SOCIO-ECONOMIC FACTORS AFFECTING ON ADOPTION OF CLIMATE RESILIENT TECHNOLOGIES BY THE MANGO GROWERS

By

PANDURANG BHARAT JADHAV

B.Sc. (Ag.)

DEPARTMENT OF EXTENSION EDUCATION

FACULTY OF AGRICULTURE

DR. BALASAHEB SAWANT KONKAN KRISHI VIDYAPEETH

DAPOLI - 415712, DIST. RATNAGIRI (M.S.)

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A thesis submitted to the

DR. BALASAHEB SAWANT KONKAN
KRISHI VIDYAPEETH, DAPOLI
(Agricultural University)
Dist. Ratnagiri (Maharashtra State)

In partial fulfillment of the requirements for the award of the degree of

MASTERS OF SCIENCE
(AGRICULTURE)

In

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Enrolment Number - 2713 **JUNE 2021**

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Approved by the Advisory Committee

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CERTIFICATE

This is to certify that the thesis entitled, '**SOCIO-ECONOMIC FACTORS AFFECTING ON ADOPTION OF CLIMATE RESILIENT TECHNOLOGIES BY THE MANGO GROWERS'** submitted to the Faculty of Agriculture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri, Maharashtra State in the partial fulfillment of the requirements for the award of the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **EXTENSION EDUCATION,** embodies the results of a piece of *bonafide* research carried out by **MR. PANDURANG BHARAT JADHAV** under my guidance and supervision. No part of this thesis has been submitted for any other degree or diploma. All the assistance and help received during the course of the investigation and the sources of literature have been duly acknowledged by him.

Place: Dapoli (S. S. Patil)

Date: Chairman,
Advisory Committee
and

Research Guide

DECLARATION OF STUDENT

I hereby declare that the experimental work and interpretation of the thesis entitled "***SOCIO-ECONOMIC FACTORS AFFECTING ON ADOPTION OF CLIMATE RESILIENT TECHNOLOGIES BY THE MANGO GROWERS***" or part of thereof has neither been submitted for any other degree or Diploma of any university nor the data have been derived any thesis / publication of any University or Scientific Organization. The sources and material used and all assistance received during the courses of investigation have been duly acknowledgment and that no part of the thesis has been submitted for any other degree or diploma.

Place: Dapoli **(Pandurang Bharat Jadhav)**

Date: JUNE 2021 **Enrollment No- ADPM/19/2713**

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Title of thesis	**:**	Socio-economic Factors Affecting on Adoption of Climate Resilient Technologies by the Mango Growers.
Name of student	**:**	**Pandurang Bharat Jadhav**
Regd. No.	**:**	ADPM/19/2713
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ABSTRACT

The present study was conducted in the South Konkan Coastal Zone consisting of two districts-Ratnagiri and Sindhudurg. The ex-post facto design of social research was used for the present study. A total of 156 respondents were selected by adopting a simple random sampling method. Data was collected with the help of an interview schedule and subjected to appropriate statistical analysis. The binary logistic regression was used to identify the factors affecting the adoption of climate-resilient technologies. It was observed that the majority of the mango growers were older and completed secondary education. They had a medium level of annual income and had small landholding with the marginal area under the mango. A huge majority had self-ownership on mango orchard, had middle age of orchard and possessed 'adequate' resources for the management of mango orchards. Further, 47.44 per cent of respondents had accessed crop insurance and 51.28 per cent of the respondent borrowed crop loan. It was found that the mango growers belonged to a medium level of extension participation and access to input sources. They cultivated mango orchards on rocky soil with hilly topography and mostly medium-long distance from the seashore. They maintained recommended planting density in mango orchards. Mango orchards were exposed to a 'high

level of climatic vulnerabilities. The sampled respondents possessed a high level of knowledge but a medium level of adoption of climate-resilient technologies. The binary logit regression analysis indicated that socio-economic and ecological factors such as age, education, operational landholdings, the area under mango, ownership of mango orchards, age of orchards, availability of resources, access to crop loans, access to crop insurance, extension participation, sources of inputs, soil type, topography, distance from the seashore, climatic vulnerability and knowledge were affected significantly on the adoption of different climate-resilient mango technologies. Therefore, the study recommends that policymakers, academicians, extension personnel and development agencies may provide attention to these factors to increase the adoption of climate-resilient technologies. As opinioned by the mango farmers, skilled workers are required for canopy management and rejuvenation of mango trees. The Agricultural University and KVKs in the jurisdiction may build the capacity of rural youths on this aspect.

CHAPTER I

INTRODUCTION

"Climate-resilient innovations that are guided by smallholders, adapted to local circumstances and sustainable for the economy and environment will be necessary to ensure food security in the future".

- Bill Gates, Co-founder, Microsoft Corporation

On every continent on the planet, the consequences of climate change are now visible. Contributing factors such as erratic weather, rising sea levels, and melting glaciers are gradually reshaping societies all over the world. The environment and climate change have been identified as the most significant challenges for world leaders during the third decade of this century (Martin, 2006; Cohen and Waddel, 2009). Between 1880 and 2012, global average land and ocean temperatures increased by 0.95 degrees Celsius (Hansen et al., 2010; IPCC, 2013). The top seven contributors- USA, China, UK, India, Russia, Japan, and international transport accounted for 65 percent, and in addition to G20 members, they contributed 78 percent (Emissions Gap Report, 2020). Current climate models forecast a 1-2°C increase in tropical temperatures by 2050 and greater incertitude with regard to rainfall variations (Deffenbaugh and Field, 2013; Loarie et al., 2009). The previous six years were the warmest on record, with 2020 being one of the three hottest on record. During the first half of 2020, 9.8 million people were displaced by hydrometeorological hazards and disasters. (World Metrological Organization, 2021).

The United Nations passed the Sustainable Development Goals (SDGs), which call for the end of poverty, inequality, and injustice, as well as the tackling of climate change. Throughout the world, unabated climate change effects manifested as droughts, cyclones, flash floods, and heat waves have impacted agriculture and rural livelihoods directly or indirectly (Prabhakar and Shaw, 2007; Ray et al., 2013). Climate change is also wreaking havoc on the global South continent, causing chaos in agricultural production and agrarian livelihoods (Eze and Onokala, 2020; Islam and Kieu, 2020; Call et al., 2019).

Climate change has remained one of the most perplexing socioeconomic and ecological phenomena affecting rural livelihoods. The situation is exacerbated for smallholders who rely entirely on agriculture for their daily subsistence and livelihood (Rao et al., 2016; Marie et al., 2020). It imposed an additional burden at a time when rapid population growth, industrialization, and resource exploitation are already putting enormous strain on socioeconomic and ecological systems (Angom et al. 2021). A number of concrete steps have been taken to investigate the effects of climate change on agriculture (Attri and Tyagi, 2010). Specifically, how it has affected rural livelihoods, food security, and the demand-supply chain management (Louwaars and de Boef, 2012; Podder and Samanta, 2019; Kabir and Serrao-Neumann, 2020).

1.1 The Indian context

Indian agriculture provides a livelihood for 58.0 percent of the population (Indian Census 2011) and makes a share of about 20.0 percent of the national GDP (Economic Survey, 2020-21). Agriculture is the primary source of income for the vast majority (70.00%) of rural residents (Indian Census, 2011). Climate change threatens global food security and agricultural livelihoods, but needful responses may be region-specific, and the areas affected by climate impacts may vary significantly (IPCC, 2019). Developing economies, such as India, are more vulnerable to climate change. India's mean annual temperature rose by 0.56 degrees Celsius during the first half of the twentieth century (Attri and Tyagi, 2010). India is combating climate change through a combination of strategies, policies, partnerships, and investment. The National Action Plan on Climate Change (NAPCC) had eight sub-missions initiated by the Government of India in 2018. Indian farmers have developed their own methods of adapting to changing weather patterns, but these methods have proven inadequate to deal with extreme weather events. The changing social dynamics and institutional structures of rural areas played a role in this catastrophe as well. The Indian Council of Agriculture Research (ICAR), New Delhi, has launched a nation-wide project to demonstrate climate-resilient technologies called ‘National

Innovations in Climate Resilient Agriculture (NICRA)' via 151 Krishi Vigyan Kendra (KVKs)-Farm Science Centres. The NICRA made a visible impact, demonstrated resilient technologies to address district-specific climatic vulnerabilities, and scaled-up proven technologies in a convergence and partnership mode. NICRA shared its experiences and lessons learned with a wide range of stakeholders, including farmers, extension workers, technologists, and policymakers.

Horticulture is a major driver of economic growth in India. Horticulture accounts for 30.00 percent of total agricultural output value. India is the world's leading producer of fruits such as mango, banana, lime, lemon, papaya, and fenugreek (Horticulture Statistics, 2018). Even though the mango is typically associated with tropical regions, it can also be successfully cultivated in subtropical regions. Temperatures between 24 and 45 degrees Celsius are optimal for mango cultivation. Alphonso mangoes, popular in the Konkan region, are known for their exceptional appearance, nutritional value, delectable taste, and exceptional flavour. The mango is considered India's "National Fruit," while the alphonso is dubbed the "King of Mangoes." Alphonso, on the other hand, is extremely vulnerable to climate change. Building resilience to weather extremes is of the utmost importance to mango farmers. Resilience is the ability of a system and its components to anticipate, absorb, accommodate, or recover from the effects of a hazardous event in an efficient manner, including by ensuring the preservation, restoration, or improvement of its essential basic structures and functions (IPCC, 2012). Climate-resilient agriculture, being an integrated approach for building agricultural resilience, is derived from cogitation on it being a holistic strategy (Rao et al., 2016; FAO, 2014; Zou et al., 2014). This has emphasized the importance of adopting climate-resilient agriculture (CRA) in the face of climate volatility.

1.2 Need for the study

Climate change affected agriculture are observed all over the world, but countries like India are more vulnerable because of the large population depending on agriculture, excessive pressure on natural resources and less awareness and adoption of climate-resilient technologies. The Indian farmers have evolved adaptation mechanisms over time, but these mechanisms are unable to fight the extreme weather condition. Changing rural social dynamics and institutional structures is also contributing to the failure of the traditional coping mechanisms. Hence, it is very important as well as very essential to use modern science along with an indigenous technique of farmers to enhance the climate resilience of Indian agriculture. Resilience is the ability of a system and its parts to anticipate, absorb, accommodate, or recover from the effects of a hazardous event in a timely and efficient manner, including through ensuring the preservation, restoration, or improvement of its essential basic structures and functions (IPCC, 2012). Climate-resilient agriculture integrates socioeconomic and ecological spheres with policy and institutional investment to achieve sustainable development (FAO, 2014). Although a lot of studies have made a significant contribution to climate change knowledge and its effects on agriculture at a global and regional level, few of them have addressed its effects on farming at a local level (IPCC, 2014). It is unusual for climate studies to associate socioeconomic and ecological indicators with the people they are relevant to for the purposes of policymaking and adaptation (Smit and Wandel, 2006). Although Indian horticultural fruit production is a rapidly expanding industry, studies on the adoption and diffusion of climate-resilient horticultural technologies are still rare.

1.3 Statement of the problem

Against this backdrop; the important questions before formulating and conducting the proposed topic are;

- Which factors are affecting climate change adaption of climate-resilient mango production technologies in the specific socio-economic and ecological system?
- Are there any climatic vulnerabilities experienced by the mango growers?

- What is the relationship between socio-economic, institutional and ecological characteristics and adoption of climate-resilient mango technologies?
- What is the socio-economic, institutional and ecological situation of mango growers?
- Which strategies would influence the course of adoption?

To answer the above questions, a present study entitled 'Socio-economic factors affecting adoption of climate-resilient technologies by mango growers' is proposed with the following specific objectives.

1.4 Objectives

1. To study the socio-economic characteristics of mango growers.
2. To study the climatic vulnerabilities experienced by the mango growers.
3. To examine the knowledge and adoption of climate-resilient technologies by mango growers.
4. To identify the factors affecting the adoption of climate-resilient technologies by mango growers.

1.5 Hypotheses of the study

Considering the prime objective of the study, the following hypotheses are formulated to test them statistically.

i. *Null hypothesis (H0)*: There may not be any factors affecting the adoption of climate-resilient technologies by mango growers.

ii. *Alternative hypothesis (H1)*: There may be certain factors affecting the adoption of climate-resilient technologies by mango growers.

1.6 Scope and importance of the study

Horticulture in India suffers a lot from erratic weather patterns such as high temperature, longer dry seasons and uncertain rainfall. Declined fruit crop yield due to unfavourable weather and climate will lead to vulnerability in the form of food insecurity, hunger and shorter life expectancies. There are some impacts of climate change for which to identify the factor affecting the adoption of climate-resilient technologies is very important. The Indian farmers have evolved adaptation mechanisms over time, but these mechanisms are unable to fight extreme weather condition because so many factors are affected by the adoption of climate-resilient technologies. Ratnagiri and Sindhudurg district of Maharashtra is a very famous and leading district in mango production but due to climatic vulnerabilities, the mango crop of these districts is more affected which is ultimately affected mango production. So, this study helps to identify these factors which are affecting the adoption of climate-resilient technologies of mango. The study also helps to find out the performance of institutions involved and hurdles they faced during the implementation of climate-resilient technologies. To study the socio-economic characteristics, climatic vulnerabilities, to examine the knowledge and adoption of climate-resilient technologies and to identify the factors affecting adoption of climate-resilient technologies by mango growers will be an immense help in finding out and overcome the problem, and develop extension strategies for capacity building of farmers towards adaptation and mitigation of adverse climatic effects. Therefore, an extension system can help the farmer to identify and overcome those factors and help them for the adoption of new climate-resilient technologies in a better way.

1.7 Limitations of the study

1. Being postgraduate research, the investigator has limitations of time, money and other resources.
2. Since the study designed as an ex-post-facto type, the extraneous factors and memory bias on the part of the respondents can’t be ruled out.
3. This field investigation restricted to the 'South Konkan’ zone of Maharashtra; therefore, the generalizations and implications that emerged out of the investigation would apply to the locale of study and certainly may apply to those regions that have similar socio-economic and agro-ecological conditions.

1.8 Organization of thesis

Any study must have proper organization. This present study also has some definite organization and is divided into six major chapters. The first chapter namely the introduction deals with different aspects like background information, the need of study, statement of the problem, objectives of the study, hypothesis, scope and importance of study, limitations and organization of the study. The second chapter on review of literature includes conceptual and empirical reviews on past studies. The third chapter highlights the research methodology which has been used to conduct this study. It includes locale of the study, research design, sampling techniques, data collection tools and method of analysis. The fourth chapter containing results and discussion related to data and it includes analysed data, its interpretation and justification of the results to fulfil the objectives. The fifth chapter comprising a summary that includes the short information related to the present study. The last chapter of this study is implications, which mainly focusing outcomes and recommendations for policymakers and academicians.

CHAPTER II

REVIEW OF LITERATURE

Research may be done alone, but it is never done in isolation. The formation of new acquaintances is inextricably linked to prior experience. One of the most important elements of the research procedure is reviewing past literature. It is needed for the development of a conceptual framework and the selection of an appropriate design. It is mainly done through having deep insight into different literature sources such as scholarly journals, articles, magazines, policy papers and thesis. This chapter attempt to review the studies related to the socio-economic factors and adoption process. Therefore, a brief account of the literature was reviewed critically and are presented as under with following sub-captions.

2.1 Personal and socio-economic characteristics of the mango growers.

2.2 Ecological characteristics of a mango orchard.

2.3 Climatic vulnerabilities experienced by the mango growers.

2.4 Knowledge and Adoption of climate-resilient technologies.

2.5 Factors affecting adoption of climate-resilient technologies.

2.1 Personal and socio-economic characteristics

2.1.1 Age

Bariya (2010) observed that the majority (61.67 per cent) of the mango growers belonged to the 'middle' age group and 21.67 per cent in the 'old' age category.

Sneha Godse (2010) reported that a huge majority (81.33 per cent) of the mango growers were 'middle' aged and 12.67 per cent belonged to the 'young' age category.

Kawale (2011) found that 75.00 per cent of the respondents had 'middle' age, followed by 15.00 per cent were in the 'old' and 10.00 per cent belonged in the 'young' age category. The average age of the respondents was 47.0 years.

Kota (2011) reported that the great majority (85.83 per cent) of the respondents were belonged to the 'middle' age category, while 10.83 per cent and 3.34 per cent of the respondents were from 'old' and ‘young age’ categories, respectively.

Mehata and Madhuri Sonawane (2012) observed that 52.00 per cent of the respondents were in the 'middle' age group, while 26.00 per cent in the 'young' age group. The remaining 22.00 per cent of the respondents were from the 'old' age group.

Pawar (2013) observed that majority (60.00 per cent) of the respondents were ‘middle’ aged, while 20.00 per cent and 16.00 per cent were in the 'old' and ‘young’ age category, respectively.

Kawale (2011) revealed that majority (69.75 per cent) of the respondents had ‘middle’ age, while 16.67 per cent were ‘old’ and 13.58 per cent were in the 'young’ age category. The average age of the respondents was 52.0 years.

Pawar (2013) revealed that a higher percentage (74.00 per cent) of the respondents were in the ‘middle’ age, while 16.00 per cent were ‘old’ and the remaining 10.00 per cent were found to be ‘younger’. The average age of the respondents was 45.0 years.

Abhishek (2017) while studying the effect of climate change on mango reported that 70.31 per cent of the mango growers were ‘middle’ aged, followed by 15.63 per cent were ‘younger' and 14.06 per cent were in the 'old' category.

Sayali Dabhole (2017) revealed that 69.23 per cent of the respondents were belonged to the ‘middle’ age category, while 13.46 per cent and 17.31 per cent of the respondents were in the ‘young’ ‘and ‘old’ age category, respectively.

Dhenge (2018) observed that 66.25 per cent of the commercial mango growers belonged to the 'middle’ age group, followed by ‘young’ (17.92 per cent) and ‘old’ (15.83 per cent). The average age of the respondents was 48.0 years.

Das and Rahman (2018) in their study on ‘Adoption and discontinuation of innovative agricultural technologies by the farmers of NICRA Village’, revealed that the majority of the respondent's age ranged from 30 to 50 years.

Chichongue (2019) in his study on ‘Factors influencing the adoption of conservation agriculture practices among smallholder farmer in Mozambique’ observed that the average age of adopters was 45.26 years and of non-adopters was 43.31 years.

2.1.2 Education

Sneha Godase (2010) showed that 44.00 per cent of the respondents had completed ‘graduation’, followed by ‘secondary education’ (31.33 per cent) and ‘higher secondary’ by 18.00 per cent.

Ravikumar *et al.* (2013) observed that 34.33 per cent were educated up to ‘middle’ school, followed by ‘high’ school’ (26.67 per cent) and ‘primary’ school (19.67 per cent). The education up to ‘graduation’ was also noticed among 10.33 per cent of the respondents and 9.00 per cent were ‘illiterate’.

Waghmode (2015) noticed that 59.00 per cent of the respondents had completed ‘graduation’, followed by ‘secondary’ by 25.00 per cent and post-graduate by 16.00 per cent.

Abhishek (2017) observed that 31.25 per cent of the mango growers had completed ‘secondary’ education, followed by ‘graduation’ (26.56per cent), ‘higher secondary’ (19.53per cent) and ‘primary’ by 14.06 per cent.

Sayali Dabhole (2017) reported that more than half of the mango growers had ‘secondary’ education (53.85 per cent), followed by ‘higher secondary’ by 21.15 per cent and ‘college’ by 21.15 per cent.

Dhenge (2018) revealed that more than one-fifth of the commercial mango growers had ‘secondary’ education, followed by 25.00 per cent and 20.00 per cent had ‘graduation’ and ‘higher secondary’, respectively. The average education was 11 standards.

Das and Rahman (2018) revealed that the majority of the farmer's education was a primary school (62.00 per cent) and 32.00 per cent had completed secondary schooling.

2.1.3 Annual income

Sneha Godse (2010) observed that 44.66 per cent of the respondents had ‘medium’ annual income, while 36.67 per cent of the respondents had ‘low’ and 18.67 per cent had ‘high’ annual income.

Kawale (2011) observed that 68.00 per cent of the beneficiaries had ‘low’ annual income, while 22.00 per cent had ‘medium’ and 10.00 per cent belonged to the 'high' category of annual income.

Joshi (2012) revealed that the majority (69.17 per cent) of the mango growers had a 'medium' annual income, while 16.66 and 14.17 per cent had 'low' and 'high' annual income, respectively.

Mehta and Madhuri Sonawane (2012) observed that 58.00 per cent of the mango growers possessed a 'medium’ annual income, followed by 27.00 per cent and 15.00 per cent had ‘low’ and ‘high’ annual income, respectively.

Pawar (2013) found fifty per cent of the mango growers belonged to the ‘medium’ category of annual income, whereas 32.50 per cent and 17.50 per cent belonged to the ‘low’ and ‘high’ income category, respectively.

Pooja Choudhari (2014) found that 43.33 per cent of the mango growers had a 'low' annual income, while 35.83 per cent had 'medium' and ‘high’ (20.84 per cent).

Sayali Thakur (2014) observed that 41.90 per cent of the mango growers reported their annual income between 'Rs.1,00,001/- to Rs. 2,00,000/-' and less than one third had annual income up to Rs. 1,00,000/-. Very few (13.33 per cent) respondents’ incomes were ranged from Rs. 2,00,001/- to Rs.4,00,000/- and 12.39 per cent had an annual income of Rs. 4,00,001/-and above.

Wagh (2015) observed that majority (67.33 per cent) of the mango growers had ‘medium’ annual income; while 18.00 and 14.67 per cent had ‘low’ and ‘high’ annual income, respectively.

Dhenge (2018) reported that 65.00 per cent of the commercial mango growers had ‘medium’ annual income, while 22.50 per cent and 12.50 per cent reported ‘high’ and ‘low’ level of annual income, respectively. The average annual income was Rs. 39.72 lakhs.

2.1.4 Landholding

Katkar (2001) indicated that most (55.00 per cent) of the mango growers came under the 'medium’ category of landholding.

Misal (2002) found that one-third (33.00 per cent) of the respondents had ‘semi medium’ landholding, 26.00 per cent had ‘medium’ landholding and ‘small’ landholding (16.00per cent). The ‘marginal’ and ‘big’ landholders were 14.00 per cent and 11.00 per cent, respectively.

Khanolkar (2004) reported that the majority of the mango and cashew growers had ‘medium’ landholding.

Wagale *et al.* (2007) indicated that the average size of holding of sampled mango growers was 2.54 ha.

Yadav *et al.* (2007) observed that the landholding size of most of the orchardists was ‘more than one acre’.

Sneha Godse (2010) found that 38.00 per cent and 40.00 per cent of the respondents had ‘semi medium and ‘medium landholdings, respectively. While 11.33 had small landholdings and 10.67 per cent had large landholding. The average landholding was 5.24 ha.

Kota (2011) revealed that 54.17 per cent of the mango growers had a ‘medium’ size of landholding (4.01 to 10.00 ha). The mango growers in the category of ‘large’ size of landholding were 40.83 per cent and ‘semi medium’ (5.00 per cent).

Das and Rahman (2018) revealed that 72.00 per cent has possessed more than 2 acres of land holding; followed by 1 to 2 acres by 18.00 per cent and less than 1 acre by 10.00 per cent. They reported the majority of the respondents belonged to a large category of landholding.

Oscar Chichongue *et al.* (2019) observed that the average landholding was 2.26 ha. Adopters had more cropped land (2.43 ha) as compared to non-adopters (2.11 ha).

2.1.5 Area under a mango

Sneha Godse (2010) in her study revealed that 34.67 per cent of the respondents had a 'semi medium' area under mango cultivation; followed by 32.00 per cent and 20.67 per cent had 'small' and 'medium' area under mango cultivation, respectively. Only 4.66 per cent of the respondents belonged to the 'large' category of the area under mango cultivation. The average area under mango cultivation was 3.90 ha.

Joshi (2012) in his study revealed that 60.00 per cent of the respondents had a 'medium' area under mango, while 26.67 per cent had 'large' and 13.33 per cent had a 'small' area under mango. The average area under mango was 5.00 ha.

Kawale (2011) observed that the majority (70.99 per cent) of the respondents had a 'medium' area, followed by 'large' (14.81per cent) and 14. 20 per cent had the 'small' size of a mango orchard. The average size of a mango orchard was 5.21 ha.

Pooja Chaudhari (2014) revealed that 57.50 per cent of the respondents had 'medium' followed by 27.50 per cent had 'low' and 15.00 per cent had 'high' area under mango cultivation. The average area under mango cultivation was 6.5 ha.

2.1.6 Age of orchard

Mundekar (1993) revealed that the majority (69.00 per cent) of the respondents had mango orchards of ‘middle’ age, while 16.50 per cent and 14.50 per cent of the respondents had ‘young’ and ‘old’ mango plantations, respectively.

Abhishek (2017) indicated that 60.16 per cent of the Alphonso mango orchards belonged to the 'middle' age group, 26.56 per cent and 13.28 per cent of the orchards were belonged to the 'young' and 'old' age category, respectively.

Sayali Dabhole (2017) reported that 69.23 per cent of the mango orchards had ‘middle’ age, followed by 21.15 per cent and 9.62 per cent of the orchards were belonged to the 'old' and 'young' age category, respectively.

2.1.7 Resource availability

Dinakar (2000) observed that 62.21 per cent of the respondents had the wells as a major source of irrigation, followed by tanks (28.12per cent) and tube wells (9.67 per cent).

Sriram (2000) observed that 42.59 per cent of the cotton growers possessed a ‘medium’ level of resources; whereas 31.41 per cent of respondents had a ‘low’ ‘resources and 26.00 per cent ‘had a ‘high’ level of resources.

Jadav (2005) observed that 67.00 per cent of the respondents possessed ‘medium’ irrigation facilities, whereas 16.00 per cent had ‘low’ irrigation potentiality and 17.00 per cent had ‘high’ irrigation potentiality.

Bharad (2007) observed that 64.00 per cent of the mango growers had a ‘medium’ level of irrigation facility; while 31.50 per cent and 4.50 per cent had ‘less’ and ‘more’ level of irrigation facilities, respectively.

Yadava *et al.* (2007) observed that 54.79 per cent of the mango growers were not having ownership of heavy agricultural implements.

Latha (2009) observed that a great majority (93.33 per cent) of the mango export farmers had ‘medium’ and 6.67 per cent had ‘high’ resources. None of the farmers was classified under the category of ‘less’ availability of resources.

Warwadekar (2014) observed that 74.17 per cent of the farmers possessed ‘optimum’ resources, followed by 15.41 per cent and 10.42 per cent belonged in the categories of ‘medium’ and ‘poor’ resources, respectively.

2.1.8 Access to crop insurance

Nair (2010) evaluated the challenges of crop insurance in India especially about National Agricultural Insurance Scheme (NAIS) and Weather Based Crop Insurance Scheme (WBCIS). An analysis of NAIS statistics reveals that the coverage and indemnity have been biased towards a few regions and crops. She suggested creating awareness among farmers for the claim structures, which are highly technical and complicated.

Chhikara and Kodan (2012) concluded that the low coverage, low operational performance, lack of awareness about the scheme and low access of farmers to the institutional source of credit were the major weakness of the National Agricultural Insurance Scheme (NAIS).

Mahajan (2012) studied the growth and development of the National Agricultural Insurance Scheme (NAIS). The average compound growth of farmers covered was 41.87 per cent. The growth of the area covered was 37.74 per cent. The average growth of farmers benefited was 58.12 per cent and the average compound growth of claims admitted was 69.78 per cent. The study concluded that proper knowledge and implementation of crop insurance scheme can increase food grain production in India and can reduce the risk of crop losses.

Swain (2015) revealed that the per hectare sum assured, a premium paid and claim received were higher for NIAS than for WBCIS.

Dey and Maitra (2017) found that claim payout could increase farmer's coverage under PMFBY, while subsidy and actuarial premium rate significantly impact farmer's coverage for WBCIS.

Mukherjee and Pal (2017) estimated the coverage of crop insurance in India and according to their analysis, 7.22 per cent of farmers were covered under crop insurance in 2012-13 and the average growth rate of crop insurance adoption from 2001 to 2013 was 6.48 per cent. With this level of coverage and growth rate, less than 10.00 per cent of farmers would be covered in 2016-17 and therefore attaining coverage of 50.00 per cent of farmers would take a long time. According to the government, however, 23.00 per cent of farmers had been covered under crop insurance in 2015-16 and around 26.00 per cent farmers in 2017. The reasons for the low spread of crop insurance are lack of awareness among farmers, delay in claim settlement, absence of an adequate number of channels and lack of information on the risk behaviour of farmers.

Rathore (2017) observed the performance of Pradhan Mantri Fasal Bima Yojana (PMFBY) over the other crop models in India including the provisions, performance and improvements of the scheme incorporation with the other models. PMFBY shows considerable improvement in the model especially in the area of premium with a uniform premium of only 2 per cent to be paid by the farmers for all *Kharif* crops, 1.5 per cent for all *Rabi* crops and 5 per cent for annual commercial and horticultural crops. He stated that PMFBY is not income insurance but only revenue loss coverage which insured against weather risk and not crop loss risk.

2.1.9 Extension participation

Chothani (1999) revealed that the majority (72.00 per cent) of the mango growers had 'medium' extension participation, followed by 'low' (15.00per cent) and 'high' (13.00per cent).

Mamatha and Hiremath (2000) reported that small, medium and artisan category of farm women participated in pieces of training, demonstrations and other extension activities.

Jadav (2005) revealed that 72.50 per cent of the mango growers had 'medium' extension participation, whereas 20.00 per cent and 7.50 per cent had 'low' and 'high level of extension participation, respectively.

2.2 Ecological characteristics of mango orchard

2.2.1 Planting density

Nimoriya (2005) reported that stem girth and branching were found maximum in square system and minimum in double hedgerow system. Plant spread (N-S and E-W) and volumes were also found maximum in the square system but minimum in the double-hedge row system. Plant and canopy height were maximum in the double-hedge row system and minimum in the square system. Maximum yield (149.50kg per plot) was found under the double hedgerow system whereas the lowest yield (87 .25 kg per plot) was obtained with the minimum plant population.

Singh *et al.* (2001) reported that mango (cv. Amrapali) plants were subjected to 5 planting systems (square system, 1600 plants/ha; hedgerow system, 2670 plants/ha; double hedgerow system, 3556 plants/ha; paired row planting, 2133 plants/ha; or cluster planting, 2844 plants/ha) in a field experiment conducted in Bhagalpur, Bihar, India. Maximum plant height was recorded from the double hedgerow system (2.95m), followed by the hedgerow system (2.69 m). Minimum plant height was obtained from the square system (2.55 m).

2.3 Climatic vulnerabilities experienced by the mango growers

2.3.1 Climatic vulnerabilities

Parsai (2004) observed that the prolonged cold spell spared major damage; frost and cold spell caused large-scale damage to horticultural plantations in Panjab, Haryana, Himachal Pradesh and Bihar. The damage to the fruit plantation was so severe and so many farmers have uprooted their well-established mango and litchi trees.

Jain (2010) reported that most of the farmers thought, atmospheric temperature and rainfall pattern affect crop production. The majority of farmers experienced that changing monsoon pattern, extended breaks in monsoon and prolonged dry spell brought a change in cropping pattern.

Anonymous (2012) found that an erratic climate hurts mango fruit crops in western India. Climate change especially dry spell has damaged half the area under mango crop in Gujrat. Further, it was found that heavy winds have damaged at least five per cent of the mango crop in the coastal belt of Junagadh and Amreli (Anonymous, 2012).

Debahash Buragohain *et al.* (2019) revealed that severe incidence of drought (73.33 per cent), increase in temperature (60.00 per cent), the occurrence of the flood (36.66 per cent) and delayed rainfall (26.66 per cent) were major climatic vulnerabilities reported by the farmers. Some of the respondents perceived that unusually heavy rainfall and insect-pest infestation were also some climatic vulnerabilities.

Neetu Kumari *et al.* (2020) observed that 34.00 per cent of the respondents perceived that climate change has a high level of overall impact on ecology and human life; while, 36.67 and 29.17 per cent of the respondents reported ‘medium ‘and ‘low’ level of the overall impact of climate change on the ecology and human life, respectively.

2.4 Knowledge and adoption of climate-resilient technologies

2.4.1 Knowledge of climate-resilient technologies

Jadhav (2009) observed that a great majority (96.67 per cent) of the mango growers knew about major pests and their control measures and 92.67 per cent knew about major diseases and their control measures.

Latha (2009) observed that the majority of mango export farmers had rich knowledge on spacing (90.00 per cent), recommended variety for export (88.34 per cent), plant material and planting (86.67 per cent), pruning (85.00 per cent), protocols for bearing orchard and canopy management (81.67 per cent), flowering and fruitfulness (75.00 per cent) pesticide residues (70.84 per cent), integrated disease management (69.17 per cent), nutrient management (65.84 per cent), irrigation management (60.84 per cent) and IPM (52.50 per cent).

Borate *et al.* (2010) observed that 47.00 per cent of the mango growers had ‘high’ knowledge; 22.00 per cent had ‘low’ and 31.00 per cent of the mango growers had ‘medium’ knowledge.

Sneha Godse (2010) observed that the great majority 80.00 per cent of the respondents had a 'medium' level of knowledge, while 8.67 per cent and 11.33 per cent of the respondents had ‘low’ and ‘high’ knowledge, respectively.

Kawale *et al.* (2011) observed that 79.00 per cent of the respondents had ‘medium’ knowledge of mango production technologies, while 15.00 per cent and 6.00 per cent had ‘low’ and ‘high’ knowledge, respectively.

Mehta and Madhuri Sonawane (2012) observed that 74.00 per cent of the respondents had ‘average’ knowledge regarding mango production technology, followed by ‘best’ (19.00 per cent) and ‘poor’ by 7.00 per cent.

Pawar (2013) revealed that the majority 71.00 per cent of the mango growers had ‘medium’ knowledge, while 18.00 per cent and 11.00 per cent of the mango growers had ‘low’ and ‘high’ knowledge about eco-friendly management practices, respectively.

Aski and Hirevenkanagoudar (2014) observed that a higher per cent of the mango cultivation respondents knew the practices like irrigation (60.00 per cent) and 50.00 per and above of the respondents knew intercropping, fertilizer and pest control.

Pooja Choudhari (2014) observed that 65.83 per cent of the respondents had a 'medium' level of knowledge, while 21.67 per cent and 12.50 per cent of the respondents had 'high' and 'low' level of knowledge, respectively.

Sayali Thakur (2014) observed that 65.71 per cent of the mango growers had ‘medium’ knowledge regarding plant protection measures, while 19.05 per cent had ‘low’ and only 15.24 per cent of the mango growers had ‘high’ knowledge.

Sowmya Shree (2015) found that two thirds (66.04per cent) of the farmers had ‘moderate’ awareness about the rejuvenation technique, whereas only 21.46 per cent had very ‘low’ knowledge, 12.50 per cent of the farmers were ‘well’ aware of rejuvenation technique of the mango trees.

Anseera and Alex (2019) found that cent per cent of the farmers were aware of rainwater harvesting, water recycling and the addition of organic matter as effective climate resilient techniques. Almost on par with this, 99.34 per cent of the farmers had awareness of mulching as an effective technique to mitigate the impact of climate change. Similarly, the vast majority (98.34 per cent) of the farmers had expressed that they were aware of cover cropping.

2.4.2 Adoption of climate-resilient technology

Katkar (2001) reported that 68.67 per cent of the mango growers had a 'medium' level of adoption of recommended practices, while 17.33 per cent had 'high' and ‘low’ (14.00 per cent). Similarly, Moulasab *et al.* (2005) also revealed same that the majority of the respondents (68.33 per cent) belonged to the ‘medium’ category of adoption.

Mahadik *et al.* (2008) indicated that a large majority (85.45 per cent) of mango growers had ‘medium’ adoption of mango cultivation technologies, while only 12.73 per cent and 1.82 per cent had ‘high’ and ‘low’ adoption, respectively.

Singh *et al.* (2010) revealed that the adoption of mango cultivation practices was 55.78 per cent. Nearly 60.00 per cent of the growers had ‘moderate’ levels of adoption, while 28.00 per cent of the growers had ‘lower’ adoption.

Sneha Godse (2010) revealed that 78.00 per cent of the respondents had ‘medium’ adoption regarding plant protection practices, while 12.00 per cent had ‘low’ and 10.00 per cent had ‘high’ adoption.

Tanwar *et al.* (2013) observed 57.50 per cent of the mango orchardists adopted recommended planting distance, varieties, methods of irrigation, fertilizers and, insecticides and pesticides.

Das and Rahman (2018) revealed that the majority of the NICRA farmers have adopted Zero tillage technology in wheat 32.00 per cent, followed by zero tillage technology in maize (28.00 per cent), irrigation from a pond (8.00 per cent) and the SRI method of paddy production by 8.00 per cent of the farmers.

Anseera and Alex (2019) in their study on 'Awareness on climate-resilient technologies and their adoption by farmers' found that adoption of rainwater harvesting was found to be 98.67 per cent and water recycling was 96.00 per cent. Practices like mulching, cover cropping, organic matter addition, live bund preparation and check dam construction were also adopted by a higher number (80.00 per cent) of the farmers. Cultivation of pest and disease resistant and drought tolerant varieties were also found to be not adopted by maximum farmers.

Oscar Chichongue *et al.* (2019) analysed that the sampled household practised intercropping (78.70 per cent) crop rotation (38.60 per cent) cover crops (17.20 per cent) and minimum tillage (15.80 per cent), respectively. Intercropping was the most adopted component of CA practices.

2.5 Factors affecting adoption of climate-resilient technologies

The previous research work on socio-economic factors affecting the adoption of climate-resilient technologies was reviewed critically and presented with the following sub-heads.

2.5.1 Age

Bright Masakha Wekesa *et. al*. (2018) in their study on 'effect of climate‑smart agricultural practices on household food security in smallholder production systems: micro‑level evidence from Kenya' found that the age of the household head was negatively associated with usage of C1F0R0S0 and positively associated with usage of C1F1R0S1 at 10% and 5% significant levels, respectively. An increase in the age of the household head by one year reduced the likelihood of using package C1F0R0S0 by 0.19 per cent, while increased the likelihood of using C1F1R0S1 by 0.16 per cent.

Mideksa Dabessa (2020) found that the age of household head was found to be statistically significant in affecting the adoption of soybean production technologies ($p < 0.058$). The result of the study indicates that the increase in the age of household head by one more year would lead to the increase in the intensity of soybean production technology adoption by 0.005 units.

Amancio Nhantumbo *et. al.* (2017) observed that the age of the household head does not influence the decision to use grafted seedling. However, it had a positive effect on the intensity of planting. This means that the older the farmer, the greater is the number of seedlings they planted. while studying socio-economic determinants of intensity adoption of cocoa innovations in Ghana concluded that older farmers will increase the intensity of technology once, they are convinced of its advantages.

2.5.2 Education

Urgessa Tilahun Bekabil *et al.* (2015) found that education has positive impacts on participation in conservation agriculture and was significant at a 1 per cent level. Consistent with this expectation, binary logistic regression showed the educational status of farmers had a strong power in explaining participation in conservation agriculture. Holding other regressors constant, a change in household head education level by one unit will increase the odds of being participated in conservation agriculture by the factor of 0.1382.

Bright Masakha Wekesa *et. al.* (2018) found that the years of education of the household head negatively influenced the usage of C1F1R0S0 which contains crop and field management practices only. One more year of education reduced the probability of using this package by 2 per cent at a 5per cent significance level.

Mideksa Dabessa (2020) found that education household head was found to positively and significantly influenced the probability of adoption of soybean production technologies (P<0.001). This result indicates that the increase in the years of formal schooling of the household head by one year would lead to increases in the probability of adoption of soybean production by 18.91 per cent. This implies that higher education soybean farmers will improve the ability to use information, process and interpret information accurately.

Kidunda B. R *et. al*. (2013) the findings revealed that every one unit increase in education level leads to a 1.265 (26per cent) increase in the log-odds of adoption of improved cashew materials holding other factors constant (*ceteris paribus*). This implied that the probability of adoption of improved cashew materials increases with an increased level of education.

Amancio Nhantumbo *et. al.* (2017) observed that the probability of using grafted seedlings is positively influenced by the education of the household head. It was found that a unit increase in education led to a 26.00 per cent increase in the log-odds of adopting cashew technologies in Tanzania.

2.5.3. Annual income

Mideksa Dabessa (2020) found that the farm income was found to be positively and significantly (P<0.005) influencing the adoption of soybean production technology. Thus, farm income of the household is increased by one ETB would lead to the increase in the probability of adoption of soybean production technology by 0.001 per cent. The result of the study implies that smallholder farmers who got income from annual agricultural production could invest in purchasing other agricultural inputs. Moreover, smallholder farmers with higher farm income tend to adopt soybean production technologies.

Francis Atube *et.al*. (2021) in their study on ‘Determinants of smallholder farmers’ adaptation strategies to the effects of climate change: Evidence from northern Uganda household heads’ found that household heads with a higher annual income were 0.325 times more likely to plant improved seeds ($p = 0.038$), 0.572 times more likely to use fertilizers (p = 0.005), 0.508 times more likely to use pesticides (p = 0.002), and 0.385 times more likely to plant trees (p = 0.022) as adaptation strategies to the effects of climate change than their counterparts with low farm income.

Cherono Janeth et.al. (2019) found that the farm income (β= -0.411; p=0.605) depicted no significant influence on participation in soil erosion management at a 5per cent level of significance.

2.5.4 Operational landholdings

Bright Masakha Wekesa *et. al*. (2018) found that the farm size ownership had a positive influence on the use of packages C1F0R1S1, C1F1R0S1, C1F1R1S0 and C1F1R1S1 and a negative association with the use of package C1F0R0S0. This implies that an increase in the size of land by 1 acre (0.40 ha) increased the probability of using packages C1F0R1S1, C1F1R0S1, C1F1R1S0 and C1F1R1S1 by 2.70 per cent, 1.1 per cent, 1.1 per cent and 0.13 per cent, respectively. While it reduced the probability of using package C1F0R0S0 by 3.8 per cent. It leads to conclude that farmers with larger farm size could use larger packages as opposed to non-usage of any package.

Mideksa Dabessa (2020) found that the total landholding was found to be statistically significant at a 1per cent ($p < 0.008$) level. Further, the result indicates that an increase in the total landholding of the household head by one more hectare would lead to an increase in the intensity of adoption of soybean production technology by 0.044 units.

Laduber Wondale *et. al*. (2016) found that the size of land owned had influenced the household decision to adopt improved varieties significantly and positively at ($p<0.05$) as compared to farmers with smallholdings.

Cherono Janeth *et.al.* (2019) found that the study revealed that land acreage has a negative significant influence on soil erosion management (β=-1.76; p=0.036). This explains that the farmers owning smaller land acreage are 0.172 times more likely to take part in soil erosion management.

2.5.5 Area under a mango

Francis Atube *et. al*. (2021) reported that household heads that cultivated large pieces of land were 0.323 times more likely to plant drought-resistant varieties (p = 0.043) and 0.822 times more likely to plant different crop varieties (p=0.004) as adaptation options to the effects of climate change than their counterparts who cultivated smaller farm sizes.

Yishak Gecho and N. K. Punjabi (2011) found that the farm size had positively and significantly influenced the probability of adoption of improved maize varieties at less than a 5 per cent significance level. This result implies that farmers with large farm size are more likely to adopt the improved maize technology (varieties) than those farmers who have small land size. The odds ratio of 157.901 for farm size indicates that other things being constant, the odds ratio in favour of adopting improved maize varieties increases by a factor of 157.901 as the farm size increases by one hectare.

2.5.6 Ownership of mango orchards

Astewel Takele *et. al.* (2019) indicated that oxen ownership has a positive and significant effect on farmers' choice on the implementation of agroforestry adaptation strategies. It has also a positive effect on-choice of short mature crops and the application of high yield variety crops as a means of climate change adaptation strategy. However, it has a negative relationship with compost preparation to cope with climate change effects. Oxen number affected the adaptation mechanism of farmers to climate change positively and significantly.

Zeray Zeleke *et. al.* (2017) found that the total asset owned by households was positively and significantly influenced the choice of ‘‘early or late planting’’ (p < 0.01), ‘‘increasing seed rate’’ (p < 0.05) and ‘‘soil and water conservation strategies’’ (p < 0.10). It increased the probability of households choosing "early or late planting", "increasing seed rate" and "soil and water conservation strategies" by 0.0006 per cent, 0.0003 per cent and 0.0001 per cent, respectively.

Yishak Gecho and N. K. Punjabi (2011) found that radio ownership affected significantly and positively the probability of adoption of improved maize technology at less than 5 per cent significance level.

2.5.7 Age of orchards

Aurora S. Paderes and Maria Excelsis M. Orden (2004) found that the age of orchards was also significant but negative implying that owners of older trees have a lower probability to adopt pruning technology than those with younger trees. Older trees are higher and are therefore riskier and more difficult to prune (Coefficient. -0.0091).

2.5.8 Resource availability

Bright Masakha Wekesa *et. al*. (2018) elucidated a positive and significant relationship between the value of productive farm assets (a proxy of wealth) and usage of CSAs. Resource-endowed farmers (those with a greater value of productive farm assets) were more likely to use larger packages C1F1R1S0 and C1F1R1S1 as opposed to non-use of any package. Precisely, the probability of using these packages increased by 0.14 per cent and 3.07 per cent, respectively for resource-endowed farmers.

2.5.9 Access to crop loan

Bright Masakha Wekesa *et. al*. (2018) showed that access to credit had a positive and significant influence on the use of C1F1R1S0 but a negative influence on the use of C1F0R0S0 and C1F1R0S0. This result indicates that farmers who received credit in the previous farming season were 0.28 per cent more likely to use C1F1R1S0. Similarly, credit constraints negatively influence investment in improved seed and inorganic fertilizers, suggesting that credit-constrained households are less likely to adopt CSA technologies that require cash outlays. Access to credit reduced the probability of using packages C1F0R0S0 and C1F1R0S0 by 4.6 per cent and 15.7 per cent, respectively. A negative influence of credit access to usage of C1F0R0S0 and C1F1R0S0 may suggest that these farmers diverted credit to fund non-farming expenses.

Mideksa Dabessa (2020) found that the use of credit was found to be significantly affecting the adoption of soybean production technologies. Further, the results indicated that being a user of input credit of the head of household would lead to an increase in the probability of adoption of soybean production technology.

Francis Atube *et. al*. (2021) revealed that those household heads who had access to credit were 0.686 times less likely to plant drought-resistant varieties (p = 0.030), 0.585 times more likely to plant improved seeds (p = 0.020), and 0.626 times more likely to plant trees (p = 0.022) than those who did not have access to credit.

Yishak Gecho and N. K. Punjabi (2011) found that the variable access to credit had a positive and significant influence on the adoption of improved maize.

Laduber Wondale *et. al*. (2016) found that access to credit had a positive and significant influence on the adoption of improved bread wheat. The result showed those farmers who had accessed to credit from formal organizations have been found more participants in adoption than those who had not.

2.5.10 Extension participation

Kidunda B. R *et. al*. (2013) found that access to extension services lead to an increase in the log-odds of adoption of improved materials. This implies that the probability of adoption for the farmers with access to extension services is higher than that of farmers without extension services.

Amancio Nhantumbo *et. al.* (2017) access to extension services determined a positive impact on the adoption of fungicide. Farmers who accessed extension services were 16.00 per cent more likely to use fungicide than their counterparts.

2.5.11 Soil type

Zeray Zeleke et. al. (2017) found that soil fertility had a negative and significant ($p < 0.01$) influence on the decision to choose adaptation strategies.

2.5.12 Topography

Nhat Lam Duyen Tran *et.al*. (2020) found that land tenure and slope of plots have positive effects on the use of alternative CSA packages. Farmers are more likely to adopt CSATs (WS1S1) if they own the land and the topography is flat as shown in the case of Bac Lieu province.

Urgessa Tilahun Bekabil *et al*. (2015) found that conservation agriculture as an adaptation strategy had average topography of their plots, while the rest were those had average topography of their plots is gentle, steep slope and mountainous.

2.5.13 Distance of orchard from the seashore

Zeray Zeleke *et. al.* (2017) found that the distance was significantly ($p < 0.05$) and positively affected the probability of households choosing seasonally appropriate sowing date (early or late planting). One additional distance increases the probability of households choosing seasonally appropriate sowing date.

Yishak Gecho and N. K. Punjabi (2011) found that the distance negatively and significantly associated with the probability of adoption of improved maize technology. The negative association suggests that the likelihood of adopting improved maize variety declines as the distance increases.

Nhat Lam Duyen Tran *et.al*. (2020) found that distance harms the CSA decisions of farmers. Local farmers are likely to apply the new technologies if their land/plot is close to the markets for their farm produce and source of farm inputs and services.

2.5.14 Planting density

Aurora S. Paderes and Maria Excelsis M. Orden (2004) found that the number of trees owned by the respondents was a positive response with a greater number of trees have a higher probability to adopt pruning.

2.5.15 Climatic vulnerability

Bright Masakha Wekesa *et. al.* (2018) found that the factors related to past experiences with extreme weather conditions by farmers also influenced the choice of CSA packages. For instance, farmers who experienced frequent floods in the past were more likely to use package C1F1R0S1. The probability of using this package was increased by 3.3 per cent for those farmers who experienced frequent floods in the recent past.

Bright Masakha Wekesa *et. al*. (2018) also reported that experience with hailstorms was also positively associated with the use of package C1F0R1S0. It was revealed that the likelihood of using this package was increased by 0.52 per cent for those farmers who had experienced frequent hailstorms recently.

Nhat Lam Duyen Tran *et.al*. (2019) found that most of the climate-related factors are found to have a significant impact on CSA adoption. CSA packages are more likely to be adopted in drought and waterlogged plots. Farmers in different provinces have also different strategies to cope with pest and disease infestation. In Bac Lieu province, farmers are not likely to apply the IS (WS0S1) on the plot areas that experienced the pest and disease infestation. However, WS in combination with IS (WS1IS1) is more likely to be adopted on plots previously affected by pests and disease in Ha Tinh and Thai Binh provinces. This result shows that the adoption of different packages of CSATs is very site-specific, which considers the unique characteristics that influence the appropriateness of the technology.

CHAPTER III

METHODOLOGY

The scientific analysis of a researchable issue necessitated applying suitable methods and procedures to reach accurate, impartial, and realistic conclusions. It explains the research approach on how to elicit data as well as what tools used to analyze the data. Specifically, it deals with the study location, research design, sampling framework, data collection tools and techniques, different variables and their empirical measurements, and statistics used for the analysis of qualitative as well as quantitative data. Therefore, this chapter is presented hereunder with the following sub-head.

3.1 Locale of the study

3.2 Research design

3.3 Sampling technique

3.4 Variables: Operationalization and their empirical measurements

3.5 Tools of data collection

3.6 Statistical analysis

3.1 Locale of the study

The Konkan division of Maharashtra consisting five districts namely, Palghar, Thane, Raigad, Ratnagiri and Sindhudurg. These districts come under the jurisdiction of Dr Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli. According to an agro-climatic zone of Maharashtra, the Konkan region further classified into two zones viz., North Konkan and South Konkan. Further, South Konkan comprises two districts namely, Ratnagiri and Sindhudurg. Rainfed agriculture, hilly topography, fragmented landholdings and subsistence farming are the characteristics features of South Konkan. This region contributes a maximum (70.00 per cent) area under mango in the State. Ratnagiri constitutes 60.11 thousand ha area and 190.0 million tonnes production; however, Sindhudurg possessed 23.50 thousand ha area and 70.38 million tonnes productions of mango (Horticultural Statistics at a Glance, 2018). Further, the status of Geographical Indicator (GI) tagged for Alphonso mangos from Ratnagiri and Sindhudurg. This status, awarded by the India Patent Office, allows a geographical region to lay an exclusive claim over a product. Considering these facts, the Ratnagiri and Sindhudurg districts were purposively selected for this study (See Figure 1).

Ratnagiri district lies between 16^{o} 13' to 18^{o} 04' North Latitudes and 73^{o} 02' to 73^{o} 52' East Longitudes. The Ratnagiri district has surrounded by the boundaries of Raigad in the north, the Arabian Sea towards the west, Sindhudurg district on the south and, Satara, Sangli and Kolhapur districts on east. The district has an area of 8,208 Km^2. The population of the district is 16,15,069; out of which, the male population is 7,61,121 and female is 8,53,948. The district has a very good literacy rate (82.18 per cent); which represents 90.93 per cent of male literacy and 74.53 per cent of female (India's Census, 2011). The average annual rainfall of the district is 3000 to 4000 mm and humid climate having an average temperature from 17^{o}C to 36^{o}C. The district is predominated by red lateritic soil. The district is well-known for horticultural crops; besides, field crops cereals, pulses and oilseeds are grown. Regarding cereals, rice and finger millet are stapled food crop during *Kharif* and pulses like horse gram, cowpea, beans are also cultivated during *Rabi.* Mango and cashew are leading high-value crops followed by coconut, areca nut, kokum, jackfruit and spices.

Similarly, the Sindhudurg district lies between 15^{o} 37' and 16^{o} 40' north latitudes and between 73^{o} 19' and 74^{o} 13' east longitudes. The district is surrounded by Ratnagiri in the north, Kolhapur in the east, the Arabian Sea towards the west and, Karnataka and Goa States towards the south. On the west, the Arabian Sea gives a seaboard of 121 Km. Total geographical area of 5,207.0 $Km^{2.}$; total population is 849,651, of which male population is 4,17,332 and female is 4,32,319. The average literacy rate is good (85.56 per cent); representing the male (91.58 per cent) and female literacy of 79.81 per cent (India's Census, 2011). The district falls under a heavy rainfall zone and the average annual rainfall is 3000 to 3500 mm. The average temperature ranges from 16^{o}C to 34^{o}C. The principal crops are grown in the district are cereals and horticultural crops such as rice, finger millet, sugarcane, mango, cashew, coconut, areca nut, sapota, kokum, karonda, jamun, jackfruit and vegetable to a small extent.

3.2 Research design

Research design is the arrangement of conditions for the collection and analysis of data in a manner that aims to combine relevance to the research objectives with an economy in procedure. According to Kerlinger (1976), a research design is the plan, structure and strategy of investigation to obtain answers to research questions and to control variance. For the present study, a researcher had adopted the 'ex-post-facto design of social research. The ex-post facto research is a systematic and empirical inquiry in which the researcher does not have direct control over independent variables because their manifestations have already occurred or they are inherently not manipulable.

3.3. Sampling technique

Sampling is the process of choosing a subset of the population in such a way that each sample has an equal chance of being selected and would represent the whole population. Therefore, the researcher adopted a simple random sampling technique to draw an adequate size of the sample (N=156). The Konkan division has the highest percentage (70.00 per cent) of the area under mango in the State. Ratnagiri and Sindhudurg district were selected purposively based on their maximum area and production of mango. Further, two Tehsils from each sampled district were selected randomly. Therefore, ‘Rajapur’ and ‘Lanja’ from Ratnagiri district and ‘Devgad’ and ‘Vengurle’ tehsils from Sindhudurg district were selected randomly (See Figure1). These tehsils are well known for mango and popularly known as Ratnagiri *Hapus* and Devgad *Hapus* in the domestic market.

Further, the list of villages was obtained from the respective *Taluka* Agricultural Office (TAO) of respective selected Tehsils. From this list, only those villages were considered that having a maximum area under mango crop. Thereafter, three villages from each tehsil were selected using a simple random sampling technique. Thus, the study comprises a total of '12' villages randomly sampled from two districts of the South Konkan. Further, a list of the farmers was obtained either from Gram Sevak, Agricultural Assistant and *Sarpanch*-a public representative of Gram Panchayat. The mango growers were identified and separated from the entire list. Lastly, '13' mango growers from each village were selected randomly. Accordingly, from each district '78' mango growers were selected randomly. Thus, the present study constitutes '156' mango growers as a respondent.

3.4. Variables: Operationalization and their empirical measurements

The selection of variables comprised in the study was done based on an extensive review of literature related to the research problem and in consultation with the experts. Finally, the variables that were found to be most relevant and applicable to the present study were selected. This section gives an operational definition and measurement used for the selected independent and dependent variables.

3.4.1 Independent variables

The phenomenon or characteristics hypothesized to be the input or antecedent variable is called the independent variable. It is presumed to cause the dependent variable and is selected, manipulated or measured before measuring the outcome of the dependent variable. In the present study, the following independent variables were selected and, their operational definitions, empirical measurements and categorization are described hereunder.

3.4.1.1 Age

It was operationally defined as the chronological age of the respondent in completed years at the time of the interview. Based on mean (49.97) ± Standard Deviation (11.93), the sampled respondents were categorized into the following three categories.

Sl. No.	Category	Age (years)
1.	Young	Up to 35
2.	Middle	36 to 50
3.	Old	Above 50

3.4.1.2 Education

Operationally, it was the educational attainment of the respondent mango growers. It was measured in completed standards. One score was given for each completed standard by the respondents. This score was considered for further statistical analysis with the dependent variable. The sampled respondents were categorized into the following standard educational groups.

Sl. No	Category	Education (Standard)
1.	Primary	Up to 4^{th}
2.	Secondary	5^{th} to 10^{th}
3.	Higher-secondary	11^{th} to 12^{th}
4.	Graduate (Any degree)	13 and above

3.4.1.3 Annual income

In the present study, annual income was operationalized as the incomes of the farmers from all sources. Based on the mean ((Rs.1295568.9) ± standard deviation (588412.1), the sampled respondents were grouped into the following three categories.

Sl. No	Category	Annual income (Rs)
1.	Low	Up to Rs. 7,07,155.9/-
2.	Medium	Rs. 7,07,156 to Rs. 1883981/-
3.	High	Above Rs. 1883981/-

3.4.1.5 Landholding

It refers to actual operational land possessed by the respondent at the time of the interview. It was measured in a hectare. Based on total land owned by the mango growers, they were grouped into standard five categories declared by the Government.

Sl. No	Category	Area (hectare)
1.	Marginal	Up to 1.00 ha.
2.	Small	1.01 to 2.00 ha.
3.	Semi-medium	2.01 to 4.00 ha.
4.	Medium	4.01 to 6.00 ha.
5.	Large	6.01 ha. and above

3.4.1.6 Area under a mango

The actual area in hectare under productive mango cultivation was taken into consideration. Based on the total area under mango owned by the respondents, they were grouped into five standard categories of landholdings.

Sl. No	Category	Area (ha.)
1.	Marginal	Up to 1.00 ha.
2.	Small	1.01 to 2.00 ha.
3.	Semi-medium	2.01 to 4.00 ha.
4.	Medium	4.01 to 6.00 ha.
5.	Large	6.01 ha. and above

3.4.1.7 Ownership of orchard

It was operationally defined as the actual ownership status of mango orchards possessed by the respondent. It was measured by assigning following a score to ownership status.

Sl. No	Ownership status	Score
1.	Leased-out	0
2.	Leased-in	1
3.	Own land	2
4.	Own + leased-in	3

3.4.1.8 Age of orchard

Several years of the orchard from a year of planting was considered. It was measured in completed years. Based on the mean (38.10) ± standard deviation (9.95), the following three categories of the age of orchard were made.

Sl. No	Category	Age (Years)
1.	New plantation	Up to 28 years
2.	Middle age plantation	29 to 48 years
3.	Old plantation	Above 48 years

3.4.1.9 Resource availability

It was operationalized as the extent of different resources available with farmers for the management of mango orchards. A teacher-made test was used. The test consists of 19 items of different important resources required for the management of mango orchards. The responses from the respondents were rated four-point continuum by assigning a score 3, 2, 1 and 0. Therefore, the minimum and maximum score one could get on the test were 0 and 57, respectively. This raw score was converted into a resource availability index by using the following formula.

$$\text{Resource availability} = \frac{\text{A total obtained score}}{\text{Maximum possible score}} \times 100$$

The respondents were classified based on this resource availability index into three categories as given below.

Sl. No	Category	Resource availability (%)
1.	Inadequate	Up to 33.33
2.	Optimum	33.34-66.66
3.	Adequate	Above 66.66

3.4.1.10 Access to crop insurance

It refers to the accessibility of mango growers to Pradhan Mantri Fasal Bhima Yojana. It was quantified in the dichotomous response of Yes and No.

Sl. No.	Category	Score
1.	Yes	1
2.	No	0

3.4.1.11 Access to crop loan

This indicates whether the mango growers borrowed crop loan from any nationalized or cooperative banks. It was quantified in the dichotomous response of Yes and No.

Sl. No.	Category	Score
1.	Yes	1
2.	No	0

3.4.1.12 Extension participation

It was operationally defined as the frequency of participation of the respondent mango growers in different extension programmes. A teacher-made test was developed to quantify this variable. The responses from the respondents were rated on a three-point continuum viz., always, sometimes and never by assigning a score of 2, 1 and 0, respectively.

Based on the mean (3.07) ± standard deviation (1.10), the sampled respondents were grouped into three categories.

Sl. No	Category	Frequency (Score)
1.	Low	Up to 2
2.	Medium	3-4
3.	High	Above 4

3.4.1.13 Sources of inputs

Operationally, it was defined as the different sources from which mango growers were accessed critical inputs required for the management of mango orchards. A teachers-made test was used. It was quantified in the dichotomous response of yes and no for each institutional source of inputs.

Based on the mean (2.42) ± standard deviation (0.64), the sampled respondents were grouped into three categories.

Sl. No	Category	Source of inputs (Score)
1.	Low	Up to 1
2.	Medium	2-3
3.	High	Above 3

3.4.1.14 Soil type

The soil type on which mango orchards are planted was considered. The soil was classified into three types as given below.

Sl. No	Soil type	Score
1.	Lateritic-Plain	1
2.	Platue-Upland	2
3.	Rocky (*Jambha*)	3

3.4.1.15 Topography

This refers to the physical characteristics and position of land on which mango orchards were established. According to that, it was categorized into two categories as given below.

Sl. No	Topography	Score
1.	Plane	1
2.	Hilly	2

3.4.1.16 Distance from the seashore

The actual geographical distance of mango orchards from the Arabian sea was taken into consideration. It was measured in Km.

Based on the mean (12.22) ± standard deviation (9.43), the respondents were grouped into three categories.

Sl. No	Category	Distance (Km)
1.	Near	Up to 3 Km
2.	Medium-long	4 to 22 km
3.	Long	More than 22 Km

3.4.1.17 Planting density

It refers to the mango trees planted per unit area. It was measured in terms of the number of mango plant per hectare. It was categorized as per recommended planting density.

Sl. No	Planting density	Trees/ha
1.	Less than recommendation	<100 trees/ha
2.	As per recommendation	100 trees/ha
3.	More than recommendation	>100 trees/ha

3.4.1.18 Climatic vulnerability

Operationally, it was defined as whether the mango orchard was exposed to or suffered from particular extreme climatic events and its perceived severity to cause an adverse impact on the mango. The teacher made test was developed to quantify this variable. The responses from respondents were rated on a three-point continuum such as extremely severe, severe and not severe by assigning a score of 3, 2 and 1, respectively. Therefore, the minimum and maximum score one could get on the test were 9 and 27, respectively. This raw score was converted into a climatic vulnerability index by using the following formula.

$$\text{Climatic vulnerability} = \frac{\text{A total obtained score}}{\text{Maximum possible score}} \times 100$$

The respondents were grouped into three categories as given below.

Sl. No	Category	Climatic vulnerability (%)
1.	Low	Up to 33.33
2.	Medium	33.34-66.66
3.	High	More than 66.66

3.4.1.19 Knowledge

English and English (1958) defined knowledge as a body of understood information possessed by an individual.

It was operationally defined as a body of understood information possessed by the individual respondents about climate-resilient mango production technologies.

A teacher made knowledge test was developed to measure the knowledge. The climate-resilient technologies developed by Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli were screened in consultation with Scientists from Horticulture and Extension Education disciplines and, also Members from Students Advisory Committee (SAC). By considering climate-resilient technologies, a set of knowledge items were converted into questions with a dichotomous response of correct and incorrect answer. Further, the knowledge items were pre-tested with 10 respondents in the non-sample area of the study. Based on the results of pretesting, the knowledge items were modified to remove the ambiguity and then finalized the test.

The knowledge test developed was administered to the respondent and measured by giving a score of one and zero for a correct and incorrect answer, respectively. The nine items were summed to get the knowledge score of individual respondents. Therefore, the minimum and maximum score one could get on the test were 0 and 9, respectively. This raw score was converted into a knowledge index by using the following formula.

$$\text{Knowledge} = \frac{\text{Actual Obtained score}}{\text{Maximum possible score}} \times 100$$

The respondents were grouped into three categories as given below.

Sl. No	Category	Knowledge (%)
1.	Low	Up to 33.33
2.	Medium	33.34-66.66
3.	High	More than 66.66

3.4.2 Dependent variable

In the present study, the adoption of climate-resilient mango production technologies was the dependent factor. It was operationalized and quantified as given below.

3.4.2.1 Adoption

It was operationalized as the extent of recommended climate-resilient technologies adopted by the respondent mango growers. A teacher-made adoption test was developed by considering all technologies screened in the knowledge test as mentioned earlier. In this test, nine technologies were considered to measure the adoption of the respondents. A binary response viz., adopted and not-adopted was taken from the sampled respondents by assigning a score of 1 for adoption and 0 for non-adoption. Therefore, the minimum and maximum score one could get on the test were 0 and 9, respectively. This raw score was converted into an adoption index by using the following formula.

$$\text{Adoption} = \frac{\text{Actual obtained score}}{\text{Maximum possible score}} \times 100$$

The respondents were grouped into three categories as given below.

Sl. No	Category	Adoption (%)
1.	Low	Up to 33.33
2.	Medium	33.34-66.66
3.	High	More than 66.66

3.4 Tools of data collection

The information on the tools and technique of data collection adopted in the present study is furnished in this part.

3.4.1 Constriction of the interview schedule

By considering the objectives of the study, the interview schedule was prepared. This schedule was developed in three parts comprises independent variables, dependent variable and, reasons for non-adoption of technologies by the mango growers. In the first part, questions related to the socio-economic and ecological characteristics of the mango growers were included. In the second part, the adoption of climate-resilient technologies was included. In the last part, open-ended questions were included for understanding the non-adoption of technologies by the mango growers and researchers' observations during a field study. The schedule was first prepared in English language and later it was translated into Marathi- a local language for helping the respondents to clearly understand the questions put to them for giving an appropriate response. After preparing the interview schedule, it was finalized with the guidance of the Students Advisory Committee (SAC) and faculty from the Extension Education discipline.

3.4.2 Pre-testing of an interview schedule

The interview schedule was pre-tested by conducting a personal interview of 30 mango growers selected from the non-sample area. The reason behind the pre-testing was to reduce the ambiguity if any, to know whether the interview schedule was clear and understandable to the respondents for giving response accurately. Based on the experiences of pre-testing, a slight modification was done to the interview schedule. The final format of the schedule for data collection is placed in Appendix II.

3.4.3 Collection of data

The ‘personal interview’ method was adopted in an informal atmosphere for the collection of field data. At the beginning of the interview, the researcher introduced himself and the purpose of the interview. He established a good rapport with the respondents. During the interview session, questions were explained to the respondents to secure a proper response from them. Each completed interview schedule was checked immediately after the closure of the interview for its completion in all respects.

3.5 Statistical analysis

The data collected from the respondents were scored, tabulated and analyzed by using appropriate statistical methods such as frequency, percentage, mean, standard deviation and a binary logistic regression analysis.

3.5.1 Percentage

$$S.D. = \sqrt{\frac{\sum (Xi - \overline{X})^2}{(n-1)}}$$

The term percentage means a fraction whose denomination is 100 and the numeration of the fraction is called a percentage. For calculating percentage, the frequency was multiplied by 100 and divided by the total number of respondents

$$p = \frac{X}{N} \times 100$$

3.5.2 Arithmetic mean ($\overline{X}$)

It is defined as the sum of all the values of the observations divided by the total number of observation (n); symbolically it is represented as;

$$\overline{X} = \frac{\sum X}{N}$$

Where,

$\overline{X}$= Arithmetic mean

ΣX = Sum of the item

N = Total number of items

3.5.3 Standard deviation (σ)

It is a positive square root of the mean of the sum of the square of the deviation taken from the mean of the distribution.

Where,

S.D.= Standard deviation

X= Score of each respondent

$\overline{X}$ = Mean

N= Number of respondents

3.7.4 Logistic Regression Analysis

Logistic regression is a statistical for analyzing a dataset in which there are oneor more independent variables that determine an outcome. The outcome is measured with a dichotomous variable.

Logistic regression provides a method for modeling a binary response variable, which takes values 1 (success) and 0 (failures).

The goal of logistic regression is to find the beast fitting model to describe the relationship between the dichotomous characteristic of interest dependent variable(response or outcome variable) and a set of independent (predictor or explanatory)variables.

Suppose that the model has the form [4]:

$$y_i = \beta_0 + \beta_1 x_i + \varepsilon_i \tag{1}$$

And the response variable y_i takes on the value either 0 or 1. We will assume that the variable y_i is a Bernoulli random variable with probability distribution as follows:

$$p\ (y_i = 1) = p_i \tag{2}$$

$$p\ (y_i = 0) = 1 - p_i \tag{3}$$

Now since $E(\varepsilon_i) = 0$, $E(y_i) = p_i$, this implies that

$$E(y_i) = \beta_0 + \beta_1 x_i = p_i \tag{4}$$

If the response is binary, the error terms ε_i can only take on two values,

$$\varepsilon i = \begin{cases} 1-(\beta_0+\beta_1 x_i), when\ y_i = 1 \\ -(\beta_0+\beta_1 x_i), when\ y_i = 0 \end{cases} \quad (5)$$

Consequently, the errors in this model cannot possible be normal, and the error variance is not constant, since

$$\sigma^2_{y_i} = p_i(1-p_i)$$

$$\sigma^2_{y_i} = E(y_i)[1-E(y_i)] \quad (6)$$

The logit response function has the form:

$$\mathrm{E}(y_i) = \frac{1}{1+e^{[-(\beta 0\ +\ \beta_1 x_i)]}} \quad (7)$$

The estimated coefficients for the independent variables are estimated usingeither the logit value or the odds value as the dependent measure. In logistic regression for a binary variable, we model the natural log of the odds ratio, which is called logit [13].

Each of these model formulations is shown here [1][4] [5]:

$$Logit = \mathrm{In}\left(\frac{p_i}{(1-p_i)}\right) = (\beta 0 + \beta_1 x_i) \quad (8)$$

$$Odd = \frac{p_i}{(1-p_i)} = e^{(\beta 0+\beta_1 x_i)} \quad (9)$$

The simple logistic regression model can be easily extended, for it to have tomore than one predictor variable [9].

$$\mathrm{E}(y_i)\ \frac{e^{(x_i\beta)}}{1+e^{(x_i\beta)}} \quad (10)$$

Where,

$$x_i\beta = \beta 0 + \beta 1 x_i + \cdots \ldots + \beta p - 1 x_i,\ p-1$$

Maximum Likelihood Estimation

Maximum likelihood method is the procedure of finding the value of one or more parameters for a given statistic which makes the known likelihood distribution a maximum [9].

Since each y_i represents a binomial count in the i^{th} population, the joint probability density function of y is [2], [15]:

$$g\ (y_\mathrm{i}) = \prod_{i=1}^{n} \mathrm{f}_\mathrm{i}(y_\mathrm{i}) = \prod_{i}^{n} =_1 p_\mathrm{i}^{y_\mathrm{i}}\ (1-p_\mathrm{i})^{\mathrm{i}-y_\mathrm{i}} \tag{11}$$

$$log(y_\mathrm{i}) = \ log \prod_{i=1}^{n} \binom{n_\mathrm{i}}{y_\mathrm{i}} p_\mathrm{i}^{y_\mathrm{i}} (1-p_\mathrm{i})^{n_\mathrm{i}-y_\mathrm{i}} \tag{12}$$

After taking exp to both sides of equation (12)

$$log(y_\mathrm{i}) = \ log \prod_{i=1}^{n} \left(e^{\sum_{k=0}^{K} x_{ik}\beta_k}\right)^{y_\mathrm{i}} \left(1 - \frac{e^{\sum_{k=0}^{K} x_{ik}\beta_k}}{1+e^{\sum_{k=0}^{K} x_{ik}\beta_k}}\right)^{n_\mathrm{i}} \tag{13}$$

$$log(y_\mathrm{i}) = \ log \prod_{i=1}^{n} \left(e^{\ y_\mathrm{i} \sum_{k=0}^{K} x_{ik}\beta_k}\right) \left(1 + e^{\sum_{k=0}^{K} x_{ik}\beta_k}\right)^{-n_\mathrm{i}} \tag{14}$$

This is the kernel of the likelihood function to maximize. Thus, taking thenatural log of equation (14) yields the log likelihood function:

$$l(\beta) = \sum_{i=1}^{n} y_\mathrm{i}\left(\sum_{k=0}^{K} x_{ik}\beta_k\right) - nlog\left(1 + e^{\sum_{k=0}^{K} x_{ik}\beta_k}\right) \tag{15}$$

To find the critical points of the log likelihood function, set the first derivativewith respect to each β equal to zero. In differentiating equation (15)

$$\frac{\partial}{\partial \beta_k} \sum_{k=0}^{k} x_{ik}\beta_k = x_{ik} \tag{16}$$

$$\frac{\partial l(\beta)}{\partial \beta_k} = \sum_{i=1}^{n} y_i x_{ik} - n_i \frac{1}{1+e^{\sum_{k=0}^{k} x_{ik}\beta_k}} \frac{\partial}{\partial \beta_k}\left(1 + e^{\sum_{k=0}^{k} x_{ik}\beta_k}\right)$$

$$= \sum_{i=1}^{n} y_i x_{ik} - n_i \frac{1}{1+e^{\sum_{k=0}^{k} x_{ik}\beta_k}} e^{\sum_{k=0}^{k} x_{ik}\beta_k} \frac{\partial}{\partial \beta_k} \sum_{k=0}^{k} x_{ik}\beta_k$$

$$= \sum_{i=1}^{n} y_i x_{ik} - n_i \frac{1}{1+e^{\sum_{k=0}^{k} x_{ik}\beta_k}} e^{\sum_{k=0}^{k} x_{ik}\beta_k} x_{ik}$$

$$= \sum_{i=1}^{n} y_i x_{ik} - n_i \, p_i \, x_{ik} \tag{17}$$

The equations in equation (17) equal to zero results in a system of k + 1 nonlinear equation each with k + 1 unknown variables, and so must be solved by iteration. The system is a vector with elements, β_k.

After verifying that the solution is the global main rather than a local maximum. The solution must be numerically estimated using an iterative process. Perhaps the most popular method for solving systems of nonlinear equations is Newton Raphson method [15].

The Coefficient of Determination (R^2)

There are several R^2like statistics that can be used to measure the strength of the association between the dependent variables and the predictor variables. Two commonly used statistics are [11]:

Cox and Snell $R2$

$$R_{cs}^2 = 1 - \left(\frac{L(\widehat{\beta}_{(0)})}{\widehat{L(\widehat{\beta})}} \right)^{\frac{2}{n}} \tag{18}$$

Nagelkerkes $R2$

$$R_N^2 = \frac{R_{cs}^2}{\left(1 - L(\widehat{\beta}_{(0)})\right)^{\frac{2}{n}}} \tag{19}$$

where $L(\hat{\beta})$is the log-likelihood function for the model with the estimated parameters and $L(\hat{\beta}_{(0)})$ is the log-likelihood with just the thresholds and n is the number of cases.

Omnibus Test of Model Coefficients

This test is applied to determine whether the overall model with all predictors is significantly different from the model with only the intercept. The Omnibus test is interpreted as a test of the capability of all predictors in the model jointly to predict the response variable. The test is based on the difference between the log likelihood for the overall model and log likelihood of the model with only the constant term, such difference follows chi square distribution where the number of predictors represent the degrees of freedom.

Wald test

The Wald test is used to testing the significance of individual coefficients in the model. This statistic is calculated as [1], [4]:

$$W = \left(\frac{b_j}{S{\cdot}E(bj)}\right)^2 \tag{20}$$

Where b represents the estimated coefficient β for explanatory variable and $S.E(b)$ is its standard error. The hypotheses are

$$\left.\begin{matrix} H_0: \beta_j = 0 \\ H_1: \beta_j \neq 0 \end{matrix} , j = 1,2, \dots, k \right\} \tag{21}$$

Each Wald statistic is compared with chi- square distribution with one degree of freedom. A large value of chi- squared (with p- value< 0.05) indicates weak fit and small chi- squared (with p- value closer to 1) indicate a good logistic regression model fit.

CHPATER IV

RESULT AND DISCUSSION

This chapter delineate the results of the statistical analysis, interpretation of the findings and discussion thereupon. The aim of this study was to determine the socio-economic factors affecting adoption of climate-resilient technologies by the mango growers. As per stated objectives, the findings of the study are presented with following captions.

4.1 Personal and socio-economic characteristics of the mango growers,

4.2 Ecological characteristics of mango orchard,

4.3 Climatic vulnerabilities experienced by the mango growers,

4.4 Knowledge and adoption of climate-resilient technologies,

4.5 Factors affecting adoption of climate-resilient technologies.

4.1 Personal and socio-economic characteristics of the mango growers

4.1.1 Age

Age is an indicator of maturity and experience, which in turn has a direct bearing on knowledge and the adoption process. The data on the chronological age of respondents was collected, analysed and presented in Table 1 and also illustrated in Figure 2.

Table 1: Distribution of the respondents according to their age

Sl. No.	Age (Years)	Frequency (N=156)	Percentage	Min.	Max.	Mean	SD
1.	Young (<35yrs.)	17	10.90	22.00	77.00	49.97	11.93
2.	Middle (36-50yrs.)	65	41.67				
3.	Old (>50 yrs.)	74	47.43				
	Total	156	100.00				

It is evident from Table 1 that the majority (47.43 per cent) of the mango growers belonged to the 'old age' category; followed by 41.67 per cent and 10.90 per cent of the respondents found in the 'middle' and 'young' age categories, respectively. The minimum age of mango growers was 22.00 years; maximum was 77.0 years and average age was 49.97 years. It could be said that older people were largely engaged in mango production.

The present finding of average age is nearly similar to the observations of Dhenge (2018). He reported that the average age of commercial mango farmers was 48.0 years. Further, the results showed a considerable percentage of the respondents belonged to the 'middle' age category. They got support from the studies of Bariya (2010), Sneha Godse (2010), Kawale (2011), Kota (2011), Mehata and Madhuri Sonawane (2012), Pawar (2013), Abhishek (2017), Sayali Dabhole (2017), Das and Rahman (2018) and Chichongue (2019). According to these researchers, the majority of mango growers are in the middle age group.

4.1.2 Education

Formal education harnesses the intellectual ability of an individual. It is the process of imparting knowledge and skills required for a particular profession. Therefore, data regarding the educational attainment of the respondents was collected, analysed and presented in Table 2 and in Figure 3.

Table 2: Distribution of the respondents according to their education

Sl. No.	Education (Standard)	Frequency (N=156)	Percentage	Min.	Max.	Mean	SD
1	Primary (<4th)	12	7.69	2.0	16.0	9.82	3.15
2	Secondary (5th -10th)	92	58.97				
3	Higher secondary (11th-12th)	28	17.95				
4	Graduate	24	15.39				
	Total	156	100.00				

It is observed from Table 2 that majority (58.97 per cent) of the mango growers were completed their education up to 'secondary' level; followed by 17.95 per cent had 'higher-secondary' and 15.39 per cent were finished 'graduation'. Further, equal per cent of the respondents (7.69 per cent) were completed 'primary' and had 'post-graduation'. The minimum family education was 2^{th} standard; maximum was post-graduation and average was 10^{th} standard. Interestingly none of the respondent was found to be an illiterate.

This leads to conclude that most of the mango growers were educated from ‘secondary’ to ‘higher-secondary’ level. Similarly, Abhishek (2017), Sayali Dabhole (2017) and Dhenge (2018) reported that most of the respondents had completed ‘secondary’ education. This reflects that educated families are mostly engaged in mango production and they may adopt advanced technologies, ideas and innovations related to mango cultivation and management.

4.1.3 Annual income

Annual income considers the incomes of the farmers from the all sources. This indicates the economic condition of the mango growers and also promote them to adopt advance innovations. Therefore, data regarding annual income was collected from sampled mango growers, analysed and presented in Table 3 and also elucidated in Figure 4.

Table 3: Distribution of the respondents according to their annual income

Sl. No.	Annual income (Rs.)	Frequency (N=156)	Percentage	Min.	Max.	Mean	SD
1.	Low (<Rs.7,07,155.9/-)	65	41.67	180500	10875000	1295568.9	588412.1
2.	Medium (Rs. 7,07,156 to Rs. 1883981/-)	66	42.31				
3.	High (> Rs. 1883981/-)	25	16.02				
	Total	156	100.00				

A critical look at Table 3 revealed that majority (42.31 per cent) of mango growers belonged to ‘medium’ income category ranged from Rs. 7,07,156 to 18,83,981/-. This followed by 41.67 per cent and 16.02 per cent of the respondent were found in ‘low’ (<Rs. 7,07,155.9/-) and ‘high’ (>Rs.18,83,981/-) income category, respectively. Further, this study also reported that average annual income of the mango growers was Rs. 12,95,569/-; maximum was Rs. 1,08,75,000/- and minimum was only Rs. 1,80,500/-.

From this data, it is clear that the financial condition of the mango growers in the study area was good. The present finding that majority of the mango growers were belonged in 'medium' category of annual income are in agreement with the results of Joshi (2012) and Mehta, Pawar (2013) and Madhuri Sonawane (2012). However, the average annual income of mango growers was high (Rs.12.95 lakh) is in confirmatory with result of Dhenge (2018) who reported the average annual income of Rs. 39.72 lakhs.

4.1.4 Operational land holding

The mango growers were grouped in to five categories on the basis of operational land owned by them and presented in Table 4 and in Figure 5.

Table 4: Distribution of the respondents according to their landholding.

Sl. No.	Landholding (ha.)	Frequency (N=156)	Percentage	Min.	Max.	Mean	SD
1.	Marginal (Up to 1.00 ha.)	18	11.54	0.80	35.00	4.28	4.91
2.	Small (1.01 to 2.00 ha.)	52	33.33				
3	Semi-medium (2.01 to 4.00 ha.)	43	27.56				
4.	Medium (4.01 to 6.00 ha.)	16	10.26				
5.	Large (Above 6.00 ha.)	27	17.31				
	Total	156	100.00				

The data presented in Table 4 revealed that one third (33.33 per cent) of mango growers were belonged to 'small' category of landholding and 27.56 per cent belonged to 'semi-medium' category. Further, 17.31 per cent, 11.54 per cent and 10.26 per cent of the respondent were found in 'large' and 'marginal' and 'medium' landholding category, respectively. The minimum landholding was

0.80 ha; maximum was 35.0 ha and average landholding of mango farmers was 4.28 ha.

It is evident from above data that most of the mango growers had small (1.01 to 2.00 ha) and semi-medium (2.01 to 4.00 ha) landholding. Similarly, Misal (2002) and Godse (2010) reported that one-third of the respondents had 'semi-medium' landholding. Remaining respondents possessed large, marginal and medium size of land holding. It was also observed that generally mango orchardists had average landholding of more than four hectare.

4.1.5 Area under mango

The area under mango has a direct impact on the overall production of the mango orchard. On the basis of total area under mango owned by the mango growers, they were grouped into five categories and presented in Table 5 and also elucidated in Figure 6.

Table 5: Distribution of the respondents according to their area under mango.

Sl. No.	Landholding (ha.)	Frequency (N=156)	Percentage	Min.	Max.	Mean	SD
1.	Marginal (Up to 1.00 ha.)	51	32.69	0.50	20.0	3.37	2.64
2.	Small (1.01 to 2.00 ha.)	37	23.72				
3	Semi-medium (2.01 to 4.00 ha.)	31	19.87				
4.	Medium (4.01 to 6.00 ha.)	13	8.33				
5.	Large (Above 6.00 ha.)	24	15.39				
Total		156	100.00				

The data presented in Table 5 revealed that majority (32.69 per cent) of mango growers were belonged to 'marginal' category, followed by 23.72 per cent belonged to 'small' category. While, 19.87 per cent, 15.39 per cent and 8.33 per cent of the respondent were found in 'semi-medium' and 'large' and 'medium' category, respectively. The minimum area under mango was 0.50

hectare; maximum was 20.0 hectare and average area reported by the sampled respondents was 3.37 hectare.

This leads to clear that most of the mango growers had marginal to small (1.00-2.00 ha) area under mango. However, considerable percentage of the respondents possessed mango cultivation on medium, semi-medium and large area of more than 10.0 hectare. This indicated that diversified category of the farmers was engaged in mango farming in South Konkan. Their average mango cultivation was more than a three-hectare area (3.37 ha). A similar observation was reported by a researcher Sneha Godse (2010) said average area under mango cultivation was 3.90 ha. However, Joshi (2012) and Pooja Chaudhari (2014) found that the average area under mango was more than 5.0 hectares.

4.1.6 Ownership of mango orchard

The ownership status of land is very imperative as it affect mango production efficiency. The process of land 'leasing-out' or 'leasing-in' is very common in rural area. The multiple reasons behind this are some people leftover farming, some are migrated in metros or some are residing away from their native place. Therefore, data regarding ownership status of mango orchard was collected, analysed and depicted in Table 6 and Figure 7.

Table 6: Distribution of the respondents according to their ownership of orchards.

Sl. No.	Ownership status	Frequency (N=156)	Percentage	Min.	Max.	Mean	SD
1.	Leased-out	00	00.00	2.00	3.00	2.11	0.32
2.	Leased-in	26	16.67				
3.	Own land	130	83.33				
4.	Own + leased-in	26	16.67				
	Total	156	100.00				

It was observed that a great majority (83.33 per cent) of the mango growers had self-ownership of the mango orchard, followed by an equal (16.67 per cent) of the respondents were in the leased in and 'Own+ leased in' (16.67per cent) category of orchard ownership (See Figure 6). None of the respondents belonged to the 'Leased-out' status of mango orchard ownership. It could be seen that most of the mango growers had their own orchards. Besides, some mango farmers have leased-in the orchards of other farmers from their locality. In South Konkan, some elite and resourceful farmers are engaged in mango trading and also, they act as an exporter of high-value Alphonso mango. Mostly these farmers lease-in the land from other farmers.

4.1.7 Age of orchard

The age of mango orchards has a direct impact on mango productivity. Therefore, data regarding the age of the mango orchard was collected, analysed and depicted in Table 7 and Figure 8.

Table 7: Distribution of the respondents according to their age of mango orchard.

Sl. No.	Age (Years)	Frequency (N=156)	Percentage	Min.	Max.	Mean	S.D.
1.	New plantation (<28 years)	26	16.67				
2.	Middle age plantation (29 to 48 years)	109	69.87	10.00	70.00	38.10	09.95
3.	Old planation (>48 years)	21	13.46				
Total		156	100.00				

Above Table 7 stated that majority (69.87 per cent) of the mango orchard belonged to 'middle' age category, followed by 16.67 per cent and 13.46 per cent in 'new plantation' and 'old plantation' age category, respectively. The minimum age of the mango orchard was 10.00 years; the maximum was 70.00 years and the average mango orchard age was 38.10 years. In all, it could be said that the majority of mango orchards are in their 'middle' years of productive age. Similar findings were reported by Mundekar (1993), Sayali Dabhole (2017) and Abhishek (2017), who stated that the majority of the respondents had mango orchards at a 'middle' age.

4.1.8 Resource availability

Extent of availability of resource with farmers have direct impact on their mango production efficiency and adoption of climate resilient technologies. Off course, resource-rich farmers are better in mango production than their counterpart resource-poor farmers. Therefore, in the present study, efforts have been made to collect data regarding resource availability, which is presented in table 8 and also in Figure 9.

Table 8: Distribution of the respondents according to their resource availability

Sl. No.	Resource availability (%)	Frequency (N=156)	Percentage	Min.	Max.	Mean	SD
1.	Inadequate (<33.33)	00	00	61.11	85.19	70.58	4.29
2.	Optimum (33.34 to 66.66)	17	10.90				
3.	Adequate (>66.66)	139	89.10				
	Total	156	100.00				

It is seen from Table 8 that a higher percentage (89.10 per cent) of the respondents had an 'adequate' level of resources for operating a mango orchard. Furthermore, it was observed that very less of the mango growers (10.90 per cent) reported that they had 'optimum' level of resource availability however; none of the respondent belonged to 'inadequate' level of resources to cultivate mango orchard. This indicated that not a single mango grower possessed 'inadequate' resources and very few farmers had 'optimum' farm resources. Most of the mango growers from South Konkan region was resourceful. Average number of resources available with mango growers were high (70.58 per cent). The present findings are disagreement with the observations of past researchers Katait (1994), Dinakar (2000), Sriram (2000), Jadav (2005), Bharad (2007), Yadava *et al.* (2007), Latha (2009) and Warwadekar (2014). They reported, majority of the farmers possessed medium level of resources with them. However, present study reported that majority of the mango growers possessed 'adequate' resources with them. They are having affordable and useful farm resources required for management of mango orchard.

Most resources required for management of mango orchards are grass cutter, HTP sprayer, chain saw, harvester, weighting machine, plastic crates, packaging boxes and secateurs. Most of the said tools and implements have been availed by them from line departments on subsidy basis. Further, they had purchased other inputs like fertilizers and micro-nutrients, insecticides, pesticides and plant regulators from authorized input dealers. Every year they are hiring labour from other states as well as from other countries like Nepal. Therefore, most of the sample mango growers reported plenty of resources with them.

4.1.9 Access to crop insurance

It refers to the accessibility of mango growers to either the Weather Based Crop Insurance Scheme (WBCIS) or the Pradhan Mantri Fasal Bhima Yojana (PMFBY). It was quantified by the dichotomous response of yes or no. The data regarding access to crop insurance was collected, analysed and depicted in Table 9 and also in Figure 10.

Table 9: Distribution of the respondents according to their access to crop insurance.

Sl. No.	Category	Frequency (N=156)	Percentage	Min.	Max.	Mean	SD
1.	Yes	74	47.44	0.00	1.00	0.47	0.20
2.	No	82	52.56				
	Total	156	100.00				

The Table 7 indicated that more than fifty percentage (52.56 per cent) of the respondents did not have access to crop insurance scheme and sizable percentage (47.44 per cent) of the respondents had accessed to crop insurance scheme-Pradhan Mantri Fasal Bhima Yojana (PMFBY). It could be said that most of the mango growers were not accessed crop insurance scheme. The reasons might be lack of awareness about scheme and lack of faith in insurance company for the settlement of claim and for getting any compensation. The same observations were reported by the Nair (2010), Amol *et al.* (2012), Chhikara and Kodan (2012), Mahajan (2012) and, Mukherjee and Pal (2017) they observed that lack of awareness among farmers, delay in claim settlement, absence of an adequate number of channels and lack of information on the risk behaviour of farmers were the main reasons behind low coverage of insurance schemes in the country. However, Rathore (2017) pointed out that PMFBY shows considerable improvement in the area of premium with a uniform premium of 5.0 per cent for annual commercial and horticultural crops. Further, he stated that PMFBY is not income insurance but only revenue loss coverage which insured against weather risk and not crop loss risk.

4.1.10 Access to crop loan

This indicates whether the mango growers borrowed crop loan from any banks. Crop loan provide financial support to the farmers which help them to manage mango orchards efficiently. It was quantified in the dichotomous responses yes or no. The data regarding access to crop loan was collected, analysed and depicted in Table 10 and Figure 11.

Table 10: Distribution of the respondents according to their access to crop loan.

<table>
<tr><th>Sl. No.</th><th>Category</th><th>Frequency (N=156)</th><th>Percentage</th><th>Min.</th><th>Max.</th><th>Mean</th><th>SD</th></tr>
<tr><td>1.</td><td>Yes</td><td>80</td><td>51.28</td><td rowspan="3">0.00</td><td rowspan="3">1.00</td><td rowspan="3">0.51</td><td rowspan="3">0.40</td></tr>
<tr><td>2.</td><td>No</td><td>76</td><td>48.72</td></tr>
<tr><td colspan="2">Total</td><td>156</td><td>100.00</td></tr>
</table>

Table 10 showed that the majority (51.28per cent) of the respondents had borrowed the crop loan and less than half 48.72 per cent respondent did not borrowed crop loan. Crop loans have generally been obtained from nationalised and cooperative banks by farmers.

4.1.11 Sources of input

The various sources from which farmers have obtained critical inputs are important for efficient mango orchard management. Therefore, data regarding sources of input was collected, and depicted in Table 11 a and Table 11 b.

Table 11 a: Distribution of the respondents according to their source of inputs

Sl. No.	Source of inputs (Score)	Frequency (N=156)	Percentage	Min.	Max.	Mean	SD
1.	Low (<1)	00	00.00	2.00	4.00	2.42	0.64
2.	Medium (2-3)	143	91.67				
3.	High (<3)	13	8.33				
Total		156	100.00				

Table 11 a showed that a large percentage (91.67 per cent) of the respondents had 'medium' levels of access to input sources. Furthermore, just 8.33 per cent of the respondents said that they had a 'high' level of input from sources. Surprisingly, none of the respondents reported 'poor' access to sources of input.

Table 11 b: Distribution of the respondents according to their different sources used to access critical inputs.

Sl. No.	Sources	Yes	
		Frequency (n=156)	Percentage
1.	Agricultural University	12	07.69
2.	Krishi Vigyan Kendra (KVK)	48	30.77
3.	Agriculture Department	146	93.59
4.	Agricultural Consultants	12	07.69
5.	Input dealer / Krishi Seva Kendra	155	99.36
6.	Private nursery owner	13	08.33

Table 11b reveals that the overwhelming majority (99.36 per cent) of mango growers reported, input dealers or Krishi Seva Kendra as the major source of input for them. Mango is highly input intensive fruit crop. It requires quality insecticides, pesticides, micro-nutrients, fertilizers and plant regulators for better management of orchards. Generally, all these critical inputs are easily available from private input dealers. These input dealers consult mango growers regarding the use of insecticides and pesticides from different private companies. Therefore, the study reported that input dealers were the main source of inputs for the mango growers. Similarly, the use of the input dealers for information in India was also well acknowledged by National Sample Survey Organizations (NSSO) in 2005. Furthermore, the Department of Agriculture had provided inputs to a large number of the respondents (93.59 per cent), followed by Krishi Vigyan Kendra (30.77 per cent), Private nursery owner (8.33 per cent), Agricultural University (7.69 per cent) and Agriculture Consultants (7.69 per cent). The Department of Agriculture provide inputs especially tools and machineries to mango growers on subsidy basis. The Krishi Vigyan Kendra and Agricultural Universities are providing grafts of different mango varieties viz., Alphonso, Kesar, Ratna, Sindhu and Konkan Samrat and technical guidance. The University and KVKs also demonstrated the advanced technologies like application of paclobutrazol, canopy management, rejuvenation of old and senile orchards.

4.1.11 Extension participation

It was assumed that the participation of the respondents in the various extension programme motivate them to adopt improved production technologies in mango. The data regarding extension participation depicted in Table 12 a and Table 12 b.

The data presented in Table 12a revealed that a higher percentage (78.85 per cent) of the mango growers belonged to the ‘medium’ category of extension participation, followed by 17.95 per cent and 3.20 per cent of the respondents in the ‘low’ and ‘high’ categories, respectively. This indicated that the majority of the respondents had a medium level of exposure to different extension organizations and frontline extension activities.

Table 12a: Distribution of the respondents according to their extension participation.

Sl. No.	Extension participation (Score)	Frequency (N=156)	Percentage	Min.	Max.	Mean	SD
1.	Low (<2)	28	17.95	02.00	14.0	03.07	01.10
2.	Medium (3-4)	123	78.85				
3.	High (<4)	05	03.20				
	Total	156	100.00				

In line with present findings, Chothani (1999), Mamatha and Hiremath (2000), and Jadav (2005) revealed that most of the mango growers had ‘medium’ extension participation.

Table 12 b: Distribution of the respondents according to their frequency of participation in different extension activities

Sl. No.	Extension activities	Frequency of Participation		
		Always	Sometimes	Never
1.	Group discussions	06 (3.85%)	150 (96.15%)	00 (0.0%)
2.	Trainings	00 (0.0%)	02 (1.28%)	154 (98.72%)
3.	Frontline demonstrations	02 (1.28%)	153 (98.08%)	01 (0.64%)
4.	Workshops	00 (0.0%)	00 (0.0%)	156 (100.0%)
5.	Farmers Mela/Rally	03 (1.93%)	127 (81.41%)	26 (16.66%)
6.	Field day	02 (1.28%)	03 (1.92%)	151 (96.80%)
7.	Mango festival/Exhibition	02 (1.28%)	24 (15.39%)	130 (83.33%)
8.	Exposure visits/Study tour	02 (1.28%)	02 (1.28%)	152 (97.44%)
9.	Campaign	00 (0.0%)	00 (0.0%)	156 (100.0%)

*Figure in parentheses indicates percentage

Further data in Table 12b indicates higher (98.08 per cent) of the respondents were sometimes participated in frontline demonstrations; followed by group discussion (96.15 per cent) and also sometimes they had attended farmers mela/rally (81.41 per cent). However, majority of the mango growers were not undergone any training program (98.72 per cent); never participated in mango festival/exhibition (96.80 per cent) and field day (96.80 per cent). Further, huge majority (97.44 per cent) of the respondents said that they had never participated in any exposure visits/study tours organized by the different extension organizations. Similarly, not a single respondent attended any workshops on mango. The reason might be the outbreak of the COVID 19 pandemic. Since last two years the government extension agencies are not organizing massive extension programs like mango festivals, exhibitions, exposure visits and workshops. Therefore, sampled respondents reported less participation in the said extension activities. The highest frequency of participation of the mango farmers was found in group discussions, frontline demonstrations and farmers' rallies organized in their villages. These off-campus activities are generally organized by the KVKs, ATMA and the Agricultural Department with a limited number of farmers and by taking precautions for the COVID 19 pandemic.

4.2 Ecological characteristics of the mango orchard

4.2.1 Soil type

The type of soil on which mango orchards were established was important for the adoption of climate resilient technologies. Soil types also affect mango production. The data regarding soil type was collected, analysed and depicted in Table 13.

A critical look at Table 13 revealed that the majority (79.49 per cent) of the mango orchards were established on ‘rocky’ soil, followed by 12.18 per cent and 8.33 per cent of the mango orchards planted on ‘red lateritic’ soil and ‘Platue’-upland type of soil, respectively. Rocky type of soil is generally found on west belt of the Konkan and also near to the coastal area.

Table 13: Distribution of the respondents according to their soil type

Sl. No.	Soil type	Frequency (N=156)	Percentage	Min.	Max.	Mean	S.D.
1.	Red lateritic	19	12.18	01.00	03.00	01.32	00.68
2.	Platue-upland	13	08.33				
3.	Rocky (*Jambha*)	124	79.49				
Total		156	100.00				

This rocky soil found very suitable for mango plantation than the other type of soil. This rocky soil gives more physiological stress to mango and hot wind from Arabian seas facilitate early maturity in mango fruits. These early matured mango fruits fetch higher prices and ultimately increase the profit of the farmers. Therefore, most of the farmers are interested to cultivate mango on rocky soil.

4.2.2 Topography

Topography refers to the physical characteristics and position of the land on which the mango orchards were established. The topography of the land on which the mango orchards were planted was taken into consideration. The data regarding topography is presented in Table 14.

Table 14: Distribution of the respondents according to their topography

Sl. No.	Topography	Frequency (N=156)	Percentage	Min.	Max.	Mean	SD
1.	Plane	20	12.82	01.00	02.00	01.32	00.52
2.	Hilly	136	87.18				
Total		156	100.00				

The Table 14 revealed that the great majority (87.18 per cent) of the mango orchards were established on ‘hilly' topography and only 12.82 per cent of respondents reported that they planted mango orchards on ‘plain' topography. In South Konkan, plain land is generally used for cultivation of paddy and minor pulses. Therefore, most of the plantation crops like cashew and mango are planted on hilly topography. Second reason is that hilly topography facilitates more sunlight from south-west side and which is suitable for reproductive growth of mango trees and also more exposure of mango plant to sunlight reduces insect-pest infestation.

4.2.3 Distance of orchard from the sea shore

The actual geographical distance of the mango orchards from the Arabian sea was taken into consideration. It was measured in Km. The data regarding the distance of the orchard from the sea shore is in Table 15.

Table 15: Distribution of the orchards according to distance from the sea shore

Sl. No.	Distance (Km)	Frequency (N=156)	Percentage	Min.	Max.	Mean	S.D.
1.	Near (<3 Km)	05	03.21	02.0	45.0	12.22	09.43
2.	Medium-long (4 to 22 Km)	114	73.07				
3.	Long (>22Km)	37	23.72				
	Total	156	100				

Table 15 shows that the majority (73.07 per cent) of mango orchards were found to be ‘medium to long' (4 to 22 Km) distance from seashore, followed by 23.72 per cent and 3.21 per cent of the mango orchards were established on ‘long’ and ‘near’ distance from sea shore, respectively. As stated earlier, the rocky type of soil is generally found on west belt of the Konkan and it found from near to medium long distance from coastal area. This west belt of 4 to 22 Km away from seashore provides conducive environment for Alphonso mango. Therefore, most of the respondents had established their mango orchards in the west belt of the Konkan rather than in the east part-near to the Sahyadri ranges.

4.2.4 Planting density

It refers to the number of mango trees per hectare of land. Mango productivity is also influenced by planting density. The information regarding planting density is depicted in Table 16.

Table 16: Distribution of the orchards according to their planting density

<table>
<tr><th>Sl. No.</th><th>Planting density</th><th>Frequency (N=156)</th><th>Percentage</th><th>Min.</th><th>Max.</th><th>Mean</th><th>S.D.</th></tr>
<tr><td>1.</td><td>Less than recommended (<100 tree/ha)</td><td>47</td><td>30.12</td><td rowspan="4">80.0</td><td rowspan="4">100.0</td><td rowspan="4">96.28</td><td rowspan="4">06.14</td></tr>
<tr><td>2.</td><td>As per recommended (100 trees/ha)</td><td>109</td><td>69.88</td></tr>
<tr><td>3.</td><td>More than recommended (>100 trees/ha)</td><td>00</td><td>00.00</td></tr>
<tr><td colspan="2">Total</td><td>156</td><td>100.00</td></tr>
</table>

The data presented in Table 16 indicated that majority (69.88 per cent) of the respondents had adopted the recommended planting density (100 trees/ha) and only 3.12 per cent of mango orchards were found to be less than the recommended planting density. The mortality of newly planted grafts might be the reasons behind observing less planting density than the recommendation. Surprisingly, none of the respondent mango orchards planting density was found to be more than the recommendation. Most of the mango plantation was done under Rural Employment Guarantee Scheme of the Maharashtra in 1989-90. As per the recommendation of the Agricultural University, Government has provided mango grafts (100/ha) to the farmers on subsidy basis. This is the main reason of present findings that majority of the respondents adopted the recommended planting density (100 trees/ha) in mango. This leads to say that Alphonso mango orchards are well established in South Konkan.

4.3 Climatic vulnerabilities

The Alphonso variety of mango is highly sensitive to climatic variability, besides its genetic habit of alternate bearing. The production of Alphonso mango solely depends on climate indices, viz., rainfall, temperature, relative humidity, cold waves, fog and frost, wind velocity and cyclones. Whether or not the mango orchard was exposed to or suffered from specific extreme climatic events, as well as the severity of such occurrences, created a negative impact on mango production and productivity in the Konkan. Therefore, the data regarding climatic vulnerabilities was presented in Table 17 a and 17 b.

Table 17 a: Distribution of the respondents according to their experience of climatic vulnerability.

<table>
<tr><th>Sl. No.</th><th>Climatic vulnerability (%)</th><th>Frequency (N=156)</th><th>Percentage</th><th>Min.</th><th>Max.</th><th>Mean</th><th>S.D.</th></tr>
<tr><td>1.</td><td>Low (<33.33)</td><td>00</td><td>00.00</td><td rowspan="4">62.96</td><td rowspan="4">81.48</td><td rowspan="4">71.95</td><td rowspan="4">03.83</td></tr>
<tr><td>2.</td><td>Medium (33.34 - 66.66)</td><td>10</td><td>06.41</td></tr>
<tr><td>3.</td><td>High (>66.66)</td><td>146</td><td>93.59</td></tr>
<tr><td colspan="2">Total</td><td>156</td><td>100.00</td></tr>
</table>

A close examination of Table 17a revealed that the majority (93.59 per cent) of the mango orchards were exposed to the 'high' level of climatic vulnerabilities and only 6.41 per cent of the mango orchards had exposed to the climatic vulnerabilities to a 'medium' extent. Surprisingly, not a single respondent was reported 'low' level of climatic vulnerability during recent past. This leads to conclusion that mango orchards in Konkan are severely exposed to extreme climatic events as majority of the respondents reported ‘highly’ sever climatic vulnerability.

A critical look at Table 17b revealed that 86.54 per cent of respondents had observed ‘moderate severity’ of delayed flowering and fruit-setting due to extended and unusual rain. However, 75.00 per cent of the mango growers reported ‘extreme severity’ of unusual rain and high humidity, leading to the incidence of anthracnose, powdery mildew, fruit flies and hoppers. The same results, also reported by Anonymous (2010), revealed that unseasonal rain in Central and South Gujarat affected the mango crop adversely.

Table 17 b: Distribution of the respondents according to their perceived severity of different climatic events/indices.

Sl. No.	Climatic shocks / stress	Severity		
		Extremely severe	Severe	Not severe
a.	Rainfall & humidity			
1.	Delayed flowering and fruit-setting due to extended and unusual rain	21 (13.46%)	135 (86.54%)	00 (0.0%)
2.	Unusual rain and high humidity lead to incidence of anthracnose, powdery mildew, fruit fly and hoppers	117 (75.00%)	39 (25.00%)	00 (0.0%)
b.	Temperature			
1.	Low temperature for prolonged period reduces the hermaphrodite flowers	00 (0.0%)	03 (1.92%)	153 (98.08%)
2.	Sudden increased temperature during inflorescent stage leads to infestation of hoppers, thrips	20 (12.82%)	136 (87.18%)	00 (0.0%)
3.	Abrupt increase in temperature causes fruit drop in mango	87 (55.77%)	69 (44.23%)	00 (0.0%)
4.	Abrupt increase in temperature leads to sun-scorching and spongy tissue	105 (67.30%)	51 (32.70%)	00 (0.0%)
c.	Cold waves			
1.	Recurrent flowering and heavy fruit drop are observed due to repeated cold waves	65 (41.66%)	91 (58.33%)	00 (0.0%)
d.	Fog and frost			
1.	Prolonged fog and frost increase the incidence of anthracnose on inflorescent	06 (3.85%)	148 (94.87%)	02 (1.28%)
e.	Wind & cyclone			
1.	Destruction of mango tress or branches and heavy fruit drop due to high wind velocity and cyclone	00 (0.0%)	112 (71.80%)	44 (28.20%)

*Figure in parentheses indicates percentage

The ‘moderate severity’ of sudden increase in temperature during inflorescent stage leads to infestation of hoppers and thrips was experienced by 87.18 per cent of the mango growers. Further, mango was ‘extreme severely’ affected due to abrupt increase in temperature causes fruit drop in mango (55.77 per cent) and, sun-scorching and spongy tissue (67.30 per cent). The majority (87.18 per cent) of the respondents reported that mango was ‘moderately’ affected due to sudden increase in temperature during inflorescent stage that leads to infestation of hoppers and thrips. Further, moderate severe (58.33 per cent) and extreme severe (41.66per cent) recurrent flowering and heavy fruit drop was observed due to repeated cold waves. The majority (94.87 per cent) of the respondents also opined that prolonged fog and frost increased the incidence of anthracnose on inflorescent and ‘moderately’ affected the mango crop. The prolonged cold spell spared major damage, frost and cold spell caused large-scale damage to horticultural plantations in Panjab, Haryana, Himachal Pradesh and Bihar (Parsai, 2004).

There was moderate destruction of mango trees or branches and significant fruit drops were observed due to high wind velocity and cyclones. This was reported by 71.80 per cent of the sampled respondents. During the last decade, the Konkan region has experienced three major cyclones, such as Phyan in November, 2009, Nisarg in June, 2020 and recently Taukte in May, 2021 the most powerful, deadly and damaging tropical cyclones in the Arabian Sea. All these cyclones have damaged the fruit crops, especially mango trees and their branches, severely in the entire Konkan belt. Other horticultural plantation crops were also damaged due to high wind velocities and cyclones. Huge economic loss in agriculture was reported by the state agricultural department.

In short, nowadays Alphonso mango became very sensitive to climate change and mango farmers had experienced different climatic vulnerabilities. The severity of climatic vulnerability varied from ‘moderate to extreme severe’.

4.4 Knowledge and Adoption of climate-resilient technologies

In this session, data on knowledge and adoption of climate-resilient technologies were collected, analysed and discussed hereunder.

4.4.1 Knowledge

The knowledge on climate-resilient technologies facilitates the farmers to cope vulnerable situation and also mitigate the impact of climate change. In this context, data on knowledge on climate-resilient mango production technologies were collected, analysed and depicted in Table 18 a and Table 18 b.

Table 18 a: Distribution of the respondents according to their knowledge on climate resilient mango technologies

<table>
<tr><th>Sl. No.</th><th>Knowledge (%)</th><th>Frequency (N=156)</th><th>Percentage</th><th>Min.</th><th>Max.</th><th>Mean</th><th>S.D.</th></tr>
<tr><td>1.</td><td>Low (<33.33)</td><td>00</td><td>00</td><td rowspan="4">55.56</td><td rowspan="4">100.0</td><td rowspan="4">78.49</td><td rowspan="4">11.95</td></tr>
<tr><td>2.</td><td>Medium (33.34 - 66.66)</td><td>15</td><td>09.62</td></tr>
<tr><td>3.</td><td>High (>66.66)</td><td>141</td><td>90.38</td></tr>
<tr><td colspan="2">Total</td><td>156</td><td>100.00</td></tr>
</table>

Table 18a indicated that 90.38 per cent of mango growers were belonged to ‘high’ category of knowledge and only 9.62 per cent of the respondents found to have a ‘medium’ degree of knowledge on climate-resilient mango production technologies. It was surprising to note that none of the respondent found in ‘low' knowledge category. Further, study reported that minimum knowledge was 55.56 per cent, maximum was 100.00 per cent and mean knowledge of the respondents was 78.49 per cent. This leads to conclude that the sampled mango growers had rich knowledge on climate-resilient mango production technologies. This finding is supported by the studies conducted by Jadhav (2009), Latha (2009) and Borate *et al.* (2010) which observed that majority of mango farmers had ‘high knowledge on production technologies. Contrary to this, Sneha Godse (2010), Kawale *et al.* (2011), Mehta and Madhuri Sonawane

(2012), Pawar (2013) and Sowmya Shree (2015) reported, most of the farmers possessed 'moderate' level of knowledge on mango production technology.

Table 18 b: Distribution of the respondents according to their knowledge on different climate resilient mango production technologies.

Sl. No.	Technologies	Knowledge-Yes	
		Frequency (n=156)	Percentage
1.	Use of recommended dose of Paclobutrazol during July-August	156	100.00
2.	Spraying of Gibberellic Acid (GA) 50 ppm to avoid recurrent flowering	96	61.53
3.	Spraying of Naphthalic Acetic Acid (NAA) 20 ppm to avoid fruit drop	11	07.05
4.	Spraying of Potassium Nitrate (1%) for more fruit retention	81	51.92
5.	Canopy management to facilitate more sunlight and thereby reduce pest infestation	134	85.89
6.	Provide irrigation (100-200 litre/tree) to reduce dropping of pea size fruits	156	100.00
7.	Use of university recommended spraying schedule for insect-pest management	156	100.00
8.	Bagging of fruit from 'Marble to Egg' stage	156	100.00
9.	Rejuvenation of Old and Senile orchard	156	100.00

Table 18 b illustrates data regarding knowledge of sample respondents on climate-resilient mango production technologies. It is evident from Table that cent per cent of the sample respondents possessed knowledge on using recommended dose of paclobutrazol during July-August; providing irrigation (100-200 litre/tree) to reduce dropping of pea size fruits, using university recommended spraying schedule for insect-pest management, paper bagging of fruits from the 'Marble to Egg' stage and rejuvenation of old and senile orchard was also reported by the 100.00 per cent of the mango growers. Further, majority (85.89per cent) of the respondents had knowledge on canopy management in mango crop which facilitates more sunlight and thereby reduce pest infestation, spraying of Gibberellic Acid (GA) 50 ppm to avoid recurrent flowering (61.54 per cent) and spraying of 1% Potassium Nitrate for more fruit retention (51.92 per cent). However, only 7.05 per cent of the respondents had knowledge of spraying Naphthalic Acetic Acid (NAA) 20 ppm to avoid fruit drop in mango.

Above results indicated that mango growers had 'high' knowledge on most of the climate-resilient technologies. However, somewhat dissimilar findings were reported by Sayali Thakur (2014) and, Aski and Hirevenkanagoudar (2014) they observed that mango farmers had 'medium' knowledge on irrigation, plant protection and fertilizer application. Similarly, Sowmya Shree (2015) also reported 'moderate' awareness of farmers about the plant rejuvenation technique in mango.

4.4.2 Adoption

Adoption of innovations and technologies enhance the farm productivity and profitability. Therefore, adoption is very important stage while diffusing innovation in socio-cultural system. The data on adoption of climate-resilient mango production technologies was collected, analysed, and depicted in Table 19a and 19b.

Table 19a: Distribution of the respondents according to their adoption of climate resilient mango technologies

Sl. No.	Adoption (%)	Frequency (N=156)	Percentage	Min.	Max.	Mean	S.D.
1.	Low (<33.33)	32	20.52	0.00	100.0	52.49	17.78
2.	Medium (33.34 - 66.66)	79	50.64				
3.	High (>66.66)	45	28.84				
Total		156	100.00				

It is seen from Table 19a that more than fifty per cent (50.64 per cent) of the respondents belonged to 'medium' category of adoption; followed by 28.84 per cent and 20.52 per cent were found in to 'high' and 'low' categories of adoption, respectively. The minimum adoption was zero per cent while maximum was 100.00 cent per cent. The mean adoption of climate-resilient mango technology was 52.49 per cent. This leads to conclusion that fifty per cent of the mango growers adopted climate-resilient mango technologies to a medium extent. Further, mean of the adoption showed that slightly more than fifty per cent of the recommended climate-resilient technologies were adopted by the sample mango growers. These results are in line with the observations of Katkar (2001), Mahadik *et al.* (2008), Singh *et al.* (2010) and Godse (2010) who reported, a large majority of the mango growers had 'medium' adoption.

Table 19 b: Distribution of the respondents according to their adoption of different climate resilient mango production technologies.

Sl. No.	Technologies	Adopted	
		Frequency (n=156)	Percentage
1.	Use of recommended dose of paclobutrazol during July-August	90	57.69
2.	Spraying of Gibberellic Acid (GA) 50 ppm to avoid recurrent flowering	81	51.92
3.	Spraying of Naphthalic Acetic Acid (NAA) 20 ppm to avoid fruit drop	53	33.97
4.	Spraying of potassium nitrate (1%) for more fruit retention	116	74.35
5.	Canopy management to facilitate more sunlight and thereby reduce pest infestation	90	57.69
6.	Provide irrigation (100-200 litre/tree) to reduce dropping of pea size fruits	133	85.25
7.	Use of university recommended spraying schedule for insect-pest management	98	62.82
8.	Paper bagging of fruits from the 'Marble to Egg' stage	55	35.26
9.	Rejuvenation of Old and Senile orchards	21	13.46

The adoption of climate-resilient mango technologies is depicted in Table 19 b revealed that a majority (85.25 per cent) had provided irrigation water of 100-200 litre/tree to reduce dropping of pea size fruits during summer and sprayed potassium nitrate 1.0% for more fruit retention (74.35 per cent). This was followed by 62.82 per cent of the respondents had adopted university recommended spraying schedule for management of insect-pest infestation on mango. Major incidence of anthracnose, hoppers, thrips and fruit fly was reported by the most of the farmers. Therefore, some farmers have adopted this technology in accordance with the recommendation of 4 to 6 need-based sprays of recommended insecticides. Similarly, Tanwar *et al.* (2013) also elucidated that the mango orchardists adopted recommended methods of irrigation, fertilizers and insecticides and pesticides. However, it was observed that some mango farmers are taking 10 to 12 sprays of such insecticides which are not recommended by the university. The reason might be that farmers are using those insecticides which are suggested by and available with input dealers. Therefore, so many farmers had over-adopted this technology in study area.

Further, equal percentage (57.69 per cent) of the respondents had adopted the resilient technology of using recommended dose of paclobutrazol during July-August and canopy management to facilitate more sunlight and thereby reduce pest infestation. Actually, Alphonso mango have genetic habit of alternate bearing. Some environmental factors also contribute to alternate bearing of Alphonso. Therefore, university has recommended the use of growth retardant- paclobutrazol to covert vegetative growth into reproductive growth of mango and thereby overcome the lacuna of alternate bearing. Further, more than fifty (51.92 per cent) of the respondents had adopted the spraying of Gibberellic Acid (GA) 50 ppm to avoid recurrent flowering; paper bagging of fruits from the 'Marble to Egg' stage (35.26 per cent) and spraying of Naphthalic Acetic Acid (NAA) 20 ppm to avoid fruit drop (33.97 per cent) due to heat stress. A meagre percentage (13.46 per cent) of the respondents had adopted the rejuvenation technology of old and senile orchards in Alphonso mango.

4.4.3 Reasons for non-adoption and over-adoption of technology

In present study, efforts were made to know the reasons for non-adoption and over-adoption of some climate resilient technologies of mango. It was observed that some climate resilient technologies were adopted by very few farmers. Therefore, data on reasons for non-adoption and over-adoption of the resilient technologies were collected, analysed and depicted in Table 19c.

Reasons for non-adoption:

It is evident from Table 19c that majority (66.03 per cent) of the respondent had not-adopted the climate resilient technology of spraying of Naphthalic Acetic Acid (NAA) 20 ppm to avoid fruit drop. Lack of knowledge of NAA spray was the main reason reported by 92.23 per cent of the respondents.

Table 19c. Reasons for non-adoption and over adoption of some climate resilient mango production technologies**.**

Sl. No.	Technologies	Frequency (N=156)	Percentage
a)	Non-adopted technologies and its reasons		
1.	Spraying of Naphthalic Acetic Acid (NAA) 20 ppm to avoid fruit drop	103	66.03
	1. Lack of knowledge	95	92.23
2.	Paper bagging of fruits from the 'Marble to Egg' stage	101	64.74
	1. Lack of awareness about technology and its importance	77	76.24
	2. Labour intensive technology	85	84.16
3.	Rejuvenation of Old and Senile orchards	135	86.54
	1. Risk factor in cutting of mango trees	71	52.59
	2. Non-availability of skilled person to rejuvenate old orchards	124	91.85
b)	Over-adopted technology and its reasons		
1.	Use of more spray of insecticides for insect-pest management	57	58.16

	1. Unaware about University Recommended Spraying Schedule	27	47.36
	2. Spraying insecticides and pesticides suggested by input dealers	51	89.47
	3.Inset and pest became resistant to insecticides	30	52.63

Similarly, paper bagging of fruits from the 'Marble to Egg' stage to minimise heat stress was also not adopted by the large (64.74 per cent) percentage of mango growers. The main reasons for non-adoption were Lack of awareness about technology (76.24 per cent) and paper bagging is labour intensive technology (84.16 per cent). Further, majority (86.54 per cent) of the respondents had not-adopted the rejuvenation technology in old and senile orchards due to non-availability of skilled person (91.85 per cent) and risk involved in cutting of mango trees (52.59 per cent).

Reasons for over-adoption:

During field survey, it was observed that some farmers were over-adopted the spraying of insecticides and pesticides than the recommended schedule for insect-pest management in mango. The university has recommended need-based 4 to 6 sprayings for mango; however, some farmers used 10 to 12 sprays for management of insect-pest. This injudicious use of insecticides and pesticides leads to over-adoption of technology. Spraying insecticides and pesticides suggested by the input dealers (89.47 per cent); inset and pest became resistant to insecticides (52.63 per cent) and unawareness about university recommended spraying schedule (47.36 per cent) were the main reasons behind over-adoption of the technology.

4.5 Factors affecting adoption of climate-resilient technologies.

The binary logistic regression analysis was used to identify the factors affecting adoption of climate resilient technologies by the mango growers to mitigate the effect of climate change. Before the variables were entered into the model the data were tested for presence of multi-collinearity. It was inferred from the Variance Inflation Factor (VIF) that its values were less than two, which indicated absence of multi-collinearity.

The Omnibus Test for model coefficient was applied to determine whether the overall model with all predictors is significantly different from the model with only the intercept. The Omnibus test is interpreted as a test of the capability of all predictors in the model jointly to predict the response variable. Therefore, post-estimation results of Omnibus Tests showed that chi-square ($\chi 2$) value with a p-value (<0.05) for all the climate resilient technologies tell us that all our models as a whole fit significantly better than their respective empty models (a model with no predictors). For example, $\chi 2$ value in Omnibus Tests for paclobutrazol application was 29.65 and p-value (0.041); $\chi 2$ value for spraying of Gibberellic Acid (GA) was 92.28 and p-value was (0.000) and $\chi 2$ value for use of Naphthalic Acetic Acid (NAA) was 19.99 and p-value was (0.003). The p-value of all these technologies was less than 0.05 indicates that all models fit significantly (See Table 20). Likewise, model for rest of all technologies viz., use of potassium nitrate; canopy management; irrigation; pest management (IPM); paper bagging of fruits and rejuvenation of mango fit significantly as p-value found less than 0.05 (Table 20).

Further, the model summary also including its log likelihood, Cox & Snell R^2 and Nagelkerke R^2 of respective climate resilient technology are also presented in Table 20.

The detailed findings of logit regression model are described hereunder. The results of the binary logistic regression showed that some of the explanatory variables influenced the adoption of particular climate resilient technologies. The combined results are presented in Table 20 and detailed results are also depicted in Table 22 to table 30 in Appendices I.

4.5.1 Age

Table 20 indicated that the age of the mango growers had a significant (p=0.49) influence on adoption of canopy management practice in Alphonso mango. This result indicates that increase in age of the respondents by one more year would lead to 0. 959 times more likelihood to adopt canopy management practice than their younger counterpart. This finding is in line with a study conducted by Bright Masakha Wekesa *et. al*. (2018) and Mideksa Dabessa (2020) showed that the likelihood of adoption of C1F1R0S1 and soybean production technology was higher with increase in the age of the respondent by one unit.

4.5.2 Education

The results of study depicted in Table 20 showed that education of mango farmers had a significant impact on adoption of irrigation (*p*=0.042) and paper bagging of fruits (*p*=0.017) as a climate resilient technology in response to the climate change. The mango growers with one more unit of formal education would reduce the likelihood of adopting irrigation and paper bagging technology by the factor of 0.808 and 0.841 times, respectively. Similar result was reported by Bright Masakha Wekesa *et. al*. (2018) found that one more year of education reduced the probability of using C1F1R0S0 which contains crop and field management practices. Contrary to this, Urgessa Tilahun Bekabil *et al*. (2015) and Mideksa Dabessa (2020) showed that increase in the years of formal schooling of the respondent would lead to increase in the odds of being participated in conservation agriculture and also increase in the probability of adoption of soybean production, respectively.

4.5.3 Operational landholding

The findings demonstrated that operational landholding of the mango farmers had a significant impact on adoption of spraying Gibberellic Acid-GA (*p*=0.047), use of Naphthalic Acetic Acid-NAA (*p*=0.041), and potassium nitrate (*p*=0.033) as a climate resilient technology to mitigate climate change. This indicates that an increase in operational landholdings by one more unit (hectare) would lead to 0. 699 and 1.322 times more likely to adopt spraying of Gibberellic Acid and use of Naphthalic Acetic Acid, respectively. However, holding other regressors constant, a unit increase in operational landholding reduced the likelihood of using potassium nitrate as a climate resilient technology by 0.637

times than the smallholders. There is a critical limit on farm size that prevents smallholders from adapting to newly introduced climate resilient technologies. This could be because large farm size allows for adopting resilient technology without running short of land to adopt the usual orchards management practices. Similar observations were noted by Bright Masakha Wekesa *et. al*. (2018) said that the farm size had a positive influence on the use of packages C1F0R1S1, C1F1R0S1, C1F1R1S0 and C1F1R1S1 and a negative association with the use of package C1F0R0S0. Addition to this Mideksa Dabessa (2020) also showed that size of land cultivated by a household tends to influence adoption of soybean production technology.

4.5.4 Area under mango

The study found that the area under mango had a significant influence on using Naphthalic Acetic Acid-NAA (p=0.035), spraying of potassium nitrate (p=0.042) and rejuvenation of old orchards (p=0.039) as a resilient technology to mitigate the effect of climate change. This implies that one hectare increase in area under mango were 0.681 more likely to use Naphthalic Acetic Acid-NAA; 1.657 times more likely to use spraying of potassium nitrate and 1.609 times more likely to adopt rejuvenation technique in old and senile orchards than their counterparts who cultivated mango on small piece of land. Probably, this might be due to non-availability of skilled labour to rejuvenate old and senile orchards. These results are in conformity with the findings of Francis Atube *et. al*. (2021) who reported that household heads cultivated large pieces of land were more likely to use drought-resistant varieties as climate change adaptation strategy than their counterparts who had smaller size of farm.

4.5.5 Ownership of orchard

The result of the study revealed that ownership of mango orchards had a significant factor (p=0.049) affecting adoption of Naphthalic Acetic Acid-NAA to avoid fruit drop in mango. The result indicates, those who had self-ownership status of mango orchard were 0.127 times less likelihood of adopting NAA technology in Alphonso mango than who leased-out or leased-in land.

Table 20: Binary Logit Model Parameter Estimates on Factors Affecting Adoption of Climate Resilient Mango Production Technologies

Explanatory variables	**Paclobutrazol Application**				**Spraying of GA**				**Use of NAA**				**Use of Potassium Nitrate**				**Canopy Management**			
	β	SE	Sig. (P)	Exp. (β)	β	SE	Sig. (P)	Exp. (β)	β	SE	Sig. (P)	Exp. (β)	β	SE	Sig. (P)	Exp. (β)	β	SE	Sig. (P)	Exp. (β)
Age (X1)	.024	.021	.261	.976	.009	.028	.741	.991	-.010	.021	.633	.990	.001	.027	.963	1.001	.042	.022	**.049**	**.959**
Education (X2)	.079	.063	.213	.924	.107	.089	.232	.899	.022	.064	.730	1.022	-.048	.089	.586	.953	.031	.064	.626	.969
Annual Income (X3)	.000	.000	.840	1.000	.000	.000	.136	1.00	.000	.000	.840	1.000	.000	.000	.861	1.000	.000	.000	.262	1.000
Operational Land (X4)	.008	.125	.947	.992	.358	.195	**.047**	**.699**	.279	.154	**.041**	**1.322**	-.451	.211	**.033**	**.637**	.031	.161	.848	.970
Area under Mango (X5)	.044	.161	.784	.957	.411	.264	.119	1.50	.384	.208	**.035**	**.681**	.505	.281	**.042**	**1.657**	.002	.195	.991	.998
Orchard Ownership (X6)	.707	.636	.267	.493	1.11	.823	.176	.328	-2.06	1.092	**.049**	**.127**	2.661	2.126	.211	14.311	.660	.708	.351	1.934
Age of orchard (X7)	.012	.023	.585	.988	-.02	.033	.393	.972	-.004	.023	.854	.996	-.062	.032	**.046**	**.940**	.029	.024	.218	1.029
Resource Availability (X8)	.024	.053	.654	.977	.018	.070	.802	1.018	-.018	.053	.739	.982	.117	.074	.114	1.124	.014	.053	.799	.987
Crop Insurance (X9)	.073	.386	.851	1.075	.960	.532	**.031**	**2.612**	-.078	.402	.845	.925	-.522	.532	.326	.593	.011	.398	.978	1.011
Access to Loan (X10)	.031	.427	.939	.968	.281	.548	.608	1.324	.082	.439	.852	1.086	1.279	.600	**.033**	**3.592**	.581	.436	.183	.559
Extn. Participation (X12)	.906	.341	**.008**	**2.474**	.008	.247	.975	.992	.126	.235	.592	1.135	.167	.416	.688	1.182	.002	.248	.993	.998
Source of Input (X3)	.307	.416	.460	1.360	.101	.508	.842	.904	.149	.417	.721	1.161	-.109	.612	.858	.897	.210	.406	.605	.811
Soil Type (X14)	.601	.296	**.042**	**1.825**	.187	.349	.591	.829	.586	.313	**.041**	**.557**	-.005	.354	.989	.995	.185	.285	.516	1.203
Topography (X15)	.138	.379	.715	1.148	.514	.565	.363	1.672	-.450	.395	.255	.638	-.506	.537	.347	.603	.271	.390	.487	.762
Seashore Distance (X16)	.071	.028	**.010**	**.931**	.045	.035	.200	.956	.017	.027	.532	1.017	-.012	.038	.762	.989	.009	.026	.747	1.009
Planting Density (X17)	.022	.036	.536	.978	.015	.048	.748	.985	-.024	.036	.508	.976	-.014	.048	.776	.987	.030	.038	.430	.971
Climatic Vulnerability (X18)	.063	.052	.221	.939	.217	.078	**.005**	**1.242**	.074	.055	.179	1.077	.036	.069	.597	1.037	.028	.054	.602	.972
Knowledge (X19)	.006	.018	.718	1.006	.179	.032	**.000**	**1.196**	.014	.018	.428	1.014	.108	.025	**.000**	**1.114**	.068	.019	**.000**	**1.071**
Constant	8.55	6.64	0.198	5182.5	25.3	9.28	0.006	0.000	1.839	7.036	.794	6.293	-18.4	9.987	.065	.000	1.56	6.90	.820	4.804
Omnibus Tests- $\chi 2$ (Sig)	23.56 (0.047)				92.28 (.000)				19.99 (.003)				58.52 (.000)				31.228 (.027)			
Model summary- -2 Log likelihood	189.199				123.744				179.956				119.083				181.327			
Cox & Snell R^2 and Nagelkerke R^2	0. .139 & 0.187				0.447 & 0.596				0.120 & 0.267				0.313 & 0.460				0.181 & 0.244			

Table Continued……

Table 20: Binary Logit Model Parameter Estimates on Factors Affecting Adoption of Climate Resilient Mango Production Technologies

Explanatory variables	**Irrigation**				**Pest Management (IPM)**				**Paper Bagging of Fruits**				**Rejuvenation**			
	β	SE	Sig. (P)	Exp. (β)	β	SE	Sig. (P)	Exp. (β)	β	SE	Sig. (P)	Exp. (β)	β	SE	Sig. (P)	Exp. (β)
Age (X1)	.026	.034	.441	1.027	-.004	.021	.856	.996	-.021	.022	.337	.979	.047	.048	.325	1.048
Education (X2)	-.213	.104	**.042**	**.808**	-.085	.066	.196	.918	-.173	.072	**.017**	**.841**	.056	.135	.677	1.058
Annual Income (X3)	.000	.000	.726	1.000	.000	.000	.902	1.000	.000	.000	.729	1.000	.000	.000	.859	1.000
Operational Land (X4)	.221	.373	.555	1.247	.040	.134	.763	1.041	.194	.226	.392	1.214	-.177	.230	.443	.838
Area under Mango (X5)	-.251	.398	.529	.778	-.148	.168	.379	.863	.041	.247	.868	1.042	.475	.280	**.039**	**1.609**
Orchard Ownership (X6)	-.618	.865	.475	.539	.883	.727	.224	2.419	.564	.668	.398	1.758	1.858	1.277	.145	6.412
Age of orchard (X7)	-.083	.041	**.046**	**.921**	-.006	.024	.799	.994	.014	.024	.568	1.014	.215	.065	**.001**	**1.240**
Resource Availability (X8)	-.106	.078	.175	.899	-.021	.055	.698	.979	-.135	.058	**.021**	**.874**	-.005	.136	.973	.995
Crop Insurance (X9)	.321	.572	.575	1.378	.103	.395	.795	1.108	-.264	.417	.527	.768	-.900	.928	.332	.406
Access to Loan (X10)	.620	.680	.362	1.859	1.041	.447	**.020**	**2.832**	-.274	.457	.548	.760	1.441	1.099	.190	4.226
Extension Participation (X12)	.623	.583	.285	1.865	-.055	.234	.813	.946	-.011	.261	.968	.990	.160	.274	.559	1.174
Source of Input (X3)	.397	.667	.552	1.487	-.074	.424	.861	.928	.715	.445	**.008**	**2.044**	-.434	.919	.637	.648
Soil Type (X14)	-.193	.378	.609	.824	.067	.278	.811	1.069	.227	.288	.430	1.255	.030	.627	.962	1.030
Topography (X15)	.199	.621	.749	1.220	-.291	.395	.460	.747	.680	.412	**.049**	**1.973**	1.553	.796	**.047**	**4.727**
Seashore Distance (X16)	.120	.067	**.023**	**1.128**	.040	.029	.170	1.041	-.072	.031	**.019**	**.931**	-.021	.063	.742	.979
Planting Density (X17)	.022	.050	.655	1.022	-.046	.038	.233	.955	-.001	.038	.971	.999	-.066	.078	.396	.936
Climatic Vulnerability (X18)	-.057	.083	.492	.944	.110	.054	**.040**	**1.117**	.019	.059	.745	1.020	-.056	.118	.636	.946
Knowledge (X19)	-.027	.026	.301	.973	.026	.018	.141	1.027	-.009	.018	.633	.991	.078	.045	**.043**	**1.081**
Constant	14.296	9.358	.127	747.5	-3.95	6.963	.570	.019	6.156	7.229	.394	471.383	-18.14	15.321	.236	.000
Omnibus Tests- $\chi 2$ (Sig)	29.65 (0.041)				21.96 (0.003)				33.35 (0.015)				70.006 (0.000)			
Model summary- -2 Log likelihood	100.834				183.922				169.137				53.255			
Cox & Snell R^2 and Nagelkerke R^2	0.173 & 0.305				0.131 & 0.279				0.293 & 0.465				0.362 & 0.662			

Lack of knowledge about technology and its desirable consequences might be the reasons for pessimistic mind set of using NAA technology largely in leased-out and leased-in mango orchards.

4.5.6 Age of orchard

The findings showed that the age of mango orchards had a significant impact on adopting potassium nitrate spray (p=0.046), irrigation (p=0.046) and rejuvenation (p=0.001) as a resilient practice to mitigate the adverse impact of climate change. This implies that a unit increase in age of mango orchards by one year that reduced the likelihood of using potassium nitrate by 0.940 times and irrigation by 0.921 times than the comparatively young age orchards. It is naturally that newly planted grafts required regular irrigation during summer season. In opposite well-established mango orchards have deep root system and have capacity to survive during heat stress. However, there is recommendation of providing 100-200 litres of water during fruiting stage. Similarly, a unit increase in age of mango orchards increases 1.240 times more likeliness to adopt rejuvenation techniques in old and senile orchards. Off course, rejuvenation technology is only recommended for old, senile and non-bearing mango trees. Therefore, unit increase in age of mango orchards that increases the adoption rate of rejuvenation technology in mango orchards.

4.5.8 Resource availability

The study revealed that the resources availability of mango farmers found a significant (p=0.021) factor affecting adoption of paper bagging technology. The mango growers with more availability of resources were 0.874 times more likelihood of adopting paper bagging to protect matured fruits than the farmers who had inadequate resources. Use of paper bagging is time consuming and labour-intensive technology which requires more. Therefore, those farmers who had adequate resources could able to adopt the technology. This finding get support from the observation of Bright Masakha Wekesa *et. al*. (2018) elucidated a positive and significant relationship between resource-endowment of farmers and adoption of technology. Their study also revealed that resource-endowed farmers were more likely to adopt larger packages of C1F1R1S0 and C1F1R1S1.

4.5.9 Access to crop insurance

The result of the study revealed that access to crop insurance of mango farmers had a significant (p=0.031) influence on adoption of spraying of Gibberellic Acid-GA as a climate resilient technology. The study stated that mango growers who had regular access to crop insurance were 2.612 times more likely to adopt spraying of GA than those who did not have access to crop insurance. With increased access to crop insurance, farmers are able to take risk in adopting new and more costly technology as they have secured their crop against climatic uncertainty.

4.5.10 Access to crop loan

The result of the study revealed that access to crop loan by mango farmers had a significant impact on adopting potassium nitrate and integrated pest management practices as a climate resilient technology. The study stated that those mango growers had access to crop loan were 3.592 times more likely to adopt potassium nitrate technology (p=0.033) and 2.832 times more likely to adopt integrated pest management practices (p=0.020) than those who did not have access to crop loan. With increased access to credit/cash flows, mango farmers are able to invest in more costly but better rewarding climate resilient practices which could reduce the adverse impact of climate change on mango production. Similarly, Bright Masakha Wekesa *et. al*. (2018); Mideksa Dabessa (2020) and Francis Atube *et. al*. (2021) revealed that those farmers who have to use formal credit are more likely to adopt different agricultural technologies. These findings, as well as our study, suggest the important role of increased institutional support in promoting climate-resilient practices to mitigate the adverse impact of climate change on mango crop.

4.5.11 Extension participation

The results depicted in Table 20 indicated that the mango growers participated in different extension programmes had a significant (*p*=0.008) effect on application of paclobutrazol in Alphonso mango. This indicates, the respondents who participated frequently in extension activities were 2.474 times more likelihood to adopt paclobutrazol as a climate-resilient technology as well as to overcome the problem of alternate bearing in mango. Similarly, those household heads received extension services were found more likely to plant drought resistant crop varieties and plant trees (Atube *et. al.* 2021). Similarly, the probability of adoption for the farmers with access to extension services is higher than that of farmers without extension services Kidunda B. R *et. al.* (2013).

4.5.12 Sources of input

Table 20 revealed that the sources of input of mango farmers had a positive and significant (*p*=0.008) influence on the use of paper bagging technology for mango fruits. With increase in one unit of input source were 2.044 times more likely to adopt paper bagging technology in mango to remove the effect of heat stress.

4.5.13 Soil type

Data presented in Table 20 also elucidated that the soil type of mango orchards had a significant factor affecting adoption of climate resilient technologies like application of paclobutrazol (*p*=0.042) and use of NAA (*p*=0.41). This inferred that those farmers planted mango orchards on rocky soil were 1.825 and 0.557 times more likely to adopt paclobutrazol and use of Naphthalic Acetic Acid (NAA) technologies, respectively than those planted mango orchards on platue and lateritic soil. However, Zeray Zeleke *et. al.* (2017) also reported, the Soil fertility was negatively and significantly ($p < 0.01$) influencing the decision to choose adaptation strategies to climatic risk factors.

4.5.14 Topography

Further, result revealed that topography of mango orchards found a significant factor influenced the adoption of paper bagging techniques in mango fruits (p=0.049) and rejuvenation (p=0.047). This indicates that those had hilly topography were 1.973 and 4.727 times more likely to adopt paper bagging and rejuvenation technology in mango than those planted mango orchards on plain topography. Land slope of plots have positive effects on the adoption of technologies (Nhat Lam Duyen Tran et.al. 2019 and Urgessa Tilahun Bekabil *et. al*. 2015)

4.5.15 Distance from sea shore

The findings demonstrated that distance from the sea shore of mango orchards had a significant impact on adoption of paclobutrazol technology (p=0.010), irrigation management practices (p=0.023), and paper bagging of fruits (p=0.019) as a resilient technology to mitigate climatic variability. With increase in one Km distance of orchards from sea shore were 0.931 and 1.128 times more likely to apply paclobutrazol and recommended irrigation management practices, respectively. However, by increase in one Km distance of mango orchards from sea shore reduced 0.931 times likelihood of adopting paper bagging technology for matured mango fruits. The distance was negatively significantly associated with the probability of adoption of improved technologies (Yishak Gecho and N. K. Punjabi, 2011; Zeray Zeleke *et. al*. 2017)

4.5.17 Climatic vulnerability

The findings demonstrated that climatic vulnerability experienced by the mango growers had a significant impact on adopting spraying of Gibberellic Acid-GA (p=0.005), and pest management-IPM (p=0.040) as a climate resilient technology. With increase in a severity of climatic vulnerability were 1.242 and 1.117 times more likely to adopt spraying of Gibberellic Acid-GA and integrated pest management practices, respectively. A similar trend was reported by Bright Masakha Wekesa *et. al*. (2018) and Nhat Lam Duyen Tran *et.al*. (2019) found that most of the climate-related factors are found to have a significant impact on technology adoption.

4.5.18 Knowledge

The findings showed that the knowledge of mango farmers had a significant impact on use of Gibberellic Acid-GA (p=0.000), use of potassium nitrate (p=0.000), canopy management (p=0.000) and rejuvenation (p=0.043) as climate resilient technologies. With increase in unit of knowledge were 1.196, 1.114, 1.071 and 1.081 times more likely to adopt spraying of GA, use of potassium nitrate, canopy management and rejuvenation technology, respectively than their counterpart with less knowledge.

Hypotheses testing

At the end, the formulated *null hypotheses (H0)* that there may not be any socio-economic and ecological factors affecting the adoption of climate-resilient technologies was rejected in present study. However, null hypothesis is accepted in case of annual income and planting density as both were not influenced the adoption of any climate resilient technology.

Further, study indicated, *alternative hypothesis (H1)* that there may be certain socio-economic and ecological factors like age, education, operational landholdings, area under mango, ownership of orchards, orchards age, resources availability, access to crop loans, access to crop insurance, extension participation, sources of inputs, soil type, topography, distance from seashore, climatic vulnerability and knowledge affected the adoption of different climate-resilient technologies. Therefore, in this study the alternative hypothesis was accepted for these factors.

4.5.19 Classification Table

The percentage of correct classification for every response variable is presented in Table 21. This is an indicator that whether the model fits well the data.

Table 21: Classification Table [a b]

1.	Dependent variable			**Paclobutrazol Application (Y1)**		
	Observed			***Predicted***		
				Y1		*Percentage correct*
				Not adopted (0)	Adopted (1)	
	Step 0	1	Not adopted (0)	0	66	0.0
			Adopted (1)	0	90	100.0
	Overall Percentage					**57.70**
	Step 1	Y1	Not adopted (0)	25	41	37.90
			Adopted (1)	18	72	80.00
	Overall Percentage					**62.20**
2.	Dependent variable			**Spraying of GA (Y2)**		
	Observed			***Predicted***		
				Y2		*Percentage correct*
				Not adopted (0)	Adopted (1)	
	Step 0	Y2	Not adopted (0)	0	75	.0
			Adopted (1)	0	81	100.0
	Overall Percentage					**51.90**
	Step Y2	1	Not adopted (0)	59	16	78.7
			Adopted (1)	13	68	84.0
	Overall Percentage					**81.40**
3.	Dependent variable			**Use of NAA (Y3)**		
	Observed			***Predicted***		
				Y3		*Percentage correct*
				Not adopted (0)	Adopted (1)	
	Step 0	Y3	Not adopted (0)	103	0	100.0
			Adopted (1)	53	0	0.00
	Overall Percentage					**66.0**
	Step 1	Y3	Not adopted (0)	95	8	92.2
			Adopted (1)	40	13	24.5
	Overall Percentage					**69.2**
4.	Dependent variable			**Use of Potassium Nitrate (Y4)**		
	Observed			***Predicted***		
				Y4		*Percentage correct*
				Not adopted (0)	Adopted (1)	
	Step 0	Y4	Not adopted (0)	0	40	0.00
			Adopted (1)	0	116	100
	Overall Percentage					**74.40**
	Step 1	Y4	Not adopted (0)	20	20	50.00
			Adopted (1)	11	105	90.50
	Overall Percentage					**80.10**
5.	Dependent variable			**Canopy Management (Y5)**		
	Observed			Predicted		
				Y5		*Percentage correct*
				Not adopted (0)	Adopted (1)	
	Step 0	Y5	Not adopted (0)	0	66	0.00
			Adopted (1)	0	90	100.0
	Overall Percentage					**57.70**
	Step 1	Y5	Not adopted (0)	35	31	53.00
			Adopted (1)	17	73	81.10

	Overall Percentage					**69.20**
6.	Dependent variable (Y6)			**Irrigation**		
	Observed			***Predicted***		
				Y6		*Percentage correct*
				Not adopted (0)	Adopted (1)	
	Step 0	Y6	Not adopted (0)	0	23	0.00
			Adopted (1)	0	133	100
	Overall Percentage					**75.30**
	Step 1	Y6	Not adopted (0)	5	18	21.70
			Adopted (1)	5	128	96.20
	Overall Percentage					**85.30**
7.	Dependent variable (Y7)			**Pest Management (IPM)**		
	Observed			***Predicted***		
				Y7		*Percentage correct*
				Not adopted (0)	Adopted (1)	
	Step 0	Y7	Not adopted (0)	0	58	0.00
			Adopted (1)	0	98	100
	Overall Percentage					**62.80**
	Step 1	Y7	Not adopted (0)	25	33	43.10
			Adopted (1)	10	88	89.80
	Overall Percentage					**72.40**
8.	Dependent variable (Y8)			**Paper Bagging of Fruits**		
	Observed			***Predicted***		
				Y8		*Percentage correct*
				Not adopted (0)	Adopted (1)	
	Step 0	Y8	Not adopted (0)	101	0	100
			Adopted (1)	55	0	0.00
	Overall Percentage					**64.70**
	Step 1	Y8	Not adopted (0)	87	14	86.10
			Adopted (1)	32	23	41.80
	Overall Percentage					**70.50**
9.	**Dependent variable (Y9)**			**Rejuvenation**		
	Observed			***Predicted***		
				Y9		*Percentage correct*
				Not adopted (0)	Adopted (1)	
	Step 0	Y9	Not adopted (0)	135	0	100
			Adopted (1)	21	0	0.00
	Overall Percentage					**86.50**
	Step 1	Y9	Not adopted (0)	130	5	96.30
			Adopted (1)	6	15	71.40
	Overall Percentage					**92.90**
a-Constant is included in the model b. The cut value is 0.500						

Data regarding paclobutrazol application (Y1) is presented in Table 21 shows that the final iteration, 37.90 per cent of cases were correctly classified for not-adopted group and 80.00 per cent for the adopted group. The overall, 62.20 per cent of the cases were correctly classified with cut value of 0.50 for its predicted probabilities (See Table 21-Step 1 model). This indicates a good performance of logistic regression model.

With respect to spraying of GA (Y2), 78.70 per cent of cases were correctly classified for not-adopted and 80.00 per cent for the adopted group. The overall 81.40 per cent of the cases were correctly classified with cut value of 0.50 for its predicted probabilities. In case of use of NAA (Y3), 92.20 per cent of cases were correctly classified for not-adopted and 24.5 per cent for the adopted group. The overall 69.20 per cent of the cases were correctly classified and indicating a good performance of logistic regression model. Further, 50.00 per cent of cases were correctly classified for not-adopted and 90.50 per cent for the adopted group of using potassium nitrate (Y4). Overall, 80.10 per cent of the cases were classified correctly showed best fit of logistic regression model. Classification data for canopy management (Y5) in Step 1 model indicates that 53.00 per cent of cases were classified correctly for not-adopted and 81.10 per cent for the adopted group. The overall percentage of correct classification was 69.20; while not correct classification percentage was 30.80 and this is a good indicator that the model fits well the data. In case of irrigation (Y4), 21.70 per cent of cases were correctly classified for not-adopted and 96.30 per cent for the adopted group. The overall 85.30 per cent of the cases were correctly classified and indicating a good performance of logistic regression model. Further, 43.10 per cent of cases were correctly classified for not-adopted and 89.80 per cent for the adopted group of Pest Management (Y4). Overall, 72.40 per cent of the cases were classified correctly showed well logistic regression model. With respect to paper bagging of fruits (Y8), 86.10 per cent of cases were correctly classified for not-adopted and 41.80 per cent for the adopted group. The overall 70.50 cent of the cases were correctly classified and indicating a good performance of logistic regression model. Lastly, logistic regression model for Rejuvenation (Y9) showed 96.30 per cent of cases were correctly classified for not-adopted and 71.40 per cent for the adopted group. The overall 92.90 cent of the cases were correctly classified and indicating a good performance of logistic regression model.

CHAPTER V

SUMMARY

Climate is one of the main determinants of agricultural production. Throughout the world, there is significant concern about the effects of climate change and its variability on agricultural production. A country like India is more vulnerable to climate change because of the large population depending on agriculture, excessive pressure on natural resources and, less awareness and adoption of climate-resilient technologies. The Indian farmers have evolved adaptation mechanisms over time, but these mechanisms are unable to fight the extreme weather condition in recent times. Many factors are affecting the adoption of climate-resilient technologies. Resilience is the ability of a system and its parts to anticipate, absorb, accommodate, or recover from the effects of a hazardous event in a timely and efficient manner, including through ensuring the preservation, restoration, or improvement of its essential basic structures and functions (IPCC, 2012). India is the world's largest producer of many fresh fruits. India is a top producer of mango in the world. However, mango is more affected by climatic vulnerabilities. It is very important to adopt climate-resilient technologies. Ratnagiri and Sindhudurg district of Maharashtra is leading districts in mango production. But climatic vulnerabilities affected the mango crop production. Therefore, the present investigation entitled "**Socio-economic factors affecting on adoption of climate resilient technologies by the mango growers"** was undertaken with the following objectives.

5.1 Objectives

1. To study the socio-economic characteristics of the mango growers.
2. To study the climatic vulnerabilities experienced by the mango growers.
3. To examine the knowledge and adoption of climate-resilient technologies by the mango growers.
4. To identify the factors affecting the adoption of climate-resilient technologies by the mango growers.

Out of two districts of South Konkan, Ratnagiri and Sindhudurg district was selected purposively. The two tahsils from each district were selected randomly. Thereafter, three villages from each tehsil were selected using a simple random sampling. Thus, the study comprises a total of '12' villages randomly sampled from two districts of the South Konkan. Lastly, '13' mango growers from each village were selected randomly. Accordingly, from each district '78' mango growers were selected randomly. Thus, the present study constitutes '156' mango growers as a respondent. The personal interview method was used to collect data from the respondents.

5.2 Socio-economic characteristics of the mango growers

The study revealed that the majority (47.43 per cent) of the respondents belonged to the old age group. A Maximum (58.97 per cent) number of the respondents had education up to secondary level and the majority of the respondents had medium annual income. The majority of the respondents belonged to the small landholding category. It was found that the majority of mango growers belonged to the marginal area under the mango. It was observed that a huge majority (83.33 per cent) of the mango growers had self-ownership on mango orchard, a majority (69.87 per cent) of the mango orchard belonged to middle age of orchard category and a higher percentage (89.10 per cent) of the respondents had 'adequate' level of resources.

Further, 47.44 per cent of respondents had accessed crop insurance and 51.28 per cent of the respondent borrowed crop loan. It was found that the higher (78.85 per cent) mango growers belonged to a medium level of extension participation and 91.67 per cent had medium levels of access to input sources. A majority (79.49 per cent) of mango orchards cultivated on rocky soil and hilly topography. The majority of mango orchards (73.07 per cent) planted on medium-long distance from the seashore and they planted mango orchards as per recommended planting density (69.88 per cent).

5.3 Climatic vulnerabilities experienced by the mango growers

The present study revealed that the majority (93.59 per cent) of the mango orchards were exposed to the 'high level of climatic vulnerabilities. In that, 86.54 per cent of respondents had observed moderate severity of delayed flowering and fruit-setting due to extended and unusual rain. However, 75.00 per cent of the mango growers reported 'extreme severity' of unusual rain and high humidity, leading to the incidence of anthracnose, powdery mildew, fruit flies and hoppers. Further, mango was 'extreme severely' affected due to abrupt increase in temperature causes fruit drop in mango (55.77 per cent) and, sun-scorching and spongy tissue (67.30 per cent). The majority (87.18 per cent) of the respondents reported that mango was 'moderately' affected due to a sudden increase in temperature during an inflorescent stage that leads to the infestation of hoppers and thrips.

5.4 Knowledge and adoption of climate-resilient technologies

It was indicated that 90.38 per cent of mango growers belonged to the high category of knowledge and only 9.62 per cent of the respondents found to have a medium degree of knowledge on climate-resilient mango production technologies. It was surprising to note that none of the respondents found it in the low knowledge category. This leads to conclude that the sampled mango growers had rich knowledge on climate-resilient mango production technologies. Cent per cent of the sampled respondents possessed knowledge on using the recommended dose of paclobutrazol; providing irrigation to reduce fruit drop, using university recommended spraying schedule for insect-pest management, paper bagging of fruits from the ‘Marble to Egg’ stage and rejuvenation of old and senile orchard. Majority of the respondents had knowledge on canopy management in mango crop which facilitates more sunlight and thereby reduce pest infestation, spraying of gibberellic acid (GA) to avoid recurrent flowering and spraying potassium nitrate for more fruit retention.

It was seen that more than fifty per cent of the respondents belonged to the medium category of adoption; followed by 28.84 per cent and 20.52 per cent were found into high and low categories of adoption, respectively. The mean adoption of climate-resilient mango technology was 52.49 per cent. The majority (85.25 per cent) had provided irrigation water to reduce the dropping of pea-size fruits during summer and sprayed potassium nitrate for more fruit retention (74.35 per cent). This was followed by 62.82 per cent of the respondents had adopted university recommended spraying schedule for management of insect-pest infestation on mango. The respondents also adopted resilient technologies like using recommended dose of paclobutrazol and canopy management to facilitate more sunlight and thereby reduce pest infestation.

5.5 Factors affecting the adoption of climate-resilient technologies

The present study indicated that the socio-economic factors viz., age, education, operational landholdings, area under mango, ownership of mango orchards, age of orchards, availability of resources, access to crop loans, access to crop insurance, extension participation, sources of inputs, soil type, topography, distance from the seashore, climatic vulnerability, and knowledge had a significant impact on the adoption of climate-resilient mango technologies. The annual income and planting density were not found to have a significant effect on the adoption of any climate-resilient technologies. The study demonstrated that unit increase in these factors leads to the likelihood of adoption of climate-resilient mango production technologies. The classification table indicated that an overall significant percentage of the cases were classified correctly by every regression model showed the best fit of logistic regression.

CHAPTER VI

IMPLICATIONS

The present study entitled “Socio-Economic Factors Affecting on Adoption of Climate Resilient Technologies by the Mango growers” was designed and conducted to elicit the socio-economic characteristics and to determine the factors affecting the adoption of climate-resilient technologies. This investigation has pointed out some important findings. Based on conclusions and major findings of the study, the following implications are brought out to give feedback to technocrats, strengthen the feedforward mechanism of extension system, administrators and policymakers.

1. The majority of ‘older’ people were engaged in mango farming, with an average age of 49.97 years. Most of the mango farmers completed formal schooling, so they intended to adopt climate-smart technologies, ideas, and innovations. A diverse category of farmers involved in mango farming. An average annual income of mango growers is ₹ 1.2 million, indicating a sound financial situation. Mango orchards ranged in age from 10.0 to 70.0 years, with an average of 38.10 years.
2. A sampled mango orchardist owns more than 4.00 hectares of operational land, with an average of 3.37 hectares of land dedicated to mango plantation.
3. Mango is a highly input-intensive crop that requires quality insecticides, pesticides, micronutrients, liquid fertilisers, and plant regulators. Therefore, financial capital is most important for mango orchardist. Most of the respondents obtained crop loans from nationalised and cooperative banks. Input dealer was the main source of information as well as source for critical inputs, followed by KVK, agricultural university and line departments.
4. The mango growers possessed plenty of farm resources. They have affordable and practical resources for managing mango plantations. However, nearly half of respondents lacked access to crop insurance

schemes like *Pradhan Mantri Fasal Bima Yojana* (PMFBY). Lack of information, distrust in insurance companies, and delay in claim settlement are the main causes.

5. According to mango growers, rocky soil is ideal for an alphonso mango because it causes greater physiological stress to the plants. Further, the hilly terrain allows for more sunlight from the south-west, that is conducive for reproductive growth and also reduces insect-pest infestation.
6. Aside from its genetic habit of alternate bearing, alphonso has become extremely sensitive to climatic variability. Climate change vulnerability ranged from 62.96 percent to 81.48 percent, with a mean of 71.95 percent. This shows mango orchards in West Coast Plains and Hills region were exposed to extreme weather events.
7. Erratic and unseasonal rainfall, as well as temperature fluctuations, are having a negative impact on flowering, fruit setting, and fruit development. Pest and disease infestations wreak havoc on production and productivity. During flowering, rainfall washed out the pollen from the stigma, leading to poor or non-existent fruit set. Insect infestation is exacerbated by high relative humidity. The physiological disorder of spongy tissue is caused by high temperature. Top-most climatic vulnerability was the prevalence of insect-pest and diseases. Mango flowering and fruit set were delayed because of prolonged and unusual rain.
8. According to the study, 85.25 percent of respondents provided summer irrigation to avoid fruit drop, and 74.35 percent sprayed 1 percent potassium nitrate to enhance fruit retention. Over half of respondents executed a university-recommended IPM programme because of the excessive prevalence of anthracnose, hoppers, thrips, and fruit flies.
9. The sampled mango producers had an intense wisdom concerning climate-resilient mango production technologies. Despite of this, resilient technologies are being adopted at a ‘moderate’ level by the mango orchardists. The average adoption of climate-resilient mango production technologies was 52.49 percent.

10. Age of mango growers had a significant effect on the adoption of canopy management practices. The increase in operational landholdings by one unit (hectare) increases the likelihood of spraying gibberellic acid and using naphthalic acetic acid. Access to crop insurance had a positive impact on adopting climate-resilient technology. Owners of mango orchards were less likely to adopt NAA technology in alphonso mango than those who leased out or leased-in land. This study discovered a positive and significant relationship between farmers' resource endowment and technology adoption. Mango growers with ample resources were more likely to adopt paper bagging technology to secure mature fruits from heat stress.
11. Farmers who are reliant on formal credit are more likely to adopt novel agricultural technologies. Mango farmers can invest in expensive but more rewarding climate-resilient practices, with increased access to credit and cash flow. As a result, providing institutional credit support can assist in the implementation of climate change adaptation strategies.
12. Further, we found that distance from the sea shore increased the likelihood of climate-related mango production technologies being adopted. The slope of the land was discovered to be an ecologically significant factor influencing the adoption of paper bagging and rejuvenation techniques. Farmers who planted mango orchards on rocky soil have more chance of using paclobutrazol and NAA technologies. Exposure to agricultural extension and advisory services increased the likelihood of adopting knowledge-intensive climate-resilient practices.
13. The incidence of spraying gibberellic acid and integrated pest management (IPM) practices were raised with increasing severity of climatic vulnerability. The study indicated that knowledge of mango cultivation had a substantial impact on the usage of gibberellic acid, potassium nitrate, and canopy management. However, annual income and planting density had no effect on adoption of climate-resilient mango technologies.

CHAPTER VII

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Appendices I

Table 22: The Results of Binary Regression Analysis for Socio-Economic Factors Affecting Adoption of Paclobutrazol Technology

Variables in the Equation									
	Explanatory variables	**B**	**S.E.**	**Wald**	**df**	**Sig.**	**Exp(B)/ Odd ratio**	**95% C.I. for EXP(B)**	
								Lower	**Upper**
Step 1[a]	Age	.024	.021	1.266	1	.261	.976	.937	1.018
	Education	.079	.063	1.553	1	.213	.924	.816	1.046
	Annual Income	.000	.000	.041	1	.840	1.000	1.000	1.000
	Operational Land Holding	.008	.125	.004	1	.947	.992	.776	1.268
	Area under Mango	.044	.161	.075	1	.784	.957	.698	1.312
	Ownership of Orchard	.707	.636	1.233	1	.267	.493	.142	1.717
	Age of Mango Orchard	.012	.023	.299	1	.585	.988	.945	1.033
	Resource Availability	.024	.053	.201	1	.654	.977	.881	1.083
	Crop Insurance	.073	.386	.035	1	.851	1.075	.504	2.294
	Loan Access	.033	.427	.006	1	.939	.968	.419	2.236
	Extension Participation	.906	.341	7.051	1	**.008**	**2.474**	1.268	4.828
	Sources of Input	.307	.416	.545	1	.460	1.360	.602	3.072
	Soil Type	.601	.296	4.136	1	**.042**	**1.825**	1.022	3.258
	Topography	.138	.379	.133	1	.715	1.148	.547	2.413
	Seashore Distance	.071	.028	6.578	1	**.010**	**.931**	.882	.983
	Planting Density	.022	.036	.384	1	.536	.978	.912	1.049
	Climatic Vulnerability	.063	.052	1.499	1	.221	.939	.848	1.039
	Knowledge	.006	.018	.130	1	.718	1.006	.972	1.042
	Constant	8.553	6.640	1.659	1	.198	5182.530		

Table 23: The Results of Binary Regression Analysis for Socio-Economic Factors Affecting Adoption of Gibberellic Acid

Variables in the Equation									
	Explanatory variables	**B**	**S.E.**	**Wald**	**df**	**Sig.**	**Exp(B)/ Odd ratio**	**95% C.I. for EXP(B)**	
								Lower	**Upper**
Step 1[a]	Age	.009	.028	.110	1	.741	.991	.938	1.046
	Education	.107	.089	1.429	1	.232	.899	.755	1.071
	Annual Income	.000	.000	2.219	1	.136	1.000	1.000	1.000
	Operational Land Holding	.358	.195	3.357	1	**.047**	**.699**	.477	1.025
	Area under Mango	.411	.264	2.427	1	.119	1.509	.899	2.531
	Ownership of Orchard	1.114	.823	1.832	1	.176	.328	.065	1.647
	Age of Mango Orchard	-.028	.033	.729	1	.393	.972	.912	1.037
	Resource Availability	.018	.070	.063	1	.802	1.018	.887	1.169
	Crop Insurance	.960	.532	3.259	1	**.031**	**2.612**	.921	7.410
	Loan Access	.281	.548	.262	1	.608	1.324	.452	3.876
	Extension Participation	.008	.247	.001	1	.975	.992	.612	1.610
	Sources of Input	.101	.508	.040	1	.842	.904	.334	2.446
	Soil Type	.187	.349	.288	1	.591	.829	.418	1.644
	Topography	.514	.565	.829	1	.363	1.672	.553	5.057
	Seashore Distance	.045	.035	1.646	1	.200	.956	.892	1.024
	Planting Density	.015	.048	.103	1	.748	.985	.897	1.081
	Climatic Vulnerability	.217	.078	7.792	1	**.005**	**1.242**	1.067	1.447
	Knowledge	.179	.032	31.767	1	**.000**	**1.196**	1.124	1.272
	Constant	-25.389	9.286	7.476	1	.006	.000		

Table 24: The Results of Binary Regression Analysis for Socio-Economic Factors Affecting Adoption of NAA

Variables in the Equation									
	Explanatory variables	**B**	**S.E.**	**Wald**	**df**	**Sig.**	**Exp(B)/ Odd ratio**	**95% C.I. for EXP(B)**	
								Lower	**Upper**
Step 1[a]	Age	-.010	.021	.228	1	.633	.990	.951	1.031
	Education	.022	.064	.119	1	.730	1.022	.901	1.160
	Annual Income	.000	.000	.041	1	.840	1.000	1.000	1.000
	Operational Land Holding	.279	.154	3.270	1	**.041**	**1.322**	.977	1.790
	Area under Mango	.384	.208	3.396	1	**.035**	**.681**	.453	1.025
	Ownership of Orchard	-2.06	1.092	3.571	1	**.049**	**.127**	.015	1.080
	Age of Mango Orchard	-.004	.023	.034	1	.854	.996	.952	1.042
	Resource Availability	-.018	.053	.111	1	.739	.982	.885	1.090
	Crop Insurance	-.078	.402	.038	1	.845	.925	.420	2.033
	Loan Access	.082	.439	.035	1	.852	1.086	.459	2.565
	Extension Participation	.126	.235	.288	1	.592	1.135	.715	1.800
	Sources of Input	.149	.417	.127	1	.721	1.161	.512	2.629
	Soil Type	.586	.313	3.503	1	**.041**	**.557**	.302	1.028
	Topography	-.450	.395	1.295	1	.255	.638	.294	1.384
	Seashore Distance	.017	.027	.390	1	.532	1.017	.965	1.071
	Planting Density	-.024	.036	.437	1	.508	.976	.909	1.048
	Climatic Vulnerability	.074	.055	1.807	1	.179	1.077	.967	1.201
	Knowledge	.014	.018	.627	1	.428	1.014	.979	1.051
	Constant	1.839	7.036	.068	1	.794	6.293		

Table 25: The Results of Binary Regression Analysis for Socio-Economic Factors Affecting Adoption of Potassium Nitrate

Variables in the Equation									
	Explanatory variables	**B**	**S.E.**	**Wald**	**df**	**Sig.**	**Exp(B)/ Odd ratio**	**95% C.I. for EXP(B)**	
								Lower	**Upper**
Step 1[a]	Age	.001	.027	.002	1	.963	1.001	.949	1.057
	Education	-.048	.089	.297	1	.586	.953	.801	1.134
	Annual Income	.000	.000	.031	1	.861	1.000	1.000	1.000
	Operational Land Holding	-.451	.211	4.553	1	**.033**	**.637**	.421	.964
	Area under Mango	.505	.281	3.230	1	**.042**	**1.657**	.955	2.873
	Ownership of Orchard	2.661	2.126	1.567	1	.211	14.311	.222	923.306
	Age of Mango Orchard	-.062	.032	3.654	1	**.046**	**.940**	.883	1.002
	Resource Availability	.117	.074	2.492	1	.114	1.124	.972	1.300
	Crop Insurance	-.522	.532	.963	1	.326	.593	.209	1.684
	Loan Access	1.279	.600	4.547	1	**.033**	**3.592**	1.109	11.633
	Extension Participation	.167	.416	.161	1	.688	1.182	.523	2.670
	Sources of Input	-.109	.612	.032	1	.858	.897	.270	2.975
	Soil Type	-.005	.354	.000	1	.989	.995	.497	1.991
	Topography	-.506	.537	.885	1	.347	.603	.210	1.729
	Seashore Distance	-.012	.038	.092	1	.762	.989	.917	1.065
	Planting Density	-.014	.048	.081	1	.776	.987	.899	1.083
	Climatic Vulnerability	.036	.069	.279	1	.597	1.037	.906	1.187
	Knowledge	.108	.025	18.859	1	**.000**	**1.114**	1.061	1.169
	Constant	-18.45	9.987	3.413	1	.065	.000		

Table 26: The Results of Binary Regression Analysis for Socio-Economic Factors Affecting Adoption of Canopy management

Variables in the Equation									
	Explanatory variables	**B**	**S.E.**	**Wald**	**df**	**Sig.**	**Exp(B)/ Odd ratio**	**95% C.I. for EXP(B)**	
								Lower	**Upper**
Step 1[a]	Age	.042	.022	3.584	1	**.049**	**.959**	.919	1.001
	Education	.031	.064	.237	1	.626	.969	.855	1.099
	Annual Income	.000	.000	1.259	1	.262	1.000	1.000	1.000
	Operational Land Holding	.031	.161	.037	1	.848	.970	.707	1.330
	Area under Mango	.002	.195	.000	1	.991	.998	.681	1.463
	Ownership of Orchard	.660	.708	.869	1	.351	1.934	.483	7.738
	Age of Mango Orchard	.029	.024	1.520	1	.218	1.029	.983	1.078
	Resource Availability	.014	.053	.065	1	.799	.987	.889	1.095
	Crop Insurance	.011	.398	.001	1	.978	1.011	.464	2.205
	Loan Access	.581	.436	1.777	1	.183	.559	.238	1.315
	Extension Participation	.002	.248	.000	1	.993	.998	.614	1.623
	Sources of Input	.210	.406	.267	1	.605	.811	.366	1.796
	Soil Type	.185	.285	.423	1	.516	1.203	.689	2.101
	Topography	.271	.390	.484	1	.487	.762	.355	1.638
	Seashore Distance	.009	.026	.104	1	.747	1.009	.958	1.062
	Planting Density	.030	.038	.623	1	.430	.971	.901	1.045
	Climatic Vulnerability	.028	.054	.272	1	.602	.972	.874	1.081
	Knowledge	.068	.019	12.759	1	**.000**	**1.071**	1.031	1.111
	Constant	1.569	6.905	.052	1	.820	4.804		

Table 27: The Results of Binary Regression Analysis for Socio-Economic Factors Affecting Adoption of Irrigation Management

Variables in the Equation									
	Explanatory variables	**B**	**S.E.**	**Wald**	**df**	**Sig.**	**Exp(B)/ Odd ratio**	**95% C.I. for EXP(B)**	
								Lower	**Upper**
Step 1[a]	Age	.026	.034	.594	1	.441	1.027	.960	1.098
	Education	-.213	.104	4.149	1	**.042**	**.808**	.659	.992
	Annual Income	.000	.000	.123	1	.726	1.000	1.000	1.000
	Operational Land Holding	.221	.373	.349	1	.555	1.247	.600	2.592
	Area under Mango	-.251	.398	.396	1	.529	.778	.357	1.699
	Ownership of Orchard	-.618	.865	.510	1	.475	.539	.099	2.938
	Age of Mango Orchard	-.083	.041	3.989	1	**.046**	**.921**	.849	.998
	Resource Availability	-.106	.078	1.842	1	.175	.899	.772	1.048
	Crop Insurance	.321	.572	.314	1	.575	1.378	.449	4.232
	Loan Access	.620	.680	.831	1	.362	1.859	.490	7.054
	Extension Participation	.623	.583	1.142	1	.285	1.865	.594	5.853
	Sources of Input	.397	.667	.354	1	.552	1.487	.402	5.495
	Soil Type	-.193	.378	.262	1	.609	.824	.393	1.729
	Topography	.199	.621	.103	1	.749	1.220	.361	4.119
	Seashore Distance	.120	.067	3.221	1	**.023**	**1.128**	.989	1.286
	Planting Density	.022	.050	.200	1	.655	1.022	.928	1.127
	Climatic Vulnerability	-.057	.083	.473	1	.492	.944	.802	1.112
	Knowledge	-.027	.026	1.070	1	.301	.973	.925	1.024
	Constant	14.296	9.358	2.334	1	.127	1617147.575		

Table 28: The Results of Binary Regression Analysis for Socio-Economic Factors Affecting Adoption of Pest Management Practices

Variables in the Equation									
	Explanatory variables	**B**	**S.E.**	**Wald**	**df**	**Sig.**	**Exp(B)/ Odd ratio**	**95% C.I. for EXP(B)**	
								Lower	**Upper**
Step 1[a]	Age	-.004	.021	.033	1	.856	.996	.956	1.038
	Education	-.085	.066	1.672	1	.196	.918	.807	1.045
	Annual Income	.000	.000	.015	1	.902	1.000	1.000	1.000
	Operational Land Holding	.040	.134	.091	1	.763	1.041	.801	1.353
	Area under Mango	-.148	.168	.772	1	.379	.863	.621	1.199
	Ownership of Orchard	.883	.727	1.476	1	.224	2.419	.582	10.057
	Age of Mango Orchard	-.006	.024	.065	1	.799	.994	.949	1.041
	Resource Availability	-.021	.055	.150	1	.698	.979	.879	1.090
	Crop Insurance	.103	.395	.067	1	.795	1.108	.511	2.403
	Loan Access	1.041	.447	5.427	1	**.020**	**2.832**	1.180	6.800
	Extension Participation	-.055	.234	.056	1	.813	.946	.599	1.496
	Sources of Input	-.074	.424	.031	1	.861	.928	.404	2.131
	Soil Type	.067	.278	.057	1	.811	1.069	.619	1.845
	Topography	-.291	.395	.545	1	.460	.747	.345	1.619
	Seashore Distance	.040	.029	1.886	1	.170	1.041	.983	1.102
	Planting Density	-.046	.038	1.421	1	.233	.955	.886	1.030
	Climatic Vulnerability	.110	.054	4.233	1	**.040**	**1.117**	1.005	1.240
	Knowledge	.026	.018	2.170	1	.141	1.027	.991	1.063
	Constant	-3.95	6.963	.323	1	.570	.019		

Table 29: The Results of Binary Regression Analysis for Socio-Economic Factors Affecting Adoption of Paper Bagging of Fruits

Variables in the Equation									
	Explanatory variables	**B**	**S.E.**	**Wald**	**df**	**Sig.**	**Exp(B)/ Odd ratio**	**95% C.I. for EXP(B)**	
								Lower	**Upper**
Step 1[a]	Age	-.021	.022	.924	1	.337	.979	.937	1.022
	Education	-.173	.072	5.722	1	**.017**	**.841**	.730	.969
	Annual Income	.000	.000	.120	1	.729	1.000	1.000	1.000
	Operational Land Holding	.194	.226	.733	1	.392	1.214	.779	1.890
	Area under Mango	.041	.247	.028	1	.868	1.042	.642	1.690
	Ownership of Orchard	.564	.668	.714	1	.398	1.758	.475	6.505
	Age of Mango Orchard	.014	.024	.325	1	.568	1.014	.967	1.063
	Resource Availability	-.135	.058	5.314	1	**.021**	**.874**	.780	.980
	Crop Insurance	-.264	.417	.401	1	.527	.768	.339	1.739
	Loan Access	-.274	.457	.361	1	.548	.760	.311	1.860
	Extension Participation	-.011	.261	.002	1	.968	.990	.594	1.650
	Sources of Input	.715	.445	2.579	1	**.008**	**2.044**	.854	4.893
	Soil Type	.227	.288	.622	1	.430	1.255	.714	2.207
	Topography	.680	.412	2.724	1	**.049**	**1.973**	.880	4.422
	Seashore Distance	-.072	.031	5.510	1	**.019**	**.931**	.877	.988
	Planting Density	-.001	.038	.001	1	.971	.999	.927	1.076
	Climatic Vulnerability	.019	.059	.106	1	.745	1.020	.908	1.145
	Knowledge	-.009	.018	.229	1	.633	.991	.957	1.027
	Constant	6.156	7.229	.725	1	.394	471.383		

Table 30: The Results of Binary Regression Analysis for Socio-Economic Factors Affecting Adoption of Rejuvenation of Old Orchards

Variables in the Equation									
	Explanatory variables	**B**	**S.E.**	**Wald**	**df**	**Sig.**	**Exp(B)/ Odd ratio**	**95% C.I. for EXP(B)**	
								Lower	**Upper**
Step 1[a]	Age	.047	.048	.968	1	.325	1.048	.955	1.150
	Education	.056	.135	.173	1	.677	1.058	.812	1.378
	Annual Income	.000	.000	.032	1	.859	1.000	1.000	1.000
	Operational Land Holding	-.177	.230	.588	1	.443	.838	.534	1.316
	Area under Mango	.475	.280	2.888	1	**.039**	**1.609**	.930	2.784
	Ownership of Orchard	1.858	1.277	2.119	1	.145	6.412	.525	78.281
	Age of Mango Orchard	.215	.065	11.056	1	**.001**	**1.240**	1.092	1.407
	Resource Availability	-.005	.136	.001	1	.973	.995	.762	1.300
	Crop Insurance	-.900	.928	.942	1	.332	.406	.066	2.503
	Loan Access	1.441	1.099	1.719	1	.190	4.226	.490	36.437
	Extension Participation	.160	.274	.342	1	.559	1.174	.686	2.009
	Sources of Input	-.434	.919	.223	1	.637	.648	.107	3.926
	Soil Type	.030	.627	.002	1	.962	1.030	.302	3.519
	Topography	1.553	.796	3.810	1	**.047**	**4.727**	.994	22.489
	Seashore Distance	-.021	.063	.108	1	.742	.979	.865	1.109
	Planting Density	-.066	.078	.720	1	.396	.936	.803	1.091
	Climatic Vulnerability	-.056	.118	.224	1	.636	.946	.751	1.191
	Knowledge	.078	.045	2.989	1	**.043**	**1.081**	.990	1.180
	Constant	-18.14	15.321	1.403	1	.236	.000		

APPENDIX II

INTERVIEW SCHEDULE

Socio-economic Factors Affecting on Adoption of Climate Resilient Technologies by the Mango Growers

Name of Researcher: Jadhav P. B. Research Guide: Dr. S. S. Patil

General Information

Respondent Code: …………………………………………….........…

Name of the Respondent: …………………………………………....

Name of the Village: …………………………………………………....

Taluka: ………………………… **District:** ………………………….

PART I

A. Socio-economic characteristics of the mango growers

1. Age ………………………………………………………… Years

2. Education ……………………………………………………… Std.

3. Annual income …………………………………………………. Rs.

Sl. No.	Sources of income	Income (Rs)
1.	Farming	
2.	Service	
3.	Agri-business/ Off-farm business /village artesian	
4.	Mango trading	
5.	Any other (Please specify)	

4. Operational landholding ……………………….....………...ha.

5. Area under mango cultivation…………………………………ha.

6. Ownership of orchard: Please give information about ownership status of your mango orchard.

Sl. No.	Ownership status	Response (Yes/No)	Area (ha)
1.	Own orchard		
2.	Leased-in		
3.	Leased-out		
4.	Own+ Leased-in		
5.	Total		

7. Age of the mango orchard ………………………………………… Years.

8. Resource availability: Which of the following resources are available with you for mango production? Please rate your response.

Sl. No.	Type of resources	Availability			Non-Availability
		Self	Within village	Nearby villages	
a)	*Critical inputs*				
1.	Organic manure/FYM				
2.	Fertilizers & micronutrients				
3.	Plant growth regulators				
4.	Insecticide/pesticides				
b)	*Labour*				
1.	Skilled				
2.	Unskilled				
c)	*Implements and machineries*				
1.	Grass cutter				
2.	Chain saw				
3.	HTP sprayer				
4.	Mango harvester-Nutan *Zela*				
5.	Weighing machine				

6.	Transport van				
7.	Cold storage				
8.	Plastic crates				
9.	Packaging boxes				
10.	Secateurs				
d)	*Water resources*				
e)	Well, /tube-well/ water stream				
f)	Micro-irrigation set				
g)	Pump (Electric/Diesel/Solar)				

9. Access to crop insurance:

Do you have access to Pradhan Mantri Fasal Bhima Yojana?.........…. Yes/No

If Yes, then how much amount of the premium that you paid…………Rs/ha

10. Access to crop loan

Have you borrowed a crop loan from any bank? ………….…..…. Yes/No

If Yes, then mention the amount of crop loan ……………………………. Rs.

11. Sources of inputs: Which of following institutional sources that you are using to access the critical inputs required for mango production?

Sl. No.	**Sources**	**Yes**	**No**
1	Agricultural University		
2	Krishi Vigyan Kendra (KVK)		
3	Agriculture Department		
4	Agriculture Consultant		
5	Input Dealer / Krishi Seva Kendra		
6	Private Nursery Owner		

12. Extension participation

Sl. No.	Extension activities	Frequency of Participation		
		Always	Sometimes	Never
1.	Group Discussions			
2.	Trainings			
3.	Frontline Demonstrations			
4.	Workshops			
5.	Farmers Mela / Rally			
6.	Field Day			
7.	Mango Festival / Exhibition			
8.	Exposure Visits/ Study tour			
9.	Campaign			

B. Ecological characteristics of the mango orchard

13. Soil type: ……………………………………. Rocky/ Platue / Lateritic

14. Topography: ………………………………………………Hilly/ Plain

15. Distance of mango orchard from sea shore: ………..…………Km

16. Planting density: ……………………………. Number of Plants/ha

17. Climatic vulnerability: Does mango orchard suffered from/ exposed to any of following climatic events? If Yes, then what is its severity to have adverse impact on yield? Please rate your response.

Sl. No.	Climatic vulnerability	Response (Yes/No)	Severity		
			Extremely severe	Severe	Not severe
a)	**Rainfall**				
1.	Delayed flowering and fruit-setting due to extended and unusual rain				

2.	Unusual rain and high humidity lead to incidence of anthracnose, powdery mildew, fruit fly and hoppers				
b)	**Temperature**				
3.	Low temperature for prolonged period reduces the hermaphrodite flowers				
4.	Sudden increased temperature during inflorescent stage leads to infestation of hoppers, thrips				
5.	Abrupt increase in temperature causes fruit drop in mango				
6.	Abrupt increase in temperature leads to sun-scorching and spongy tissue				
7.	**Cold waves**				
8.	Recurrent flowering and heavy fruit drop are observed due to repeated cold waves				
c)	**Fog and frost**				
9.	Prolonged fog and frost increase the incidence of				

	anthracnose on inflorescent				
d)	**Cyclone and high wind velocity**				
10.	Mango orchards were damaged by high wind speeds and cyclones, resulting in fruit loss.				

18. Knowledge

Sl. No.	Questions	Response	
		Yes	**No**
1	Which technology does the university recommend for Hapus to flowering every year? **Ans:** Use of recommended dose of Paclobutrazol during July-August		
2	What technology has been recommended by the university to prevent recurrent flowering of mangoes due to cold wave? **Ans:** Spraying of Gibberellic Acid (GA) 50 ppm		
3	How to control mango fruit drop in case of sudden rise in temperature **Ans:** Spraying of Naphthalic Acetic Acid (NAA) 20 ppm		
4	Which technology is recommended by university for improving the quality of mango fruit? **Ans:** Spraying of Potassium Nitrate (1%)		
5	How do you manage plant canopy to increase yield per plant? **Ans:** Canopy management to facilitate more sunlight and thereby reduce pest infestation and increase yield		

6	What is the rate of watering per tree to prevent pea-shaped fruits from falling? **Ans:** Provide irrigation (100-200 liter/tree)		
7	How many sprays has been recommended by the university for integrated pest and disease management in mangoes? **Ans:** As per need 4-6		
8	What measures are taken for the production of spotless fruit in mango? **Ans:** Bagging of fruit from 'Marble to Egg' stage.		
9	Which technology is used to rejuvenate old and senile mango orchards? **Ans:** Rejuvenation of Old and Senile orchard technique recommended by university.		

PART II

19. Adoption: Do you adopt any of the following climate resilient technologies? If Yes, then Please rate your response.

Sl. No.	Technologies	Yes	No
1	Use of recommended dose of Paclobutrazol during July-August		
2	Spraying of Gibberellic Acid (GA) 50 ppm to avoid Recurrent Flowering		
3	Spraying of Naphthalic Acetic Acid (NAA) 20 ppm to avoid Fruit Drop		
4	Spraying of Potassium Nitrate (1%) for more Fruit Retention		
5	Canopy management to facilitate more sunlight and thereby reduce pest infestation		

6	Provide irrigation (100-200 liter/tree) to reduce dropping of pea size fruits		
7	Use of university recommended spraying schedule for insect-pest management		
8	Paper Bagging of fruit from the 'Marble to Egg' stage		
9	Rejuvenation of Old and Senile orchard		

PART III

Reasons for non-adoption and over adoption of some climate resilient mango production technologies**.**

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Researchers' observations (If any)

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APPENDIX IV

Table: list of selected villages for survey

Sl. No.	Village name	Tehsil	District
1.	Lanja	Lanja	Ratnagiri
2.	Dhundhare		
3.	Punas		
4.	Satawali		
5.	Harche		
6.	Upale		
7.	Agave		
8.	Kumbhavde	Rajapur	
9.	Ansure		
10.	Sagve		
11.	Janshi		
12.	Midgaavne		
13.	Dale		
14.	Nate		
15.	Madban		
16.	Kuveshi		
17.	Urshi	Devgad	Sindhudurg
18.	Jamsande		
19.	Dabhole		
20.	Patthar		
21.	Waada		
22.	Pural		
23.	Math	Vengurle	
24.	Adeli		
25.	Vetore		
26.	Sataye		
27.	Ansur		
28.	Tulas		
29.	Hodawade		

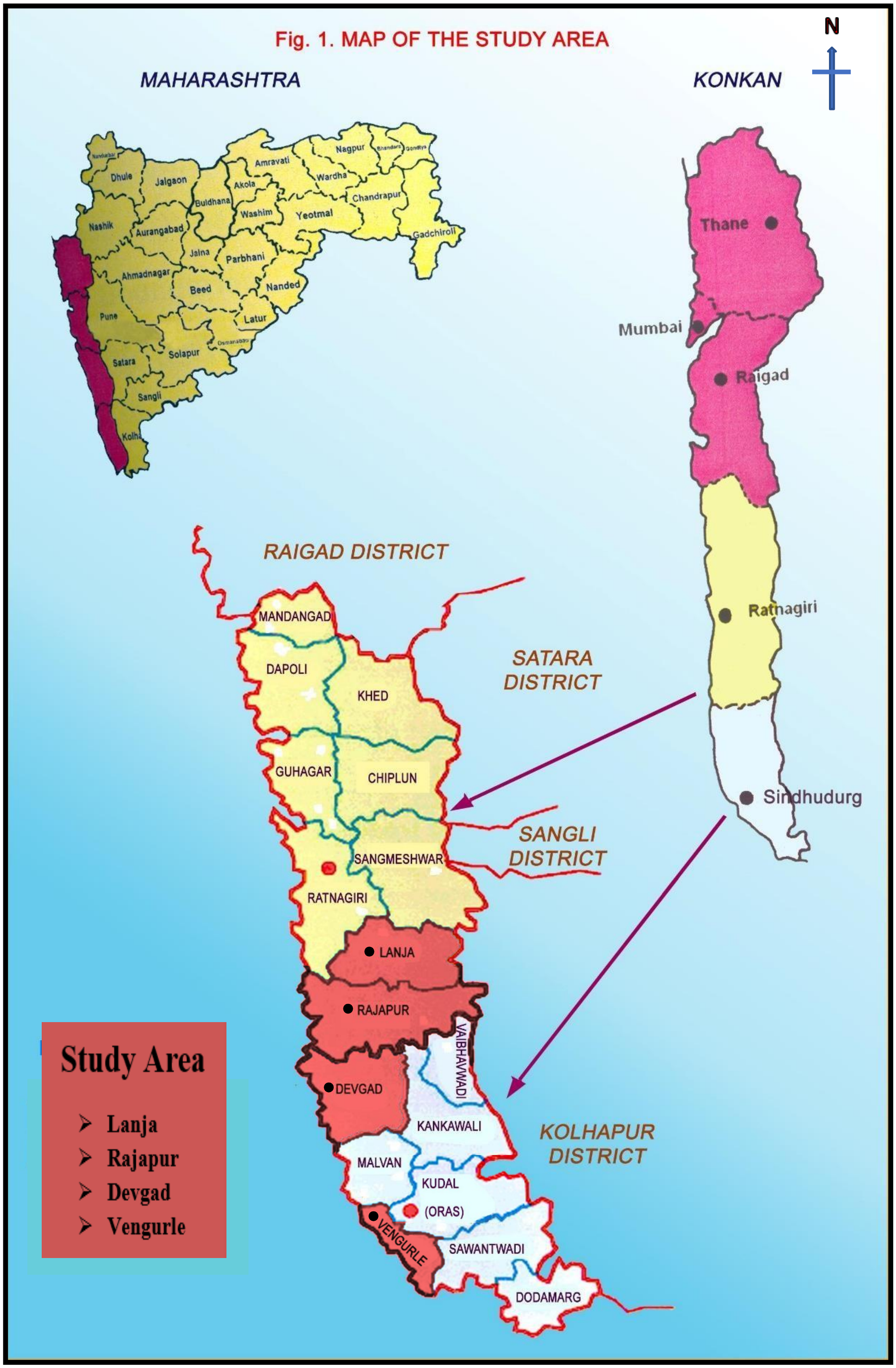

Fig. 1. MAP OF THE STUDY AREA

Plate1: Investigator while interviewing the respondents.

Plate 2: Investigator while interviewing the respondents.

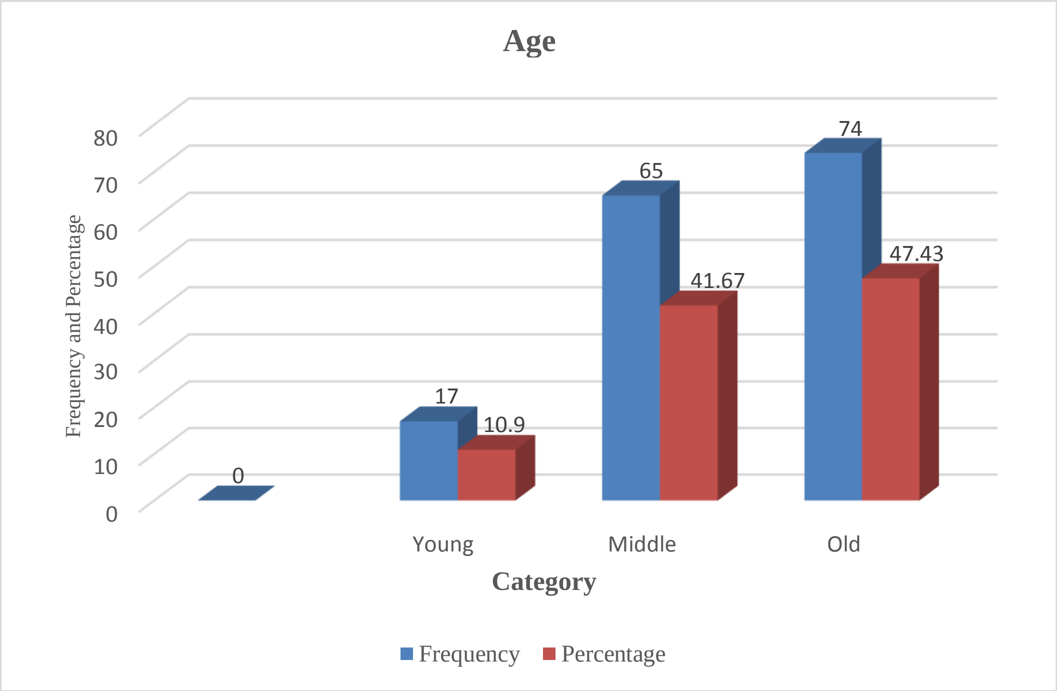

Figure 2: Distribution of the respondents according to their age

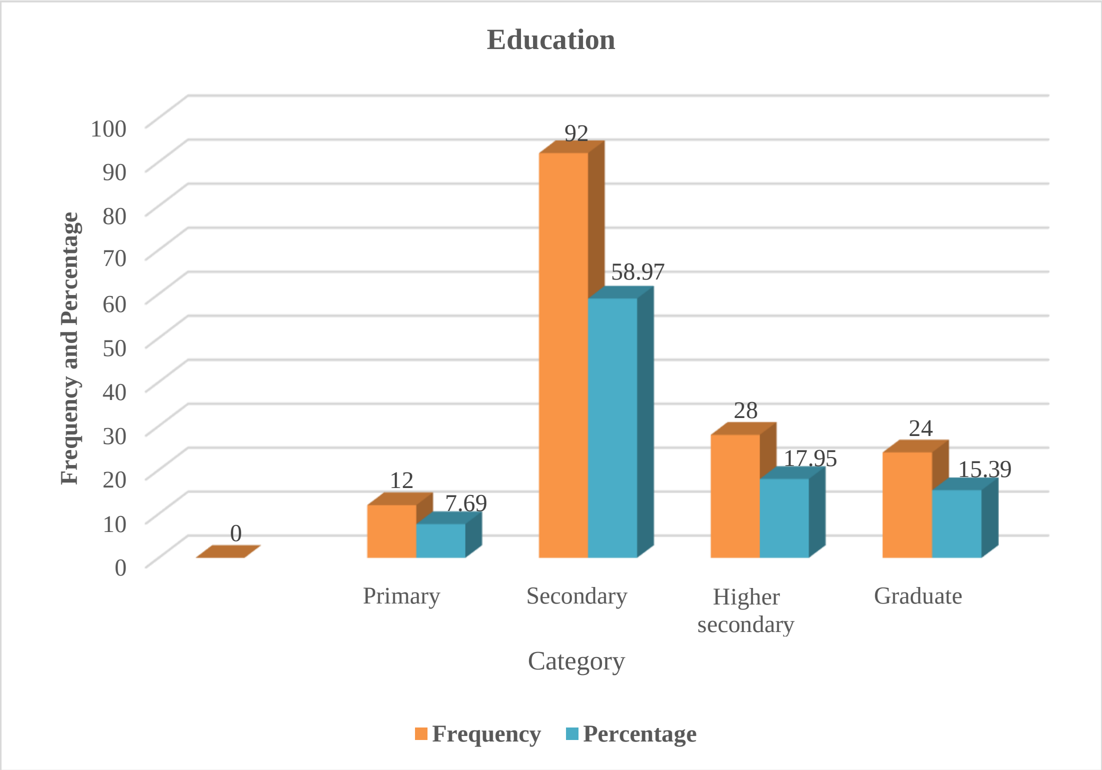

Figure 3: Distribution of the respondents according to their education

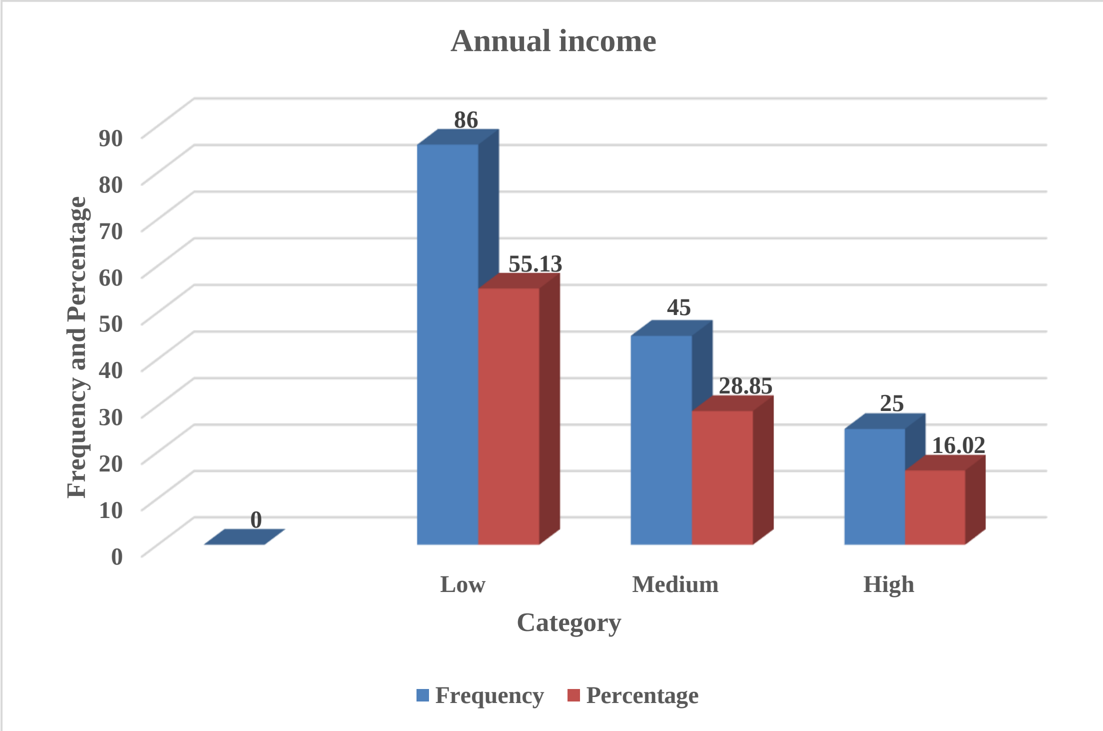

Figure 4: Distribution of the respondents according to their annual income

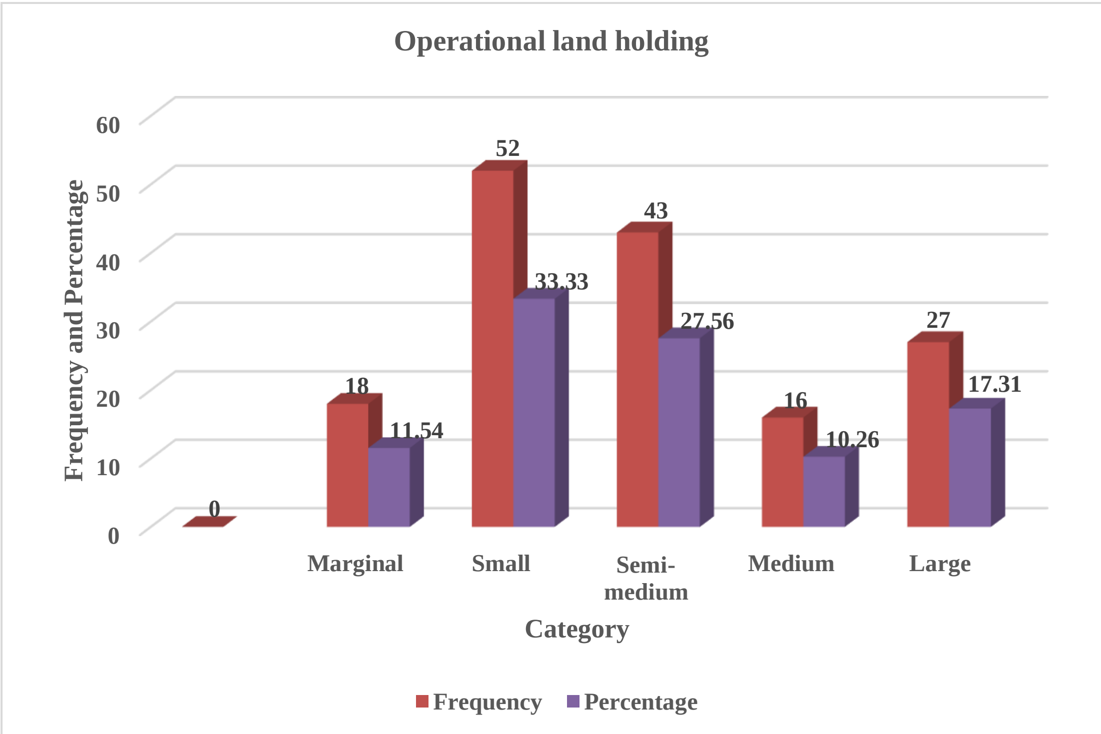

Figure 5: Distribution of the respondents according to their landholding

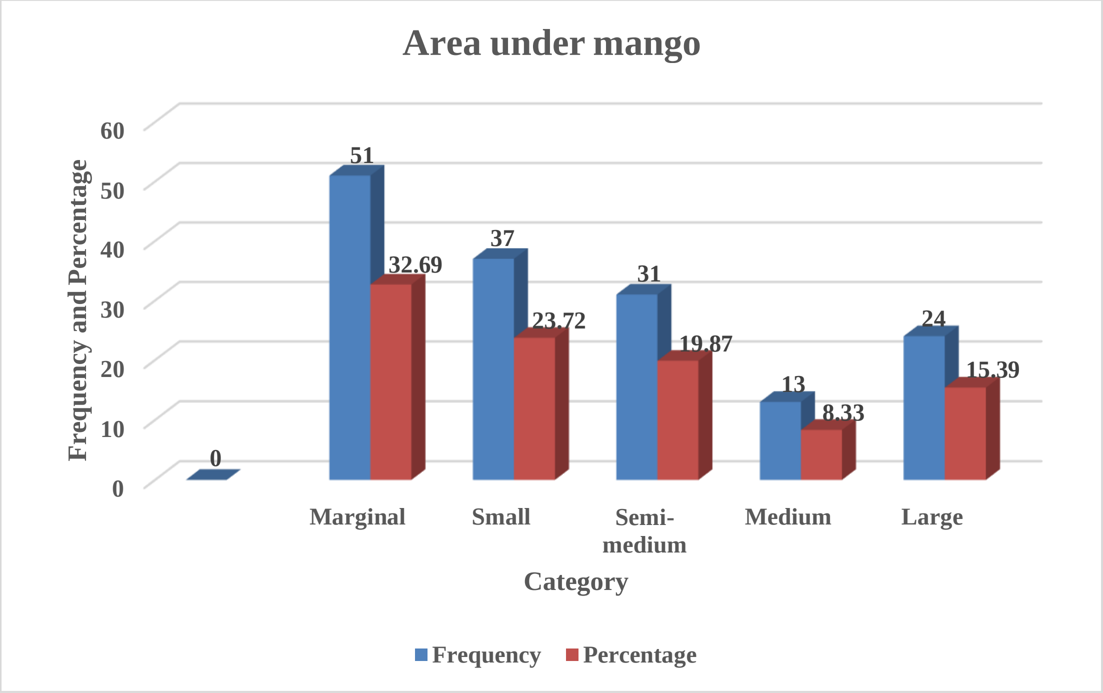

Figure 6: Distribution of the respondents according to their area under mango.

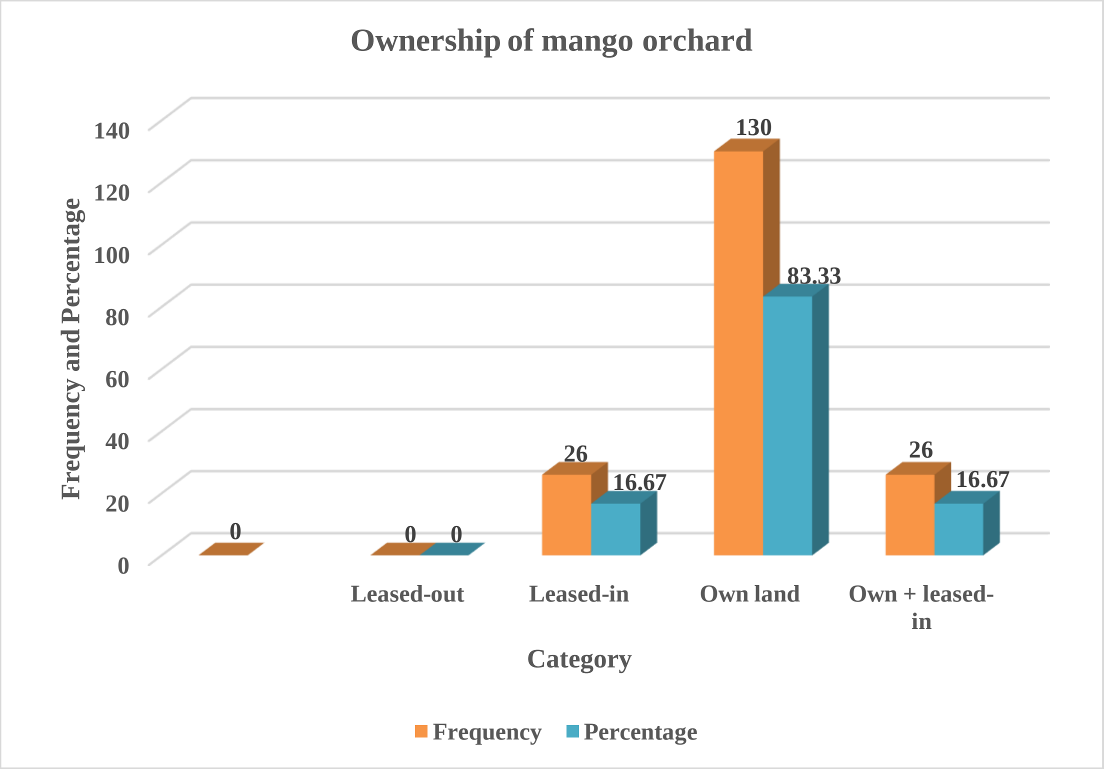

Figure 7: Distribution of the respondents according to their ownership of orchards.

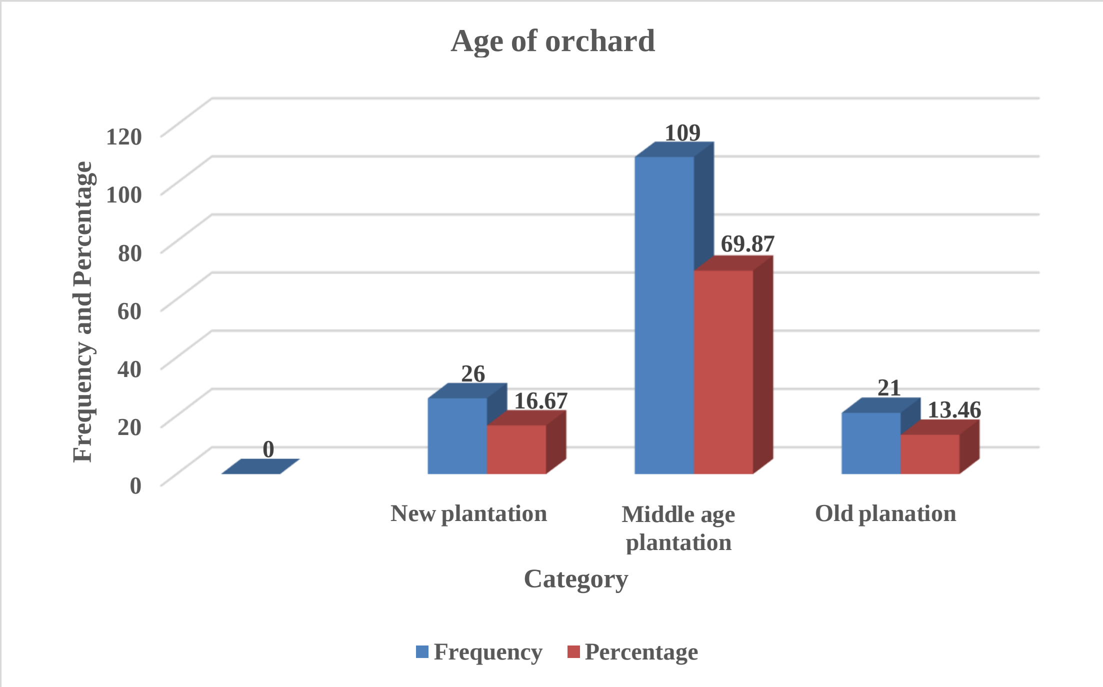

Figure 8: Distribution of the respondents according to their age of mango orchard.

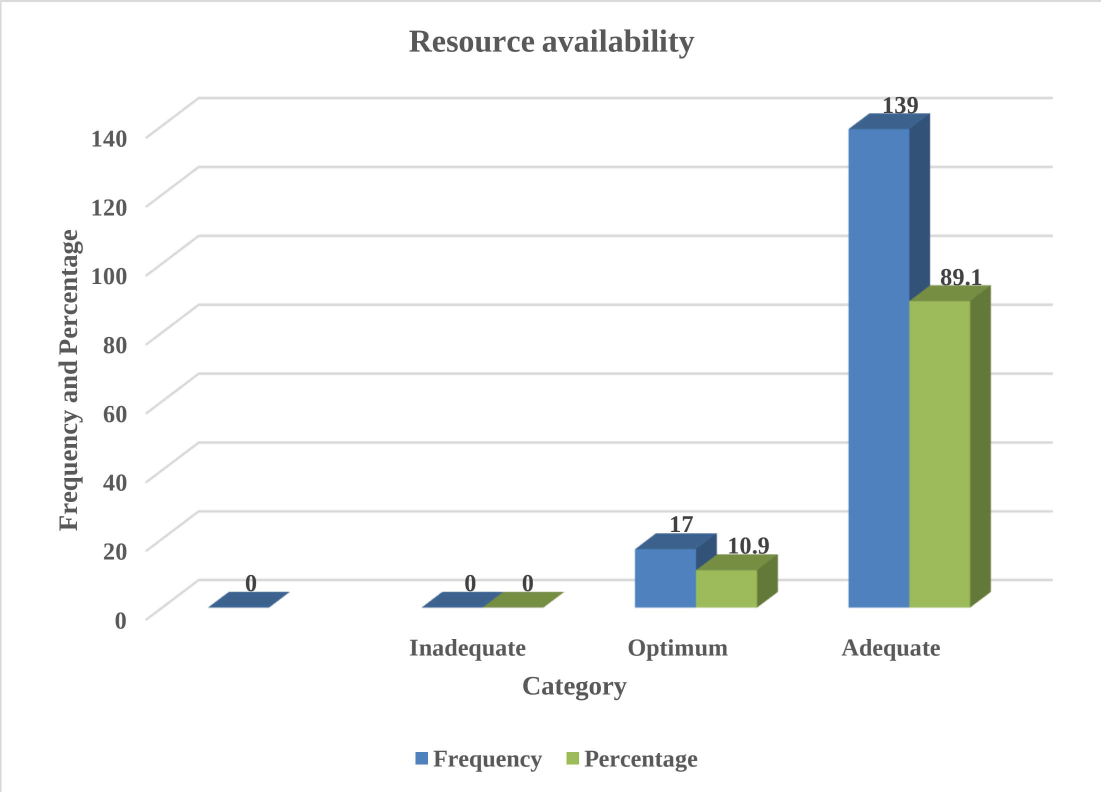

Figure 9: Distribution of the respondents according to their resource availability

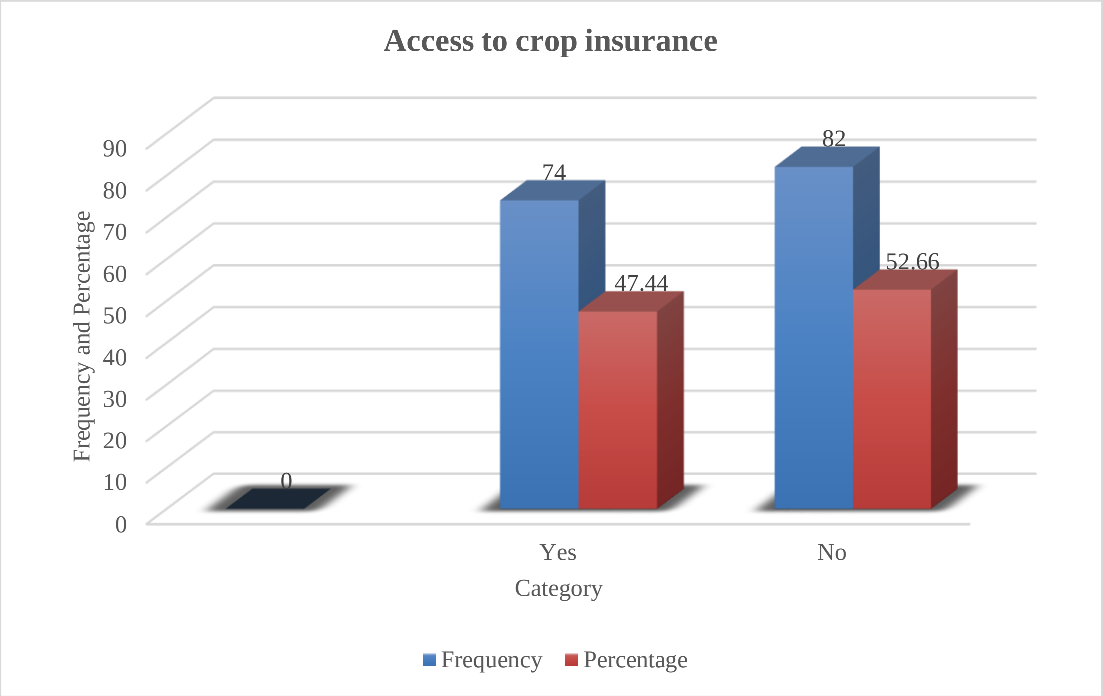

Figure 10: Distribution of the respondents according to their access to crop insurance.

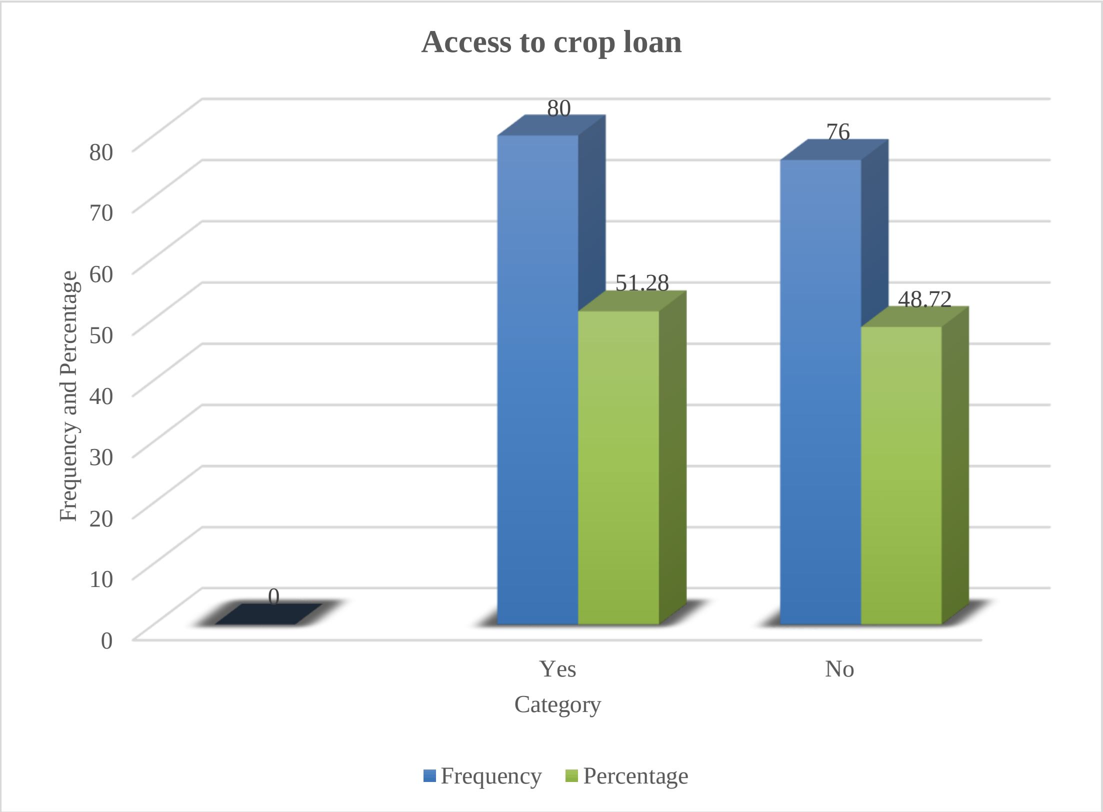

Figure 11: Distribution of the respondents according to their access to crop loan.

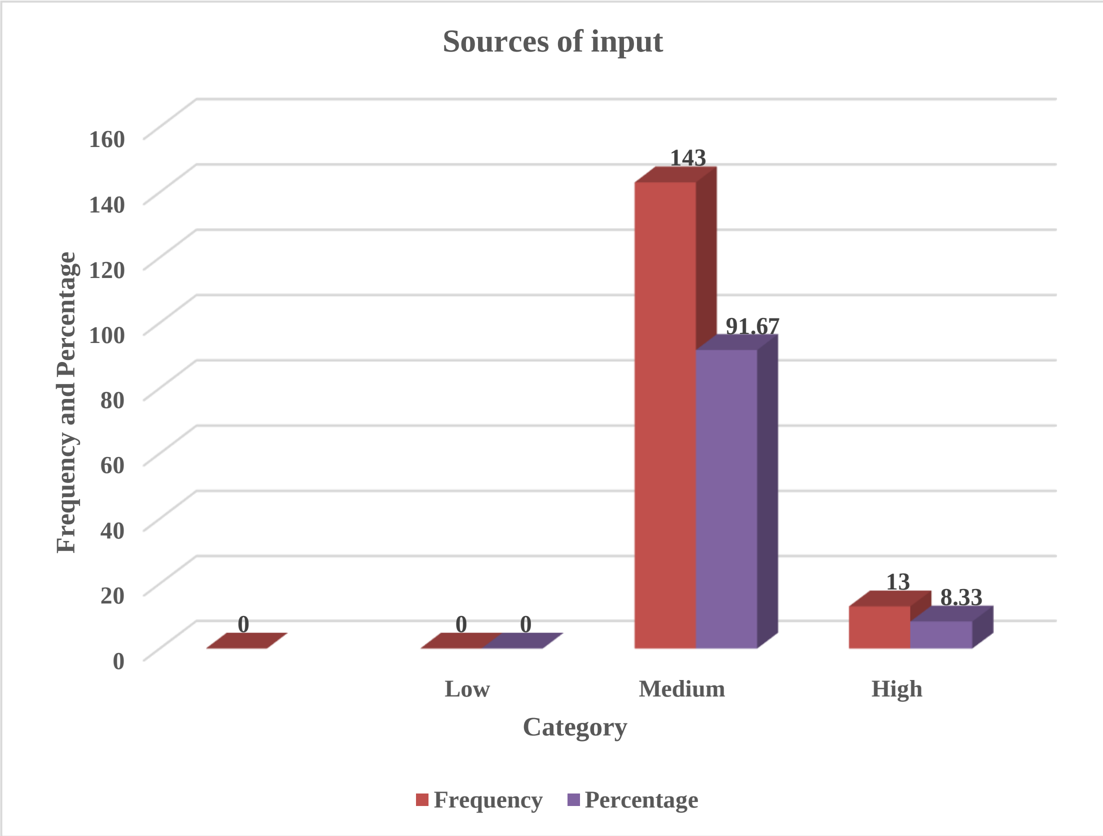

Figure 13: Distribution of the respondents according to their source of inputs

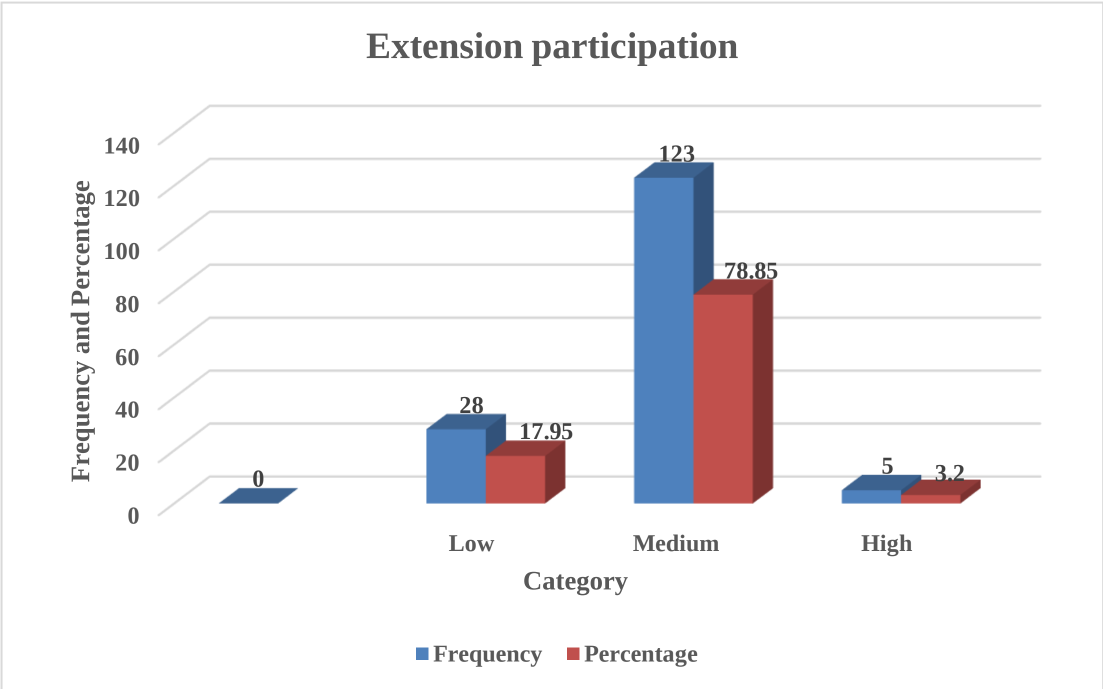

Figure 12: Distribution of the respondents according to their extension participation.

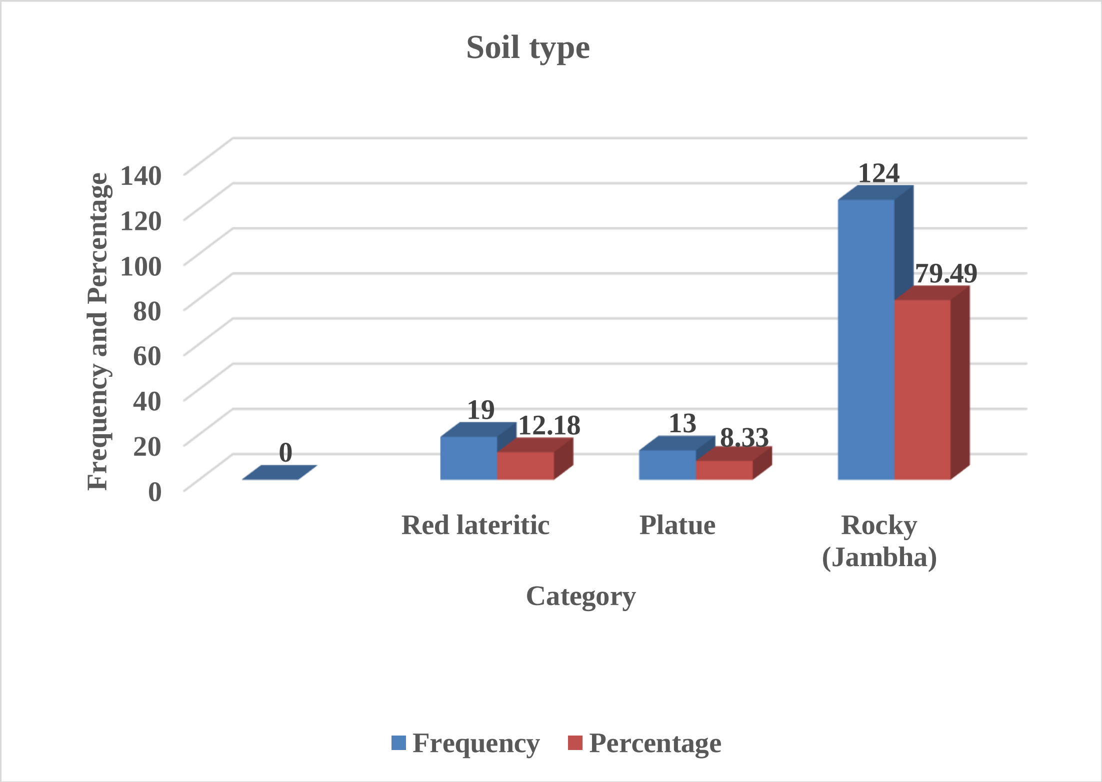

Figure 14: Distribution of the respondents according to their soil type

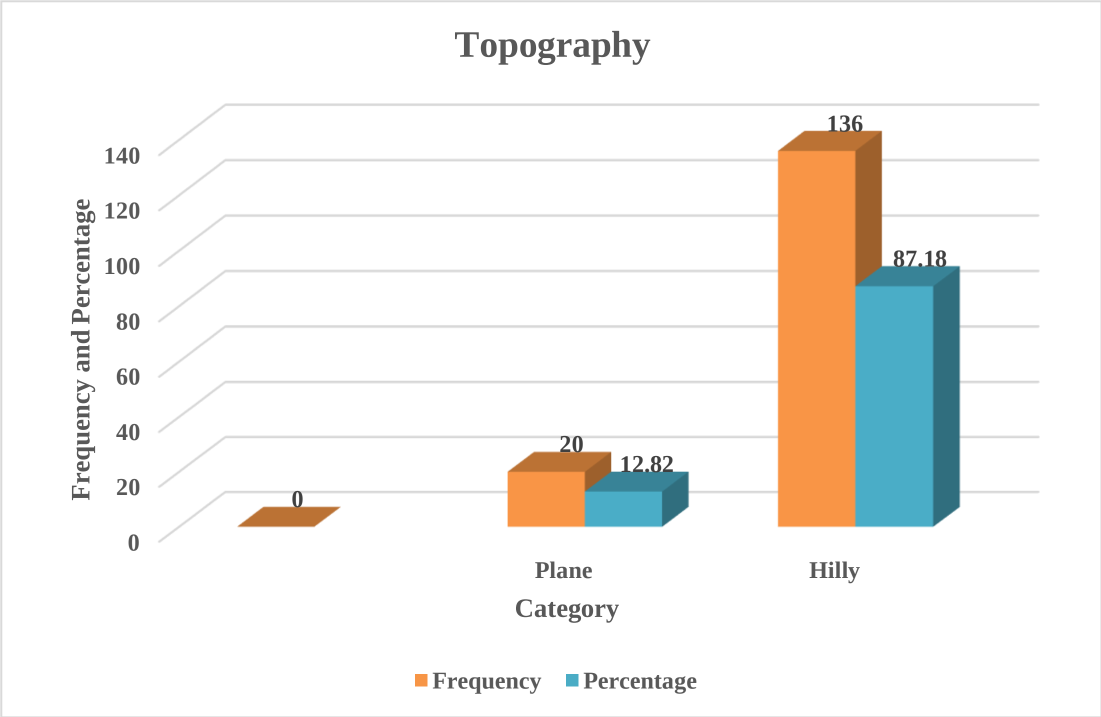

Figure 15: Distribution of the respondents according to their topography

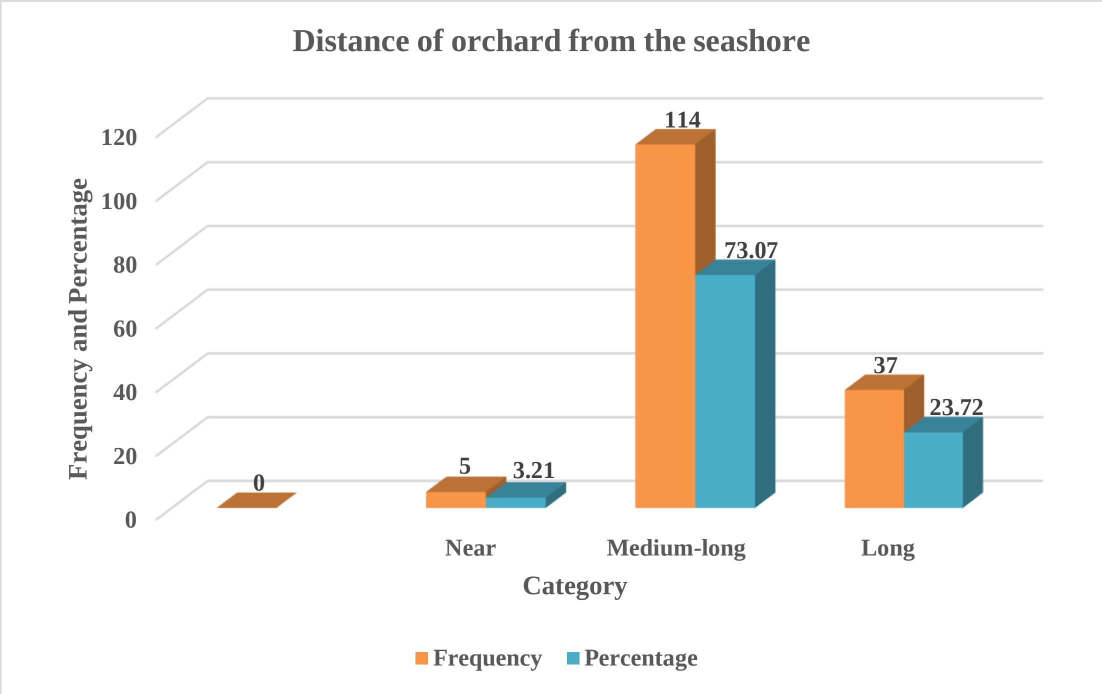

Figure 16: Distribution of the respondents according to distance of orchard from the sea shore

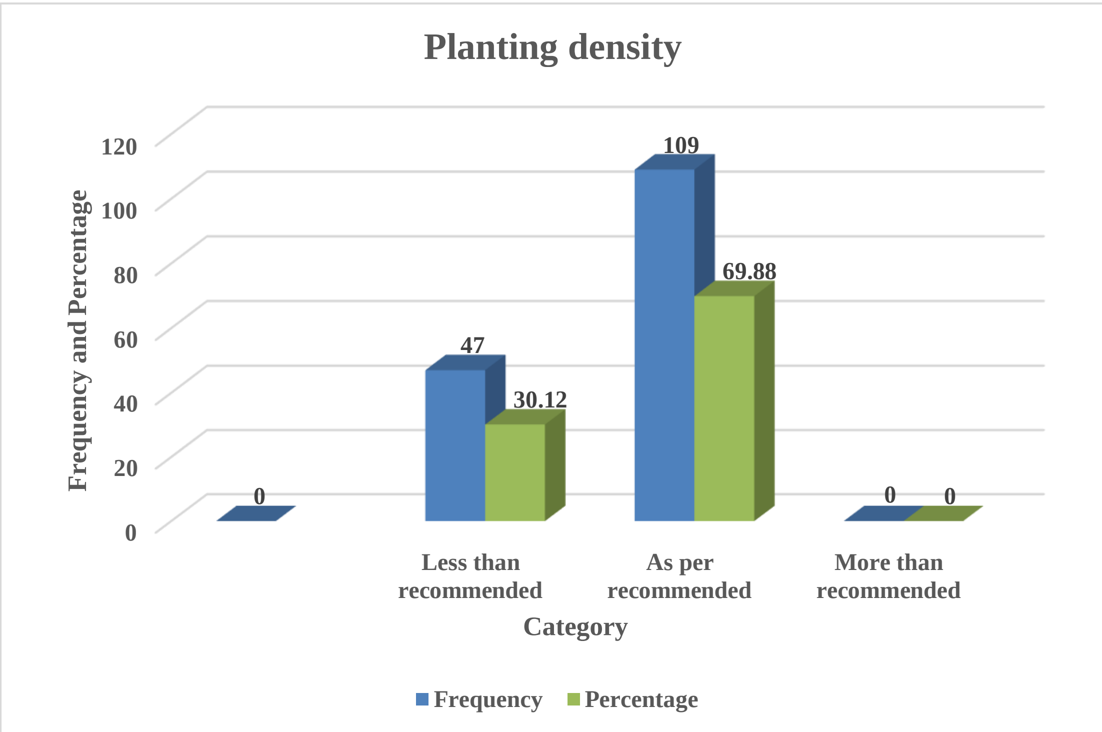

Figure 17: Distribution of the respondents according to their planting density

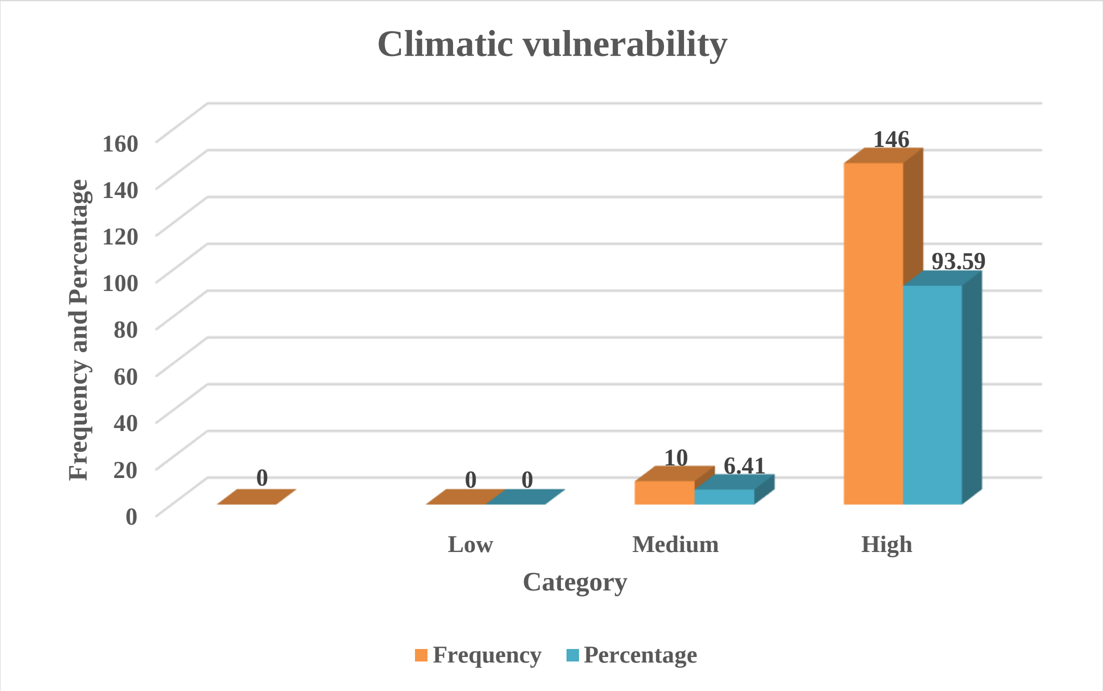

Figure 18: Distribution of the respondents according to their climatic vulnerability

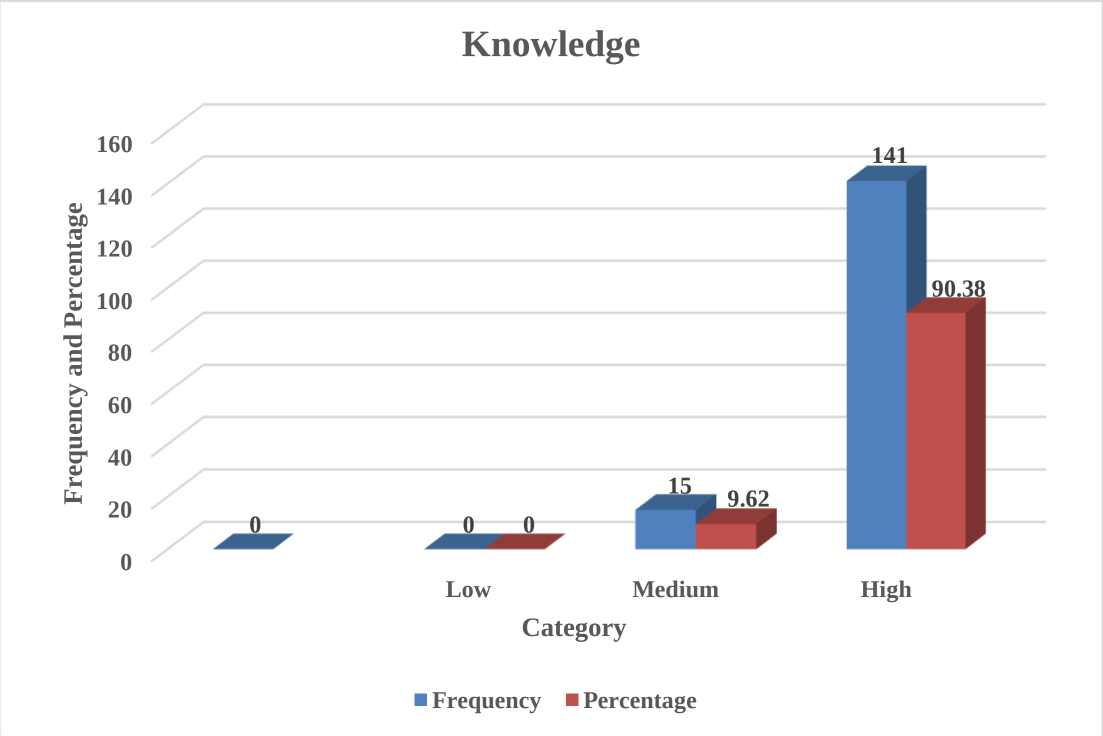

Figure 19: Distribution of the respondents according to their knowledge on climate resilient mango technologies

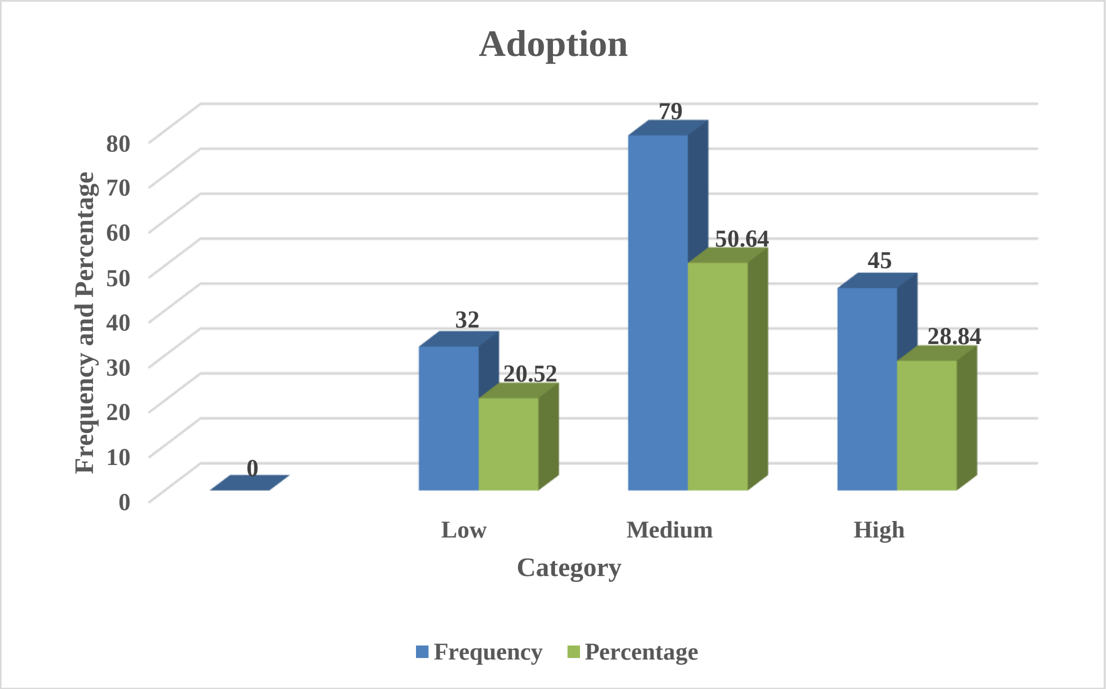

Figure 20: Distribution of the respondents according to their adoption of climate resilient mango technologies

Fig. 21 Empirical Model of the Investigation