception about sowing time of crops changing, Farmer's perception about increase temperature affecting crops, Farmer's perception about agriculture vulnerability to CC, Farmer's perception about the change in night temperature challenge, and Farmer's perception about harvesting time of crops changing.

Factor rotation simplifies the loading structure and makes the factors that more clearly distinguishable and easier to interpret (graph is given in Appendix A4, A5). The rotation matrix also highlights the six most important factors that are workable and important to interpret. In rotational matrix we adopt the most interpretable results. Similar line, the rotated matrix also sort the rotated loadings to more clearly assess the loadings within a factor. In our estimate, the rotated factor matrix shows that component 3, 4, 1, and 5 are important and interpretable. In factor, 'Farmer's perception about increase temperature affecting crops (0.785)', 'Farmer's perception about lack of rainfall affecting crops (0.680)', 'Farmer's perception about agriculture vulnerability to CC (0.583)','Farmer's perception about the change in night temperature challenge (0.400)' have large positive loadings on factor 1, so this factor describes the farmer's perception the climate change and productivity growth in agriculture sector. In component 1 factor 15 shows farmer negative perception about climate change and agriculture productivity. The component 2 shows that factor 4, 5, 6, 7, and 8 are positively describing the farmer perception about climate change and agriculture productivity. While the component 2 indicates that factor 11 highlights the negative perception of farmer about climate change.

**4.5. Frequency Results of Farmer's Satisfaction about Adoption Policy**

It is widely acknowledged that selecting the best policy at the appropriate time helps to increase economic stability and productivity. The formulation of policy is not a fundamental issue; rather, the adoption of the proper policy and its implementation is of paramount importance to every economy. This study's second questionnaire focused on Punjab's policy measures, the adoption of such measures, and the role of the government. Ten questions on a Likert scale were used to gauge how satisfied farmers were with government initiatives. The frequency table reveals that, on average, farmers are dissatisfied with the adoption strategies and policy initiatives related to climate change. The Punjabi government is accountable and has a big role in educating farmers about climate change. 35 percent of farmers in Punjab are satisfied with the government's response to the impact of climate change, while 31 percent are dissatisfied. Moreover, 34% of farmers are responding neutrally, demonstrating that they are not aware of any government policies concerning climate change (the frequency graphs are given in Appendix B1).

The farmer level of satisfaction relevant to institutional structure in Punjab is investigated through asking a question "climate resilient institutional structure in Punjab', there are 38 percent farmers are disagree with this statement and 34 percent are respond neutrally. There is 28 percent respondent whose are satisfied on the working institutional structure Punjab. The farmers are remained silent on the issue which may give an idea that they are unaware of any such institution. In similar line, the question about government laws and regulation related to climate change also asked from the respondents. 49.5 percent respondent are dissatisfied on the government laws and regulation about climate change even though 288 percent respond neutrally and they are unaware about law and regulation. There are only 22 percent farmers are satisfied on government policies regarding climate change and implementation of such policies. It is highly needed to activate the functioning of ministry of climate change, its laws, facilitations and policy implementation as well as provides awareness to the farmers. On question about the performance of research institutions, 29 percent showed that they are satisfied with the performance of research institutions like PARC, NARC and Ayub research institution. However, overall 45 percent farmers are dissatisfied on the performance of research institutions and there functioning in Punjab. Research institute in any country plays important role to facilitate and provide knowledge regarding any event in the economy. The government needed to increase the research facilities in Punjab also functionalized the agriculture research institutes for protection of agriculture productivity from climate change.

The question about 'facility of weather or disaster alert mechanism' asked from respondents. There are 48 percent claimed that facility of weather and disaster alter mechanism is quite satisfactory. The institutions like NDMA are working good to inform farmers and be alert about weather condition and disaster. But 30 percent showed dissatisfaction which means that the overall performance of NDMA needs further improvement. On the question regarding climate resilient efforts of NGO's, there are 21 agreed that they are satisfied with the performance of NGOs working in their areas to control climate change impacts but 41 reported dissatisfaction which means that NGOs failed to make any significant impact at field level agriculture productivity. In addition, 38 percent respondents are unaware about the functioning of NGO's in Punjab province. The role of international climate change organizations is also investigated through asking a question 'initiatives and interventions of international organizations'. In this regard, 27 percent respondents are satisfied on the functioning of international organizations related to climate change while 44 percent farmer's are dissatisfy because they don't think that interventions international organization is helpful to protect the agriculture productivity from climate change.

In Pakistan, farmers are very helpful for each other and farmers have strong connectivity with each other at community level. If there is any uncertainty in any community farmer are ready to intervene and help the others. There are 35 percent respondents agreed to think that community level interventions are satisfactory. 37 percent claimed that they are dissatisfied with the interventions done at community level. 28 percent of the farmers showed neutral response. The government needs to work at community level so that any kind of disaster situation can be catered properly. In addition, 23 percent of famers think that climate related funds are available and they are satisfied with them. But 58 percent of farmers showed dissatisfaction on availability of funds to deal with climate change. They think that government needs to work on it and increase allocation of funds to deal with climate change challenges. Similar line, the performance of public private partnership is quite satisfactory for 21 percent for respondents. 31 percent reported that they are not aware of any impact of those public private partnerships on climate change. But 48 percent of farmers showed dissatisfaction which means that PPP adaptations for climate change are not satisfactory to many.

### 4.6. Factor Analysis of farmer satisfaction level regarding policies and institutional set-up

Factor analysis about farmer's satisfaction level regarding policies and institutional reforms is done in this part. The correlation coefficient results shows that there is weak correlation among estimated variables (correlation among most of the estimated variables is less than 50 percent expect few ones). The correlation among Punjab government response to climate change and climate resilient institutional structures in Punjab is high, which is about 54 percent. The correlation coefficient of "Public Private Partnership moves for adaptation to climate change" and "initiative and interventions of international organizations" are highly correlated and correlation is about 44.4 percent. Similarly the correlation coefficient of "climate resilient institutional structures in Punjab" and "suitable laws and regulation related to climate change" is correlated with each other at 48 percent. The lowest correlation observed in variables is 9 percent (the results are given in appendix B2).

### 4.7. Principal Component Analysis (PCA)

Factor analysis point out a smaller number of interpretable and key factors that explain the maximum amount variability in the data. The component analysis is proceeding through orthogonal rotation (varimax) on 10 factors. The estimated value of Kaiser Meyer Olkin (KMO) is 0.815, which is confirmation of the adequacy of sample size and sampling. If estimated value of KMO is greater than 50 percent we consider the acceptable range of sample size for further analysis. (Field, 2012). Calculated value of Bartlett's Test of Sphericity is high and significant; the Bartlett's Test value shows that correlation between variables is sufficiently larger principal component analysis. Initially, the PCA perform and obtain the Eigenvalues for selection factors from the list. The Eigenvalue of 3 components has greater than Kaiser's criterion value and jointly explain the variance by 57.077 percent. The estimates results of total variance are given in table 3.

**Table 3: Total Explained Variance**

| Kaiser-Meyer-Olkin Measure of Sampling Adequacy. | .815 |
|---|---|
| Bartlett's Test of Sphericity | 788.469<br>(0.000) |

**Total Variance Explained**

| Component | Initial Eigenvalues | | | Extraction Sums of Squared Loadings | | | Rotation Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|---|---|---|
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 3.437 | 34.373 | 34.373 | 3.437 | 34.373 | 34.373 | 2.310 | 23.104 | 23.104 |
| 2 | 1.199 | 11.993 | 46.366 | 1.199 | 11.993 | 46.366 | 2.194 | 21.940 | 45.044 |
| 3 | 1.071 | 10.711 | 57.077 | 1.071 | 10.711 | 57.077 | 1.203 | 12.033 | 57.077 |
| 4 | .906 | 9.063 | 66.140 | | | | | | |
| 5 | .742 | 7.415 | 73.556 | | | | | | |
| 6 | .713 | 7.133 | 80.688 | | | | | | |
| 7 | .617 | 6.171 | 86.859 | | | | | | |
| 8 | .490 | 4.903 | 91.761 | | | | | | |
| 9 | .432 | 4.323 | 96.085 | | | | | | |
| 10 | .392 | 3.915 | 100.000 | | | | | | |
| Extraction Method: Principal Component Analysis. | | | | | | | | | |

Source: Author Calculation

Scree plot is also provides the trending graph of Eigenvalues of selected components like Principal Component Analysis (as plot given in appendix B3). The criterion for selection of components in case of Scree plot is same as the Principal Component Analysis. The scree plot suggests how much factors due to the way the slope levels off twice. The scree plot also shows the 3 components that are higher than one and slope of graph is twice.

The Principal Component Analysis extracted six important factors that are highly valuable from the fifteen variables. Factor rotation simplifies the loading structure and makes the factors that more clearly distinguishable and easier to interpret (the rotation factors results are given in appendix B4 & B5). The rotation matrix also highlights the six most important factors that are workable and important to interpret. In rotational matrix we adopt the most interpretable results. Similar line, the rotated matrix also sort the rotated loadings to more clearly assess the loadings within a factor. The component 10, 7, 6, 9, 8, and 2 are important fundamental for policy aspect. The most important factor is component 10 which is "Level of Satisfaction about public private partnership (PPP) for Climate Change adaptation" (0.752)'. Similarly the other important factors are Level of Satisfaction about initiatives & intervention of international organizations(0.749)', Level of Satisfaction about climate resilient efforts of NGOs (0.677)', Level of Satisfaction about availability of climate related funds (0.597)', Level of Satisfaction about community level interventions (0.423)', and Level of satisfaction about climate resilient institutional structure in Punjab (0.270)'.

Climatic changes are required to have wide-running effects on Pakistan, influencing rural efficiency, water accessibility and expanded recurrence of extreme climatic occasions. Mean Temperature rise and environmental change will affect the planning and quality of rainstorm precipitation. From the data analysis it is concluded that climate change effect the increased vulnerability of agriculture and reduce the per hectare yield over the time. Variation in temperature (even variations in day and night temperature), changing pattern in precipitation (rainfall), mutable sowing and harvesting time creates alarming situation for agriculture productivity in Punjab Pakistan. Farmers are keenly observing that high temperature and changing pattern of rainfall has negative impact on crops production and reduce the overall agriculture performance of economy of Pakistan. Most of the farmers are not happy with existing seed varieties and demanding heat resistant and drought resistant varieties. Whereas remaining showed neutral respond regarding existing crop varieties, so due to lack of knowledge about efficiency of new varieties farmers are not concern about new climate resilient varieties. The results concluded that farmers are not adopting the field level measures related climate change. Even though, agriculture extension services are fails to perform their role to educate the farmers about the vulnerability of climate change for agriculture output. Climate change and extreme environmental changes also shoddily affect the soil fertility, soil moisture, underground water level, yellow rust, agriculture productivity due to which farmers are shifting from agricultural business. The results show that small farmers are more vulnerable to climate change over large farmers.

It is commonly admitted that choice of right policy at right time leads to boost the economic stability and high production. The development of policy is not a basic problem, implementation of policy and adoption of right policy is major concern for every economy. From results it is determined that the farmers are not satisfied regarding policy measures and adoption techniques regarding climate change. Farmers are not satisfied (even unaware) about government and climate resilient institutional structure in Punjab and their responsibility to educate the farmers about vulnerability of climate change. Famers are not satisfied regarding government laws and regulation (government policies) about climate change and implementation of such policies. Farmers are dissatisfied about performance and functioning of Research Institutions and NGOs in Punjab who failed to make any significant impact at field level agriculture productivity while respondent claimed that facility of weather and disaster alters mechanism is quite satisfactory. Furthermore, farmers are not satisfied about initiatives and interventions of international organizations and show that such organizations are not helpful to protect the agriculture output from climate change. If there is any uncertainty in any community farmer are ready to intervene and help the others but community level intervention is not much satisfactory. The farmers are dissatisfied about climate resilient funds and performance of public private partnership to protect from climate change.

The Principal Component Analysis extracted six important factors that are highly valuable among fifteen factors about farmer's perception regarding climate change. The most important component is "Farmer's perception about lack of rainfall affecting crops" that needs for policy development and key intention. Similarly, other important factors are "Farmer's perception about sowing and harvesting time of crops changing", Farmer's perception about increase overall temperature and especially night temperature affects agri-crops", and finally, the Farmer's perception about agriculture vulnerability to Climate Change. Such instruments required fundamental consideration for policy purpose and address to protect the agriculture output from climate change. The factor analysis regarding farmer perception about performance of Punjab government showed that there is weak correlation among estimated variables. The principal component analyses dig out three tectonic factors for policy address. The public and private partnerships (PPPs) for climate change are important measures to adopt and implementation. In addition, the other key factors are enhance the role of NGOs, initiatives & intervention of international organizations, improvement in the role of climate resilient institutional structure in Punjab and community level interventions. The results show that farmer are not satisfied with performance of PPPs, the efforts of NGOs, initiatives of international organizations, lack of community level interventions and poor performance of climate resilient institutions of Punjab.

## 5. Conclusion and Recommendation

This research found that farm households are worried about a number of climate-related risks, such as crop pests, insect attacks, animal diseases, and extreme weather. Farmers are especially vulnerable to the effects of climate change because they don't have enough water, they are poor, and their local governments aren't doing a good job of building the infrastructure they need. Farmers in the study districts said that the worst effects of climate-related hazards were uncertain or lower crop and livestock yields, changes to cropping schedules, and water shortages. The sole positive result, according to reports, was increased agricultural productivity. This study also identified a number of farm-level adaptation techniques employed by farm households, including changes to crop variety, crop type, planting dates, and input mix. These tactics varied based on the risks associated with climate change. Many constraints, such as a lack of resources, information gaps, a lack of money, and institutional support, limit the ability of farm households to adapt. This study also demonstrates how teamwork has a positive impact on the adaptation process, while disagreement has a negative one. To lower the obstacles to adaptation and improve farm-level cooperation, the study suggests expanding institutional service distribution and outreach, particularly for climate-specific farm advisory services.

Our study found that farm households in the study area had to deal with a lot of problems that made it hard for them to use adaptation strategies to deal with changes in the weather. Some of these problems were a lack of workers, an unstable system for owning land, a lack of access to markets, poverty, a lack of government support, a lack of access to assets, a lack of water sources, a lack of credit sources, and a lack of information and knowledge. The results of this study offer the competent authorities responsible for policy implementation insightful information. Other evidence from our study points to the need for the government to give farmers the support they need, including access to farm inputs, information, and extension services on climate variability and adaptation.

According to the findings, younger farmers, farmers with more education, farmers with more money, farmers who work on larger plots of land, and farmers who live with their families are more likely to use these adaptation strategies. It was found that the number of adaptation practices that were used was related to education, male household heads, land size, household size, extension services, loan availability, and wealth. Farmers who adopted more adaptation strategies had better levels of food security (8–13%) and less poverty (3-6%) than those who did not. So, techniques for adapting to climate change on farms could help with development in a big way in addition to making people less vulnerable to weather risks. Based on the conclusion this research suggest the following policies:

1. Government need to have those varieties which are drought resistant or heat resistant.
2. The extension services should educate the farmers about the sowing and harvesting pattern shift of crops that will be help to increase productivity.
3. Government should develop the coordination between climate resilient institutions and introduce the new climate zones for crop variation to a particular zone.
4. Precipitation pattern is creating the problem of shortage of storage facilities. For this purpose Government need to be focused on building small and large scale dams which protect from floods and soil fertility.
5. The government need to start campaigns like the one started recently that is preventing the use of plastic bags. All such kind of campaigns should be backed by law to get the desired results.
6. The government need to aware the farmers about climate change policies and there implementation. It is productive measures that government taken to develop law and regulations but there is need of implementation of climatic policies.
7. The performance of public private partnership is better and helpful to protect climate change vulnerability, the government should uplift such institutions those are helpful in swear weather conditions.
8. The government should focus on allocation of climate funds and their utilization.

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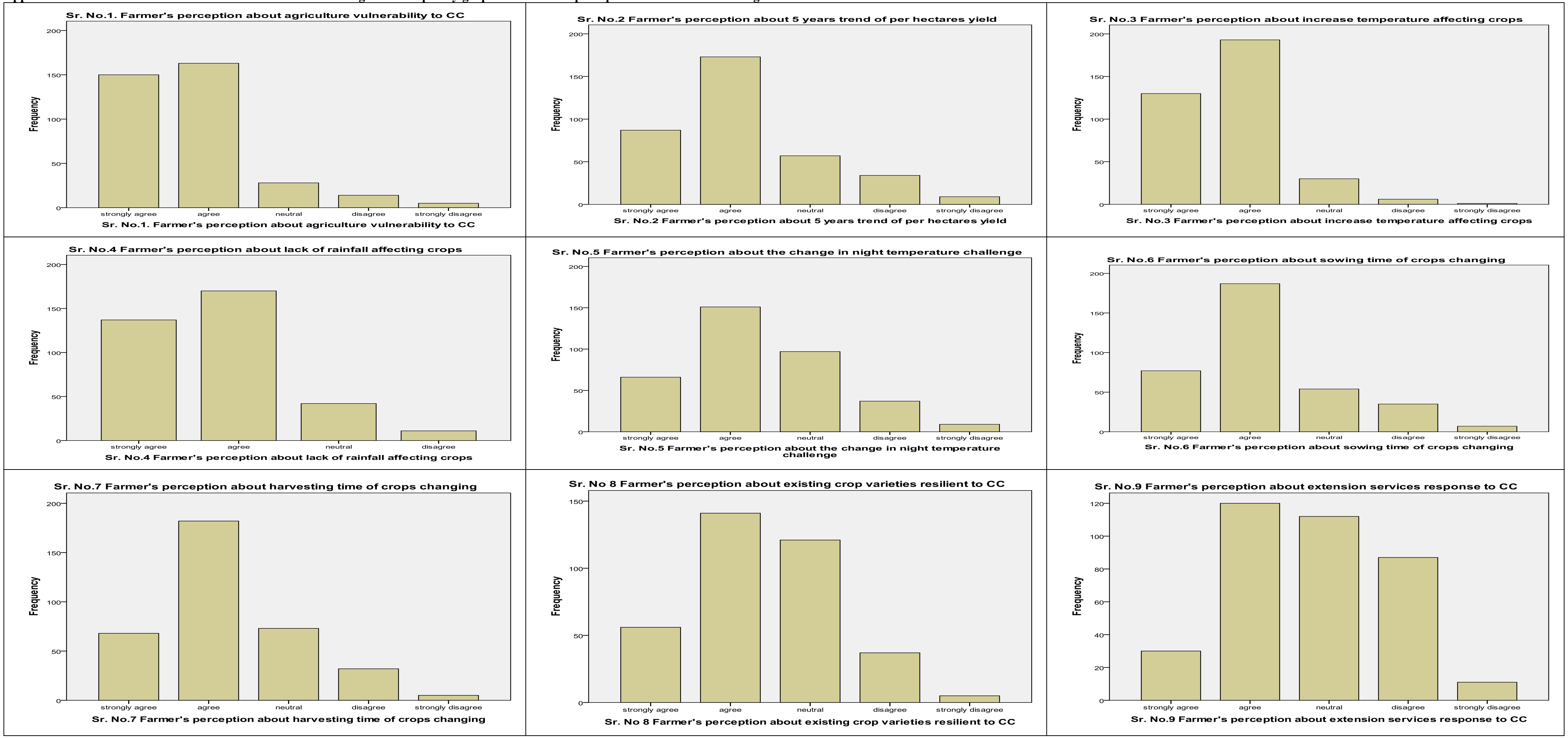
## Appendixes

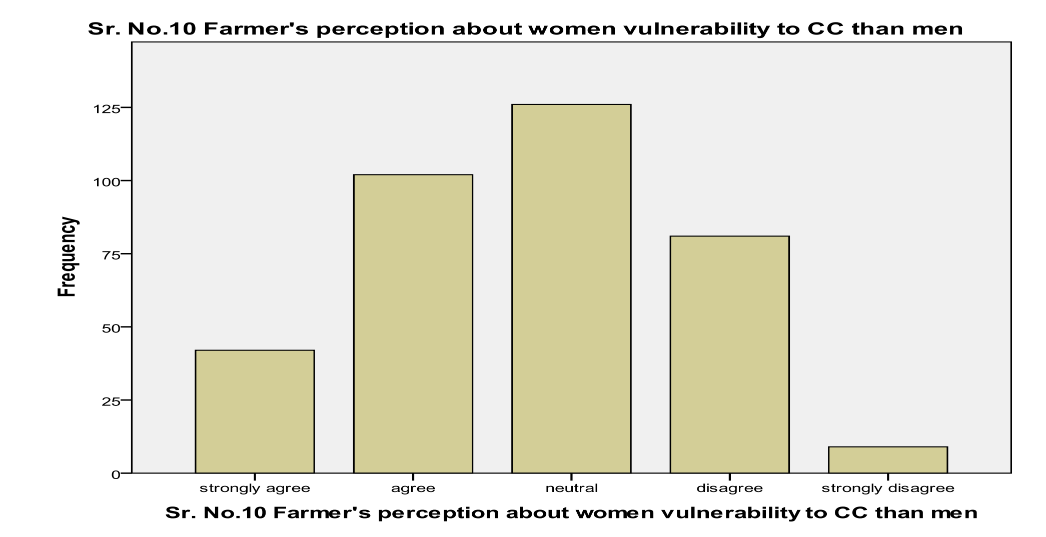
**Table 1: Descriptive Statistics**

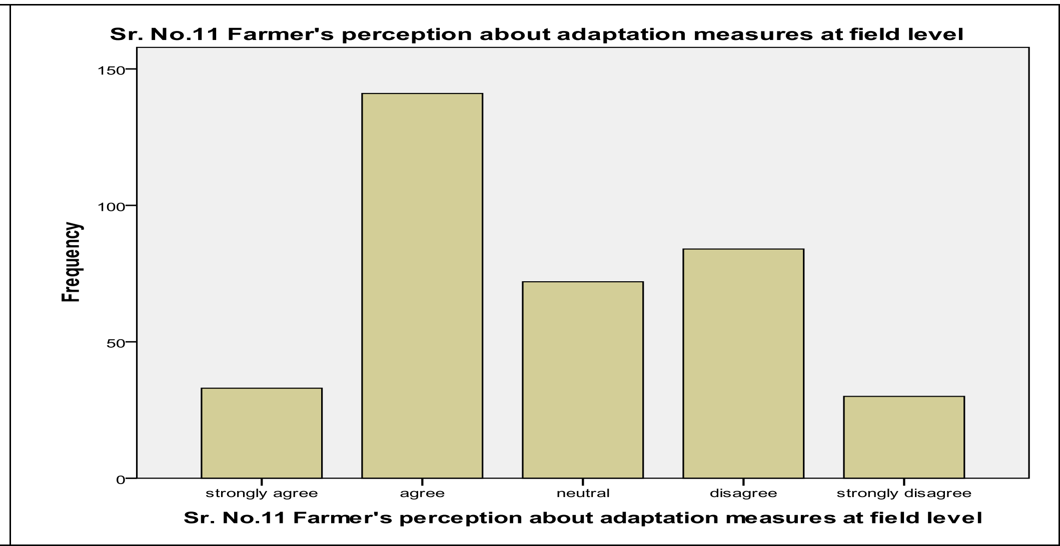
| Sr.No | Variables | Mean | Minimum | Maximum | Std. Deviation |
|---|---|---|---|---|---|
| D1 | Acres of land holding | 29.7861 | 0.00 | 470.00 | 49.99 |
| D2 | Respondent Age | 44.37 | 22.00 | 75.00 | 9.96 |
| P1 | Vulnerability to CC | 1.78 | 1.00 | 5.00 | 0.85 |
| P2 | Per Hectares Yield | 2.1806 | 1.00 | 5.00 | 0.98 |
| P3 | Increase in temperature | 1.76 | 1.00 | 5.00 | 0.69 |
| P4 | Lack of precipitation | 1.79 | 1.00 | 4.00 | 0.76 |
| P5 | Night temperature | 2.36 | 1.00 | 5.00 | 0.97 |
| P6 | Sowing Time | 2.18 | 1.00 | 5.00 | 0.94 |
| P7 | Harvesting Time | 2.23 | 1.00 | 5.00 | 0.90 |
| P8 | Crop Varieties | 2.42 | 1.00 | 5.00 | 0.92 |
| P9 | Extension Services | 2.80 | 1.00 | 5.00 | 0.99 |
| P10 | Women Farmer | 2.75 | 1.00 | 5.00 | 1.00 |
| P11 | Adaptation measures | 2.82 | 1.00 | 5.00 | 1.14 |
| P12 | Small Farmers Vulnerability | 2.16 | 1.00 | 5.00 | 1.10 |
| P13 | Extreme Events | 3.37 | 1.00 | 5.00 | 1.21 |
| P14 | Soil Fertility | 3.51 | 1.00 | 5.00 | 1.21 |
| P15 | Farming Migration | 2.54 | 1.00 | 5.00 | 1.14 |
| S1 | Punjab Government | 2.95 | 1.00 | 5.00 | 1.12 |
| S2 | Institutional Structure | 3.14 | 1.00 | 5.00 | 1.02 |
| S3 | Laws & Regulation | 3.32 | 1.00 | 5.00 | 1.11 |
| S4 | Research Institutes | 3.18 | 1.00 | 5.00 | 1.13 |
| S5 | Weather Mechanism | 2.81 | 1.00 | 5.00 | 1.23 |
| S6 | NGOs | 3.26 | 1.00 | 5.00 | 1.02 |
| S7 | International Organizations | 3.18 | 1.00 | 5.00 | 1.10 |
| S8 | Community Interventions | 3.01 | 1.00 | 5.00 | 0.99 |
| S9 | Climate Funds | 3.46 | 1.00 | 5.00 | 1.14 |
| S10 | Public Private Partnership (PPP) | 3.35 | 1.00 | 5.00 | 1.07 |
| In this table D's are used for demographic variables, P's are used for variables addressing the farmer's perception about climate change and S's are representing the farmer satisfaction level about policy adoption related to climate change. | | | | | |

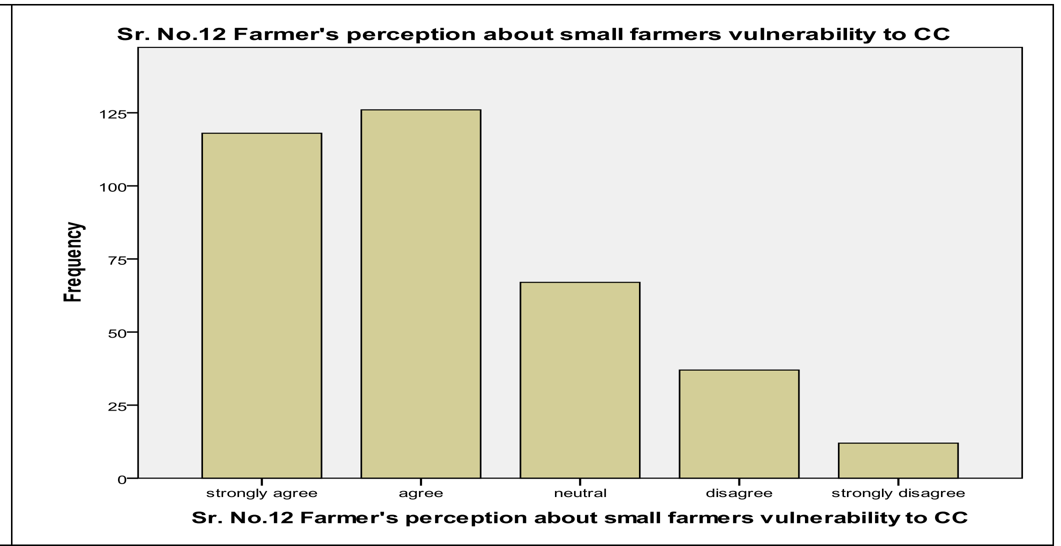
Source: Author calculation

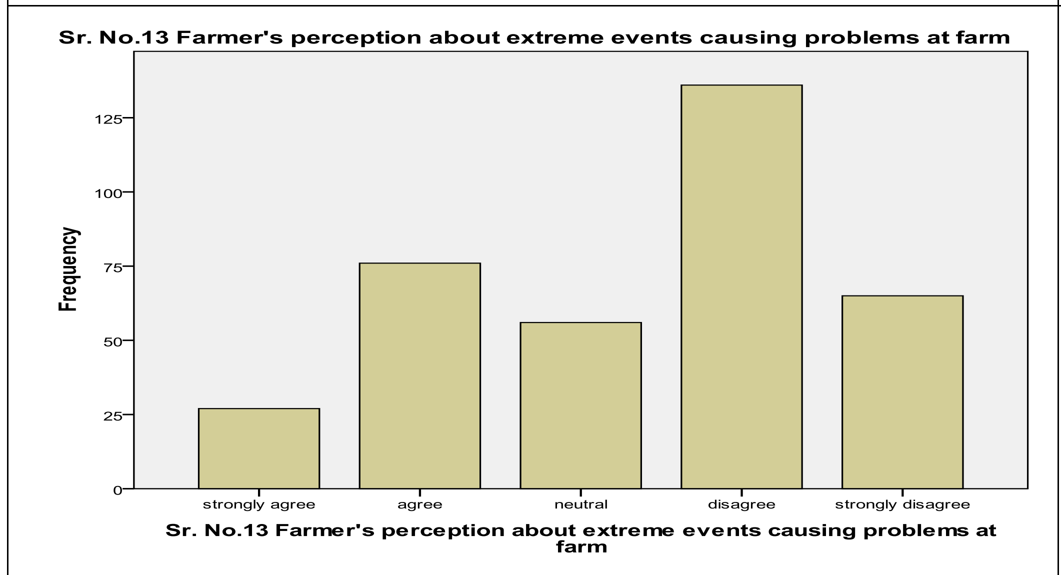
**Appendix A1** **Figure1: Frequency graphs of Farmer's perception about Climate Change**

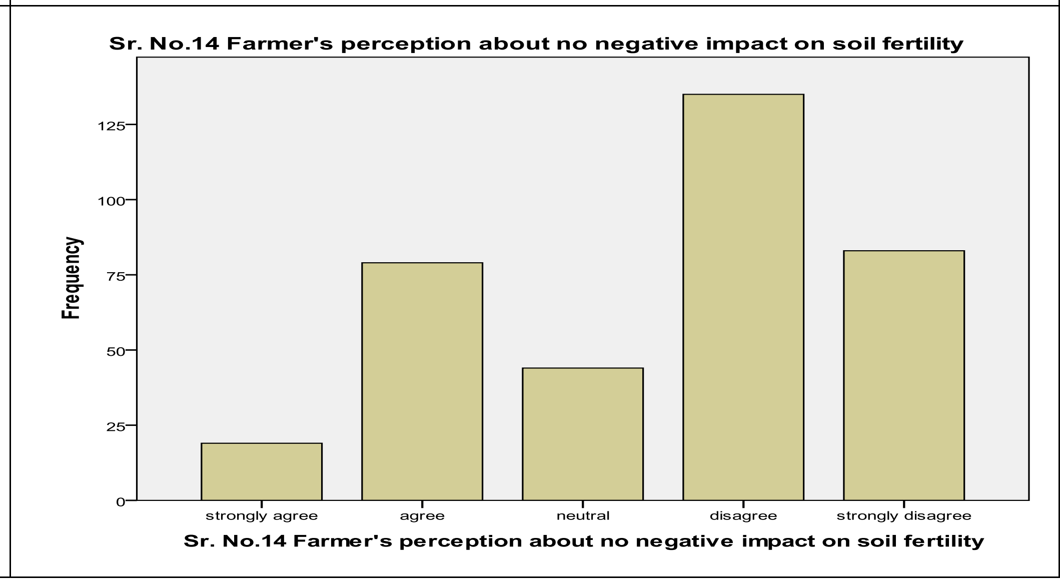


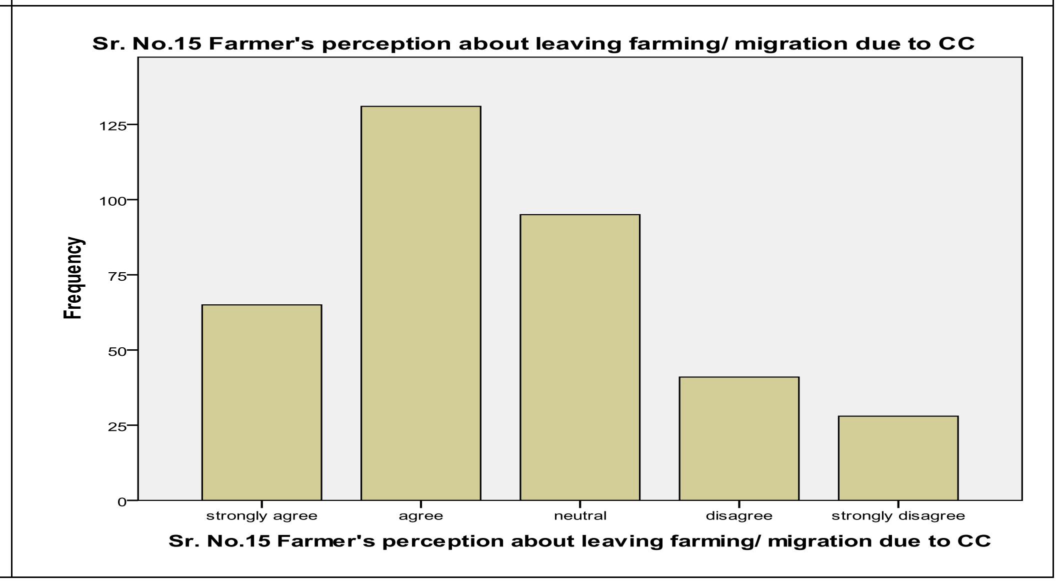

Sr. No.10 Farmer's perception about women vulnerability to CC than men
Frequency
0
25
50
75
100
125
strongly agree
agree
neutral
disagree
strongly disagree
Sr. No.10 Farmer's perception about women vulnerability to CC than men


Sr. No.11 Farmer's perception about adaptation measures at field level
Frequency
0
50
100
150
strongly agree
agree
neutral
disagree
strongly disagree
Sr. No.11 Farmer's perception about adaptation measures at field level


Sr. No.12 Farmer's perception about small farmers vulnerability to CC
Frequency
0
25
50
75
100
125
strongly agree
agree
neutral
disagree
strongly disagree
Sr. No.12 Farmer's perception about small farmers vulnerability to CC


Sr. No.13 Farmer's perception about extreme events causing problems at farm
Frequency
0
25
50
75
100
125
strongly agree
agree
neutral
disagree
strongly disagree
Sr. No.13 Farmer's perception about extreme events causing problems at farm


Sr. No.14 Farmer's perception about no negative impact on soil fertility
Frequency
0
25
50
75
100
125
strongly agree
agree
neutral
disagree
strongly disagree
Sr. No.14 Farmer's perception about no negative impact on soil fertility


Sr. No.15 Farmer's perception about leaving farming/ migration due to CC
Frequency
0
25
50
75
100
125
strongly agree
agree
neutral
disagree
strongly disagree
Sr. No.15 Farmer's perception about leaving farming/ migration due to CC

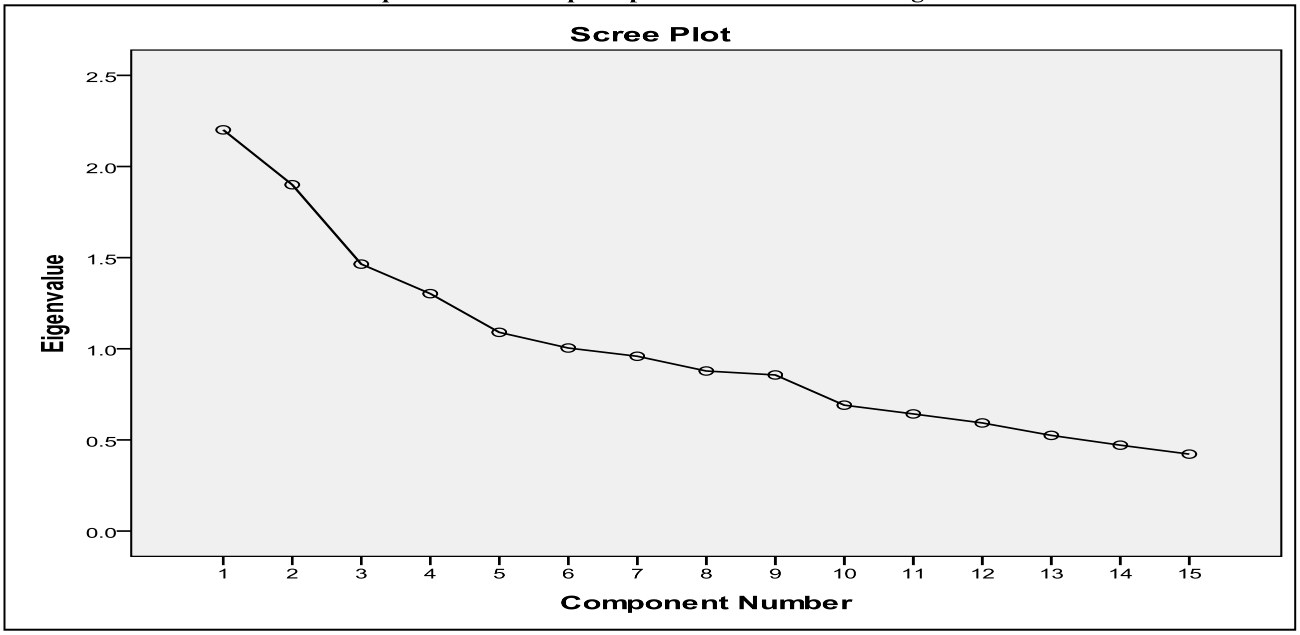
**Appendix A2**
**Correlation Matrix**

| Correlation | Sr. No.1. | Sr. No.2 | Sr. No.3 | Sr. No.4 | Sr. No.5 | Sr. No.6 | Sr. No.7 | Sr. No 8 | Sr. No. 9 | Sr. No.10 | Sr. No.11 | Sr. No.12 | Sr. No.13 | Sr. No.14 | Sr. No.15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sr. No.1. | 1.000 | .193 | .302 | .240 | .137 | .145 | .099 | .084 | -.048 | -.100 | .078 | .175 | -.046 | -.099 | -.066 |
| Sr. No.2 | .193 | 1.000 | .095 | .049 | .076 | .074 | .031 | .034 | -.003 | .139 | -.016 | .073 | -.029 | .011 | .081 |
| Sr. No.3 | .302 | .095 | 1.000 | .431 | .152 | .115 | .075 | -.012 | -.019 | -.034 | .067 | .055 | -.069 | -.095 | -.111 |
| Sr. No.4 | .240 | .049 | .431 | 1.000 | .227 | .200 | .146 | .112 | .079 | -.078 | .049 | .010 | -.080 | -.105 | -.033 |
| Sr. No.5 | .137 | .076 | .152 | .227 | 1.000 | .274 | .167 | .169 | .089 | .166 | -.070 | -.033 | .129 | .166 | -.037 |
| Sr. No.6 | .145 | .074 | .115 | .200 | .274 | 1.000 | .449 | .211 | .010 | -.028 | -.088 | .048 | -.028 | -.014 | -.031 |
| Sr. No.7 | .099 | .031 | .075 | .146 | .167 | .449 | 1.000 | .124 | -.057 | .114 | -.066 | .023 | -.027 | .051 | .003 |
| Sr. No 8 | .084 | .034 | -.012 | .112 | .169 | .211 | .124 | 1.000 | .153 | .019 | -.045 | .101 | .052 | .086 | -.013 |
| Sr. No.9 | -.048 | -.003 | -.019 | .079 | .089 | .010 | -.057 | .153 | 1.00 | .047 | .286 | -.034 | .172 | .201 | .043 |
| Sr. No.10 | -.100 | .139 | -.034 | -.078 | .166 | -.028 | .114 | .019 | .047 | 1.00 | -.025 | .079 | .032 | .151 | .148 |
| Sr. No.11 | .078 | -.016 | .067 | .049 | -.070 | -.088 | -.066 | -.045 | .286 | -.025 | 1.000 | .103 | .203 | .069 | .039 |
| Sr. No.12 | .175 | .073 | .055 | .010 | -.033 | .048 | .023 | .101 | -.034 | .079 | .103 | 1.000 | .022 | -.023 | .126 |
| Sr. No.13 | -.046 | -.029 | -.069 | -.080 | .129 | -.028 | -.027 | .052 | .172 | .032 | .203 | .022 | 1.000 | .506 | .004 |
| Sr. No.14 | -.099 | .011 | -.095 | -.105 | .166 | -.014 | .051 | .086 | .201 | .151 | .069 | -.023 | .506 | 1.000 | .158 |
| Sr. No.15 | -.066 | .081 | -.111 | -.033 | -.037 | -.031 | .003 | -.013 | .043 | .148 | .039 | .126 | .004 | .158 | 1.000 |

Source: Author calculation

**Appendix A3**

**Scree plot of farmer's perception about climate change**




Source Author Calculation

**Appendix A4**

**Component Matrix farmer's perception about climate change**

| | Component | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| Lack of precipitation | .638 | | .297 | | | .267 |
| Sowing Time | .628 | | -.362 | | .279 | |
| Increase in temperature | .568 | | .400 | | -.324 | |
| Vulnerability to CC | .548 | | .325 | .229 | | -.349 |
| Night temperature | .521 | .334 | | | -.331 | |
| Harvesting Time | .512 | | -.452 | | | |
| Soil Fertility | | .774 | | | | -.255 |
| Extreme Events | | .703 | | | | -.451 |
| Adaptation measures | | .300 | .646 | | .213 | |
| Small Farmers Vulnerability | | | | .588 | .461 | -.259 |
| Farmer's Migration | | .265 | | .544 | | .304 |
| Per Hectares Yield | .261 | | | .527 | -.298 | |
| Women Farmer | | .341 | -.332 | .427 | -.353 | .276 |
| Crop Varieties | .348 | .267 | | | .455 | |
| Extension Services | | .505 | .356 | | | .521 |
| Extraction Method: Principal Component Analysis. | | | | | | |
| a. 6 components extracted. | | | | | | |

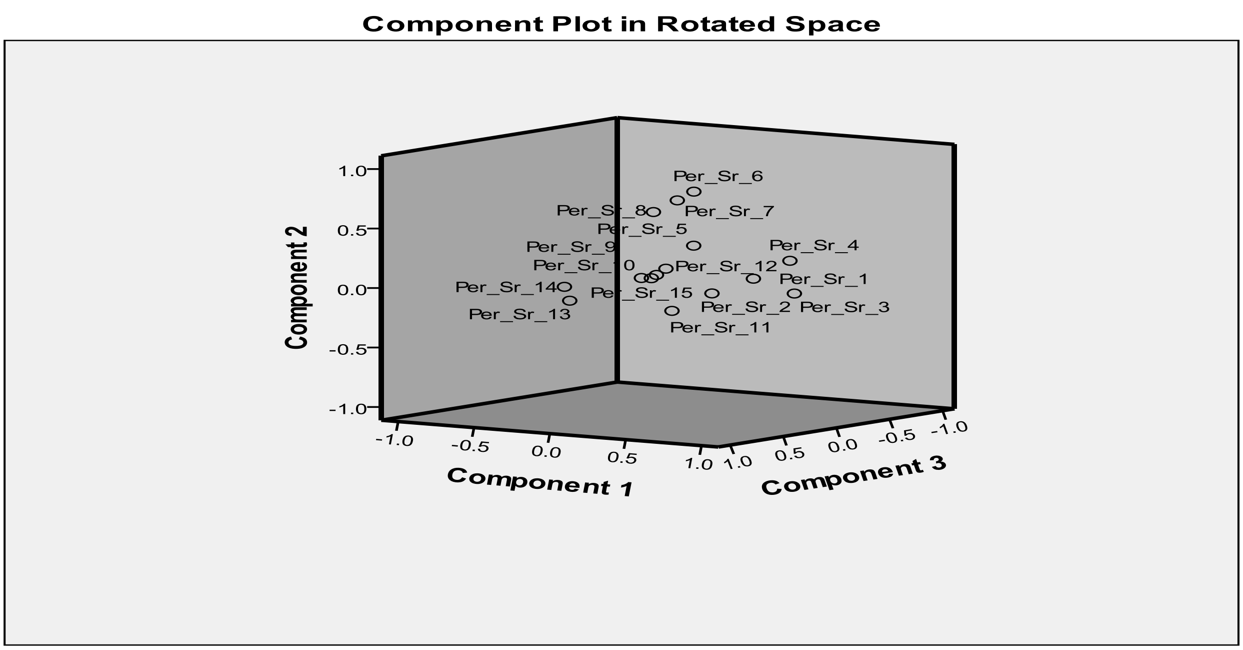
Source: Author Calculation

**Appendix A5**
**Rotated Component Matrix farmer's perception about climate change**

| | Component | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| Increase in temperature | .785 | | | | | |
| Lack of precipitation | .680 | .224 | | .235 | | |
| Vulnerability to CC | .583 | | | | | .480 |
| Night temperature | .400 | .396 | .329 | | .206 | -.282 |
| Sowing Time | | .775 | | | | |
| Harvesting Time | | .695 | | | | |
| Crop Varieties | | .590 | | .255 | | |
| Extreme Events | | | .859 | | | |
| Soil Fertility | | | .797 | | | |
| Extension Services | | | | .801 | | |
| Adaptation measures | | -.207 | | .650 | | .270 |
| Women Farmer | | | | | .759 | |
| Farmer's Migration | -.223 | | | .207 | .593 | .208 |
| Per Hectares Yield | .323 | | | | .495 | .234 |
| Small Farmers Vulnerability | | | | | | .800 |
| Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization. | | | | | | |
| a. Rotation converged in 7 iterations. | | | | | | |

Source: Author's Calculation

**Appendix A6**
**Rotated plot of farmer's perception about climate change**




**Source: Author's Calculations**

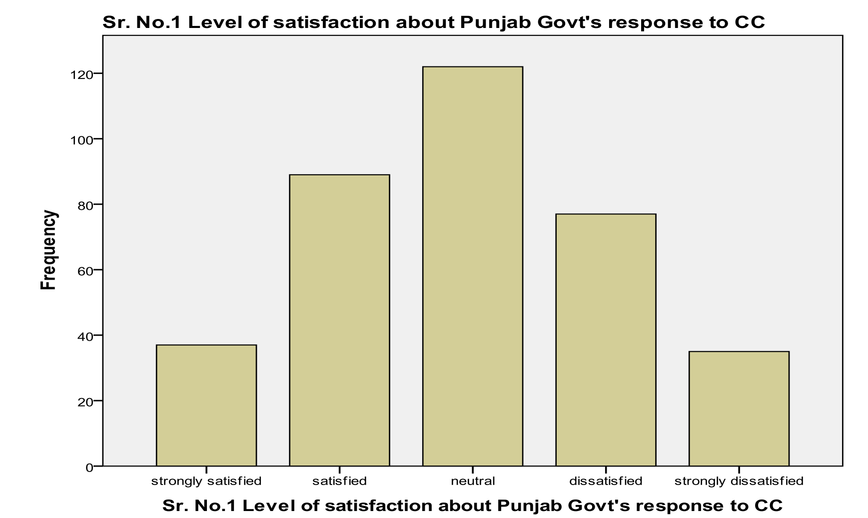
**Appendix A7**

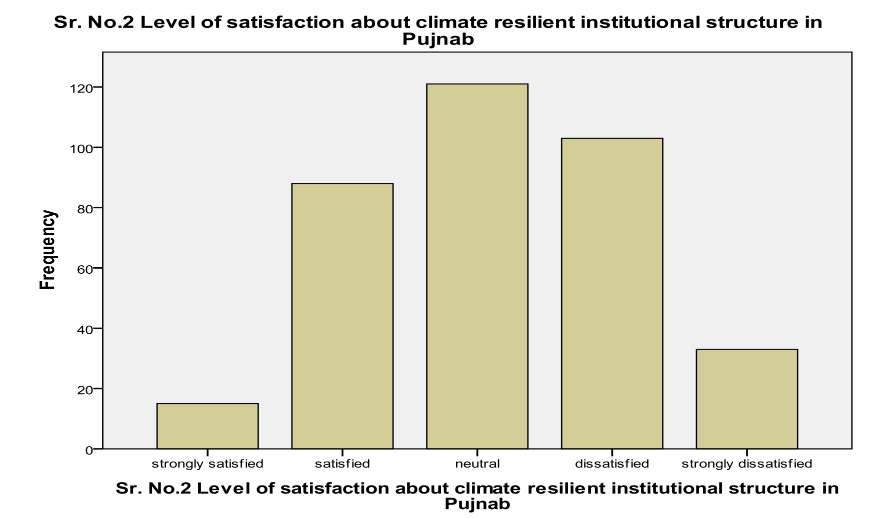
| Component Score Coefficient Matrix | | | | | | |
|---|---|---|---|---|---|---|
| | Component | | | | | |
| | 1 | 2 | 3 | 4 | 5 | 6 |
| Sr. No.1. Farmer's perception about agriculture vulnerability to CC | .303 | -.023 | .095 | -.127 | -.102 | .377 |
| Sr. No.2 Farmer's perception about 5 years trend of per hectares yield | .211 | -.119 | .047 | -.166 | .382 | .153 |
| Sr. No.3 Farmer's perception about increase temperature affecting crops | .470 | -.130 | -.002 | .005 | .009 | -.046 |
| Sr. No.4 Farmer's perception about lack of rainfall affecting crops | .365 | .055 | -.139 | .210 | .014 | -.156 |
| Sr. No.5 Farmer's perception about the change in night temperature challenge | .229 | .150 | .205 | -.076 | .138 | -.259 |
| Sr. No.6 Farmer's perception about sowing time of crops changing | -.027 | .464 | -.029 | -.037 | -.079 | .030 |
| Sr. No.7 Farmer's perception about harvesting time of crops changing | -.060 | .415 | -.014 | -.096 | .024 | .009 |
| Sr. No 8 Farmer's perception about existing crop varieties resilient to CC | -.147 | .393 | -.042 | .214 | -.079 | .123 |
| Sr. No.9 Farmer's perception about extension services response to CC | -.003 | .066 | -.064 | .623 | .072 | -.173 |
| Sr. No.10 Farmer's perception about women vulnerability to CC than men | .016 | -.020 | -.002 | -.025 | .589 | -.152 |
| Sr. No.11 Farmer's perception about adaptation measures at field level | .075 | -.123 | .023 | .466 | -.065 | .198 |
| Sr. No.12 Farmer's perception about small farmers vulnerability to CC | -.085 | .079 | -.004 | .012 | .054 | .669 |
| Sr. No.13 Farmer's perception about extreme events causing problems at farm | .015 | -.051 | .582 | -.045 | -.162 | .095 |
| Sr. No.14 Farmer's perception about no negative impact on soil fertility | -.031 | .007 | .501 | -.039 | .066 | -.027 |
| Sr. No.15 Farmer's perception about leaving farming/ migration due to CC | -.140 | .016 | -.145 | .182 | .454 | .144 |
| Extraction Method: Principal Component Analysis. | | | | | | |
| Component Scores. | | | | | | |

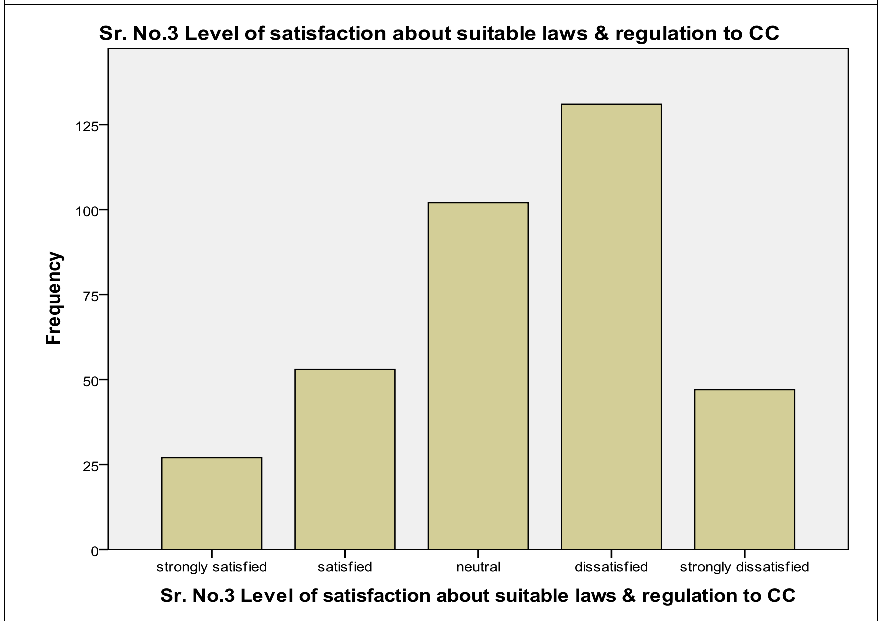
Source: Author own Construction

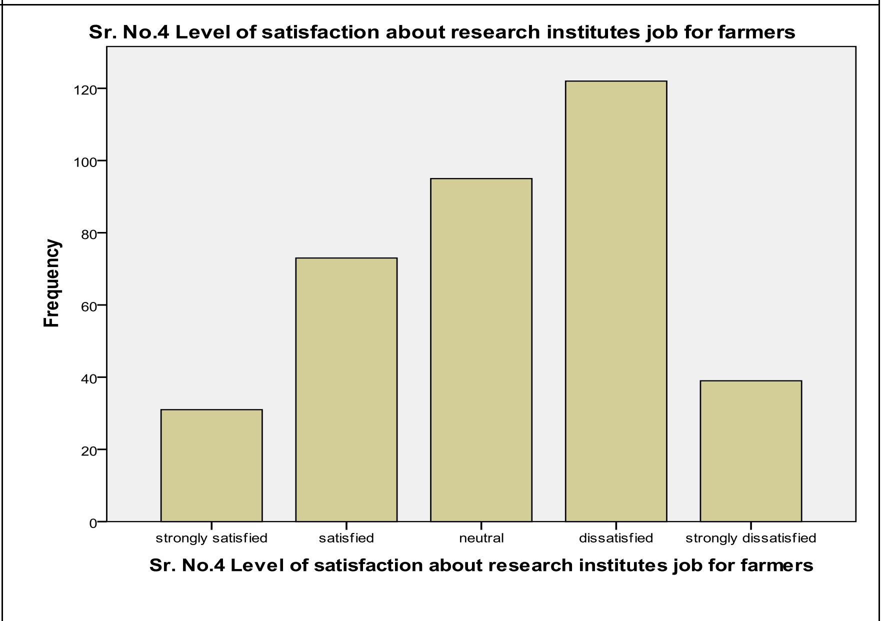
**Appendix B1**

## Frequency graph of Farmer Satisfaction Level Regarding Policy Adoption

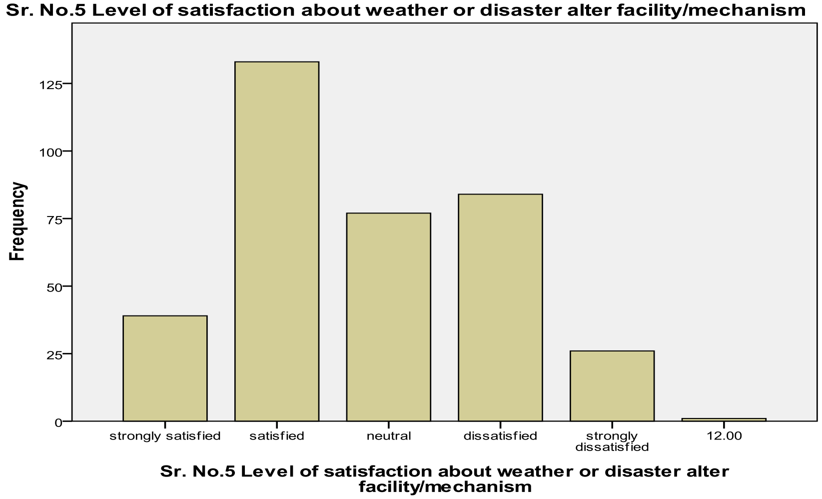


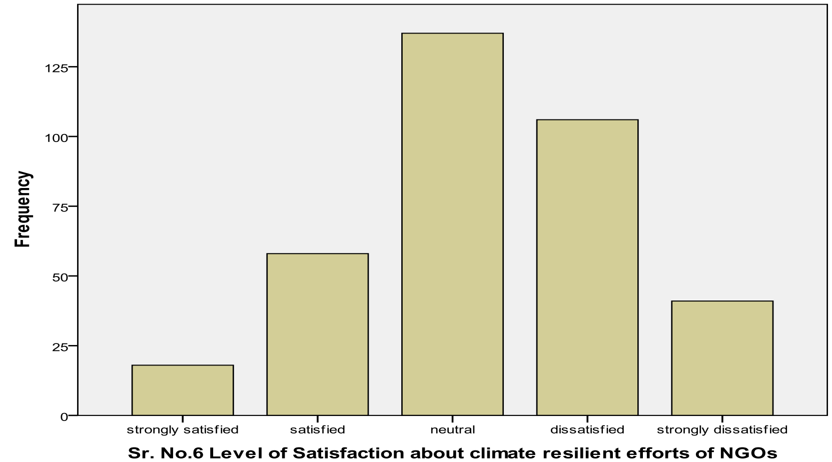



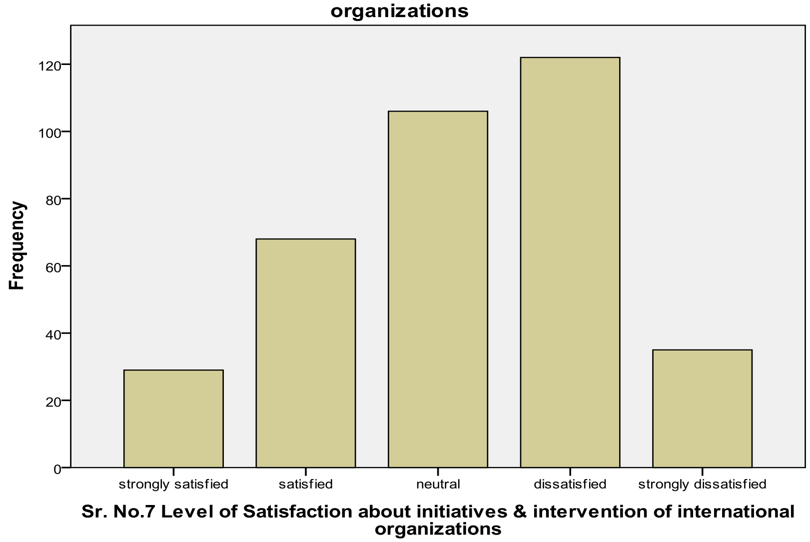
**Sr. No.5 Level of satisfaction about weather or disaster alter facility/mechanism**



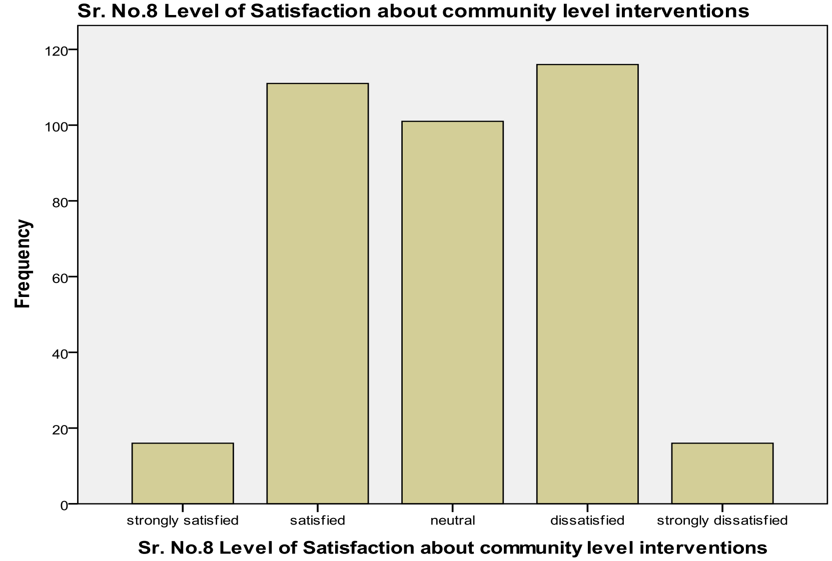

**Sr. No.6 Level of Satisfaction about climate resilient efforts of NGOs**

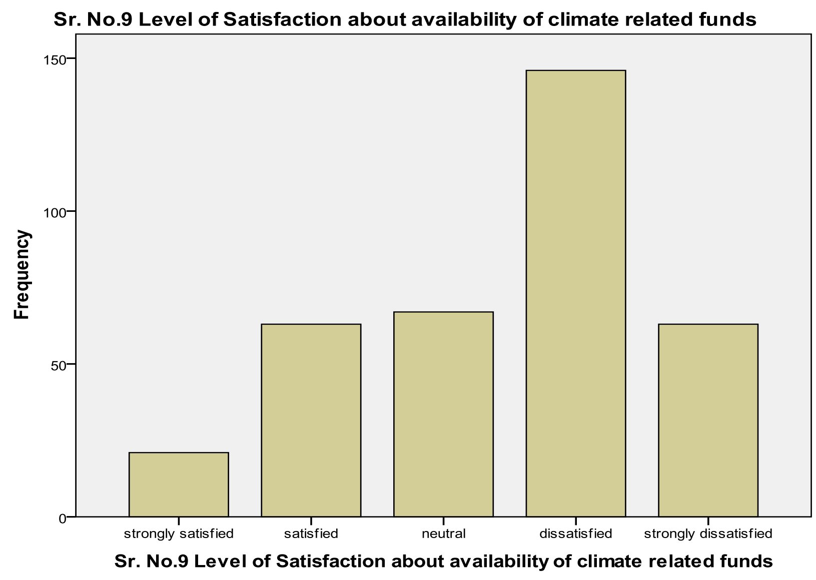


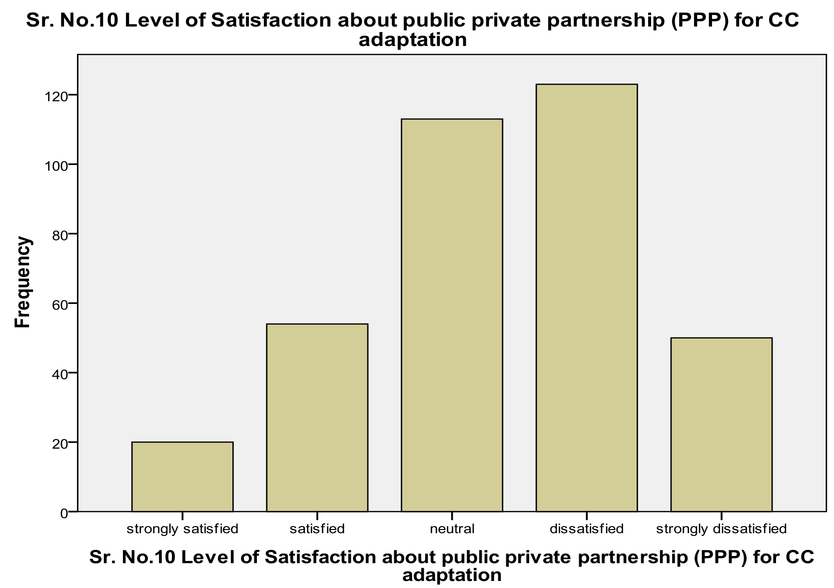

**Sr. No.7 Level of Satisfaction about initiatives & intervention of international organizations**




**Sr. No.8 Level of Satisfaction about community level interventions**






**Appendix B2**

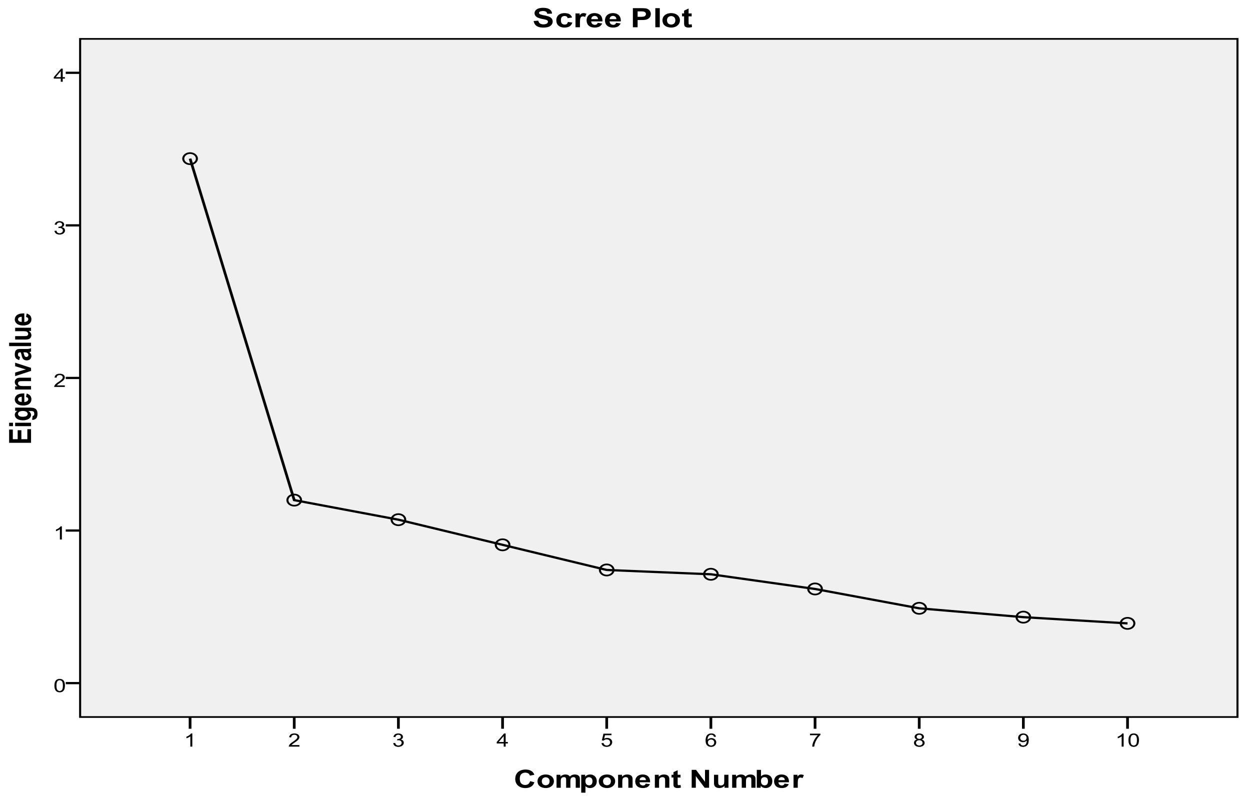
**Correlation Matrix of Farmer Satisfaction Level Regarding Policy Adoption**

| | | Sr. No.1 | Sr. No.2 | Sr. No.3 | Sr. No.4 | Sr. No.5 | Sr. No.6 | Sr. No.7 | Sr. No.8 | Sr. No.9 | Sr. No.10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Correlation | Sr. No.1 | 1.000 | .543 | .378 | .312 | .155 | .170 | .311 | .205 | .272 | .213 |
| | Sr. No.2 | .543 | 1.000 | .480 | .227 | .014 | .249 | .418 | .173 | .375 | .251 |
| | Sr. No.3 | .378 | .480 | 1.000 | .265 | .148 | .281 | .385 | .175 | .399 | .166 |
| | Sr. No.4 | .312 | .227 | .265 | 1.000 | .175 | .151 | .190 | .222 | .154 | .038 |
| | Sr. No.5 | .155 | .014 | .148 | .175 | 1.000 | .193 | .148 | .091 | .094 | .094 |
| | Sr. No.6 | .170 | .249 | .281 | .151 | .193 | 1.000 | .495 | .194 | .273 | .322 |
| | Sr. No.7 | .311 | .418 | .385 | .190 | .148 | .495 | 1.000 | .309 | .463 | .444 |
| | Sr. No.8 | .205 | .173 | .175 | .222 | .091 | .194 | .309 | 1.000 | .309 | .218 |
| | Sr. No.9 | .272 | .375 | .399 | .154 | .094 | .273 | .463 | .309 | 1.000 | .356 |
| | Sr. No.10 | .213 | .251 | .166 | .038 | .094 | .322 | .444 | .218 | .356 | 1.000 |

Author own construction

**Appendix B3**

**Scree plot of Farmer Satisfaction Level Regarding Policy Adoption**




Source Author Calculation

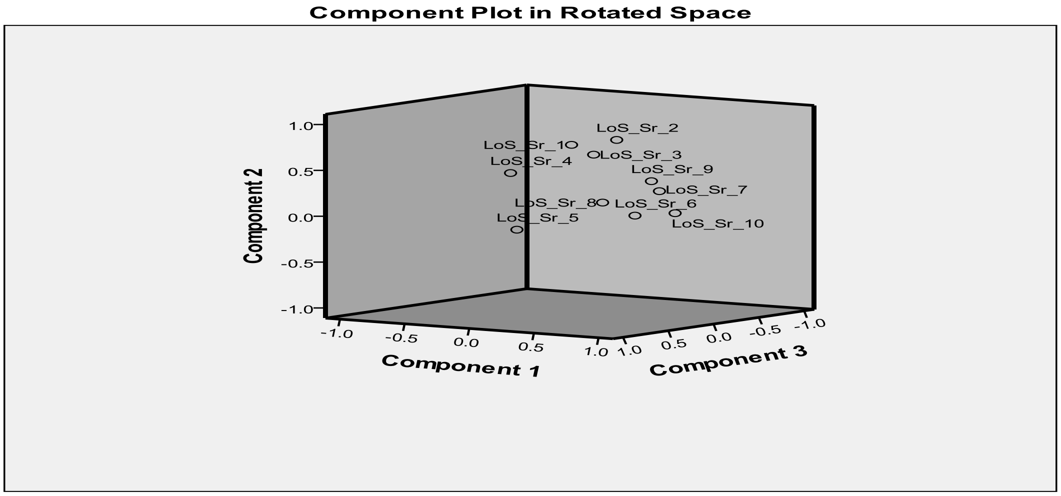
**Appendix B4**

**Rotated Component Matrix of Farmer Satisfaction Level Regarding Policy Adoption**

| | Component | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| Sr. No.10 Level of Satisfaction about public private partnership (PPP) for CC adaptation | .752 | | |
| Sr. No.7 Level of Satisfaction about initiatives & intervention of international organizations | .749 | .312 | |
| Sr. No.6 Level of Satisfaction about climate resilient efforts of NGOs | .677 | | .249 |
| Sr. No.9 Level of Satisfaction about availability of climate related funds | .597 | .387 | |
| Sr. No.8 Level of Satisfaction about community level interventions | .423 | | .242 |
| Sr. No.2 Level of satisfaction about climate resilient institutional structure in Punjab | .270 | .792 | |
| Sr. No.1 Level of satisfaction about Punjab Govt's response to CC | | .763 | |
| Sr. No.3 Level of satisfaction about suitable laws & regulation to CC | .266 | .667 | |
| Sr. No.5 Level of satisfaction about weather or disaster alter facility/mechanism | | | .829 |
| Sr. No.4 Level of satisfaction about research institutes job for farmers | | .500 | .572 |
| Extraction Method: Principal Component Analysis. | | | |
| a. Rotation converged in 6 iterations. | | | |

Author own construction

**Appendix B5**
**Rotated plot of Farmer Satisfaction Level Regarding Policy Adoption**




**Source: Author's Calculations**

**Appendix B6**
**Component Score Coefficient Matrix of Farmer Satisfaction Level Regarding Policy Adoption**

| | Component | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| Sr. No.1 Level of satisfaction about Punjab Govt's response to CC | -.144 | .412 | .033 |
| Sr. No.2 Level of satisfaction about climate resilient institutional structure in Pujnab | -.041 | .421 | -.232 |
| Sr. No.3 Level of satisfaction about suitable laws & regulation to CC | -.032 | .319 | .005 |
| Sr. No.4 Level of satisfaction about research institutes job for farmers | -.210 | .249 | .458 |
| Sr. No.5 Level of satisfaction about weather or disaster alter facility/mechanism | .041 | -.175 | .733 |
| Sr. No.6 Level of Satisfaction about climate resilient efforts of NGOs | .345 | -.166 | .157 |
| Sr. No.7 Level of Satisfaction about initiatives & intervention of international organizations | .335 | -.015 | -.028 |
| Sr. No.8 Level of Satisfaction about community level interventions | .172 | -.030 | .160 |
| Sr. No.9 Level of Satisfaction about availability of climate related funds | .241 | .084 | -.139 |
| Sr. No.10 Level of Satisfaction about public private partnership (PPP) for CC adaptation | .419 | -.155 | -.148 |
| Extraction Method: Principal Component Analysis. | | | |
| Component Scores. | | | |

Author's own Construction

**Appendix B8**
**Component Score Covariance Matrix of Farmer Satisfaction Level Regarding Policy Adoption**

| Component | | 1 | 2 | 3 |
|---|---|---|---|---|
| dimension0 | 1 | 1.000 | .000 | .000 |
| | 2 | .000 | 1.000 | .000 |
| | 3 | .000 | .000 | 1.000 |
| Extraction Method: Principal Component Analysis. | | | | |
| Component Scores. | | | | |

Author's own Construction