ECONOMIC IMPACT OF CLIMATE CHANGE ON LIVELIHOOD STATUS OF DAIRY FARMERS IN MANDI DISTRICT OF HIMACHAL PRADESH

Thesis

by

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(F-2021-04-M)

submitted to

Dr. YASHWANT SINGH PARMAR UNIVERSITY OF HORTICULTURE AND FORESTRY SOLAN (NAUNI) HP - 173 230 INDIA

in

partial fulfilment of the requirements for the degree

of

MASTER OF SCIENCE (Ag.)
AGRICULTURAL ECONOMICS

DEPARTMENT OF SOCIAL SCIENCES
COLLEGE OF FORESTRY

2023

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CERTIFICATE- I

This is to certify that the thesis titled, **"Economic impact of Climate Change on the livelihood status of dairy farmers in Mandi district of Himachal Pradesh**" submitted in partial fulfilment of the requirements for the award of the degree of **MASTER OF SCIENCE (Ag.)** in the discipline of **AGRICULTURAL ECONOMICS** to Dr. Yashwant Singh Parmar University of Horticulture and Forestry, (Nauni) Solan (HP) – 173230 India is a record of bonafide research work carried out by**Ms. Jahanvi Saini (F-2021-04-M)** daughter of Mr. Thakar Dassunder my supervision and that no part of this thesis has been submitted for any other degree or diploma.

The assistance and help received during the course of this investigation have been fully acknowledged.

Place: Nauni, Solan
Dated: 30.09.2023

Dr Shilpa
Chairman
Advisory Committee

CERTIFICATE-II

This is to certify that the thesis titled, **"Economic Impact of Climate Change on Livelihood Status of Dairy Farmers in Mandi District of Himachal Pradesh"**, submitted by **Ms. Jahanvi Saini (F-2021-04-M)** daughter of Mr. Thakar Dass to the Dr. Yashwant Singh Parmar University of Horticulture and Forestry, (Nauni) Solan (HP) - 173230 India in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE (Ag.)** in the discipline of **AGRICULTURAL ECONOMICS** has been approved by the Advisory Committee after an oral examination of the student in collaboration with the External Examiner.

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ACKNOWLEDGEMENT

Not for the sake of convention done but out of deep-seated conviction, it gives me profound pleasure to express my heartfelt feeling for those, who helped me a lot in completing this work.

Firstly, I would like to express my sincere graceful filled thanks to ***"ALMIGHTY GOD"****, who has protected me so long and permitted me undertake this journey. The journey is still continuing with many more destinations to cover.*

It is my privilege to express my deep sense of gratitude to my major advisor ***Dr. Shilpa*** *Assistant professor, Department of Social Sciences, College of Forestry, UHF, Nauni, Solan, HP for her valuable guidance, timely suggestion, close counsel critical evaluation, everlasting patience, constant encouragement at every step of work and creating research ability and aptitude in me.*

It is my sole prerogative to place on record my indebtedness and everlasting gratitude to esteemed members of my advisory committee ***Dr. Chandresh Guleria,*** *(Assistant Professor, Department of Social Sciences),* ***Dr. Nisha Thakur,*** *(Assistant Professor, Department of Social Sciences) and* ***Dr. Ajit Sharma,*** *(Assistant Professor, Department of Basic Sciences) for their valuable suggestions and generous cooperation during the course of investigation and preparation of this manuscript.*

I am grateful to my grandfather ***Sh. Puran Chand Saini****, my grandmother* ***Smt. Kubja Devi*** *my father* ***Sh. Thakar Dass*** *who has been always a source of motivation behind all my achievements, my mother* ***Smt. Sunita Devi*** *who has been a constant source of encouragement for me, my siblings and cousins* ***Jagriti Saini, Janshi Saini, Aadarsh Saini, Anshita Saini, Pranshul Saini, Akshat Saini and Anaya Saini*** *for their blessings and moral support.*

No adequate words can be found to express my warmest thanks to all my seniors and juniors especially Lekhika di, Alisha di, Shubham sir, Pradeep sir and Bharti.

Genuine appreciation goes for my classmates and friends who kept me in an exalted state even during the moments of despondency and were always with me with supporting hand, Mittu, Pranchal, Adit, Disha, Anu, Manshi, Swati, Aaditi Kapoor, Ishaan, Aditi, Monika, Nidhi, Aprajita and Jatin.

Acknowledgements are inherently endless & incomplete, and I request indulgence from many friendly & helpful people whom I could not name here, due to paucity of space.

Needless to say, all omissions and errors are mine.

Place: Nauni, Solan

Date: (**Jahanvi Saini)**

CONTENTS

ABBREVIATIONS

R^2	:	Coefficient of multiple determination
%	:	per cent
&	:	And
CRC	:	Capital Recovery Cost
DF	:	Dry Fodder
et al.	:	etalia (Coworkers)
Etc	:	Et cetera
Wef	:	with effect from
FAO	:	Food and agriculture organisation
GOI	:	Government of India
Fig.	:	Figure
GDP	:	Gross Domestic Product
GF	:	Green Fodder
ha	:	hectare
I to XV	:	Roman number (1 to 15)
R^2	:	Coefficient of multiple determination
SAU	:	Standard Animal Unit t/ha
TFC	:	Total Fixed Cost
TVC	:	Total Variable Cost
Viz.	:	That is to say

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Chapter-1

INTRODUCTION

Livestock is a significant part of agriculture in India and is crucial to the livelihood of a sizeable portion of the country's poor population. Livestock contribute to their livelihood in a variety of ways. The first benefit is that it produces a constant flow of income, which is frequently used to cover their daily living costs and other expenses. Second, it is a crucial piece of natural capital that the poor can use to maintain their standard of living during difficult times. Third, livestock enables the underprivileged to receive private benefits from resources that belong to everyone (in terms of animal grazing and fodder collection). Fourth, livestock provides protection from income shocks caused by crop failures. Finally, raising livestock gives women the ability to support themselves by taking on a variety of dairy farming-related tasks. In addition to being a significant source of draught power and manure inputs for the crop subsector, livestock are a significant source of food and nutritional security. Through export revenue, livestock contribute to the foreign exchange market (Birthal and Rao, 2002).

Particularly in regions that are prone to drought, the livestock sector holds out a lot of promise for generating income and creating jobs. It is interesting to note that, even during the height of the Green Revolution, when the focus of policy was primarily on crop production, the growth in livestock income has always been higher than the growth in crop income. Livestock farming systems have been affected in many ways by climate change. The world weather pattern will possess numerous knock-on impacts, both direct and indirect, including changes in the basic productivity based on fodder and rangelands and the direct impacts of atmospheric conditions and extreme weather events (flood and drought) on animal welfare, disease parasites, development, and procreation (animal milk). In terms of "drought proofing" and ensuring income and employment for a sustainable rural lifestyle, dairy farming assumes greater relevance (Patel, 1993). About 70 per cent of the cost of producing milk is attributable to feed costs. Lack of feed resources is a serious issue that is more important when there is a drought. Given the unpredictability of crop production, increasing livestock production is a key strategy for boosting the income of landless, marginal, and small farmers. Particularly in dry and rain-fed regions.

India is the world's largest milk producer. Milk production was 209.96 million tons (MT) during 2020-21 against 198.44 MT in 2019-20. India accounted for 21 per cent of the

global output. The livestock sector has been growing at a compound annual growth rate (CAGR) of 7.93 per cent from 2014-15 to 2020-21 In the years 2022, the nation produced 203 million tonnes of milk. According to former studies, farmers who joined dairy cooperatives saw a considerable boost in milk production and productivity, as well as a decrease in the price of producing one unit of milk, enabling them to increase output pricing, cut transaction costs, and boost profits. (Raval and Chandawat 2011).

Himachal Pradesh is located in the western Himalayas and in the northern part of India. The majority of the state's land is made up of mountains, making up 68.65 per cent of its total area according to the livestock census 2007, which is divided into valleys with numerous perennial rivers. The prospects of dairying in hilly terrain would be extremely advantageous to farmers with limited resources and would maximize resource use effectiveness. Additionally, this industry can significantly support income redistribution in favor of weaker groups generally. There hasn't been much in-depth research recently in the state focused on the complex economic issues of dairy farming. There are 68.65 lakh people living in the state as a whole, with 90 per cent of them living in rural areas. According to the animal husbandry department the state's economy heavily relies on hydropower, tourism, horticulture, and agriculture. 13.92 lakh tonnes of milk are produced as a result of livestock, one of the major contributors to the agricultural sector.

Mandi district is the largest producer district of milk in the state after Kangra. Large part of the population is associated with farming activities. Mandi has an area of 3,951sq.km with a population of 9,00,987 residing in 392 villages. According to the livestock census 2012 total livestock population in Mandi district was 9,41,489 which comprised 485,895 cattle, 81643 buffalo, 1,40,837 sheep, 2,26,485 goats and 6,629 other livestock. Whereas, the milk production in mandi district is 293.401 thousand tones according to state animal husbandry department.

Climate change is likely to continue to increase average daily temperature and the frequency of heat waves, which can reduce meat and milk production in animals. The effects of extreme heat on dairy production and health and well-being of animals have been widely documented in the animal science literature. Warmer temperature can lead to increased animal heat stress and economic losses. With projected increases in heat and precipitation spells and continued technological changes, a greater understanding of the effects of weather and new technologies on the efficiency and productivity of dairy farm operations is important for focusing management and public policies on mitigating adverse weather effects and promoting adoption of input augmenting technologies. In addition, extreme cold temperatures

have been acknowledged as negatively affecting dairy cow production. Not enough rainfall over a period of time can cause drought conditions, which can impact pasture growth and reduce the amount and quality of feed. Farmers need to buy supplemental feed to keep milk production going or dry off (stop milking) stock earlier than planned. Reduced amounts of rainfall can cause drought conditions. (Lopez *et al*.,2022).

The variability in climatic conditions such as temperature variations, uneven rainfall affects livestock habitat, metabolism and internal and external processes which ultimately lead to less revenue growth from livestock rearing practices.

Hence keeping in view, the immense potential of livestock sector in the state, the proposed study was conducted to understand the economics of milk production along with factors affecting the dairy farming with the following objectives: -

1. To study the socio-economic status of dairy farmers,
2. to study the economics and impact of climate change on dairy production of selected dairy farms,
3. to examine the factors affecting the adoption of risk adaptation strategies constraints faced by dairy farm households.

Chapter-2

REVIEW OF LITERATURE

A detailed literature is important for carrying out any scientific research. As, review of literature consists of related studies, theoretical and actual work done in the field. It highlights the past studies related to the research problem which helps in formulating methodology, choice of analytical tools, concepts related to study, formulation of hypothesis and helps the researcher to accomplish the given objectives. Therefore, this chapter presents the review of various studies carried out by different researchers in Himachal Pradesh, India and abroad on economic analysis of dairy farming. The work done relevant to the given objectives has been compiled in this chapter and classified into following sub-heads

2.1 Socio-economic status of dairy farmers

2.2 Economics and impact of climate change on dairy production

2.3 Factors affecting the adoption of risk adaptation strategies and constraints faced by dairy farm households.

2.1 Socio-economic status of dairy farmers

Chauhan *et al.* (2004) in his study on 'Impact of farmer's status on milk production in tribal area found that, approximately 28.00 per cent of dairy farmers fell within the age range of 36 to 45 years, with the next largest group being those aged between 46 and 55 years, accounting for 27.00 per cent. Farmers above the age of 55 constituted 25.00 per cent of the total, whereas individuals aged between 26 and 35 years represented 16.00 per cent. The smallest proportion was found among farmers below the age of 25, comprising only 4.00 per cent of the total.

Chauhan *et al.* (2004) studied the status of milk production in the tribal area of Kinwat Tehsil of Marathwada region and the study found no significant correlation between the age and educational level of dairy farmers and milk production. However, it revealed that the size of landholding and the occupation of dairy farmers had a notable and positive impact on milk production. Additionally, the research indicated that farmers in the age range of 46 to 55 years showed a stronger inclination towards dairy farming compared to both younger and older farmers.

Bohra *et al.* (2004) studied the peri-urban dairy farming in the mountainous region of Uttaranchal and the study reported that adopting a market-oriented dairy farming system proved beneficial for smallholders, as it led to increased milk production and higher output prices. This, in turn, enabled them to meet their household's basic needs more effectively. The rise in milk production also translated into higher income for the farmers, ultimately leading to positive lifestyle changes within the study area.

Bordoloi *et al.* (2005) studied the socio-economic and personal characteristics of dairy farmers of West Bengal and according to the report, the overall literacy rate was found to be 88.65 per cent. The overall literacy index (2.51) showed the quality of education was low in the study area.

Bhowmik and Sirohi (2008) studied the economics of milk production and technological changes in dairy farming in South Tripura. In the study area, the respondents had an average landholding of 0.58 hectares, and the average family size was approximately five members. It was noticed that as landholding increased, there was a slight rise in family size. Among the sampled households, the literacy rate was recorded at 78 per cent, with most individuals having completed their education up to the high school level. Additionally, on an average, each household reared about 4.9 animals.

Chand *et al.* (2008) analysed the socio-economic status of dairy farmers of middle Andaman and the dairy farmers in the study area had an average annual income of Rs. 74,000. Out of this income, 60.81 per cent came from non-farming activities, while 39.19 per cent was derived from farming practices. On an average, each household owned 1.65 animals and had a landholding size of approximately 1.11 hectares. The distribution of livestock reared by the farmers included 0.78 per cent local cows, 0.27 per cent crossbred cows, and 0.60 per cent buffaloes per family.

Ranganath (2008) reported that the average size of operational land holding was 6.81 acres. In western Maharashtra, the landholding size varied across different categories of farmers, ranging from 1.5 acres for marginal farmers to 37.60 acres for large farmers. The average family size was 6.3 members, and it tended to increase with larger landholdings. The study found an average of 3.59 standard animal units (SAU's) per household. Regarding literacy, around 80 per cent of the total sample households were found to be literate. Among the literate individuals, 41 per cent had completed primary education, 32 per cent had secondary education, and the remaining 7 percent had obtained a graduation degree or higher.

Gangasagare and Karanjkar (2009) reviewed the situation of dairy farming with the objectives to study milk production trends and socio-economic status of the dairy farmers in Marathwada region of Maharashtra. The majority of the farmers, approximately 59 per cent, belonged to the general category, while 25 per cent were from backward communities, and both scheduled castes and scheduled tribes accounted for 8 per cent each. The study concluded that as the number of milch animals increased, the performance of herd lactation decreased, primarily due to the lack of year-round fodder availability.

Thakur (2010) studied the cost of milk production and socio-economic status of dairy farmers in Samastipur district of Bihar and the study revealed a clear correlation between family size and landholding, with an average family size of 9 persons per family. Landless households had an average family size of 7 members, while larger households had an average of 13 members. In the study area, approximately 62 per cent of the heads of families were literate, while the remaining 38 per cent were illiterate, with landless households constituting the highest proportion at 59 per cent. Regarding occupations, the results showed that 42 per cent of the households had agriculture as their main occupation, followed by dairying at 13 per cent. The remaining 45 per cent of households were associated with various sectors such as services, business, and agricultural labor as their primary occupations.

Kumar *et al.* (2010) in a study on informal markets on dairy farming reported that the most of the informal milk market agents in the state of Assam are small and derive their household income from it. The study findings indicated that large traders achieved higher net returns through milk processing and value addition compared to fresh milk marketing. On the other hand, small traders were more focused on raw milk marketing. The study concluded that the returns from milk marketing were either equal to or greater than the prevailing wages for an unskilled worker. Furthermore, it was revealed that value addition of milk played a significant role in enabling dairy farmers to command higher prices for their products.

Paul and Chandel (2010) conducted a study on the adoption of crossbred cattle in the north-eastern states of India to tackle the milk deficit issue, it was concluded that implementing crossbred cattle could help resolve the milk deficit problem in the region. Currently, the proportion of crossbred cattle in the area stands at 3.46 per cent, significantly lower than the national average of 13.33 per cent. The productivity of crossbred cattle was found to be relatively low, producing an average of 4.8 liters per day. The study identified technological and socio-economic constraints as major factors influencing the milk yield of

crossbred animals in the north-eastern states. To address these challenges, the study recommended adopting improved management and feeding practices, disease control measures, and enhancing socio-economic conditions for farmers through training, education, and improved access to finance.

Sathyanarayan *et al.* (2010) investigated the socio-economic profile of livestock farmers of Narasapura village of Bangalore and the study revealed that 53.85 per cent of the population belonged to the medium-sized category, followed by 40 per cent in the small-sized category, and a minority of 6.16 per cent in the large-sized category. Additionally, it was observed that the majority of respondents (96.92%) fell into the low family income group, while the high and medium family income categories accounted for 1.54 per cent each. The study emphasized the importance of disseminating knowledge on dairy farming through veterinary universities and other agencies. This initiative aims to uplift the socio-economic profile of dairy farmers, thereby fostering progress and development in the dairy farming sector.

Raval and Chandawat (2011) while studying the level of knowledge of improved animal husbandry practices and socio-economic condition of dairy farmers in Kheda of Gujarat, the report revealed that a significant portion of marginal land households in the study area belonged to the middle-age group, with secondary education, and were associated with social organizations. They primarily relied on canals for irrigation. The study concluded that dairy farmers in this region possessed commendable knowledge on various aspects, such as nutritional management, breed improvement, water management, improved milking techniques, and disease control methods. This expertise played a pivotal role in enabling the farmers to obtain higher prices for their dairy products.

Shinde (2011) carried out a study in the Solapur district of Maharashtra to analysis the socio-economic conditions of dairy farmers and the study's findings revealed that a significant portion of small farmers in irrigated areas, approximately 42 per cent, worked as wage earners. However, in non-irrigated areas, about 44 per cent of small farmers were primarily engaged in dairy farming. In irrigated areas, the majority of farmers (53%) were rearing an average of 2-4 animals, while in non-irrigated areas, 30 per cent of farmers had 3-5 animals.

Gopi *et al.* (2016) conducted a study in the two diverse agro climatic zones of Villupuram and Salem district of Tamil Nadu and reported that livestock plays a crucial role in the rural economy, and the study area reflects this significance. The majority of

respondents, comprising 76.67 per cent, fall into the middle and old-aged categories. Furthermore, 45 per cent of the respondents are illiterate. Agriculture is the primary occupation for 78.33 per cent of the respondents, while 21.67 per cent are primarily engaged in dairying. The respondents mostly belong to nuclear families and possess substantial experience in the field of dairying.

Sonawane *et al.* (2016) carried out a study on economic analysis of dairy farms in Amravati district of Maharashtra. According to the report, the average family size for small, medium, and large categories of dairy farmers were 4.89, 4.54, and 4.61, respectively. It was found that the annual maintenance cost for crossbred cattle was higher than for local cows, and a similar trend was observed for local and crossbred buffaloes. Additionally, the annual maintenance cost for local and improved buffaloes was higher compared to that of local and crossbred cows. The study highlighted that feed and fodder expenditure constituted the major expenses for maintaining dairy farms. The study's conclusion revealed that 77.77 per cent of dairy farmers in the study area faced challenges with higher costs of concentrate, while 50 per cent of farmers encountered difficulties due to the unavailability of green fodder during lean periods.

Kumari and Malhotra (2016) studied the impact of dairy co-operative society on income and employment in Begusarai district of Bihar. The study involved data collection from 80 members and 80 non-member milk producing households, which were categorized based on herd size. It was observed that monthly income from both crossbred cows and buffaloes was higher for women dairy cooperative society (WDCS) members compared to non-members. Furthermore, the study indicated that there was a positive and significant seasonal impact on income. In conclusion, the women dairy cooperatives played a crucial role in elevating income levels and generating employment opportunities, ultimately leading to an enhancement in the socio-economic status of women dairy farmers in the study area.

Rai *et al.* (2017) conducted a study on the socio-economic characteristics of tribal dairy farmers of Una and Sirmaur districts of Himachal Pradesh. The findings of the study showed that 50 per cent of the farmers belonged to the medium age group, and 31.25 per cent had received education up to the primary level. Within the study area, 45.62 per cent of the respondents had a low herd size, out of which 40 per cent fell into the medium category of milk production, and 42.50 per cent had low average milk productivity. The study highlighted the necessity of improving communication between farmers and veterinary staff to provide a

reliable source of information. By addressing this gap, there is an opportunity to positively impact the status of tribal dairy farmers in the study area, leading to potential improvements in their dairy farming practices.

Kumar *et al.* (2018) studied the socio-economic status and role of livestock to improve the livelihood status of the tribes of Jharkhand. The study noted that livestock played a significant role in providing nutritious food and contributing to family incomes. The research findings indicated that the livestock sector yielded higher annual income for the tribal community compared to other sources such as wage employment, remittance, and shopkeeping.

Kumar *et al.* (2019) studied the socio-economic profile and problems faced by dairy farmers of Sardhana block of Meerut district and the study area primarily consisted of dairy farmers below the age of 50, with livestock rearing as their main source of livelihood. The average milk production per household in the region exceeded 10 kg per day. The study's conclusion emphasized that the adoption of modern dairy farm technologies and the establishment of a marketing yard in the area could contribute to enhancing the socioeconomic status of the farmers.

2.2 Economics and impact of climate change on dairy production

Saha and Gupta (2000) examined the economics of milk production of local cow and crossbred cows in the Murshidabad district of West Bengal. The study revealed that crossbred cows exhibited higher milk production, leading to the conclusion that maintaining local cows was not economically feasible due to their low milk production and poor genetic potential. Interestingly, it was found that marginal farmers and landless laborers achieved higher milk production with crossbred cows compared to large farmers.

Bardhan *et al.* (2004) observed an economic analysis of milk production from indigenous cows in Udham Singh Nagar district of Uttaranchal. Among all types of farmers, a significant portion of total expenses was attributed to the cost of feed and fodder. Specifically, the feed cost accounted for 57.32 per cent of the overall maintenance expenses. Labor costs constituted 19.50 per cent of the total expenses, while depreciation and veterinary expenses made up 2.25 per cent and 8.42 per cent, respectively, of the overall maintenance costs.

Das (2004) conducted a study on economic efficiency of milk production in West-Bengal and the study revealed that during the rainy season, the marketed surplus was

approximately 81.00 per cent, which was significantly lower at 80.00 per cent during the winter. Moreover, it was observed that milk output and pricing had a positive and substantial influence on the marketed surplus in both seasons, with a direct correlation to the herd size, leading to increased surplus levels.

Bardhan *et al.* (2004) studied economic analysis of milk production from indigenous cows in Udham Singh Nagar district of Uttaranchal. The study findings indicated that feed and fodder costs constituted a significant portion of the total expenditure for all categories of farmers. The proportion of feed cost to the overall maintenance cost was determined to be 57.32 per cent. Additionally, labor costs accounted for 19.50 per cent of the total expenditure, while veterinary costs and depreciation made up 2.25 per cent and 8.42 per cent of the total maintenance cost, respectively.

Desai (2005) undertook a study on milk production and its disposal pattern in the rural area of Bidar district of Karnataka and reported that the feed cost was the major cost followed by labor cost in all the species. The study's findings indicated that the highest net return (Rs. 3.72 per liter of milk) was obtained from crossbred cows, followed by buffaloes. However, in the case of local cows, negative returns were recorded. Additionally, the study concluded that green fodder was underutilized among all milch animals, and concentrate feeding was underutilized specifically in the case of crossbred cows.

Bhowmik (2006) studied economics of milk production and analysed technological change in dairying in South Tripura. The study households, on average, owned only 0.58 hectares of operational land. The average family size was five members, and the size of the landholding somewhat contributed to this number. A little over (78%) of farmers were literate, with the majority having completed high school. On average, each household raised approximately 4.9 animals.

Singh (2006) in his study on economics of milk production and marketed surplus in Imphal district of Manipur observed that for native cows and crossbred cows, The cost of producing one liter of milk was found to be Rs. 16.70 for crossbred cows and Rs. 13.09 for local cows. Approximately 82 per cent of the gross maintenance cost consisted of total variable costs. For crossbred cows, the net return on milk production was as low as Rs. 1.0 per liter, while it was negative for local cows.

Chauhan and Sharma (2006) conducted a study on economic analysis of milk production in the tribal area of Udaipur district of Rajasthan and observed that the average daily milk yield for a milch local cow was found to be 1.49 liters, while buffaloes had an average yield of 2.38 liters. The estimated average maintenance cost per day for local cows was Rs. 21.24, and for buffaloes, it was Rs. 29.26. Concentrate feed was identified as a significant variable that positively influenced milk production for both local cows and buffaloes.

Jeyakumar and Rai (2006) studied the economics of milk production from local and crossbred cows in Andaman and Nicobar Islands. According to the study, there was a negative correlation between the percentage of local cows and farm size, whereas a positive correlation was observed in the case of crossbred cows. The cost of milk production per liter was lower for local cows (Rs. 5.79) compared to crossbred cows (Rs. 7.65).

In Singh's (2006) investigation on milk production and marketed surplus in Imphal district, Manipur, it was found that the cost of milk production per liter was Rs. 16.70 for local cows and Rs. 13.09 for crossbred cows. Crossbred cows exhibited positive net returns of Rs. 1.00, while local cows resulted in negative returns. The study indicated that approximately 82 per cent of the gross maintenance cost was attributed to total variable costs.

Stephan *et al.* (2007) studied the milk production of crossbred cattle in Thrissur district in Kerala. The study employed that least squares analysis of variance was used to study the influence of socio-economic factors. of farmers on the milk production of their cows. The least squares mean 305-day milk production of the crossbred cows was 1.862 + 60.3 kg. The ANOVA showed that the different centres, years of calving, parity and herd strength exerted highly significant influence on milk yield and cattle season of calving had significant effect at 5% significant level. Socio-economic factors of farmer such as land holding, occupation, educational levels type of sheds did not influence the milk yield of cows.

Seo *et al*. (2007) studied the Climate change impacts on animal husbandry in Africa: a ricardian analysis. This paper investigates the influence of climate change on animal husbandry in Africa using the Ricardian method, which employs a cross-sectional approach to analyse the economics of livestock farming in the region. The study examines net revenue derived from animal husbandry on both small and large farms across Africa, and it assesses the climate sensitivity of livestock by regressing the revenue against climate, soil, and other control variables. The research is based on data from a survey conducted by the World Bank

and the Global Environment Facility (GEF) project, involving over 9000 farmers across 11 countries in Africa, with a focus on 5400 farms that rely on livestock.

Shravankumar and Jain (2008) studied the cost and returns of different types of milch animals in Trichy and Erode districts of Tamil Nadu. It was concluded that concentrate and labour cost was major cost component in total cost of milk production followed by green and dry fodder. The cost of concentrate contributed maximum in the total cost. Labour cost was higher for small farms (Rs.29.50 to 34.47 per cow per day) which were due to the involvement of whole family labour in the milk production. The net return was found highest in medium farmer (Rs 22.40 to 54.78 per cow per day). Higher use of green fodder and concentration increases the return from daily animals.

Kabubo-Mariara (2008) carried a study on the Economic Impact of Global Warming on Livestock Husbandry in Kenya: A Ricardian Analysis. The study examined the effect of several climatic scenarios on livestock income. The Ricardian results revealed that livestock production in Kenya was very sensitive to climate change and climate change and livestock productivity had a non-linear relationship. The estimated marginal impacts indicated that rising temperatures result in very slight gains and increased precipitation results in very modest losses. This suggests that farmers are likely to pursue adaptation steps to mitigate the effects of climate change, such as shifting livestock to crops or changing the species mix.

Seo *et al.* (2008) studied the Measuring impacts and adaptations to climate change: a structural Ricardian model of African livestock management. According to the findings, in regions experiencing higher temperatures, African farmers tend to shift from beef cattle to more heat-tolerant options like goats and sheep. Similarly, in areas with increased rainfall, farmers switch from cattle and sheep to goats and chickens. The study suggests that large-scale commercial livestock operations focused on beef cattle will face significant challenges due to climate change, while small-scale farmers who can readily adapt and substitute with goats and/or sheep are likely to exhibit greater resilience in the face of climate impacts.

Lippert C. *et al.* (2009) carried out a study on Ricardian analysis of the impact of climate change on agriculture in Germany. This study examines the impact of climate change on German agriculture using a Ricardian approach that accounts for regional autocorrelation and relies on recent climate change estimates at a low spatial scale. The predicted benefits of climate change are depicted in maps of Germany in 439 districts; the calculated aggregate rent rise equates to around 5-6 per cent of net German agricultural output.

Kusalo *et al.* (2012) conducted a study on the perceived impact of climate change on smallholder dairy farm production in northern Malawi. A survey was used to collect farmer's perceptions, which were then examined using a multi-nominal regression model. The findings revealed a statistically significant link between a drop in milk production and a decrease in water availability ($p < 0.05$), consistent water availability ($p < 0.01$) and a decrease in pasture output ($p < 0.05$). Consistent milk output was caused by consistent water availability ($p < 0.01$) and illness occurrence ($p < 0.05$). The model explained 32 per cent to 36 per cent of the variation in milk output with a classification accuracy of 60 per cent. The findings emphasise the importance of future research into the susceptibility and adaptation of smallholder dairy farmers to climate change.

Huong *et al*. (2017) conducted a study on Economic impact of climate change on agriculture using Ricardian approach: A case of northwest Vietnam. The study discovered a nonlinear significant relationship between household revenue and meteorological factors, as well as an inverted U-shaped relationship between the two seasons. During the dry season, net revenue decreases as temperatures and rainfall rise while net revenue is expected to fall by 17.7 per cent and 21.28 per cent in 2050 and 2100, respectively, due to climate change without adaptation and with the adaption model, net revenue would be down by 0.37 per cent in 2050 and 0.20 per cent in 2100.

2.3 Factors affecting the adoption of risk adaptation strategies and constraints faced by dairy farmers

Malik *et al.* (2005) studied the existing dairy farming practices in Uttar Pradesh and founded that Artificial insemination (AI) was the breeding practise used in both crossbred and local cow. The disposal of crossbred male calves is a severe issue for cattle owners, particularly in places where cow slaughter is prohibited. The most common problem that dairy farmers encountered was a lack of veterinarian and AI facilities in the community which hampered the adoption of good dairy fanning practises.

Manhas and Sharma (2008) made an attempt to study the constraints faced by 200 dairy farmers in the Jammu district of Jammu and Kashmir. According to the survey, 32.5 and 17.5 per cent of respondents experienced high and low levels of costraints respectively while 50 per cent of dairy producers experienced a medium degree of constraints. The respondents identified infrastructure limitations as the biggest barrier whereas technological limitations

were having the least impact on the dairy industry and with regard to the restrictions, they faced there was a considerable variation between the various responder groups.

Mertz *et al.* (2009) studied the Farmer's Perceptions of Climate Change and Agricultural Adaptation Strategies in Rural Sahel. This study examines the perceptions of climate change and coping strategies adopted by sedentary farmers in the central Senegal savanna zone. The households demonstrate a clear awareness of climate variability and identify wind and occasional excess rainfall as the most destructive climate-related factors. These households faced various challenges such as reduced crop yields and livestock health issues, to climate factors, particularly highlighting the impact of wind.

Deressa *et al.* (2009) carried out a study on the determinants of farmer's choice of adaptation methods to climate change in the Nile basin of Ethiopia. The study founded that the main adaptation strategies adopted by farmers in Ethiopia's Nile Basin, the variables influencing their decision, and the obstacles to adaptation. The results of the discrete choice model showed that farmer's decisions are influenced by a variety of factors, including the degree of education, gender, age, and wealth of the household's head; access to extension and credit and knowledge of the local climate, social capital, agro ecological settings and temperature.

Sofoluwe *et al.* (2011) studied the Farmers' perception and adaptation to climate change in Osun State, Nigeria. In this research, farmers' adaptation techniques and the factors influencing their choices were investigated in a specific study area. The study involved a cross-sectional survey of 10 villages in two local government areas of Osun State, and data analysis was conducted using descriptive statistics and multinomial logit. The farmers' perceptions of climate change highlighted a notable increase in temperature and a decrease in rainfall. As a response, the farmers adopted six distinct adaptation methods. Comparing explanatory variables to the null model, it was observed that certain variables led to better accuracy for no adaptation, early and late planting, and tree planting techniques. Furthermore, the analysis of factors influencing climate change adaptation revealed that access to loans and livestock ownership had a more significant impact on the farmers' decision-making process compared to other explanatory variables. These findings shed light on the adaptation strategies employed by farmers in the study area and the key factors driving their choices in the face of climate change challenges.

Mandleni and Anim (2012) carried out a study on climate change and adaptation of small-scale cattle and Sheep farmers to look into the variables that influenced small-scale farmer's decisions to raise sheep and cattle and results were founded using the Binary Logistic Regression model. The findings suggested that a wide range of socioeconomic factors had an impact on farmer's decisions towards climate change adaptation. The study also founded that non-farm income, perceived weather, livestock ownership, distance to weather stations, distance to input markets, adaptation tactics and yearly average temperature were the most important variables influencing climate change and adaptation.

Varathan *et al.* (2012) carried out a study in Tiruvannamalai district of Tamil Nadu to assess the production and marketing constraints perceived by women SHG members and non-SHG members who reared livestock and study revealed that access to credit facilities was the biggest barrier by SHG members and not a barrier for non-members. Members saw a lack of marketing information and the nature of the procurement agency as important marketing restraints while non - members saw the nature of the procurement agencies and the low cost of livestock products as major constraints.

Mensah *et al.* (2012) studied the Farmer's perception and adaptation to climate change: a case study of Sekyedumase district in Ghana. The study revealed that a significant majority of the respondents, approximately 92 per cent perceived a rise in temperature, while 87 per cent observed a decline in precipitation over time. Among the identified adaptation strategies, crop diversification, using short-season crop varieties, altering crop species, and adjusting planting dates were prominent. Logit regression analysis indicated that access to extension services, credit facilities, soil fertility, and land tenure were the most influential factors affecting farmers' perceptions and adaptation decisions. The main barriers hindering adaptation efforts included insufficient information on adaptation strategies, poverty, and a lack of weather-related knowledge. Despite high awareness of climate issues within the communities, only 44.4 per cent of farmers had adjusted their farming practices to counter the impacts of rising temperatures, and 40.6 per cent had adapted to cope with decreased precipitation. The primary obstacle to implementing adaptation measures was the lack of financial resources.

Eqbal *et al.* (2013) conducted a study on constraints faced by tribal dairy farmers in Lohargada district of Jharkhand. The Study was carried out in four villages from two blocks of Lohardaga district by personally interviewing 120 tribal respondents and founded that the

most of the respondents were facing the constraint as lack of credit facilities for purchase of feeds, fodders and mineral mixture (X=3.35), non-availability of diagnostic facilities (X=3.18), lack of artificial insemination facility (X=3.17), poor conception rate (X=3.09), non-availability of doctors (X=3.00), non-availability of essential medicines (X=2.90) and high cost of treatment (X=2.66) in dairy farming practices. Thus, it can be stated that tribal dairy farming practices were hampered by limits in all key areas of dairying, namely breeding, feeding, management and health care.

Ghimire *et al.* (2013) conducted a study on the perception and responses to climate change among farmers in Nepal's Gulmi district and founded that temperature increase was occurring more slowly throughout the district. Farmers have adapted their farming practices by altering crop types, cropping schedules, patterns, planting techniques, the application of pesticides and chemical fertilizers, and the use of resource-saving technologies like zero tillage. Both upland and lowland areas are used by farmers for surface planting. The findings demonstrated that the farmers can adjust to some extent and are aware of how climate change will impact agriculture. The endeavor involves both local and national government levels.

Rao TKS *et al.* (2013) in their study on the constraints limiting the livestock productivity of tribal community in high rain coastal region of India founded that the biggest obstacles were unprofitable price for milk (38.2%), lack of personal funds (31.18%), high feed costs (27.71%) and the prevalence of repeat breeding (21.90%) .

Rani *et al.* (2013) worked out the constraints perceived by dairy farmers in adoption and repayment of dairy loans. It was discovered that the attitude of the loan officer, too many intermediaries, a drawn-out, complex loan application process, an inadequate loan amount and borrower illiteracy were the main issues. Since most dairy farmers lack literacy, they find it difficult to comprehend the bank loan application process. The lack of high-quality breed animals, the high cost of feed and fodder and the high price of animals were also mentioned as limitations.

Moreiki JC and Tsopito CM (2013) conducted a study on effect on climate change production in Bostwana and its Suitable Mitigation Strategies and founded that the livestock productivity was significantly reduced by changes in rainfall patterns, frequent droughts, high rates of parasites and animal diseases (such as mastitis and FMD) and high ambient temperatures mostly due to high temperatures and inadequate feeds, there is a drop in milk production and lower animal weight increase in dairy cows.

Esiobu and Onubugo (2014) conducted a study on trends, perceptions and adaptation options of Livestock Farmers to Climate change in Imo state, Nigeria: A Multinominal Logit Model Approach and founded that the socioeconomic status of the farmers significantly affects their ability to adapt to climate change. Thus, Effective agricultural policies and projects should, concentrate on raising public understanding of climate change

Zalkuwi *et al.* (2015) conducted a study on farmer's perception of adaptation strategies to climate change and their determinants: the case of Punjab province, Pakistan. The study revealed that there is a high level of awareness of climate change in the region and that farm households adapt their crops in response to climatic change. The binary logistic model's findings showed that a farmer's decision to take adaptation measures is influenced by their level of education, farm experience, household size, land area, tenancy status, ownership of a tube well, access to market information, knowledge of weather forecasts and availability of agricultural extension services. The study's findings indicate that in order to increase farmers' wellbeing more funding should be devoted to farmer education and institutional setup for climate change adaptation.

Taqi *et al*. (2015) identified the possible impact of climate change and adaptation options on African livestock: A review. The majority of climate change's direct effects on an animal's health, happiness, and productivity (such as growth, reproduction, and milk production) and are brought on by elevated ambient temperatures and concomitant modifications to heat exchanges between the animal and its surroundings. Therefore, in response to a variety of current demands, threats, and objectives, successful adaptations may be seen as those acts that reduce vulnerability and boost resilience overall.

Kant *et al.* (2015) conducted a study on constraints perceived by the dairy farmers in adapting to changing climate in Western dry region of India. The results of the current study indicated that repeat breeding, lack of in-depth knowledge of climate impacts, high concentrate costs, absence of a government policy on climate problems, shortage of pasture and lack of meteorological information were the major constraints. The organization of a campaign to raise awareness about climatic issues, the planting of improved, drought-resistant grasses on pasture land, the provision of high-quality bulls and the offering of animal health services at a reasonable cost were the respondent's most significant recommendations for overcoming these limitations.

Nagrale *et al.* (2015) conducted a study on the constraints faced by dairy farmers in Vidarbha region of Maharashtra and concluded that the institutional constraints existed in study area where, farmers had difficulty in marketing of liquid milk and breeding had difficulty because of the low productivity of the animals. Farmers were also discovered to have a significant feeding problem because to a lack of access to green fodder.

Addisu et al. (2016) carried out a study on perception and adaptation models of climate change by the rural people of Lake Tana Sub-basin Ethopia and founded that the age, educational attainment, financial well-being, access to agricultural extension services and distance to the closest medical facility were found to be significant factors in affecting climate change adaptation according to the results of Heckman probit and multinomial logistic regression models. Farmer's opinions of climate change were found to be statistically significant in relation to variables like marital status, farm size, access to climate change information and income generational level and majority of respondents stated that further enforcement is necessary for the policies and programs of climate change adaptation to be completely implemented to the level of expectations.

Prusty and Tripathy (2016) conducted a study to analyze the economics of milk production in organized and unorganized sectors in the Cuttack district of Odisha and founded that the primary challenges faced by farmers in the dairy industry included a lack of medical facilities, inadequate inputs (such as feed, fodder, manpower, etc.), input services at a higher cost and insufficient government and NGO subsidies. Thus, state government should build private dairy farms, especially in the unorganized sector, to support the lucrative dairy industry.

Thoai *et al.* (2017) studied the Determinants of farmer's adaptation to climate change in agricultural production in the central region of Vietnam. This research utilized binary logit and multivariate probit models to investigate the factors influencing farmers' decisions regarding climate change adaptation in their agricultural production, with a focus on TiO2-N' as a measure. The study found that training attendance, farm size, damage level, educational level, farming experience, access to credit, and gender significantly influenced the likelihood of farmers adapting to climate change. Among these factors, attendance in climate change training and farm size emerged as the most critical determinants impacting farmers' decisions on climate change adaptation, while labor availability and membership in local organizations showed no significant influence.

Fadina and Barjolle (2018) carried out a study on Farmer's Adaptation Strategies to Climate Change and their implications in the Zou Department of South Benin and the findings indicated that farmers had a sophisticated understanding of climate change. According to the study, Benin farmers employ a wide range of climate change adaptation tactics: the use of better varieties, chemical fertilizers and pesticides, Agroforestry and perennial plantation, Use of good practices (mulching, organic fertilizer), Diversification of income-generating activities and Crop-Livestock Diversification were used as climate change adaptation options. Further, it was founded from the binary logit model that farming experience and educational level of household head have a beneficial impact on adaption choices.

Sreema V *et al.* (2018) conducted a study on Constraints perceived by dairy farmers of Kerala State and results revealed that higher cattle feed prices, non-remunerative milk prices, excessive loan costs, a lack of essential staff for cattle health care, a lack of dry and green fodder and other significant restrictions were reported by the majority of respondents.

Pilaniya *et al.* (2019) conducted a study on Constraints in dairy husbandry being perceived by the dairy farmers in Sabarkantha district of Gujarat. According to RBQ, the constraints perceived by dairy farmers for providing good sheds for animals were higher interest rate on borrowed capital (28.66%) and lack of adequate space (24.66%), whereas the constraints for feeding practices were high cost of feed (30.66%), lack of knowledge of balancing ration (24.66%), lack of awareness about treatment of poor-quality straw to improve its nutritive value (16.66%). Thus, it was advised that the government and allied entities make simultaneous and cumulative efforts to address these obstacles.

Adhikari *et al.* (2020) conducted a study on Constraints faced by dairy farmers in Hill region of Uttarakhand and founded that the inaccessibility of green fodder throughout the year, low animal productivity and unprofitable milk pricing were the top three challenges faced by dairy farmers and other problems included the high cost of concentrate mixture, the lack of resource people, the lack of knowledge about government programms, the lack of concentrate mixture, improper animal waste disposal, the occurrence of animal diseases, the lack of drinking water and the low success rate of artificial insemination.

Marie *et al.* (2020) carried out a study on Farmer's choices and factors affecting adoption of climate change adaptation strategies: evidence from north-western Ethiopia and results indicated that the farmers' selection of climate change adaptation measures was

significantly influenced by age, gender, family size, farm income and farm size and farmer's adoption of adaptation measures to climate change is significantly influenced by characteristics related to access to climate information, total yearly farm revenue and market access. As a result, it was suggested that the future adaptation-related initiatives should concentrate on strengthening market access, increasing access to knowledge about climate change and advancing research into the use of rainwater harvesting technologies.

Marthe montocho *et al*. (2021) conducted a study on Perception and Adaptation Strategies of Dairy Farmers towards Climate Variability and Change in West Africa and noticed that a decline in the rainy season and yearly rainfall but an increase in the dry season and annual temperature had an impact on their operations. In the climate zones of Benin, Burkina Faso, and Niger, dairy farmers fed their cattle primarily on natural pastures, crop residues and agro-industrial byproducts.

Lopez *et al.* (2022) conducted a study on Climate change adaptation for livestock production in southern Australia: transdisciplinary approaches for integrated solutions. The transdisciplinary method used in this study can be extended to work for research on climate change adaptation in a wide range of agricultural production systems, from smallholder farms in developing nations to intensive dairy production systems. The key to the strategy's success is bringing together farmers, consultants and academics from other fields in an iterative process that generates fresh, practical information for coping with climate change.

Ranasinghe *et al.* (2023) conducted a study on Climate Change adaptation and adaptive capacities of dairy farmers: Evidence from Village tank cascade systems in Sri Lanka and results showed that a majority of dairy farmers reported perceived. Climate change effects such as pasture lack, milk productivity loss and animal growth retardation and adaption measures used by dairy farmers are geared at mitigating the impacts of Climate change on animal physiology. Fewer farmers are implementing adaptive measures to alleviate pasture shortages. The extent of adaptation is determined by the farmer's perception of CC, socioeconomic traits, and resource endowment, while the AC moderates the relationship between perception and response to CC. The institutional and social setting in which dairy producers operate distinguishes their AC. Women and poorer farmers typically have lesser AC. Access to resources explains the disparity in AC between various social groupings. The paper suggests strategies to bridge socioeconomic disparities in AC, emphasizing the necessity of enhancing and expanding extension services and rural finance facilities.

Chapter-3

MATERIALS AND METHODS

This chapter explains sampling design, data collection and methods applied to meet out the objectives of the study. The use of appropriate techniques determines accuracy of results and their applicability. Various tools and techniques applied in the analysis have been selected based on study domain, data type and objectives. The assumptions of the technique and properties of estimates have been kept in view while selecting the method.

The detailed methodology used during the course of this study is described under the following sub-heads:

3.1 Sampling procedure

3.2 Data collection

3.3 Analytical framework

3.1 Sampling procedure

The multistage random sampling technique was used for the selection of the ultimate respondents and a representative sample of 120 dairy farmers was selected for the detailed study.

3.1.1 Selection of study area

District Mandi of Himachal Pradesh was randomly selected for the present study and is purposively chosen as it is second largest milk producer in the state. The district has the milk plants of the state located at Chakkar about 9 Kms from Mandi. The district is home to two cattle breeding farms at Kamand and Karsog, dedicated to supplying improved breed animals, along with two feed and fodder development centres operating at Kamand and Sinog. The district is thus, endowed with basic infrastructure for milk production and marketing. Therefore, Mandi district was selected for comprehensive study of economic impact of climate change in the livelihood status of dairy farm households in the area.

3.1.2 Selection of the sample

For the selection of ultimate respondents, a multistage random sampling technique was used. In the first stage, out of eleven blocks, 4 blocks from district Mandi namely; Balh, Sundernagar, Gohar and Dhanotu were selected randomly with regards to higher milk production.

In the second stage, 3 gram-panchayats were selected randomly from each selected block. Thereafter, in the third stage, 10 dairy farmers were drawn randomly from each selected panchyat thus making a total sample of 120 dairy farmers.

3.2 Nature and sources of data

For the study, both primary and secondary data were collected. The primary data were collected from the sample households by conventional survey method using a well-structured schedule through personal interviews.

3.2.1 Primary data

The primary data on demographic features such as family size, age, education and occupation, Socio- economic parameters (land inventory, farm building, livestock, cropping pattern and cost of milk production) and perceptions of dairy farmers regarding adaptation to climate change and various constraints faced by the dairy farmers were collected from the selected households in the study area for the year 2022-23.

3.2.2 Secondary data

Secondary data about the total geographical area of the district, agro-climatic features, infrastructural facilities for dairying and animal husbandry, milk supply/dairying societies, etc. were collected from various sources viz., State Animal Husbandry Department and monthly information on climatic variables maximum temperature, minimum temperature and annual rainfall from Indian Metrological Department, Shimla for duration of forty years wef 1981 to 2021. Thereafter, data collected were scrutinized, coded and tabulated on the excel sheets for further analysis.

3.3 Analytical Framework

To achieve the objectives of the study, the data collected from 120 dairy households were scrutinized, tabulated and analyzed by employing various analytical tools. These tools have been discussed objective wise in the following section:

3.3.1 Standard Animal Units (SAUs):

Considering the differences in regional endowments of animal wealth and species, the dairy animals have been converted into SAUs using factors suggested by Sirohi *et al.* (2019) for the Northern region. This study apart from labour utilization, the bodyweight of the animal was also taken into consideration for the estimation of the SAUs. Based on expert opinion, 60 per cent weight was given to labour utilization and 40 per cent to body weights of animals for the final estimation. As the study area falls in the hilly region so Standard Animal Units for this region was used as given below in table 3.1

Table 3.1: Standard animal units for Hill regions of India

Category of animals	Local Cow	Crossbred Cow	Buffalo
Adult Male (≥3 years)	1.11	1.48	1.43
Adult Female (≥3 years)	1.00	1.71	1.70
Young stock male (<1 year)	0.29	0.41	0.35
Young stock female (<1 year)	0.63	0.72	0.63
Young stock male (>1 year)	0.55	0.71	0.73
Young stock male (>1 year)	0.82	1.08	0.94
Heifer	0.98	1.24	1.09

Source: Sirohi *et al.,2019*

For the data analysis dairy farms based on herd size were categorized into three different categories, namely; small (1-3 SAUs), medium (4-6 SAUs) and large (>6 SAUs) using the random method of distribution. The broad categories of the dairy farmers were discussed in table 3.2.

Table 3.2: Distribution of sampled household according to the herd size

Herd-Size Categories	Number of dairy farmers	Percentage
Small (1-3 SAUs)	57	47.51
Medium (4-6 SAUs)	46	38.33
Large (>6 SAUs)	17	14.16
Total	120	100

3.3.2 Tabular analysis

The primary data collected on survey schedules were tabulated to examine the socio-economic status of sampled households. This technique was adopted to compile the general characteristics of sampled households viz., family structure, educational status, occupational status, land use pattern, cost structure, livestock production, income and expenditure pattern etc. Simple statistical tools like averages and percentages were used to compare and interpret the results. The literacy rate, literacy index and dependency ratio w.r.t. total workers were calculated using the following formulae:

1. Literacy rate (%) = $\frac{\text{Total number of literate persons}}{\text{Total Population}}$ x 100
2. Literacy Index = $\frac{\sum W_i X_i}{\sum X_i}$

   Where, W_i = weights (0, 1,2,3,4 and 5) for illiterate, primary, middle, matriculate, senior secondary and graduation, respectively.

   X_i = number of persons in respective category.
3. Dependency ratio w.r.t total workers= $\frac{\text{No. of dependents in the family}}{\text{Total workers}}$ x 100
4. Cropping Intensity = $\frac{\text{Grossed Cropped area}}{\text{Net Sown area}}$ x 100

3.3.3 Estimation of Cost and Returns of Milk Production

The total cost involved in the dairy farm operations is composed of fixed cost and variable cost. These costs when compared with returns indicate the economic efficiency of milk production and the profitability of the enterprise. The budgeting technique was used to estimate these costs and returns. The different components of costs and returns, their definition and method of calculation are discussed briefly in the following section.

Fixed costs: Fixed costs do not vary with the level of output and remain unchanged over a short period of time. The various components of fixed cost are depreciation and interest on fixed capital. Capital Recovery Cost (CRC) method was used to calculate the fixed cost. The interest on fixed capital does not need to be accounted for separately in CRC approach.

Depreciation costs: It is the loss in the value of an asset due to normal wear and tears, time and technological obsolescence. The Capital Recovery Cost (CRC) method used to estimate depreciation cost is defined as the annual payment that will repay the cost of fixed input over the useful life of input and provide an economic rate of return on investment. The formula for estimation of CRC is given as:

$$R = Z \left[\frac{(1+r)^n r}{(1+r)^n - 1}\right]$$

Where,

R = Capital recovery cost

Z = Initial value of the capital asset

r = Interest rate (rate was taken at market rate i. e. 9.5 per cent)

n = Useful life of the assets

In case of practical difficulties in getting the information on the initial outlay at the field level, the current value of the asset was considered. When the asset was purchased from borrowed capital, the actual interest rate charged by the bank was taken as 'r', while in the case of owned funds; the interest on a term deposit of 1-5 years was taken. The useful life of assets was assumed to be 50 years for pucca cattle shed, 10 years for kuccha shed, 6 years for manual chaff cutter, 10 years for power-operated chaff cutter. The useful life of milch animals also varied with the type of animal and was taken as 10, 8 and 10 years for local cow, crossbred cow and buffalo, respectively. The total CRC was then apportioned to the individual animal in accordance with the Standard Animal Units (SAUs).

Variable Cost: Variable costs are those costs, which are incurred on the variable factors of production and can be altered in the short run. The major variable costs are feed and fodder cost, labour cost, veterinary expenses and miscellaneous expenditure.

Feed and Fodder Cost: This included the cost of feeding dry fodder, green fodder and concentrates to animals. In the case of purchased feed and fodder, the cost was worked out by multiplying quantity of fed to animal and purchase price of respective feed. In the case of home-grown feed and fodder, the relevant prices were the farm-harvest prices. For certain types of fodder, especially cultivated green fodder, where farm-harvest prices were not available, the imputed value of the crop was taken at the prevailing price in the village. For computation of cost for concentrate prepared at home, weighted prices of ingredients used in the concentrate were taken, the weights being the share of each ingredient in the concentrate composition.

Labour Cost: The information on total time spends for doing various operations on the farm was collected from farmers. Total time spent was converted to man-days.

1 day of women labour = 0.67 man-day (3 women = 2men)

1 day of child labour = 0.50 man-day (2 children = 1 man) by assuming 8 working hours a day.

The cost of grazing of animals was also included in labour cost.

Veterinary and Miscellaneous Costs: The expenditure on breeding and health care of the animals were covered under the veterinary expense. It included, cost of artificial insemination (AI), natural service, vaccination, medicines, fee of veterinary doctor and other related expenses. The miscellaneous expenditure included expenses on repair of fixed assets, water and electricity charges, insurance premium and any other incidental charges. These being joint costs, therefore further divided based on SAUs.

Other Cost Concepts:

Gross cost: It was obtained by adding all the cost components including fixed and variable costs.

Gross cost = Total variable cost + Total fixed cost

Net cost: The net cost was worked out by deducting the imputed income earned through dung, from the gross cost.

Net cost = Gross cost − Value of dung

Cost of Milk Production: All the costs were calculated for per animal per day which indicates the cost of maintaining an animal per day. When the cost of maintaining animal was divided by milk productivity, it gives cost of milk production in terms of cost per litre of milk.

Gross returns: Gross returns were obtained by multiplying the milk yield of an individual milch animal with respective prevailing prices.

Gross returns = Quantity of milk × Market price of milk

Net returns: Net returns were calculated by subtracting net cost from gross returns

Net returns = Gross returns -Net cost

3.3.4 Impact of Climate Change on Net revenue from Dairy

Studies of the impact of climate change on agriculture and animal husbandry employ the Ricardian analysis (Mendelsohn *et al*. 1994). The Ricardian approach is based on the observation by David Ricardo that land rents reflect the net productivity of farmland and it examines the impact of climate and other variables on land values and farm revenues. The approach is a cross-sectional model that takes into account how variations in climate change affect net revenue or land value. The model has also been utilized to study the response of livestock values to climate change. Following Seo and Mendelsohn (2008), we start by assuming that the farmer maximizes net income by choosing which livestock to purchase and which inputs to apply:

$$\text{Max } \pi = P_{qi}Q_j(L_G, F, L, K, C, W, S) - P_F F - P_L L - P_K K \quad \text{(3.3.4.1)}$$

Where: π is net income

P_{qj} is market price of animal j

Q_j is a production function for animal j

L_G is grazing land

F is feed

L is vector of labour inputs

K is vector of capital inputs

C is vector of climate variables

W is available water

S is a vector of soil characteristics

P_F is a vector of prices for each type of labour

P_K is the rental price of capital

The farmer chooses the species j and the number of animals that maximizes profit. The resulting net income can be defined as:

$\pi^* = f(P_q, C, W, S, P_F, P_{L,} P_k)$ _____(3.3.4.2)

The Ricardian function is derived from the profit maximizing level of equation and explains how profits change across all the exogenous variables facing a farmer. The change in welfare (ΔU) resulting from Climate Change C_0 to C_1 can be measured as follows:

$\Delta U = \pi^*(C_1) - \pi^*(C_0)$_____(3.3.4.3)

The Ricardian model treats a farmer as though he is an income generating entity. Seo and Mendelsohn (2006) have shown that although this assumption fits large farms, it can be applied to small farms by addressing issues of valuation of household labour and own consumption.

This Ricardian approach has been found attractive because it corrects the bias in the production function approach (Rosenzweig and Iglesias 1994) by using economic data on the value of land. By directly measuring farm prices or revenues, the Ricardian approach accounts for the direct effects of climate on the yields of different crops and livestock as well as the indirect substitution of different inputs, the introduction of different activities/livestock species and other potential adaptations to different climates (Mendelsohn *et al*., 1994). It is also attractive because it includes not only the direct effect of climate on productivity but also the adaptation response by farmers to local climate. He have however shown that the Ricardian model is useful for predicting the impact of climate change because the way farmers respond to alternative climate scenarios over space is the same way that farmers will respond in the long run to those same changes in climate over time.

So, for estimation the final model is specified as follows:

$\pi = \alpha_0 + \alpha_1 T + \alpha_2 T^2 + \alpha_3 t + \alpha_4 t^2 + \alpha_5 R + \alpha_6 R^2 + \alpha_7 Z + \varepsilon$_____ (3.3.4.4)

Where π is net revenue, T and T^2 capture levels and quadratic terms for maximum temperature, t and t^2 for minimum temperature and R and R^2 capture levels and quadratic terms for annual rainfall, Z is a vector of socio-economic variables and ε is a random disturbance term. The quadratic terms for temperature and annual rainfall are expected to capture the nonlinear shape of the climate response function. When the quadratic term is

positive, the net revenue function is U-shaped, but when the quadratic term is negative, the function is hill shaped.

Table 3.3 presents the summary of the variables used in the study (explanatory) and their unit of measurement.

Different kinds of variables such as climatic variables, socio-economic variables, livestock variables were used in the analysis. The climatic variables include; Maximum temperature, Minimum Temperature and rainfall data as well as their quadratic terms wheras socio-economic variables included the family size, land in hectares and Livestock variable included the value of milking animal, green fodder, dry fodder, Concentrate and Labour to capture effects on net farm revenues.

Table 3.3: Summary of variables used in ricardian model

Variables	**Description**	**Unit**	**Expected Sign**
MT	Maximum Temperature	^{o}C	-
MT^2	Maximum $Temperature^2$	$^{o}C^2$	+
Mt	Minimum Temperature	^{o}C	+
Mt^2	Minimum $Temperature^2$	$^{o}C^2$	-
R	Rainfall	Cm	+
R^2	$Rainfall^2$	cm^2	-
FS	Family Size	Ordinal variable, 0=1-3, 1=4-6, 2=7-9, 3=10-12	+/-
LH	Land in Hectare	Continuous variable (number)	+/-
VM	Value of milking animal	Continuous variable (Rs.)	+/-
GF	Green fodder	Continuous variable (Rs.)	+/-
DF	Dry fodder	Continuous variable (Rs.)	+/-
CC	Concentrate	Continuous variable (Rs.)	+/-
LB	Labour	Continuous variable (Rs.)	+/-

The underlying assumption is that further increase in temperature and reductions in rainfall are less favourable for crop production and thus livestock becomes an important option under very stressful conditions. Household size was used to assess the effect of labour

availability on net farm revenue with households with large labour pools assumed to have higher net farm revenues (Mano and Nhemachena , 2007).

From the equation (3.3.4.4) we can derive the expected marginal impact of Maximum and Minimum temperature and rainfall changes on net revenues of dairy households as in equations (3.5.4.5), (3.5.4.6), (3.5.4.7) below given respectively:

$$E\left[\frac{\partial \pi}{\partial T}\right] = \alpha_1 + 2\alpha_2 E[T] \quad (3.3.4.5)$$

$$E\left[\frac{\partial \pi}{\partial t}\right] = \alpha_3 + 2\alpha_4 E[t] \quad (3.3.4.6)$$

$$E\left[\frac{\partial \pi}{\partial P}\right] = \alpha_5 + 2\alpha_6 E[R] \quad (3.3.4.7)$$

Hypothesis testing for Ricardian model results:

We employed a null hypothesis strategy to examine the regression overall significance. In order to construct a null hypothesis for this analysis, we assumed that:

H_0 = There is no impact of climate change variables on the net revenue of dairy households.

H_1 = Climate Change have a significant impact on net revenue of dairy households.

If the study revealed that the climatic variables have a significant impact on net revenue of dairy households then the null hypothesis will be rejected.

3.3.5 Factors affecting the adoption of risk adaptation strategies

In order to knew driving forces affecting the adoption decisions of dairy farmers for various risk adaptation strategies binary logistic model was used. Researchers have utilised this approach to assess related studies on livestock farmers' decisions regarding the effects of climate change (Seo *et al*., 2005). According to Gujrati and Porter (2003), a binary logistic model specification is employed to model climate change adaptation strategies of farmers involving dummy dependent variables with binary choices. The dependent dummy variable in the data is adaptation. In order to create the dummy, a value of 1 was given to farmers who said they had taken adaptation measures in response to the negative effects of climate change, and a value of 0 was given to farmers who said they had taken no adaptation measures at all. For instance, a farmer is said to have "adapted" if they employ at least one coping mechanism to mitigate the negative effects of climate change.

In BLR, a single outcome variable Y_i (i=1, ..., n) follows a Bernoulli probability function that takes on the value 1 with probability P_i and 0 with probability 1-P_i. P_i/1-P_i and is referred to as the odds of an event occurring. P_i varies over the observations as an inverse logistic function of a vector X_i, which includes a constant and K explanatory variables (Greene, 2003). The Bernoulli probability function can be expressed as:

$$\ln\left[\frac{P_i(Y_i=1)}{1-P_i(Y_i=1)}\right] = \ln(\text{odds}) = \alpha_0 + \sum_{k=1}^{k} \beta_k X_{ik} \quad \text{(3.3.5.1)}$$

Equation 3.3.5.1 above is referred to as the log odds and also the logit and by taking the antilog of both sides; the model can also be expressed in odds rather than log odds, that is:

$$\text{Odds ratio} = \left[\frac{P_i(Y_i=1)}{1-P_i(Y_i=1)}\right] = \exp\left[\alpha_0 + \sum_{k=1}^{k} \beta_k X_{ik}\right] \quad \text{(3.3.5.2)}$$

The unknown α_0 is a scalar constant term and β' is a K x 1 vector with elements corresponding to the explanatory variables. In this study, the parameters of the model were estimated by maximum likelihood. That is, the coefficients that make the observed results most likely were selected. The likelihood function formed by can be written as:

$$L(\alpha, \beta) = \prod_{i=1}^{n} P_{xi}^{Yi}(1 - P_{xi})^{1-Y_i} \quad \text{(3.3.5.3)}$$

To random sample (x_i, y_i), i=1, 2..., n, by taking logs and using equation (3), the log-likelihood simplified to:

$$\text{Ln}[L(\alpha_0, \beta)] = \sum_{i=1}^{n}\{y(\alpha + \beta x) - \ln(1 + \exp(\alpha + \beta x) \quad \text{(3.3.5.4)}$$

The estimator of unknown parameter α and β can be gained from the following equations by means of maximum- likelihood estimation.

$$\frac{\delta \ln[L(\alpha_0,\beta)]}{\delta \alpha_0} = \sum_{i=1}^{n} | y_i - \frac{\exp(\alpha+\beta x)}{1+\exp(\alpha+\beta x)} = 0 \quad \text{(3.3.5.5)}$$

$$\frac{\delta \ln[L(\alpha_0\beta)]}{\delta \beta_0} = \sum_{i=1}^{n} | y_i - \frac{\exp(\alpha+\beta x)}{1+\exp(\alpha+\beta x)} = 0 \quad \text{(3.3.5.6)}$$

Since equations (3.3.5.5) and (3.3.5.6) are non-linear, the maximum likelihood estimators must be obtained by an iterative process, such as the Newto-Raphson or Davidson-Flecher-Powell or Berndt-Hall-Hall Hausman algorithm (Greene, 2003).

A statistical model based on likelihood ratio (LR) was deemed appropriate. This ratio was defined as follows:

$$LR = 2(\text{Log}L_R - \text{Log}L_u)$$

Where $\text{Log}L_u$ was defined as the log-likelihood for the unrestricted model and $\text{Log}L_R$ was the log-likelihood for the model with k parametric restrictions imposed. The likelihood ratio statistic follows a chi-square (χ^2) distribution with k degrees of freedom.

Table 3.4 presents the descriptive statistics and an explanation of the variables used in the study (both dependent and independent) and units of measurement.

The model used three dummy variables as its dependent variables: Crop Livestock diversification, Use of well acclimatized breeds, Regular feed change/supply equivalent to one if the household choose to adapt, else zero. The explanatory factors in the model are based on a survey of adoption literature studies and our interpretation of theoretical work; nonetheless, given the dearth of simple theoretical predictions, this analysis is still relatively exploratory. The study's independent variables are a few of the many elements that influence how adaptation options are used at the farm level.

Table 3.4: Description, Definition and values of variables used in the binary logistic regression

Variable	**Definition**	**Value and Unit of Measurement**
Dependendent variables		
Adaptation Strategy	Adaptation Strategies considered in this study included Crop Livestock diversification, Use of well acclimatized breeds, Regular feed change/supply	Dummy, 0= not using the adaptation strategy, 1= using the adaptation strategy
Variable	**Definition**	**Value and Unit of Measurement**
Independendent variables		
Gender	Gender of the Household Head	Dummyvariable,0=male,1=female
Household Size	Number of family members	Categorical, 0=1-3, 1=4-6, 2=7-9, 3=10-12
Farming Experience	Number of years of farming by household	Continuous variable(years)
Farm Income	Average monthly income	Continuous variable (Rs.)
Access to Market	Access to market services	Dummy variable,1=access to market and 0=otherwise
Credit services	Access to credit services	Dummy variable,1=access to credit and 0=otherwise
Extension services	Access to extension services	Dummy variable,1=access to extension and 0=otherwise

Despite the possibility of numerous other factors influencing farmers' usage of adaptation options, this study found that the six independent variables indicated in Table 3.4 were most useful in describing how farming households used various adaptation options. These include the Family Size, Farming Experience, Farm Income and Access to Market, Credit services and Extension services.

Hypothesis Testing for Model Significance

We employed a null hypothesis strategy to examine the models' overall significance. In order to construct a null hypothesis for this analysis, we assumed and set all the logistic model regression coefficients to zero, as opposed to the alternative that at least one of the regression coefficients (k) is not zero (Peng e*t al.*, 2002):

H_0: β_k is equal to 0,

H_1: at least one β_k is not equal to 0.

On the basis of test statistics, we can reject the null hypothesis (H_0) and accept the other alternative hypothesis (H_1) if at least one of the regression coefficients (β_k) is not zero.

3.3.7. Constraints analysis

To meet the final objective of identifying the various constraints experienced by the farmers in existing dairy farming in the study area, Garrett's ranking method was used. The prime advantage of this technique over simple frequency distribution is that the constraints are arranged based on their severity from the point of view of farmers (Zalkuwi *et al*., 2015). As per this method, the farmers were asked to assign the rank for each category of the constraints proposed to them. The per cent position for each rank was calculated with the help of the following formula:

Per cent Position = $\frac{100(R_{ij}-0.5)}{N_j}$

Where,

R_{ij} = Rank given for the i^{th} factor by the j^{th} respondent.

N_j = Numbers of problems ranked by j^{th} respondent.

The per cent position was converted into scores by referring to the table (Garrett ranking conversion table) given by Garrett and Woodworth (1969). Then, the scores of the individual respondents were added together and divided by the total number of respondents for whom scores were added. These mean scores for all the factors were arranged in descending order and the most influencing factors were identified through the ranks assigned as the factors having the highest mean value score was considered to be the most severe problem faced by the farmers in the study area. Further, in order to test the significant difference for the problem among selected farm categories, the Chi-Square test was used. The details of the Chi-Square (χ^2) test are given below:

$\chi^2 = \sum_{i=1}^{N}(\frac{(O_i - E_i)}{E_i}) \sim \chi^2 (N-1)$

Where,

O = Observed Value

E = Expected Value

N = Farm Categories

Limitation of the study

Although great care was taken to meet the objectives of the study yet, the present study might have confronted following limitations:

Dairy farmers don't maintain record of various costs that incurs in the milk production on daily basis. Therefore, the data collected on inputs and outputs are entirely based on memory recall of the farmers and hence, reliability of the information might have suffered to an extent.

Due to the time and resource constraints, the study was restricted to only to Mandi district of Himachal Pradesh with limited sample size of 120 dairy farmers hence, the study results cannot be generalized to the state as a whole, though the analysis gives a vivid picture of the study area or similar situations.

Chapter-4

RESULTS AND DISCUSSION

This chapter deals with the results and interpretations of the topic "**Economic Impact of Climate Change on Livelihood Status of Dairy Farmers in Mandi District of Himachal Pradesh**" which will help in getting the insight about the dairy farmers in the study area. The study is divided into following sub heads:

4.1 Socio-economic status of dairy farmers

4.2 Economics of milk production

4.3 Impact of Climate Change on the dairy farm households

4.4 Factors affecting the adoption of risk adaptation strategies

4.5 Constraints faced by dairy farmers

4.1 Socio-economic status of dairy farmers

The results of the socio-economic profile of the farmers helps in gaining the idea about the family size and structure, their educational status, non-farm workers, dependency ratio, land utilization pattern, farm investments and livestock size in the sampled households.

4.1.1 Family size and structure

The family plays a central role in all farm activities, making it crucial and relevant to examine the family's composition and organization. Table 4.1 provides a breakdown of the family size and structure of the sampled households. On an average, the family size was 5.13 persons. The family size varied across categories, with the large category having an average family size of 4.86, while the medium category with 5.42 persons. Regarding the gender distribution, the study revealed that males were 54.45 per cent, and females were 45.55 per cent of the sampled households and the percentage of males was highest in the large category (54.87%), followed by the medium category (54.80%), and the small category (53.68%). Whereas, the percentage of females was highest in the small category (46.32%), followed by the medium category (45.20%), and the large category (45.15%).

The sampled households comprised 29.01 per cent joint families and 70.99 per cent nuclear families. Among the different herd size categories, joint families were more portion in the medium farms (41.30%), whereas nuclear families were more common in the

large farms (82.35%). The similar findings were reported by Bohra *et al.* (2004) in West Bengal.

Table 4.1: Demographic status of sampled households

Particulars	Herd size category			
	Small	Medium	Large	Overall
Average size of family (No.)	5.10	5.42	4.86	5.13
Males (%)	53.68	54.80	54.87	54.45
Female (%)	46.32	45.20	45.13	45.55
Structure of the family				
Joint family (%)	28.07	41.30	17.65	29.01
Nuclear family (%)	71.93	58.70	82.35	70.99

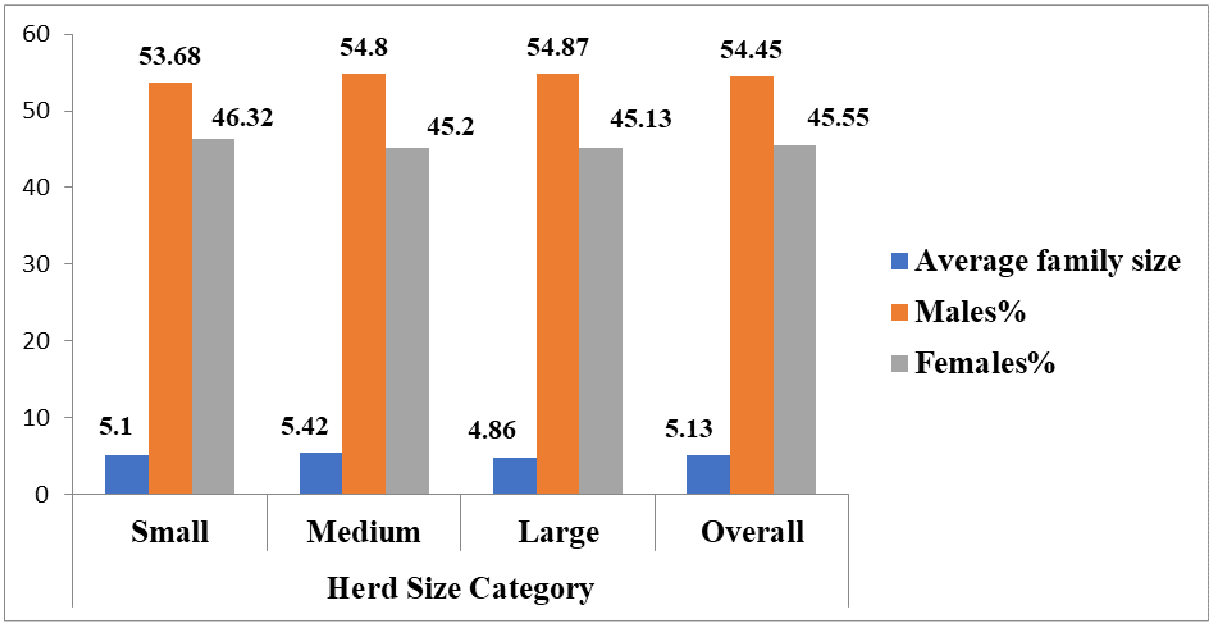

Figure 4.1: Family Size of sampled households

4.1.2 Workforce

The working force is defined as the people between the age of 15 and 60 who are actually engaged in meaningful activities. The presence of active members in dairy households effects its economy. As shown in Table 4.2, the overall there were 5.13 persons in family out of which 71.19 per cent were workers and 28.81 per cent were dependents. The highest share of workers in the households were found in medium category with 3.79 persons and the highest share of dependents were also found in medium category i.e., 1.63 persons. At overall, the percentage of dependents was 28.81 per cent, resulting in a dependency ratio of

0.41. This indicated that, on an average, one worker was needed to support less than one family member in all farm size categories.

Table 4.2 Distribution of workers and dependents of the sampled households

Particulars	Herd size category			
	Small	**Medium**	**Large**	**Overall**
Average No. of workers	3.58 (70.20)	3.79 (69.93)	3.57 (73.46)	3.65 (71.19)
Average No. of dependents (<15yrs&>60yrs)	1.52 (29.80)	1.63 (30.07)	1.29 (26.54)	1.48 (28.81)
Average family Size (Number)	5.10 (100)	5.42 (100)	4.86 (100)	5.13 (100)
Dependency ratio w.r.t total workers	0.42	0.43	0.36	0.41

Figures in the parenthesis represent the percentage to the total.

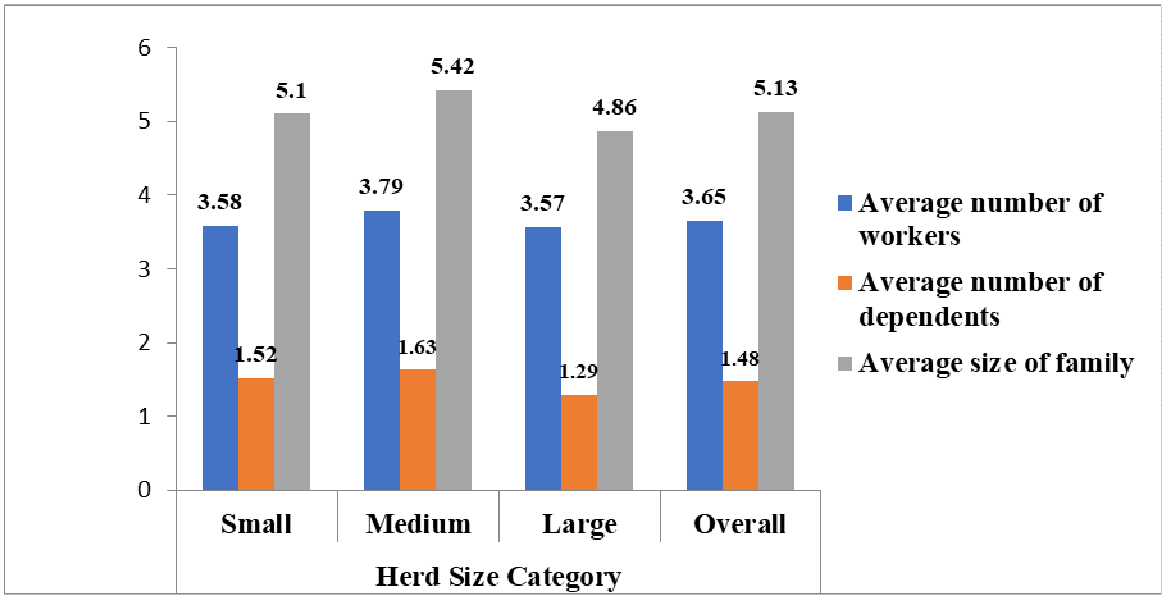

Figure 4.2: Distribution of workers and dependents of sampled households

4.1.3 Occupational structure

The occupational structure provides valuable insights into the economic profile of the farmers and their families, highlighting their involvement in various activities such as services, business, and agriculture including dairying.

Based on the sampled households, the occupational structure is shown in Table 4.3 which revealed that at overall 73.05 per cent of households were engaged in agriculture and

dairy, followed by 13.15 per cent were involved in services and 13.80 per cent in business. Moreover, the study founded that the large sized farmers were engaged in the dairy sector, with 74.18 per cent, followed by 72.83 per cent for medium farmers, and 72.13 per cent for small farmers. This indicates the significance of dairy-related activities in the livelihoods of farmers across various farm. Similar finding was reported by Bhowmik and Sirohi (2008) in South Tripura.

Table 4.3 Occupational status of sampled households in the study area

(Percent)

Particulars	Herd size category			
	Small	Medium	Large	Overall
Agriculture+Dairy	72.13	72.83	74.18	73.05
Business	12.45	14.45	14.50	13.80
Services	15.42	12.72	11.32	13.15
Total	100.00	100.00	100.00	100.00

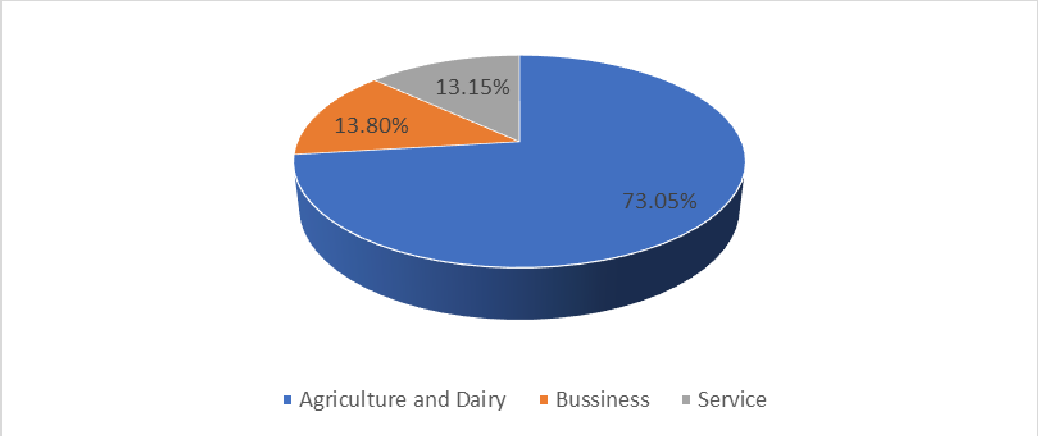

Figure 4.3: Occupational distribution of sampled households

4.1.4 Literacy Status

Literacy serves as a crucial indicator of the socio-economic status of farmers, providing insights into the educational levels of households and family members. The educational status of the sampled dairy households is presented in Table 4.4.

The study showed that at overall level, 23.45 per cent of the persons have acquired education households had studied up to high secondary level, followed by 20.24 per cent up to the matriculate level, 16.02 per cent up to the middle level, 16.45 per cent up to the primary level, and 14.30 per cent up to the graduation level. Moreover, 9.54 per cent of households were found to be illiterate. The overall literacy rate in the study area was found to be 89.21 per cent. The overall literacy index, with a value of 2.73, indicated that the quality of

education in the study area was relatively low. Thus, literacy remains a significant aspect influencing the socio-economic landscape of farmers and their families in the region.

Table 4.4 Literacy status of the family members of sampled households (Percent)

Particulars	Herd size category			
	Small	Medium	Large	Overall
Illiterate	11.02	10.04	7.58	9.54
Primary	18.14	16.06	15.15	16.45
Middle	15.12	19.08	13.85	16.02
Matriculate	20.30	20.08	20.35	20.24
Higher Secondary	23.33	21.69	25.32	23.45
Graduation	12.09	13.05	17.75	14.30
Literacy Rate	88.88	89.71	89.03	89.21
Literacy Index	2.61	2.66	2.93	2.73

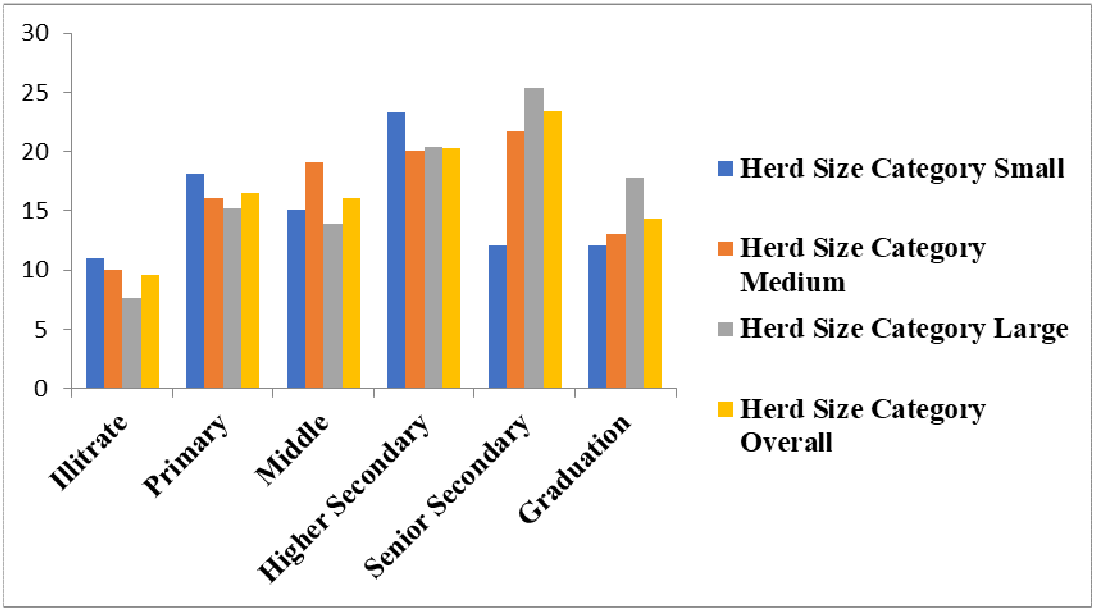

Fig 4.4: Literacy status of the family members of sampled households

4.1.5 Investment on dairy implements

Dairy investments serve as an indicator of the economic status of farmers, reflecting their financial commitments to enhance agricultural activities. The analysis of farmers investments in farm implements used in dairy business were presented in Table 4.5, where the implements were categorized into major and minor category.

Major farm implements were used in dairy viz: chaff cutter manual and chaff cutter power whereas minor implements are bucket, milk can, animal rope and basket. The findings revealed that, on an average, 85.40 per cent of the total investment was allocated to major farm implements, while 14.60 per cent was invested in minor implements by households in the study area. The study indicated a positive relationship between the size of the farm and the investment made by farmers, suggesting that larger farms tend to invest more in farm implements. These results provide valuable perception into the economic behavior and priorities of farmers in the study region.

Table 4.5 Average investment on the farm implements in the sampled households

(Rs. /herd size category)

Particulars	Small	Medium	Large	Overall
Major implements				
Chaff cutter manual	907.10 (12.3)	1166.70 (12.1)	1506.00 (13.6)	1036.90 (12.65)
Chaff cutter power	5040.50 (68.1)	6751.70 (70.0)	8882.00 (80.1)	6891.40 (72.75)
Sub total	5947.60 (80.4)	7918.4 (82.1)	10388.0 (93.7)	8084.67 (85.40)
Minor implements				
Bucket	220.50 (3.0)	290.90 (3.0)	350.20 (3.2)	287.20 (3.05)
Milk can	556.50 (7.5)	600.30 (6.2)	656.20 (5.9)	604.33 (6.55)
Animal rope	120.50 (1.6)	150.20 (1.6)	190.00 (1.7)	153.57 (6.55)
Basket	556.20 (7.5)	683.60 (7.1)	745.90 (6.7)	661.90 (7.11)
Sub total	1453.70 (19.6)	1725.00 (17.9)	695.60 (6.3)	2791.11 (14.60)
Total	7401.30 (100.00)	9643.40 (100.00)	11083.60 (100.00)	9376.10 (100.00)

Figures in the parenthesis represent the percentage to the total

4.1.6 Land utilization pattern

Land utilization pattern of the study area helps in determining the type of farming prevailing

in the sampled households and determines the livelihood, economic and social status of the households.

Table 4.6 presents the land use distribution among the sampled households. The study showed that on an average landholding size ranged from 2.19 to 3.19 hectares among different farm categories, with an overall average of 2.66 hectares. At overall, 87.92 per cent of the total land holding was utilized for cultivation. The highest cultivated area was observed in small farms (89.04%), followed by middle-sized farms (88.46%) and large farms (86.26%). The total irrigated area varied from 65.63 to 79.91 per cent across different farm sizes, with an average of 72.87 per cent for all categories. Unirrigated area occupied 15.05 per cent. The highest unirrigated area was observed in large farms (20.63%), followed by medium farms (15.38%) and small farms (9.13%). Barren lands and pastures covered 2.10 per cent and 2.08 per cent of the total area, respectively. Additionally, orchard crops occupied 5.08 per cent of the land in the study area.

Table 4.6 Land use pattern of sampled households

(Per hectare)

Particulars	**Herd size category**			
	Small	**Medium**	**Large**	**Overall**
Cultivated area	1.95 (89.04)	2.30 (88.46)	2.76 (86.26)	2.34 (87.92)
Irrigated	1.75 (79.91)	1.90 (73.08)	2.10 (65.63)	1.92 (72.87)
Unirrigated	0.20 (9.13)	0.40 (15.38)	0.66 (20.63)	0.42 (15.05)
Orchard	0.09 (4.11)	0.07 (2.69)	0.28 (8.75)	0.15 (5.08)
Total Operational area	2.04 (93.15)	2.37 (91.15)	3.03 (95.10)	2.48 (93.00)
Ghasnies/Pastures	0.05 (2.29)	0.07 (2.69)	0.04 (1.25)	0.05 (2.08)
Barren Land	0.05 (2.28)	0.08 (3.08)	0.02 (0.61)	0.05 (2.10)
Fallow land	0.05 (2.28)	0.08 (3.08)	0.10 (3.13)	0.08 (2.83)
Total land holding	2.19 (100.00)	2.60 (100.00)	3.19 (100.00)	2.66 (100.00)

Figures in the parenthesis represent the percentage to the total

4.1.7 Cropping pattern

Cropping pattern refers to the allocation of land to different crops at various points in time. It reflects the timing and arrangement of crops within a specific area. Several factors influence cropping patterns, such as agro-climatic conditions, rainfall, family requirements, available

resources, irrigation facilities, and soil fertility. Changes in the percentage of land allocated to different crops in the total cultivated area indicate agricultural diversification in the study area. Understanding the proportional share of each crop in the gross cropped area among different farm sizes provides insights into the preferences for specific crops among the sampled households. The data on cropping patterns provides valuable information about the distribution of crops on different farm sizes and the degree of intensification in agricultural practices. helps to understand the diversification of crops and their relative importance in the study area.

Table 4.7 Cropping pattern of sampled households in the study area (Per hectare)

Particulars	**Herd Size Category**			
	Small	**Medium**	**Large**	**Overall**
Kharif				
Maize	0.16 (5.22)	0.29 (7.61)	0.38 (7.27)	0.27 (6.70)
Paddy	0.13 (4.24)	0.24 (6.29)	0.6 (11.49)	0.32 (7.34)
Vegetables	0.9 (29.41)	1.02 (26.77)	1.22 (23.37)	1.04 (26.51)
Fodder Crops	0.03 (0.97)	0.04 (1.04)	0.07 (1.34)	0.04 (1.12)
Pulses	0.02 (0.64)	0.03 (0.78)	0.05 (0.97)	0.03 (0.79)
Rabi				
Wheat	0.46 (14.85)	0.53 (13.91)	0.69 (13.22)	0.56 (14.02)
Barley	0.10 (3.24)	0.13 (3.43)	0.17 (3.26)	0.13 (3.30)
Mustard	0.10 (3.24)	0.16 (4.19)	0.25 (4.78)	0.17 (4.07)
Vegetables	1.08 (35.06)	1.28 (33.59)	1.42 (27.20)	1.26 (31.95)
Fodder Crops	0.01 (0.31)	0.02 (0.54)	0.09 (1.73)	0.04 (0.85)
Fruit Crops	0.09 (2.82)	0.07 (1.85)	0.28 (5.37)	0.14 (3.35)
Gross Cropped Area	3.08 (100.00)	3.81 (100.00)	5.22 (100.00)	4.03 (100.00)
Net Sown Area	2.04	2.37	3.03	2.48
Cropping Intensity	150.98	160.75	172.27	161.33

Figures in the parenthesis represent the percentage to the total.

Table 4.7 presents the cropping pattern of the sampled households. Among the average farms, with respect to kharif and rabi crop, vegetables emerged as the most significant crop,

accounting for 26.51 per cent 31.95 per cent respectively of the total cropped area. The gross cropped area for small, medium, large, and overall farms were 3.08, 3.81, 5.22, and 4.03 hectares, respectively. The net sown area in the study area was 2.48 hectares. Cropping intensity, which indicates the degree of crop intensification varied among different farm sizes, Overall, the cropping intensity in the area was 161.33 per cent with the highest intensity of 172.27 per cent observed in large farms, followed by 160.75 per cent and 150.98 per cent in medium and small households, respectively.

4.1.8 Livestock holding

Livestock holds significant potential for economic and social change, particularly for weaker sections of the rural community. In the study area, livestock played a crucial role in generating income, making it an essential component of the local economy.

Table 4.8 Number of livestock in sampled households

(Number/Farm)

Particulars	**Herd Size category**			
	Small	**Medium**	**Large**	**Overall**
Local Cow				
In Milk	0.10 (5.56)	0.20 (4.08)	0.40 (4.76)	0.23 (4.80)
Crossbred Cow				
In Milk	0.80	2.00	2.80	1.87
Dry	0.00	0.10	0.20	0.10
Total	0.80 (44.44)	2.10 (42.86)	3.00 (35.71)	1.97 (41.01)
Buffalo				
In Milk	0.40	1.40	3.40	1.73
Dry	0.10	0.10	0.20	0.13
Total	0.50 (27.78)	1.50 (30.61)	3.60 (42.86)	1.87 (33.75)
Young Stock	0.30 (16.67)	0.60 (12.25)	0.90 (10.72)	0.60 (13.21)
Heifer	0.10 (5.55)	0.50 (10.20)	0.50 (5.95)	0.37 (7.23)
Total	1.80 (100.00)	4.90 (100.00)	8.40 (100.00)	5.03 (100.00)

Figures in the parenthesis represent the percentage to the total

To better understand the livestock holdings were categorized into milch animals, including local cows, crossbred cows, and buffaloes. Additionally, the livestock were further classified

into heifer and young stock, providing a comprehensive analysis of the livestock composition in the study area. The analysis of livestock distribution among different farm sizes (Table 4.8), with crossbred cows being the dominant livestock category among sampled households. On an average the proportion of crossbreed cows was highest in the study area (41.01%). The proportion of crossbreed cows ranged from 44.44 per cent on small-sized farms to 35.71 per cent on large farms. Similarly, the share of buffaloes varied between 27.78 to 42.86 per cent across different farm categories in the study area. Where, the share of local cows was only 4.80 per cent as compared to buffaloes, which accounted for 33.75 per cent of the livestock. These findings indicate the dominance of crossbred cows in the region.

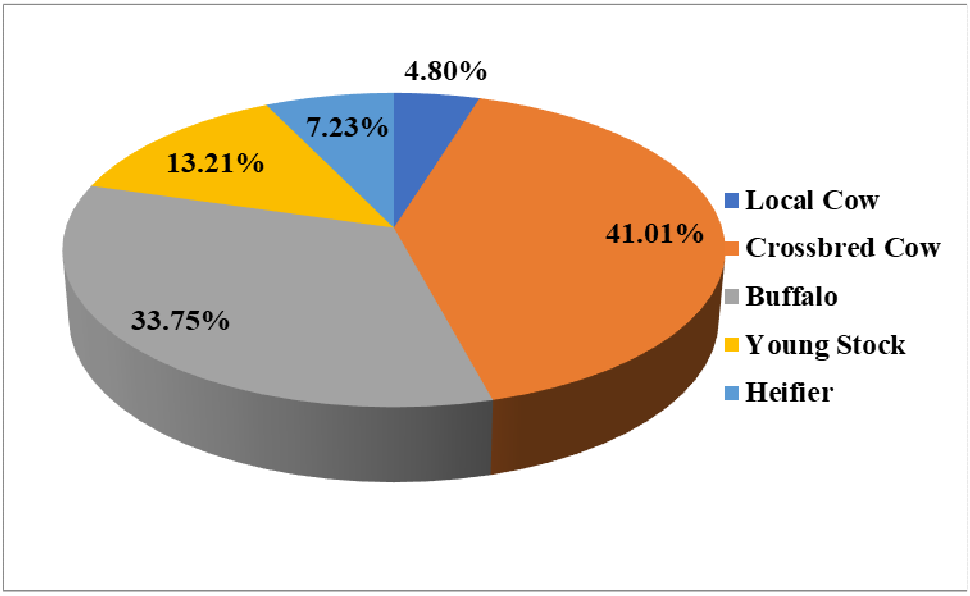

Fig 4.5: Average number of livestock in sampled households

4.2 Cost and returns from milk production

To assess the viability of any enterprise, understanding its economic profitability is importance. In this regard, data related to cost and returns plays a vital role in guiding farmers and policy makers. Cost and returns were analyzed for various milch animals based on their daily milk production. This analysis allowed for the estimation of both variable and fixed costs, which in turn helped to determine the net returns from the dairy enterprise. Variable costs took into account expenses for green fodder, dry fodder, concentrates, labor, veterinary services, and miscellaneous items. On the other hand, fixed costs encompassed depreciations on capital assets like cattle sheds, equipment used in dairy farming, and the dairy animals themselves. These considerations provided valuable insights into the economics of milk production, empowering decision-making processes for stakeholders.

4.2.1 Cost and returns from local cow

Local cows typically refer to cattle breeds that are native or well-adapted to a specific geographic region. These cows are often raised by local farmers and have characteristics that make them suitable for environmental conditions, available resources and agricultural practices of that particular area. Table 4.10 provides a detailed analysis of the cost of milk production for local cows across different categories of households. The study revealed that the variable cost accounted for the highest percentage share (92.41%), with fixed cost comprising a smaller proportion (7.57%) at the overall level. Among the households, medium-sized households had the highest total fixed cost in milk production per animal per day (7.77%), followed by large households (7.53%) and small households (7.40%).

Within the variable cost, expenditure on dry fodder constituted (28.42%) of the total, followed by concentrates (16.47%) and green fodder (26.81%) among the sampled households. Feed and fodder costs made up the highest share (63.33%) of the total variable cost, with labor costs accounting for 19.18%, and veterinary and miscellaneous costs combined comprising (12.18%).

A comparison across household categories showed that feed and fodder costs were highest in large households (72.97%), followed by medium households (70.60%) and small households (56.06%). Labor costs were found to be highest in medium-sized households (19.85%), followed by small households (18.53%) and large households (17.40%). This was due to a higher average number of individuals associated with dairy farming in the small-sized households compared to the medium and large categories. Veterinary costs and other miscellaneous costs were highest in large households (18.45%), followed by medium households (14.23%) and small households (10.14%).

The overall cost of milk production per litre was found to be Rs 33.63, varying slightly from Rs 32.50 in medium households to Rs 33.04 and Rs 34.77 in large and small households. The average milk production per animal was 3.31 litres, with large households producing 3.71 litres, medium households producing 3.42 litres, and small households producing 3.2 litres. The net returns from local cows were found to be Rs 11.54 among the sampled households, with returns per litre (Rs 3.46). The decline in the adoption of local cows was attributed to factors such as low productivity, high labor costs, lack of pure breeds, and higher feed and fodder expenses.

Table 4.9 Cost and Return of milk production from local cow in the study area

Rs/animal/day

Cost Components	Herd size Category			
	Small	**Medium**	**Large**	**Overall**
Total fixed cost (TFC)	9.35 (7.40)	9.82 (7.77)	10.47 (7.53)	9.74 (7.57)
Green Fodder (F_1)	34.33 (27.19)	33.43 (26.43)	36.42 (26.18)	33.38 (26.81)
Dry Fodder(F_2)	36.42 (28.84)	35.41 (28.00)	35.60 (25.59)	35.91 (28.42)
Concentrate(F_3)	21.20 (16.79)	20.45 (16.17)	29.50 (21.21)	20.82 (16.47)
Feed and fodder cost V1=F1+F2+F3	91.95 (56.06)	89.29 (70.60)	101.52 (72.97)	90.62 (63.33)
Labour cost(V_2)	23.40 (18.53)	25.10 (19.85)	24.20 (17.40)	24.25 (19.18)
Veterinary cost and miscellaneous (V_3)	1.58 (10.14)	2.25 (14.23)	2.92 (18.45)	1.915 (12.18)
Total variable cost $TVC=V_1+V_2+V_3$	116.93 (92.59)	116.64 (92.23)	128.64 (92.47)	116.78 (92.41)
Gross cost (A=TFC+TVC)	126.28 (100.00)	126.46 (100.00)	139.11 (100.00)	128.70 (100)
Value Of Dung (B)	15.00	15.30	15.50	15.15
Net Cost (C=A-B)	111.28	111.16	122.61	111.22
Price of milk	37.42	36.78	37.42	37.10
Average milk production(lt/animal/day)	3.2	3.42	3.71	3.31
Gross returns (D)	119.74	125.78	138.82	122.76
Net returns(D-C)	8.46	14.62	16.21	11.54
Cost of milk production (Rs/ liters)	34.77	32.50	33.04	33.63
Returns (Rs/ liters)	2.64	4.27	4.37	3.46

Figures in the parenthesis represent the percentage to the total.

4.2.2 Cost and return from crossbred cow

Crossbreed cows are the result of breeding two different breeds of cattle to create offspring that inherit characteristics from both parent breeds. Farmers often crossbreed cows to combine desirable traits from different breeds. Table 4.10 provides a detailed analysis of the cost of milk production among different categories of households for crossbred cows. The study revealed that at the overall level, the percentage share of variable cost was highest (91.86%), followed by fixed cost, which accounted for (8.14%) of the total cost. Among the households, small-sized households had the highest total fixed cost in milk production per animal per day (8.48%), followed by medium households (8.04%) and large households (7.66%). The expenditure on concentrates (31.45%) was the highest component in the variable cost, followed by dry fodder (23.15%) and green fodder (18.42%) among the households. Feed and fodder costs constituted the highest share (74.08%) of the total variable cost, followed by labor costs (15.67%) and veterinary and miscellaneous costs (2.10%). A comparison across household categories showed that feed and fodder costs were highest in large households (74.53%), followed by medium households (74.08%) and small households (73.87%). Labor costs were recorded highest in the small category (15.81%), followed by medium category (15.66%) and large category (15.40%) households, respectively.

The average number of individuals associated with dairy farming in small-sized households was more compared to medium and large households, leading to higher labor costs. Veterinary and miscellaneous costs were highest in large households (2.40%), followed by medium households (2.22%) and small households (1.84%). Among the different categories of households, the overall cost of milk production per liter was found to be Rs 26.26, with slight variations from Rs 25.95 in small households to Rs 26.52 in medium households. The average milk production per animal was 7.05 litres, with large households producing 7.62 litres, medium households producing 7.12 litres, and small households producing 6.74 litres. This observation aligns with the findings of Saha and Gupta (2000). Net returns from a single crossbred cow were found to be Rs 110.79, with the highest net returns in large households (Rs 141.11), followed by medium households (Rs 120.55) and small households (Rs 89.35). The overall net returns per litre were found to be Rs 15.63 among the households, reflecting the increasing trend in the adoption of crossbred cows due to their higher productivity and easy availability.

Table 4.10 Cost and return of milk production from crossbred cow in the study area

Rs/animal/day

Cost components	Herd size category			
	Small	**Medium**	**Large**	**Overall**
Total fixed cost (TFC)	16.06 (8.48)	16.38 (8.04)	16.63 (7.66)	16.29 (8.14)
Green Fodder (F_1)	38.1 (20.11)	35.22 (17.29)	37.23 (17.15)	36.84 (18.42)
Dry Fodder (F_2)	44.85 (23.68)	46.7 (22.93)	48.8 (22.47)	46.28 (23.15)
Concentrate (F_3)	56.98 (30.08)	65.34 (32.08)	71.72 (33.03)	62.89 (31.45)
Feed and fodder cost $V_1=F_1+F_2+F_3$	139.93 (73.87)	150.87 (74.08)	161.84 (74.53)	148.14 (74.08)
Labour cost (V_2)	29.95 (15.81)	31.9 (15.66)	33.45 (15.40)	31.34 (15.67)
Veterinary cost and miscellaneous (V_3)	3.49 (1.84)	4.52 (2.22)	5.22 (2.40)	4.20 (2.10)
Total variable cost $TVC=V_1+V_2+V_3$	173.37 (91.52)	187.29 (91.96)	200.51 (92.34)	183.68 (91.86)
Gross cost (A=TFC+TVC)	189.43 (100.00)	203.67 (100.00)	217.14 (100.00)	199.97 (100.00)
Value Of Dung (B)	14.54	14.86	15.35	14.81
Net Cost (C=A-B	174.89	188.81	201.79	185.16
Price of milk	39.2	43.45	45	41.89
Average milk production(lt/animal/day)	6.74	7.12	7.62	7.05
Gross returns (D)	264.21	309.36	342.90	295.94
Net returns(D-C)	89.35	120.55	141.11	110.79
Cost of milk production (Rs/liters)	25.95	26.52	26.48	26.26
Returns (Rs/ liters)	13.25	16.93	18.52	15.63

Figures in the parenthesis represent the percentage to the total.

4.2.3 Cost and returns from buffalo

Buffalo is characterized by their large, stocky bodies, long faces, and curved horns. Buffalo is raised for their milk, hides and other products. Table 4.11 provides a comprehensive analysis of the cost of milk production among different categories of households for buffalo. The study revealed that at the overall level, the per cent share of variable cost to the total cost was 90.81 per cent, with fixed cost accounting for 9.19 per cent of the total cost. Similar trends were observed for buffalo among different household categories. The total fixed cost was found to be highest in small-sized households (9.40%), followed by medium-sized households (9.23%), and large households (8.68%). In the variable cost, the largest share of expenditure was on concentrates (40.41%), followed by dry fodder (21.41%) and green fodder (17.29%) among the households. Feed and fodder costs accounted

for the highest share (72.20%) of the total variable cost, followed by labor cost (15.51%) and veterinary & miscellaneous costs (3.09%). A comparison across household categories showed that feed and fodder costs were highest in large households (72.80%), followed by medium households (72.30%) and small households (71.83%) in the study area. Labor costs were recorded highest in the small category (15.72%), followed by medium households (15.53%) and large households (15.07%), which can be attributed to the larger number of people involved in dairy activities in small-sized households compared to medium and large categories.

Table 4.11 Cost and return of milk production from buffalo in the study area

Rs/animal/day

Cost components	**Herd size category**			
	Small	**Medium**	**Large**	**Overall**
Total fixed cost (TFC)	18.32 (9.40)	19.25 (9.23)	19.3 (8.68)	18.86 (9.19)
Green Fodder (F_1)	32.4 (16.63)	35.25 (16.89)	43.25 (19.45)	35.48 (17.29)
Dry Fodder (F_2)	40.55 (20.81)	45.2 (21.66)	49.25 (22.15)	43.93 (21.41)
Concentrate (F_3)	74.42 (38.20)	81 (38.82)	107 (48.13)	82.92 (40.41)
Feed and fodder cost $V_1=F_1+F_2+F_3$	139.93 (71.83)	150.87 (72.30)	161.84 (72.80)	148.14 (72.20)
Labour cost (V_2)	30.62 (15.72)	32.4 (15.53)	33.5 (15.07)	31.83 (15.51)
Veterinary cost and miscellaneous (V_3)	5.95 (3.05)	6.15 (2.95)	7.67 (3.45)	6.34 (3.09)
Total variable cost TVC=$V_1+V_2+V_3$	176.50 (90.60)	189.42 (90.77)	203.01 (91.32)	186.31 (90.81)
Gross cost (A=TFC+TVC)	194.82 (100.00)	208.67 (100.00)	222.31 (100.00)	205.17 (100.00)
Value Of Dung (B)	6.52	7.12	7.32	6.90
Net Cost (C=A-B	188.30	201.55	214.99	198.27
Price of milk	52.25	54.9	58.45	54.40
Average milk production(lit/animal/day)	6.29	7.4	8.25	7.07
Gross returns (D)	328.65	406.26	482.21	386.55
Net returns(D-C)	140.35	204.71	267.22	188.28
Cost of milk production (Rs/liters)	29.94	27.24	26.06	28.19
Returns (Rs/ liters)	22.31	27.66	32.39	26.21

Figures in the parenthesis represent the percentage to the total

Among the different categories of households, the veterinary and miscellaneous costs were found to be highest in the large category (3.45%), followed by the small category (3.05%), and the medium category (2.95%). The overall cost of milk production per liter was found to be Rs 28.19, with variations from Rs 26.06 in large households to Rs 29.94 in small households. This observation aligns with the findings of Jeyakumar and Rai (2006). The overall milk production was 7.07 litres per animal. The lower productivity of buffalo milk was attributed to the prevalence of local breeds, which were common among the sampled households in the study area. Specifically, the large households had the highest milk production at 8.25 litres, followed by the medium category with 7.4 litres and the small households with 6.29 litres. The net returns per buffalo were recorded at Rs 188.28 and were highest in the large category households (Rs 267.22), followed by the medium category (Rs 204.71) and the small households (Rs 140.35). The overall net returns per litre were found to be Rs 26.21 among the sampled households. The cost and return analysis of milk production highlighted that feed and fodder constituted a major component among different costs, accounting for (72.20%) for buffalo, (74.08%) for crossbreeding, and (72.00%) for local cows, respectively, of the total variable costs. Therefore, focusing on improving feeding practices, utilizing locally available resources, and implementing effective fodder storage and procurement strategies during lean seasons can help in reducing costs and improving returns from milk production per animal.

4.4 Impact of Climate Change on Net revenue of dairy farm households

Changes in the climate can have a significant impact on the livelihoods of dairy farmers. These changes, such as reduced livestock production and less abundant grass for grazing, can lead to smaller herds and lower reproductive rates among the animals. This, in turn, can result in food insecurity, increased poverty and a higher likelihood of destitution among dairy farmers.

To understand the extent of climate's influence on dairy farming, this study employs the Ricardian method, as developed by Mendelsohn *et al.* in 1994. This method operates on the assumption of perfect competition, where the value of a farm is indicative of its land productivity. Essentially, it assesses how environmental factors impact farm revenue. In this study, we used the Ricardian approach to examine how climate change variables affect net revenue in dairy farming

4.12: Summary Statistics of variables used in Ricardian model

Variables	**Min**	**Max**	**Mean**
Maximum Temperature(^{o}C)	35.00	40.22	38.17
Minimum Temperature(^{o}C)	6.90	12.23	10.20
Annual Rainfall(mm)	56.70	71.62	62.60

Table 4.12, the mean maximum temperature recorded was 38.17^{o}C while the maximum temperature reaching 40.22^{o}C and the minimum maximum temperature measured at 35.00^{o}C. Additionally, the mean minimum temperature in the study area was 10.20^{o}C, with the maximum minimum temperature recorded at 12.23^{o}C and the minimum temperature was 6.90^{o}C. The mean annual precipitation in the study area was 62.60 cm, with the maximum annual rainfall reaching 71.62 cm and the minimum annual rainfall measuring 56.70 cm.

Ricardian results for model Significance

The Ricardian model was developed to explain the variations in agricultural values observed in different climate zones worldwide. This variation is attributed to the historical influence of temperature and precipitation changes on the per-hectare land value of croplands. Similarly, when examining livestock net revenue, it was found that this model remains valid, as demonstrated by Seo *et al*. in 2008. The most significant aspect of the Ricardian approach is its departure from using agricultural or livestock yields as the main focus of the equation. Instead, it places emphasis on revenue or land rents as the dependent variables. This unique approach enables a more direct estimation of the economic "cost" associated with environmental changes.

The table 4.13 indicate that the maximum temperature has a highly significant impact at the 1per cent level ($p<0.001$), whereas both the minimum temperature and annual rainfall have a significant positive effect at (10%) ($p<0.009$) level of significance. This suggests that the model's findings are statistically significant, and we can reject the null hypothesis. In simpler

terms, it means that climate variables have a significant impact on the net revenue of the households included in the study

Table 4.13: Results of Ricardian model

Variables	**Model Results**	
	Standard Coefficient	**Standard Error**
Maximum temperature	-247.655***	53.85
Maximum Temperature^2	2.576***	0.65
Minimum Temperature	128.657*	68.29
Minimum Temperature^2	-6.142*	3.29
Annual Rainfall	0.186*	0.10
Annual Rainfall^2	-.0001*	0.00009
Family Size	5.514*	2.42
Farm size	-1.159	6.16
Value of Milking Animal	0.0003***	0.0001
Green fodder	1.279*	0.72
Dry fodder	-0.341	0.38
Concentrate	-0.042	0.20
Labour	-0.753	0.50
R^2	0.88	
Adjusted R^2	0.87	

***Significant at 10%Level, **Significant at 5%Level, ***Significant at 1%Level**

Maximum temperatures can hinder the growth of grass, but minimum temperature and increased annual rainfall can support the growth of grass and fodder. Assuming that annual rainfall remains steady, this can motivate farmers to stock up on grass. Although the quadratic term has a negative effect, it is relatively minor and implies that excessively high minimum temperatures and annual rainfall can be harmful. Overall, these findings show that there is a nonlinear connection between net revenue and climate variables.

The socio-economic factors such as size of the family, the farm's size, the value of milking animals, and the availability of green fodder all contribute positively to the net income. This is likely because larger households tend to have more livestock, and larger farms can produce more green fodder. Moreover, the positive relationship between the value of milking animals suggests that using well-suited or acclimatized breeds enhances the income generated from cattle, thus increasing net revenue.

Marginal effects of climatic variations on net revenue

Marginal values, which are influenced by the specific regression equation employed and the climate under consideration, are commonly generated to evaluate the marginal effects of a change in climate variables. By measuring the change in mean net revenues of dairy households as a result of unit change in temperature and precipitation, the marginal effects on net revenue were evaluated.

It measures how a slight change in one variable affects the overall outcome, while keeping the other factors unaffected. It refers to change in the outcome or dependent variable resulting from a small change in one of the independent variables while holding all other variables constant.

Table 4.14: Marginal effects of climatic variations on net revenue of dairy households per day

Marginal Impacts	**Variable Models**
Maximum Temperature	-40.44***
Minimum Temperature	3.40*

***Significant at 10%Level, **Significant at 5%Level, *Significant at 1%Level**

As per table 4.14, it's clear that maximum temperature has a significant impact on the income of households, whereas minimum temperature has a slightly positive and significant impact. The data reveals that for every 1^{o}C rise in maximum temperature, the daily net revenue

decreases by Rs. 40.44, while a 1°C increase in minimum temperature leads to a Rs. 3.40 increase in daily net revenue.

4.4. Adoption of risk adaptation strategies

The combination of extreme climate change and global economic shifts poses a significant threat to the sustainability of dairy farming, which is known for its profitability. In the conditions of livestock farming, this pertains to economic strategies that ensure the well-being of both farmers and animals, provide farmers with a reasonable and stable income, and minimize adverse environmental impacts (Napel *et al.*, 2011). It has become evident that climatic changes have affected agricultural activities and ways of life in several regions. Therefore, it is important to study about the livestock management and the various factors influenced by climate change. To address the negative impact of climate change, it's essential to embrace different strategies for climate adaptation. Implementing climate-smart farming practices can assist farmers in achieving sustainability in their production, leading to increased income from their farms.

Table 4.15: Adaptation and non-adaptation strategies used by farmers

Adaptation Strategies	**Frequency**	**%**
Crop Livestock diversification	58	48.3
Use of well acclimatized breeds	23	19.2
Feed Change	18	15.0
No adaptation strategy	21	17.5
Total number of respondents	120	100

Some of the risk-reduction strategies include diversifying crops and livestock, utilizing breeds that are well-suited to the local climate, and ensuring a consistent supply of feed. The table labelled as 4.15 presents the perceptions of farmers regarding climate change and the corresponding findings. The results showed that, among dairy farmers, the adaptation strategy that was most frequently employed was crop-livestock diversification, with (48.3%)

of them using it. On the other hand, the least commonly used adaptation practice was changing or supplying feed regularly, with only (15.00%) of farmers adopting this approach. In total, approximately (82.5%) of farmers were implementing various adaptation strategies, while (17.5%) of them were not actively engaged in such strategies.

4.4.1 Logistic regression model

Logistic regression is a statistical method used when the primary focus of an investigation is to determine whether an event is present or absent, without considering its timing (i.e., time-related information is not considered). This approach is commonly applied because it is well-suited for modelling situations involving adaptation status (i.e., whether something has been adapted or not) and decision-making outcomes (e.g., "yes" or "no" decisions). When the predicted variable has more than two categories, more advanced versions of logistic regression, referred to as multinomial logistic regression, can be used. Logistic regression is versatile and can handle both continuous and categorical independent variables. However, the analysis is most powerful when the independent variables are normally distributed and exhibit a linear relationship with the dependent variable. For each individual case, logistic regression calculates the probability that a case with specific values for the independent variables belongs to a particular category within the model. It's important to note that because logistic regression relies on maximum likelihood coefficients as estimates, it generally requires a larger sample size compared to linear regression (Burns *et al*., 2008).

Binary logistic regression is used for analyzing the relationship between a binary dependent variable and one or more independent variables. Binary logit is particularly useful when you want to understand how independent variables influence the probability of the event of interest. A binary logit regression analysis aimed at investigating the impact of different socioeconomic factors on the adoption of various climate change adaptation strategies among livestock farmers. In this analysis, a binary logit regression model was utilized, where one category was normalized, typically known as the "reference" or "base category." In this specific context, the "no adaptation" group was set as the reference point for the study. The independent (explanatory) variables included household characteristics such as family size, farming experience, farming income, access to extension services, access to credit, access to market. In the analysis, no adaptation served as the baseline.

Table 4.16: Results of binary logit model

Variable	Coefficient
Family Size	.066(.673)
Farming Experience	.054***(.032)
Farm Income	.005***(.003)
Market Access	-.669(.594)
Credit Services	.790(.594)
Extension Services	.070(.545)
χ^2	12.67
df	6
P level	0.000

Figure in parenthesis represents Standard error

***Significant at 10%, **Significant at 5%Level, ***Significant at 1%Level**

When binary logistic regression was employed to assess the factors affecting a farmer's decision regarding their choice of climate change adaptation methods, it became evident that both the farmer's experience in farming and their income from the farm played significant roles in influencing their adoption of various adaptation methods. Table 4.16 showed that χ^2 statistics (12.67) is highly significant at 1per cent (P>0.001) level of probability indicating that model has good capacity for explanatory power.

Farming Experience: Farming experience exhibited a strong positive correlation with the selection of different climate change adaptation strategies. The study's results indicated that households with more farming experience showed a greater propensity to adopt all available adaptation options. These seasoned farmers have accumulated knowledge and insights over time, enabling them to employ a diverse range of farm management practices and strategies in preparation for the impacts of climate change in their region. Similar findings were reported by various researchers, including Marie *et al*. (2020), Mensah *et al.* (2012) and

Thoai *et al*. (2017), who also found that farming experience increases the likelihood of adopting various adaptation measures. This is because experienced farmers possess a deeper understanding of climate variations and livestock management practices. Additionally, their advanced agricultural skills and management abilities may make them more effective in diversifying risks across their livestock and off-farm activities compared to less experienced counterparts.

Farm Income: Farm income displayed a positive and statistically significant correlation with the likelihood of choosing all available adaptation options. This positive relationship can be attributed to the fact that farmers with higher farm incomes typically encounter lower climate-related risks, have better access to knowledge resources, and can implement climate change adaptation measures with greater ease due to reduced financial constraints. These adaptation measures often involve higher costs, as noted by Marie and Yirga (2020). This observation aligns with the findings of Mertz and Mbow (2009), also observed a positive link between farmer's income and the adoption of agricultural technologies, underscoring the importance of financial stability in undertaking such measures.

4.5 Constraints faced by dairy farm Households

The challenges that farmers face in effectively running and overseeing their dairy operations are known as constraints. Several problems within the local dairy production have hindered the sector's seamless growth.

Table 4.17: Feeding Constraints by sampled households

Particulars	Small	Medium	Large	Overall	Rank	Chi-Square Value
Scarcity of fodder	75.05	49.66	48.13	63.50	I	7.94**
Improved fodder crops	69.65	60.61	51.44	64.82	II	2.74
Balance diet	48.14	26.61	29.67	38.71	III	7.80**

***Significant at 10%, **Significant at 5%Level, ***Significant at 1%Level**

These problems were ranked based on the percentage of dairy farmers who recognized them as issues within the dairy industry. With the exception of improved fodder crops, awareness

about climate variability, dairy cooperatives and veterinary facilities, all problems at the overall level are found to be significant at the 5 per cent level, indicating that there was no difference in how each category of farmers responded to these issues. Chi-square was used to test whether there were any appreciable differences in the issues experienced by marginal, small, and medium farmers.

The constraints faced by dairy farmers were assessed and ranked in Table 4.17 using Garrett's score methodology, which helped to highlight the significant issues. In the research area, the most prominent constraint was fodder scarcity, particularly during times of scarcity, and it claimed the top position with a percentage 63.50. Farmers often had to purchase expensive fodder during shortages. Improved fodder crops ranked second, with percentages of 63.50 and limited knowledge about balanced diet with 38.71 per cent.

Table 4.18: Technological constraints faced by sampled households

Particulars	**Small**	**Medium**	**Large**	**Overall**	**Rank**	**Chi-Square Value**
Awareness about climate variability	56.35	40.65	30.22	48.42	III	8.16**
knowledge about adoption measures	65.65	48.45	36.85	56.94	II	8.35**
Awareness about technologies	61.16	56.91	34.15	57.35	I	8.32**

***Significant at 10%, **Significant at 5%Level, ***Significant at 1%Level**

Table 4.18 shows the technological constraints faced by sampled households. Lack of understanding of new agricultural technologies was rated first, affecting 57.35 per cent of households. The second most significant barrier was a lack of knowledge about adaptation strategies, affecting (56.94%) of households. This lack of knowledge may be linked to factors such as limited financial resources, limited access to media and extension services, and unfavourable geographic conditions that hinder the reach of many agricultural agencies. Climate variability awareness occupied the third position, with 48.42 per cent. A finding consistent with Talior *et al.* (2012).

Table 4.19: Facilities constraints faced by sampled households

Particulars	Small	Medium	Large	Overall	Rank	Chi-Square Value
Irrigation facilities	49.15	27.05	28.56	39.33	II	8.73**
Dairy cooperatives	49.36	34.26	29.65	42.18	IV	5.63
Credit Facilities	55.48	36.25	31.38	46.42	III	7.91**
Veterinary services	38.45	30.00	25.52	34.27	I	2.75

***Significant at 10%, **Significant at 5%Level, ***Significant at 1%Level**

Table 4.19 shows the facilities constraints faced by sampled households. Access to veterinary facilities were ranked first, impacting (34.27%) of households. Irrigation facilities and participation in dairy cooperatives held the second and forth positions among the surveyed homes, with percentages of (39.33%) and (42.18%), respectively. Credit facilities were ranked third among the sampled families, with a rate of (46.42%). Since dairy farming requires financial resources for animal maintenance, farmers often struggle to invest in high-yielding breeds or other farm machinery. However, higher milk prices could potentially offset these challenges if farmers receive competitive prices for their dairy products. Many farmers were found to still be using outdated dairy farming practices, highlighting the need for improved extension services to modernize and enhance their farming practices.

Chapter-5

SUMMARY AND CONCLUSIONS

India has the world's largest population of cattle and buffalo constituting 37.28 per cent and 21.23 per cent of the global total, respectively. The country's overall livestock population stands at a staggering 512.1 million, with a predominant presence of 190.90 million cattle, 135.17 million goats, 108.70 million buffaloes, and 65.07 million sheep (Sonavale *et al*., 2020). Furthermore, India holds the distinction of being the world's leading milk producer, contributing 22.00 per cent to global milk production (FAO, 2022). To enhance livestock productivity, the government has implemented various initiatives, leading to a substantial increase in milk production and notable advancements in the dairy sector. The per capita milk availability in India stood at 407 grams per day.

Himachal Pradesh, situated in the northern region of India within the western Himalayas, is a predominantly hilly state. These mountainous terrains cover approximately 68.65 per cent of the state's total geographical area. Himachal Pradesh features numerous valleys and is intersected by perennial rivers. In the state's economic landscape, fruits hold a significant position, contributing 36.4 per cent to the gross domestic product, followed by livestock at 28.8 percent, cereals at 23.28 per cent, and vegetables at 8.11 per cent (Rana et al., 2015). Given the state's challenges of low crop productivity, limited land holdings, and specific climatic conditions, households in Himachal Pradesh have increasingly turned to livestock as a dependable source of livelihood. Dairy farming, particularly in hilly regions, offers a promising avenue to enhance the well-being of resource-poor farmers and optimize resource utilization. Furthermore, the dairy sector has the potential to contribute significantly to income redistribution, especially in favor of marginalized sections of society. Despite these prospects, there has been a scarcity of comprehensive, recent studies in the state focusing on the intricate economic aspects of dairy farming.

According to the 2017 livestock census, Himachal Pradesh accounts for approximately 1.14 per cent of the country's cattle population and 0.39 per cent of the buffalo population. The state's livestock population stands at 4.4 million, consisting of 2.149 million cattle, 0.716 million buffaloes, 0.80 million sheep, 11.1252 million goats, and various other types of livestock. In 2010-11, the livestock sector contributed around 15.81 per cent to the State

Agricultural Gross Domestic Product (GDP), and the average state yield has increased from 1.38 to 2.54 kilograms over the past two decades. Regarding milk production, Himachal Pradesh is ranked twentieth among the different states in the country, and it boasts a per capita milk availability of 565 grams, surpassing the national average of 394 grams.

The present study is carried out to find out the major aspects of dairy farming in the study area. The objectives for the study are: -

1. To study the socio-economic status of dairy farmers
2. To examine the economics and impact of climate change on dairy production of selected dairy farms.
3. To examine the factors affecting the adoption of risk adaptation strategies and constraints faced by dairy farm households.

A study was conducted in Mandi district, which was chosen randomly as the study location. Multi-stage random sampling method was employed to select the final participants. Initially, at the first stage, four blocks namely; Balh, Sundernagar, Dhanotu, and Gohar were randomly chosen. In the second stage, three panchayats were randomly selected from each of these blocks. Finally, in the third stage, 10 dairy farmers were randomly chosen from each selected panchayat. In total, a sample of 120 dairy farmers was selected for this study. The data collected and analyzed pertained to the reference year 2022-23.

The information for our study was collected from two sources i.e, primary and secondary data. For primary data, we talked to specific people we selected and used a carefully prepared questionnaire that we had tested before. This primary data includes details about dairy households, like their backgrounds, how they use their land, what crops they grow, where they get their income, what they invest in for their homes, how many animals they have, and what they think about adapting to climate change.

The secondary data from different places to learn about things like infrastructural facilities for dairying, animal husbandry and groups that supply milk. This extra information came from places like the State Animal Husbandry Department in Himachal Pradesh. We also gathered monthly information about the weather i.e., maximum temperature, minimum temperature and rainfall from the Indian Meteorological Department in Shimla for the years 1981 to 2021, focusing on Mandi district.

5.1 Major findings

- The study's findings indicated that, there was a higher representation of males than females in all farm categories. The average family size among the sampled households was 5.13 members.
- Among the households included in the sample, there was a greater prevalence of nuclear families, accounting for 70.99 per cent, in contrast to joint families, which made up 29.01 per cent.
- Total of 71.19 per cent were workers at overall. Large-scale farmers had the largest proportion of workers at 73.46 per cent, followed by small-scale farmers with 70.20 per cent, and medium-sized farmers with 69.93 per cent, respectively.
- The dependency ratio, which stands at 0.41, indicates that, on average, one worker is required to support one family member across all farm sizes.
- At overall 73.05 per cent of households were engaged in dairy sector. The dairy sector had the highest participation among large sized farmers, with 74.18 per cent of them engaged in it. medium farmers followed closely with 72.83 per cent involvement, and small farmers had a participation rate of 72.13 per cent.
- The overall literacy rate in the area was calculated to be 89.21 per cent. It's worth noting that the overall literacy index, which was at 2.73 per cent, suggested that the quality of education in the study area was relatively low.
- The major implements used in dairy sector accounted for 85.40 per cent of the total investment, while the minor implements represented 14.60 per cent of the total investment.
- At overall, 87.92 per cent of the total land holdings were under cultivation among the sampled households. Irrigated land varied from 65.63 to 79.91 per cent across different farm sizes, with an average of 72.87 per cent at overall. Barren lands accounted for 2.10 per cent of the total land area, while pasture or ghasnies covered 2.08 per cent. Orchards constituted 5.08 per cent of the total land area in the study region. The average landholding size ranged from 2.19 to 3.19 hectares among different farm categories, with an overall average of 2.66 hectares.
- Upon analysing the cropping pattern among the sampled households, it was observed that, on the whole, vegetables were the predominant crop, occupying 31.95 per cent of the total cultivated area in the study region.

- The cropping intensity, which reflects the degree of crop intensification in the study area, showed that large farms had the highest cropping intensity at 161.33 per cent, followed by medium-sized farms at 160.75 per cent, and small households at 150.98 per cent. In general, the overall cropping intensity for the area averaged at 161.33 per cent.
- It's worth noting that in the study area, local cows accounted for a 4.80 per cent share, while crossbred cows represented a substantial 41.01 per cent, and buffaloes constituted 33.75 per cent. This analysis clearly highlights the prevalence of crossbred cows in the region.
- In the context of local cows, the highest milk yield was recorded in large households, with an average of 3.71 litres per day, followed by medium-sized households and small households, in that order. On the other hand, for buffaloes, the overall average milk yield was 7.07 litres per day. Among households, the highest milk yield was observed in large households, with an average of 8.25 litres, followed by medium-sized households and then small households. Notably, it was observed that the milk productivity of crossbred cows increased as farm size increased in the study area.
- The overall cost per litre of milk production was found to be the highest for local cows at Rs 33.63, followed by buffaloes at Rs 28.19, and crossbred cows at Rs 26.26. This suggests that among the sampled households, the highest returns were obtained from buffalo farming at 26.21, followed by crossbred cows at 15.63, and local cows at 0.98.
- Variable costs constituted the largest proportion of all costs, with local cows accounting for 92.41 per cent, crossbred cows at 91.86 per cent, and buffalo at 90.81 per cent among the sampled households.
- The cost associated with feed and fodder expenses ranged from 74.08 per cent in crossbred cows to 72.20 per cent in buffalo cows and 63.33 per cent in local cows, respectively.
- The findings from the Ricardian analysis indicate that when it comes to temperature, the maximum temperature follows a U-shaped pattern, whereas the minimum temperature and precipitation exhibit a hill-shaped pattern. This suggests that higher minimum temperatures and increased precipitation tend to encourage the growth of grass and fodder, while a rise in maximum temperatures has the opposite effect, leading to a decrease in grass growth.

- The Marginal Impact analysis reveals that for every 1°C rise in temperature, there is a reduction in daily revenue by Rs. 40.44. Conversely, for every 1°C decrease in temperature, daily revenue increases by Rs. 3.40.
- The study revealed that generally adoption strategy followed by the farmers is crop-livestock diversification (48.3%) followed by Use of well acclimatised breeds (19.20%) and Regular feed Change/ Supply (15.00%) and 17.50 per cent farmers who were not following the climate adoption strategy.
- The results from the Binary Logit model reveal that there is a meaningful relationship between the adoption of risk adaptation strategies and factors such as farming experience and farm income.
- Scarcity of fodder, lack of improved fodder crops, less awareness about climate variability, limited knowledge about adoption measures, lack of irrigation facilities, lack of irrigation facilities, lack of dairy cooperatives, limited knowledge about balanced diet, lack of credit facilities and lack of veterinary facilities were the main issues in the study area.
- Scarcity of fodder crops was most significant and lack of dairy cooperatives was the least significant problem in the study area.

Suggestions and policy implication

- The variability in climatic conditions such as temperature variations, uneven rainfall affects livestock habitat, metabolism and internal and external processes which ultimately lead to less revenue growth from livestock rearing practices. Farmers should be educated about the susceptibility of certain livestock breeds to climate change and encouraged to adopt suitable breeds, alongside supportive policies such as livestock market development, risk-sharing, insurance policies, and socio-economic improvement for livestock-dependent households.
- The livestock-dependent households necessitate the implementation of interventions aimed at augmenting their understanding of factors like climate variability, and technology awareness, simultaneously addressing issues of fodder scarcity by improving feeding habits, and rely on native fodder crops.
- Milk can spoil quickly, but farmers can make extra money by turning it into different dairy products. To learn how to do this, farmers and women can get training at nearby agricultural or horticultural universities or Krishi Vigyan Kendras.
- Encouraging cooperation between the government and private companies in the dairy industry will boost milk production in rural regions.

- The research found that the biggest cost in producing milk is the feed and fodder that animals eat. To lower these coasts, it’s recommended to grow nutritious fodder. This way, during times when food is scarce, it will help save money when producing milk in the area.
- Farmers should be encouraged to adopt suitable breeds like desi cow, gojri buffalo which is suitable for that climate conditions.

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APPENDICES

Appendix-3.1: - Name of the development block in the Mandi district of Himachal Pradesh

Sr. No.	Name of the block
1	Balh
2	Mandi Sadar
3	Sunder Nagar
4	Gopalpur
5	Dharampur
6	Drang
7	Chauntra
8	Seraj
9	Gohar
10	Karsog
11	Balichowki
12	Nihri
13	Dhanotu
14	Churag

Appendix-3.2: - List of selected Blocks and panchayats

Sr. No.	Name Of Block	Name of panchayat
1.	**Balh**	Khandla
		Sakroha
		Kadd
2.	**Sunder Nagar**	Dehar
		Chambi
		Kepahi
3.	**Gohar**	Daan
		Dari
		Basa
4.	**Dhanotu**	Dinak
		Jarol
		Jaral

Appendix-3.3: - Survey schedule for data collection

DR Y S PARMAR UNIVERSITY OF HORTICULTURE AND FORESTRY NAUNI, SOLAN-173230 (H P) DEPARTMENT OF SOCIAL SCIENCES

Sample Household Survey Schedule

Economic Impact of climate change on the livelihood status of dairy farmers in Mandi district of Himachal Pradesh

I. General Information

District	
Block	
Panchayat	
Village	
Mobile No.	

II. Demographic profile of Household

1.	**Name of the Head of the household (S/O)**			
2.	**Gender of the Head of the household**			
3.	**Age of the head of the household**			
4.	**Occupation of household**			
5.	**Religion of household**			
6.	**Social group of households**			
7.	**Type of Ration card**			
8.	**Type of family**			
9.	**Total Members in the Family (including children)**	**Male**	**Female**	**Total**
10.	**Total Adult members in the Family**			

II. Occupation and income of the household

Sr. No.	Name of the Family Member	Gender	Age	Education	Occupation	Income
1.						
2.						
3.						
4.						
5.						
6.						
7.						
8.						
9.						
10						

 # including head of the household; * mention per month or per annum

II. Land holding

Type of Land	Own land		Leased in land		Leased out land	
	Acre	Bigha	Acre	Bigha	Acre	Bigha
Cultivated land						
Non-cultivated land						
Tank Irrigation						
Canal irrigated						
Well Irrigated						
Pastures/*Ghasnies*						
Barren Land						
Orchard						
Non-Agriculture Land						

IV. Livestock holding

A. Bovine Population

Particulars		Buffaloes		Crossbred		Indigenous	
		No.	Value (Rs.)	No.	Value (Rs.)	No.	Value (Rs.)
Milch Animals	In milk						
	Dry						
Heifers	Pregnant						
	Non-Pregnant						
Young Stock (1-2 Years)	Male						
	Female						
Below 1year	Male						
	Female						
Draught Animal							
Bulls							

V. Economic Traits of below 1 year

Below I year	Male Female
Breed	Indigenous /CB/Buffaloes
Present Age	
Age at the time of purchase	
Month and year of purchase	
Home grown Purchased	
Cost (if purchased)	

VI. Feeding Pattern of the Animal

Particulars	Summer					Winter					Rainy				
Type	GF	Dry	Silage	MM	Con	GF	Dry	Silage	MM	Con	GF	Dry	Silage	MM	Con
Quantity															
Source															
Market Price															

GF= GREEN FODDER MM= MINERAL MIXTURE CONS. = CONCENTRATES

VII. Other miscellaneous expenses:

Particulars	Rupees
Monthly Veterinary Expenses	
Monthly Labour charges	
Annual Insurance Premium	
Annual Interest rate if purchased on loan	

VIII. Fixed Investment on Dairy Enterprise

Particulars	Unit Dimension	YoP/YoC	Present Value	Expected life	Annual maintenance
Cattle Shed					
Store room					
Chaff-cutter					
Cans					
Other utensils & tools					
Permanent Labour					

YoP = Year of Purchase YoC= Year of Construction

IX. Annual dung production…… and sold at price …….

X. Socio-economic characteristics of dairy farmers

Farming Experience	____Years
Market access	Yes/No
Credit access	Yes/No
Extension access	Yes/No

XI. Perceptions regarding adoption of climate risk adaptation strategies

Adoption strategy	Yes/ No
Crop Livestock diversification	
Use of well acclimatised breeds	
Regular feed change / supply	

XII. Constraints:

1. Feeding Constraints:

Sr. No.	Constraints	Ranks
1.	Scarcity of fodder	
2.	Lack of improved fodder crops	
3.	Limited Knowledge about Balanced diet	

2. Technological Constraints:

Sr. No.	Constraints	Ranks
1.	Less awareness about climate variability	
2.	Limited Knowledge about adaptation measures	
3.	Lack of awareness about technologies	

3. Facilities Constraints:

Sr. No.	Constraints	Ranks
1.	Lack of irrigation facilities	
2.	Lack of dairy cooperatives	
3.	Lack of credit facilities	
4.	Lack of veterinary facilities	

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Title of Thesis	:	**Economic impact of Climate Change on the livelihood status of dairy farmers in Mandi district of Himachal Pradesh.**
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Admission Number	:	F- 2021-04-M
Major Advisor	:	Dr. Shilpa
Major Field	:	Agricultural Economics
Minor Field	:	Statistics
Degree Awarded	:	M. Sc.
Year of Award of Degree	:	2023
No. of pages in Thesis	:	71+vi
No. of words in Abstract	:	434

ABSTRACT

The current research examined the “Economic impact of Climate Change on the livelihood status of dairy farm households in Mandi district of Himachal Pradesh” during the year 2022-23. The study employed a multistage random sampling method to choose participants from four randomly chosen blocks, namely Balh, Sundernagar, Dhanotu, and Gohar, out of a total of six blocks. Subsequently, three panchayats were randomly selected from each of these chosen blocks, and ten dairy farming households were randomly selected from each of these villages, resulting in a sample size of 120 for gathering primary data. To facilitate data analysis, all dairy producers were categorized into three groups: small category (1-3 SAUs), medium category (4-6 SAUs), and large category (>6 SAUs). According to the socioeconomic data, the farmers in the region were found to have an average family size of 5.13 members, an 89.21 per cent literacy rate, and a literacy index of 2.73. The dependency ratios for both family members and all workers were 0.41. The majority, 87.92 per cent, of the total landholding consisted of cultivated land. The study area exhibited a crop intensity of 161.33 per cent. On average, there were 5.03 cattle units per household, comprising 4.80 per cent local cows, 41.01 per cent crossbred cows, 33.75 per cent buffalo, 13.21 per cent young stock, and 7.23 per cent heifers This study looked at how climate change affects dairy farm households in Mandi district by using weather data from 1981 to 2021 provided by the Indian Meteorological Department in Shimla. The results showed that climate change has an impact on these households, and there is a nonlinear relationship among climate change and net revenue. When maximum temperatures rise, it reduces the income of dairy farms, but when minimum temperatures and annual rainfall increase, it can boost their income. To explain it further, for every 1^{o}C increase in minimum temperature and 1^{o}C decrease in maximum temperature, dairy farm income could drop by Rs. 40.44 and increase by Rs. 3.40 per day, respectively. The study also used a Binary Logistic Regression model to figure out why some farmers choose to adapt to climate change while others don't. It found that factor like farm income and their experience in farming influence their decision to adapt. In the study area, the biggest problem faced by dairy farmers was a lack of better fodder crops (64.82%), and the least concerning issue was a shortage of veterinary facilities (34.27%). In order to adapt with climate change suitable adaptation practices should be followed like improving feed practices and use of well acclimatized breeds and following the crop livestock diversification method.

Signature of Major Advisor **Signature of the student**

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BRIEF BIO-DATA

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10+2	March, 2017	H.P Board	83%	First
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Whether sponsored by some state/Central Govt./Univ./SAARC : No

Scholarship/ Stipend/ Fellowship, any other financial assistance received during the study period : Yes

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