

PERSPECTIVES OF FARMERS ON EFFECT OF CLIMATE CHANGE ON AGRICULTURE AND LIVESTOCK

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1. INTRODUCTION

Climate change is the most serious environmental threat of the 21st century. The effect of global climatic change on agriculture has recently become a subject of global importance. Climate constitutes complex inter-related variables such as temperature, rainfall, wind speed and sun shine, having varied role to play. Change in one variable triggers changes in other. There is a weak link between factors such as cloudiness and wind, but temperature, evaporation and rain fall are strongly correlated. The increase in green house gases concentration is the ultimate factor responsible for all the climatic changes. Because of green house effect, the solar radiation cannot escape from atmosphere, as an associated factor temperature is also increasing. According to the Inter Governmental Panel on Climate Change (IPCC, 2001), average world temperatures are likely to be between 1.4° C and 5.8° C higher by 2100 than they were in 1990s. More specifically, global warming up by 0.74° C over the past 100 years and 1998-2008 decade has been declared as the hottest decade since global surface temperatures are measured (since 1850). Sea level has increased at an average of 10.00 cm to 25.00 cm over the past 100 years (Sethi, 2007a). This rise was related to increase in surface temperature, which was caused by melting of glaciers and ice caps. The temperature induced evaporation leading to the higher moisture led to the cyclones. So, there was also been increase in average precipitation during the 20th century (Dai *et al.*, 1997). More regional changes have also been observed, including changes in arctic temperature, ocean salinity, wind pattern, drought, precipitation, frequency of heat waves and intensity of tropical cyclones. The World Trade Organization (2004) says that an extra 1, 50,000 people are dying each year due to global rise in temperature.

The predictions by Indian Meteorological Department reported an annual mean area-average surface warming over the Indian subcontinent to range between 3.5 and 5.5° C over the region by 2080s. These projections showed more warming in winter season over summer and *kharif*. The spatial distribution of surface warming suggests a mean annual rise in surface temperatures in north India by 3° C or more by 2050. The rise in average annual temperature by 1.3° C in the State of Karnataka during 1950 to 1990 has been observed.

On the rainfall front, the scenario over the past half century, the world ocean has absorbed about 20 times much heat to a substantial depth. As a result of this warming, the water vapour content over the ocean has increased by 4.00 per cent since 1970, which has led to a more frequent and intensive cyclone. The increase in greenhouse concentration may lead over all increase in the rainfall of about 1.00 to 4.00 mm per day. There is a variation in the rainfall pattern in the atmosphere over the years, in some areas receiving higher and in some areas receiving lower rainfall. There is a variation in the timing of rainfall, some areas may receive early and some areas may receive late onset of rainfall from the predicted period where it affects the agricultural operations.

In Indian context, the rainfall is highly variable with greater spatial variability across regions and seasons. The trend analysis of rainfall data from 1140 meteorological stations carried out at CRIDA (Rao, D. G. and Sinha, S. K., 1994) showed negative trend among the stations situated in deep southern parts, southern peninsular, central India and parts of north Indian regions. Positive deviation is seen at Gujarat, Maharashtra, coastal A.P., Rayalseema and Orissa. However, parts of country comprising the areas in central parts covering eastern U.P., eastern M.P., east coast and greater parts of North West India did not show any changes. The summer monsoon rainfall during 1901-2000 has shown significant decreasing trends in the subdivision of North India, viz., Nagaland, Manipur, Mizoram etc. It is estimated that by the end of the 21st century rainfall will increase by 15.00-31.00 per cent and the mean annual temperature will increase by 30° C to 60° C in the country.

Global warming would cause an increase in rainfall in some areas, which would lead to an increase of atmospheric humidity and the duration of wet seasons. Combined with higher temperatures, these could favour the development of fungal diseases and vector borne diseases which affect human health. Pathogens and insect population strongly dependent upon temperature and humidity, changes (increase) in the atmospheric parameter would change their population dynamics resulting in crop production loss.

It has become common knowledge that the poor are likely to be hit hardest by climate change and that capacity to respond to climate change is lowest in developing countries and among the poorest people in those countries. It seems clear that vulnerability to climate change is closely related to poverty, as the poor are least able to respond to climatic stimuli.

Climate change is a change in state of the climate that can be defined (e.g. using statistical tools) by change in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer. It refers to any changes in climate over time, whether due to natural variability or as a result of human activity (IPCC, 2001).

Climate change and agriculture are interrelated processes, both of which take place on a global scale. Global warming is projected to have significant impacts on conditions affecting agriculture including temperature, precipitation and glacial run-off. These conditions determine the carrying capacity of the biosphere to produce enough food for the human population and domestic animals. Agriculture is more affected than other sectors of the economy by extreme weather events like floods, droughts, cold spells, heat waves, cyclones, typhoons, salinity intrusion and soil degradation. Despite some advantages like increasing length of growing period, relaxation from severe cold, increasing availability of land to the higher latitude regions, it has contradictory impact to the rest of the World. The IPCC (2001) third assessment report concluded that the poorest countries would be hardest hit, with reductions in crop yields in most tropical and sub-tropical regions due to decreased water availability and new or changed insect pest incidence. Fall in agricultural productivity of, up to 30.00 per cent over the 21st century is projected. In South Asia, loss of 10.00 per cent yield of many regional staples such as rice, millet and maize have been observed.

Agriculture and food security are among the major casualties of climate change in India. Although there has been substantial growth in production, there is also substantial variability in production trend. Variability in weather and climate is regarded as the primary cause of year to year fluctuation in yields. More subtle fluctuations in weather during critical phases of crop development can also have substantial impact on yields. The effect of climate change on agriculture will depend on the ultimate form of changed climate, particularly the geographic pattern of temperature, rain fall, relative humidity, wind blow and sun shine. The effect of global climate change hits country in many ways by means of frequent droughts, floods, heat waves, rise in sea level, change in availability of fresh water, length of growing period, suitability of land under cultivation, spread of tropical pest and diseases, depletion of household assets, increased rural urban migration, increased biodiversity loss, depletion of wildlife and other natural resource base, changes in the vegetation type, decline in forest resources, increased health risks and change in the livelihood systems etc. (Reilly, 1999, Abeja, I. B. and Giwa, P. N., 2007).

Indian agriculture is the one field where, most of the activities are environmentally associated, which has affected a lot. Agriculture in India is contributing 16.30 per cent towards GDP and provides livelihoods to 65.00-70.00 per cent population (Dar, W.D., 2009 and Sharma, K. N., 2008). Basically yield of some crops like wheat, rice and pulses will go down while this would present a major challenge to India's prospects of self sufficiency in food production. Small changes in temperature and rainfall would have significant impact on quality of fruits, vegetables, tea, coffee, spices, aromatic and medicinal plants. Rise in temperature has an impact on the yield and quality of most of the crops in India. The production of *rabi* crops in India is seriously threatened due to increase in temperature and higher uncertainties in rainfall (Agarwal, 2003).

In India the change in sowing season due to temperature variations is impacting the wheat yield in Haryana (Sethi, 2007b). For rice, wheat, maize, soyabean, sorghum and barley the net impact of climate trends on yield since 1980 was negative (Lobell and Field, 2007). Even with the increased irrigation potential and other chemical and fertilizer inputs average annual production of paddy, pulses, oilseeds, potato, onion and other vegetables have decreased in the state by 06.80, 56.40, 44.00, 20.70, 14.40 and 24.80 per cent respectively, in a decade (WIB, 2007). Possibilities of 30.00 per cent reduction in sugar cane yield and 12 per cent in rice yield is reported by World Bank. The prediction is that in the river Ganga, the loss of glacier melt reduces water flow between July to September by two third causing water shortage for 37.00 per cent of Indian irrigated land. The impact of the global climate change on Indian agriculture indicates the possibility of loss of four to five million tons in wheat production with every rise of 1°C temperature throughout the growing period. There by it

directly impact on food security of the nation. Crop productivity will fall especially in non irrigated land, as temperature rises by 1.2°C on an average by 2040 and greater crop loss of over 25.00 per cent as temperature rise up to 05.40 per cent by end of this century. According to a case study by Sinha and Swaminathan (1991) 2°C rise in temperature could decrease the rice yield by 0.75 t/ha and 0.5°C rise in winter temperature could reduce wheat yields by 0.45 t/ha. An increase in winter temperature of 0.5°C would thereby translate into a 10.00 per cent reduction in wheat production in the high yielding states of Punjab, Haryana and Uttar Pradesh and also there is a wide spread incidence of (pest) locust in those areas. In Rajasthan 2°C rise in temperature was estimated to reduce production of pearl millet by 10-15 per cent. Every 1°C increase in temperature reduces wheat production by 4-5 million tons (Singh *et al.*, 2009). Plant and animal (human) diseases and insect distributions are likely to change. For example during 1994, Surat in Gujarat was hit by plague resulted in 59 deaths and increase in the population of locusts was also high.

Groundnut area in the state has shown a clear cut trends in relation to changing climatic factors from region to region. The area under groundnut has increased drastically from 07.59 lakh.ha in 1980 to 11.94 lakh.ha in 1990. However from 1990 onwards it has shown a steep decline from 11.94 lakh.ha to 10.40 lakh.ha (Rajegowda *et al.*, 2009) due to variation in weather events.

Climate change poses formidable challenge to the development of livestock sector in India. The predicted negative impact of climate change on Indian agriculture would also adversely affect livestock production by aggravating the feed and fodder shortages. There are number of changes in reproductive performance such as decrease in length and intensity of oestrous period, decreased fertility rate and decreased growth, size and it also lead to reduced disease resistant mechanism. The anticipated rise in temperature between 2.3° C and 4.8° C over the entire country together with increased precipitation resulting from climate change is likely to aggravate the heat stress in dairy animals, adversely affecting their productive and reproductive performance and reducing the total grazing area where high yielding dairy cattle can be economically reared. The warming effect is likely to increase water, shelter and energy requirement for livestock for meeting the projected milk demand. Under climatic stress there can be a decrease in the efficiency of nutrient utilization and dry matter intake to animals subjected to heat stress.

It is estimated that collectively disease cause 24.00 per cent reduction in livestock production due to adverse climate. The decline in minimum temperature (less than 30° C) during winter and increase (more than 40° C) during summer than normal temperature was observed to negatively impact milk production up to 30.00 per cent (Upadhyay, R. C. and Madan, M. L., 2001). Under the climatic stress there can be decrease in the milk production of 10.00 to 20.00 per cent in summer hot days (Madan, 2009). The impact on pastures and fodder crop yield is likely to vary between geographical systems because of expected differences in the nature of climate change between regions. Increase in atmospheric carbon dioxide (CO₂) concentration improves water use efficiency thus leading to improved crop yield in temperate pastures by 10.00-25.00 per cent and tropical grasses by 0-10 per cent. High temperature may lower otherwise positive CO₂ effects on yield by reducing grain number, size and forage quality (Taneja, 2009). Increased temperature increases lignifications of plant tissues and therefore reduces the digestibility. The direct impact on climate change is reported to be worse due to considerable reduction in nitrogen concentration of plants during summer grazing months. Some grazing lands are projected to deteriorate progressively as a result of increased temperature and reduced rain fall but this unlikely to occur until after 2030.

Population that derive sustenance from agriculture are particularly vulnerable to loss of livelihood options due to inundation of coastal land, desertification, land degradation, loss of biodiversity and water scarcity. There is overwhelming evidence to show that climate change presents growing threat to farmers' health security such as vector borne diseases like malaria, kala-azar, *Japanis encephalitis*, filaria and dengue. The climate change lead to impact cereals, vegetables and fruit crop production and a loss of 9.00 to 25.00 per cent net farm revenue. A rise in mean temperature of 2° C and 7.00 per cent increase in mean precipitation will reduce net revenues by 12.30 per cent for the country as a whole (Sanghi *et al.*, 1998).

A survey conducted in Orissa reveals 90.00 per cent of farmers were of the view that their last five year production has been less than the peak production level. Indian agriculture has already been pushed into crises and 1.5 lakh farmers have committed suicide since 1995 due to frequent crop loss caused by extreme weather (Nagaraj, 2002).

A disaster caused by human induced climate change could be a serious disruption to the functioning of a community or a society causing widespread human, material, economic or environmental losses which exceed the ability of the affected community or society to cope using its own resources. Studies focusing on the socio-economic aspects of global climatic change are sparse and have almost exclusively restricted their analyses to the impact of environmental modifications on agricultural production (e.g. Kumar, 2009). Micro-level studies on the effect of climatic variability on people's livelihoods at the farm level and their consequent responses are relatively few. Thus, the human response is critical to understand and estimate the effects of climate change on production and food supply. Accounting of the perception and adaptations to climate change is difficult but necessary in order to measure impacts at the farmer's level. To this end, individual farmer's understandings and perceptions of effect of climate change on agriculture and livestock assume critical importance.

Keeping the above aspects in view this study has been designed with the following objectives

1. to document the farmers views on climate change
2. to find out the reasons for climate change as perceived by the farmers
3. to study the effect of climate change on agriculture and livestock as felt by farmers
4. to elicit the suggestions of the farmers to mitigate the climate change

Specific feature

The novel investigation helps to find out the level of farmers perception about climate change. This study serves as an effective tool to assess the farmer's perception on effect of climate change on agriculture and live stock production. The study also attempts to pool the possible suggestions of the respondent to mitigate the climate change on agriculture and live stock production at farm level.

Climate change although a global phenomena but the real cost of it is being paid by the poorest of the poor like farmers and agricultural labour. There are number of studies made on climate change both at national and international level to understand the effect of climate change on agriculture and animal husbandry. However, very limited studies have been done to understand farmer's perspectives and experiences of climate change in crop cultivation and animal husbandry. It is felt very essential to understand their perspectives also, so that better holistic policy decision could be made. Therefore the present study is proposed.

Limitations of the study

Basically study was handicapped to an extent that it was a single student venture. Hence, the associated constraints like time, funding, physical facilities made the researchers to confine the study to a limited sample size. In spite of this, researcher made worthwhile efforts to select ideal location in each ecosystem so that the result of the study could be easily made applicable to similar situation.

2. REVIEW OF LITERATURE

A conceptual framework for the study based on the ideas and concepts gathered from review work of existing literature of both theoretical and empirical nature will facilitate planning for the study in a comprehensive manner. It also helps to know the previous research work done in that area and acts as a torch for the new researchers. Better ways are needed to generalize the research findings from laboratory studies to operational settings, from one experimental study to another and from one operational setting to another. It provides a basis for theoretical framework, suggest operational definitions of major concepts and provide a basis for interpretation of findings.

The proposed study is new in its subject treatment. Adequate reviews covering all the identified variables of the study for Indian conditions could not be gathered. Some of the closely related studies have been included to augment this scarcity. The literature survey on different dimensions is presented in the following subheads.

- 2.1 Farmers view's on climate change
- 2.2 Reasons for climate change
- 2.3 Effect of climate change on agriculture and livestock
- 2.4 Suggestions of the farmers and scientists to mitigate the effect of climate change

2.1 Farmers views on climate change

Vernon (1994) conducted a study on agriculture, environment, climate and health: sustainable development in the 21st century and recollected small holder farmer in Africa and narrated how weather variability has brought greater suffering and altered their lifestyle. They perceived that, over the years they have seen great increase in temperature and severe changes in rainfall patterns. They expressed that maize has been a staple food crop but, planting time has shifted much with low yield from long dry spells. Also, they reported that many farmers keep cattle and there is not enough grass and water for the animals.

Sinha *et al.* (1998) reported in his study on deforestation, climate change and sustainable nutrition security: a case study of India climatic change, that during the past 25 years, significant changes in climate are observed over different regions of the country. For example, many parts of northern India show increase in minimum temperature by about 1°C in *rabi* cropping season.

O'Connor *et al.* (1999) examined the relationship between risk perceptions and willingness to address climate change in United States and reported that perceptions of individual on climate change were related to their individual behavioural intentions. They also concluded that behavioural intentions regarding climate change were complex and intriguing.

Vedwan and Rhoades (2001) examined how apple farmers in the western Himalayas of India perceived climatic change. This is done by comparing the locally idealized traditional weather cycle with climate change as perceived by the farmers of the region using snowfall and rainfall data to measure the accuracy of perceptions. More than 85 per cent of the informants (n = 58) felt that the timing of the snowfall had undergone a change. Locals said the monsoon rains were slightly displaced to the period beyond mid-August. Local perceptions further indicated that the incidence of rainfall in March and April has increased, coinciding with a significant increase in the number of cloudy days during that period.

Dwyer *et al.* (2004) in his study on quantifying social vulnerability: a methodology for identifying those at risk to natural hazards reported that people in Australia perceive earthquake as one important risk as it required more time to recover than other risks.

Climate Change and African Agriculture Review Report (2006) observed that large number of African agriculturalists already perceived that the climate has become hotter and the rain is less predictable and shorter in duration. The data indicated that across the ten countries studied significant numbers of farmers believed that average temperatures had increased. In six out of the ten countries the majority of farmers believed rainfall levels had decreased. A sizeable minority also believed they had witnessed a change in the timing of the rains.

Leiserowitz (2006) conducted a study on climate change risk perception and policy preferences: the role of affect, imagery, and values and reported that a large portion of people of America believed in scientific consensus on the reality of climate change. Study also revealed that Americans have moderate climate change risk perceptions, strongly support a variety of national and international policies to mitigate climate change and strongly oppose several carbon tax proposals.

Maddison (2006) in his study on perception and adaptation to climate change in Africa reported by using data of 9,500 farmers from eleven African countries that the climate has changed. Significant number of farmers on climate change believed that temperature has already increased and that precipitation has declined in eleven African countries. Farmers with the more farming experience were more likely to notice changes in climatic conditions which according to the study are consistent.

Dietz *et al.* (2007) in a study on Support for Climate Change Policy reported that two-thirds of the sample in Virginia and Michigan reported that they had some knowledge about climate change and 28.00 per cent said they knew little about climate change. Only 9.00 per cent said they had a lot of knowledge. Eight per cent of the respondents had not obtained any type of climate change information from any of the sources about which they asked.

Gareau (2007) in his study entitled, ecological values amid local interest: natural resource conservation, social differentiation and human survival in Honduras reported that local people believed that natural environment had been depleted over the years. Forest vegetation, watershed vegetation and all types of animal species are observed to be declined. He also found that integration of outside knowledge with local ideas led to conflict and discord.

Nhemachen and Hassan (2007) assessed micro-level analysis of farmers' adaptation to climate change in Southern Africa and indicated that 51.41 per cent farmers perceived that temperature is increasing, one forth of farmers perceived that there is no change and 04.05 per cent measured that they do not have any idea. On the other hand, the perception of farmers (45.01%) on long term changes in precipitation was that the region is getting drier and that there are pronounced changes in the timing of rains and frequency of drought.

Gahendar and Dinanath (2008) in his study on an integrated approach to climate change adaptation during recent decades reported that people in Chitwan district of central Nepal have experienced hotter summers while winters are shortening. Ninety eight per cent of all villagers recognized changes in the climate, while 95.00 per cent mentioned drought and erratic rainfall patterns as the main indicators of change. Villagers have witnessed an increasing number of floods.

Ishaya and Abaje (2008) studied Jema local government of Nigerian people's perception of climate change on their various activities and perceived hindrance to its adaptation. People perceived that the environment, climate in particular, has been changing over the years due to diverse human activities. Findings also revealed that the threat of climate change is more on health, food supply, biodiversity lost and fuel wood availability than on businesses and instigating of disaster and it is the poor, who depend heavily on the natural resources that are mostly affected by incidence of climate change.

Apata *et al.* (2009) examined the people's perception about climate change and adaptation among arable food crop farmers in South Western Nigeria. This study also focused that there is a need for agricultural economists and other stakeholders in environmental management and agricultural sustainability in developing countries to come to terms with negative impacts of climate change and likely positive and beneficial response strategies to global warming.

Gebitobo (2007) in his study on understanding farmers perception and adaptation to climate change and variability, a case of Limpopo basin how farmers perceptions examined correspond with climate data at meteorological stations. The statistical analysis of the climate data shows that temperature has increased over the years. Rainfall is characterised by large inter annual variability. Indeed, the analysis showed that farmers perception of climate change are in line with the climatic data records.

Swaminathan (2009) said that climate awareness at the grassroots level in United Nations could help local communities to manage better the adverse impact of climate change. He also introduced the concept of local level climate risk managers who can spread both climate and genetic literacy and create awareness about climate change among the people at grass root level.

The generalization that could be drawn from the above studies is that there was variation in perception level of the respondents about climate change but most of the farmers were having agreement on gradual change in climate and there is a wide variation in season to season and year to year weather condition in the recent decades. These studies have given a base to study the farmers' views on climate change in regional as well as at global level.

2.2 Reasons for climate change

Lal *et al.* (1995) in his study entitled effect of transient increase in greenhouse gases and sulphate aerosols on monsoon climate and presented a climate change scenario for the Indian subcontinent, taking projected emissions of greenhouse gases and sulphate aerosols into account. The potential role of the sulphate aerosols in obscuring the green house gas induced warming over the Indian subcontinent during the past century, they predicted an increase in annual mean maximum and minimum land surface air temperatures of 0.7°C and 1.0°C during 2040's. Since the warming over land is projected to be lower in magnitude than that over the adjoining ocean, the land-sea thermal contrast that drives the monsoon mechanism could possibly decline. However, there continues to be considerable uncertainty about the impacts of aerosols on the monsoon. So the scientific information on possible impact of decline in monsoon is uncertain.

Dale (1997) in his study on the relationship between land use change and climate change observed that in USA land-use change is related to climate change as both a causal factor and a major way in which the effects of climate change are expressed. As a causal factor, land use influences the flux of mass and energy and as land-cover patterns change, these fluxes are altered. Projected climate alterations will produce changes in land-cover patterns at a variety of temporal and spatial scales.

Lonergan (1998) in his study on climate warming and measuring impact of climate change on Indian agriculture, estimated that climate could become warmer under conditions of increased atmospheric carbon dioxide. The average temperature change is predicted to be in the range of 2.33°C to 4.78°C with a doubling in CO_2 concentrations.

Mingkui *et al.* (1998) in their study entitled global methane emission from wetlands and its sensitivity to climate change observed that the concentration of atmospheric methane (CH_4) exerts a strong influence on atmospheric chemistry and the global climate. Natural and cultivated wetlands (rice paddies) are important sources of CH_4 . Estimate of global emission was 145 Tg yr^{-1} , of which 92 Tg yr^{-1} came from natural wetlands and 53 Tg yr^{-1} from rice paddies. The models also showed that modest global warming may produce a higher CH_4 emission, but that this effect may be reversed by larger increases in temperature, due to the effect of soil moisture depletion.

Peter *et al.* (2000) studied on acceleration of global warming due to carbon-cycle feedbacks in a coupled climate model and found that the continued increase in the atmospheric concentration of carbon dioxide due to anthropogenic emissions is predicted to lead to significant changes in climate. About half of the current emissions are being absorbed by the ocean and by ecosystems, but this absorption is sensitive to climate as well as to atmospheric carbon dioxide concentrations, creating a feedback loop.

Thomas and Kevin (2003) in their study on modern global climate change observed that the main source of global climate change is human-induced changes in atmospheric composition. These perturbations primarily result from emissions associated with energy use, but on local and regional scales, urbanization and land use changes are also important. It is clear that these changes will be increasingly manifested in important and tangible ways, such as changes in extremes of temperature and precipitation, decreases in seasonal and perennial snow and ice extent, and sea level rise.

Badami (2004) conducted a study on environmental policy-making in a difficult context: motorized two-wheeled vehicle emissions in India and stated that motor vehicle activity was growing rapidly in India which is contributing seriously to health and welfare hazard of human being, energy insecurity, acidification and climate change. So, the author emphasised on proper policy making, implementation and value focused thinking to mitigate the climate related problem.

Kumar (2004) studied unsustainable utilization of mangrove forest and revealed that degradation of mangrove forest posed a serious threat to their conservation and consequently adverse effect on the local environment.

Ramesh and Purvaja (2004) conducted a research on climate change and Indian Coastal ecosystem and showed that amount of trace gases notably CO₂, N₂O and CH₄ have been increasing in the earth's atmosphere. They try to review the processes involved in climate change and its effects on sea level rise and on the coastal ecosystems.

Johzen (2005) conducted a study in Canada on soil carbon: a matter of ecosystem response in a changing world and stated that industrialization and the combustion of fossil fuel, along with land- use changes are primary sources of anthropogenic green house gas emissions.

Dolan *et al.* (2006) observed in his study on soil organic carbon and nitrogen as related to tillage, residue and nitrogen management in Australia and observed that threat of global climate change is largely due to anthropogenic green house gas emission in the form of carbon dioxide, nitrous oxide and methane.

Jorgenson (2006) in his study on global warming and the neglected greenhouse gas: a cross-national study of the social causes of methane emissions intensity, reported that both the intensity and social organization of production in different sectors contribute to methane emissions per capita. In particular, the production of beef and veal, manufacturing and petroleum sectors, oil and natural gas, and biomass energy all positively affect methane emissions intensity.

IPCC (2007) conducted a study in Cambridge on impacts, adaptations and vulnerability to climate change and revealed that agriculture is responsible for about 10.00 per cent of total green house gas emission globally among other sectors.

Johnson *et al.* (2007) conducted a study on agricultural opportunities to mitigate green house gas emissions and observed that in non-irrigated field crops of the mid west U.S., agriculture practice affect the production of green house gas mainly through fossil fuel use, nitrogen fertilizer application and soil disturbances thereby affecting our environment.

Julia (2007) in his study on climate change effects and assessment of adaptation potential in the Russian federation observed that temperature had increased by 1°C in Russia in 1900-2004 in comparison with global 0.74°C temperature growth. Mean annual amount of precipitation is expected to increase further, mainly due to its increase in the cold period. The most significant increase is expected in the north of Eastern Siberia (by up to 7-9.00%).

Hammoal (2009) in his study on re-examining the relationship between tillage regime and global climate change in United States reported that anthropogenic green house gas emissions are a major contributor to global climate change. Conventional tillage is the main cause for green house gas emission. Zero tillage is a best alternative solution.

Benedicta *et al.* (2010) in his study on farmers' perception and adaptation to climate change; A case study of Sekyedumase district in Ghana, revealed that causes of about 63.30 per cent of the farmers attributed perceived rise in temperature to deforestation, 18.9 per cent to bush burning, 03.30 per cent to increased population and 8.90 per cent to other factors. Great majority of interviewees (87.20%) perceived deforestation as the key cause of declining rainfall. All the past researchers have observed that Greenhouse gases (GHGs) discharged in the course of industrialization and modernization of socio-economic activities over the world have changed the carbon dioxide, methane, nitrogen dioxide, CFC's concentration in the atmosphere. This gradual change has caused the global temperature to increase, variation in normal rain fall, so that ecological systems and human societies may suffer from complex large-scale effects.

2.3 Effect of climate change on agriculture and livestock

Sinha and Swaminathan (1991) in their study on deforestation, climate change and sustainable nutrition security: a case study of India estimated that a 2°C increase in mean air temperature could decrease rice yield by about 0.75 ton/ha in the high yield areas and by about 0.06 ton/ha in the low yield coastal regions. Further, a 0.5°C increase in winter temperature would reduce wheat crop duration by seven days and reduce yield by 0.45 ton/ha. An increase in winter temperature of 0.5 °C would thereby translate into a 10 per cent reduction in wheat production in the high yield states of Punjab, Haryana and Uttar Pradesh.

Klinedinst *et al.* (1993) in their study conducted in Europe on the potential effects of climate change on summer season dairy cattle milk production and reproduction observed that they have relatively large summer season, milk production declines resulting from normally hot conditions. Thus, the actual impacts of increased production declines may be greater in other areas, which are not accustomed to large summer season declines and therefore may require more extensive mitigation measures.

Rao and Sinha (1994) in their study on impact of climate change on simulated wheat production in India and the study estimated that under a (increased carbon dioxide) climate change scenario, the wheat yields could decrease by 28-68 per cent without considering the carbon dioxide fertilization effects.

Holloway and Ilbery (1996) examined the attitudes of farmers/farm managers towards the environment and climate change in the United States, which uses the examples of two crops (vining peas and navy beans) to explore the adaptations farmers may make to climate change. Farmers predicted a combination of positive and negative impacts from global warming, but most think that logistical changes will enable them to adapt to climate change and most would also consider the possibility of introducing new crops such as navy beans.

Pearce *et al.* (1996) in his study on social costs of climate change: greenhouse damage and benefits of control reported that climate has changed in Africa and Africa's agriculture is negatively affected by climate change.

Crosson (1997) in his study on impacts of climate change on agriculture found that in United States both crop and animal output would fall under the type of long-term climate change and is likely to occur in response to a doubling of atmospheric CO₂. The model used in this study took account of climate change impacts elsewhere in the world, and the consequent changes in U.S. trading opportunities in agricultural commodities. The crop production declines in the United States would be small from 0.80 per cent to 03.40 percent. Livestock production would fall between 0.50 per cent and 01.30 percent. The study found that world cereal production would increase 0.20 to 01.20 percent.

Kumar and Parikh (1998) conducted a study on climate change impacts on Indian agriculture and reported that the loss in farm-level net revenue will range between 9.00 and 25.00 per cent for a temperature rise of 2-3.5°C.

Richard *et al.* (1998) observed that possible physical effects of climate change on agriculture, such as changes in crop and livestock yields, as well as the economic consequences of these potential yield changes. Findings concentrated the role of human adaptations in responding to climate change, possible regional impacts to agricultural systems and potential changes in patterns of food production and prices.

Robbinson (1998) in a study on agricultural practice, climate change and the soil erosion hazard in parts of Southeast England stated that most of the farmers believed the climate has changed in the recent years, but impressions of how it has changed are inconsistent. Knowledge of future climate change is very limited. Majority of farmers in the surveys considered erosion to be a minor annoyance to their farming operations which has minimal impact on their past, present or future agriculture land use policy.

Sanghi *et al.* (1998) in their study on the climate sensitivity of Indian agriculture in measuring the impact of climate change on agriculture reported that a rise in mean temperature of 2°C and a 7.00 per cent increase in mean precipitation will reduce net revenues by 12.30 per cent for the country as a whole.

Agriculture in the coastal regions of Gujarat, Maharashtra and Karnataka is likely to be affected negatively. Small losses are also indicated for the major food grain-producing regions of Punjab, Haryana and western Uttar Pradesh.

Winters *et al.* (1998) conducted a study on economic and welfare impacts of climate change on developing countries, analyzed the impact of global climate change on developing countries by using CGE (Computable General Equilibrium) multiple market models for three economies representing the poor cereal importing nations of Africa, Asia and Latin America. Results show that all these countries will potentially suffer income and production losses because of climate change.

Darwin (1999) studied farmer's view of the Ricardian approach to measuring agricultural effects of climatic change during the past few years and observed that farmers adaptation in response to global climatic change have taken into consider. Estimates of climate-induced changes in farm real estate capture first-round adaptations by farmers. Results also indicate that changes in Ricardian rents on agricultural land are poor quantitative, but good qualitative, measures of how global climatic change is likely to affect the welfare of agricultural landowners.

IPCC (2001) in its third assessment report on climate change impacts, adaptation and vulnerability mentioned that increase of CO₂ concentrations can lead to an equilibrium warming of between 2.0°C to 4.8°C. Indeed, scientists have observed that over the 20th century the mean global surface temperature increased by 0.6°C.

Kumar and Parikh (2001a) examined the impact of climate change on Indian agricultural crop yields, GDP and welfare by considering a range of equilibrium climate change scenarios and projected a temperature rise of 2.5°C to 4.9°C. They estimated that without considering the carbon dioxide fertilization effects yield losses for rice and wheat vary between 32.00 and 40.00 per cent, and 41 and 52.00 per cent, respectively GDP would drop by between 3.4 to 1.80 per cent.

Frank *et al.* (2001) in their study conducted on climate change effects on livestock production in Great Plains region of the United States observed that increased ambient temperatures lead to depressed voluntary feed intake, reduced weight gains and lower milk production. Animals are somewhat able to adapt to higher temperatures with prolonged exposure but production losses will occur in response to higher temperature events. Exploration of the effects of climate changes on livestock allows producers to adjust management strategies to reduce the potential economic losses due to environmental changes. Fischer *et al.* (2002) in their study on impact of climate change on agro-ecology reported that irrigation demand in arid and semi-arid regions of Asia is estimated to increase by at least 10.00 per cent for an increase in temperature of 1°C.

Olesen and Bindi (2002) studied knowledge on effects of climate change on agricultural productivity in Europe and the consequences for policy and research. They reported that warming was expected to lead to a northward expansion of suitable cropping areas and a reduction of the growing period of determinate crops (e.g. cereals) but an increase for indeterminate crops (e.g. root crops). Research study indicated that increasing atmospheric CO₂ concentrations will directly enhance plant productivity and also increase resource use efficiencies in this region. On the other hand in northern areas climate change may produce positive effects on agriculture through introduction of new crop species and varieties, higher crop production and expansion of suitable areas for crop cultivation.

Tol (2002) in his study on new estimates of the damage costs of climate change observed changes in ocean circulation patterns, such as the Atlantic conveyor belt, may affect fish populations and the aquatic food web as species seek conditions suitable for their lifecycle. Higher ocean acidity (resulting from carbon dioxide absorption from the atmosphere) could affect the marine environment through deficiency in calcium carbonate, affecting shelled organisms and coral reefs. Climate change impacts can be observed in different folds viz., physiological effects on crops, pasture, forests and livestock (quantity, quality), changes in land, soil and water resources (quantity, quality), increased weed and pest challenges, shifts in spatial and temporal distribution of impacts, sea level rise, changes to ocean salinity, sea temperature rise causing fish to inhabit different ranges, socio-economic impacts, decline in yields and production, reduced marginal GDP from agriculture, fluctuations in world market prices, changes in geographical distribution of trade regimes, increased number of people at

risk of hunger and food insecurity, migration and civil unrest. Agarwal (2003) in his study on impact of climate change on agriculture predicted that, due to impact of climate change, average temperature of the air above the earth surface is expected to rise by 1.4-5.8°C over the next 100 years and CO₂ rising at the rate of 1.8 ppm. Change in rainfall pattern lead to direct and indirect effects. The production of *rabi* crops is seriously threatened due to increase in temperature and higher uncertainties in rainfall.

Lautze *et al.* (2003) in their study entitled, risk and vulnerability in Ethiopia reported even though there has been a long history of drought, its frequency has increased over the past few decades, especially in the lowlands.

DFID (2004) report on climate change suggested that climate of southern Africa is highly variable and unpredictable and the region is prone to extreme weather conditions, including droughts and floods. Climate change with expected long-term changes in rainfall patterns and shifting temperature are expected to have significant negative effects on agriculture, food and water security and economic growth in Africa; and increased frequency and intensity of droughts and floods is expected to negatively affect agricultural production and food security.

Meinke *et al.* (2004) in their study on applying climate information to enhance the resilience of farming systems exposed to climatic risk in South and Southeast Asia emphasised on better understanding of climate variability impacts and climate related vulnerabilities. Most of the farmers (70.00%) in Thamaraikulam changed from cotton to early sorghum. Some reduced planting densities of groundnut. About 20.00 per cent of the farmers who planted cotton abandoned their crops by August.

FAO (2005) in its report on impact of climate change on agriculture, pests and diseases on food security and poverty reduction in developing countries, observed that 11.00 per cent of arable land could be affected by climate change, including a reduction of cereal production in 65 countries, about 16.00 per cent of agricultural GDP.

Mc. Clean (2005) in his study on African plant diversity and climate change observed that in Africa 25–42.00 per cent of the species habitats could be lost, affecting both food and non-food crops. Habitat change is already underway in some areas, leading to species range shifts, changes in plant diversity which includes indigenous foods and plant-based medicines.

Terry (2005) conducted a study on global climate change, issues, trends, outlook and estimated that, earth's temperature increased by 1.5°F during the 20th century. There is a rise in sea level by 7 inches in California since 1850 and also shrinking snow pack – spring runoff decreased by 10.00 per cent thereby affecting crop growing period and crop ecosystem adversely.

Sathaye *et al.* (2006) conducted a study on climate change, sustainable development and India. He mentioned that as India is a large developing country with nearly two-thirds of the population depending directly on the climate sensitive sectors such as agriculture, fisheries and forests, the projected climate change under various scenarios is likely to have implications on food production, water supply, biodiversity and livelihoods. Thus, India has a significant stake in scientific advancement as well as an international understanding to promote mitigation and adaptation. This requires improved scientific understanding, capacity building, networking and broad consultation processes.

Deressa (2007) in his study on measuring the economic impact of climate change on Ethiopian agriculture inferred that, climate has changed and agriculture is one where, it is contributing to the overall economy in higher proportion. This sector is challenged by many factors, of which climate-related disasters like drought and flood (often causing famine) are the major ones.

Ludi *et al.* (2007) studied impacts of climate change on agricultural production and trade. The study was conducted by combining climate change models with agricultural trade model such as the 'Basic Linked System' (BLS) developed by FAO. They developed a model of environmental constraints for agriculture which show that under current climatic condition about two-thirds of the global land surface (8.9 billion hectares) will suffer severely as 13.20 per cent is under too cold condition, 26.50 per cent is under too dry condition, 4.6 per cent land is too steep, 2.00 per cent is too wet and 19.80 per cent is too poor soil for crop

cultivation. The result of modeling shows that under current climatic scenario, agricultural land suitable for crops will expand significantly in North America (40.00% increase), 16.00 per cent increase in Europe, 64.00 per cent increase in Russian Federation and 10.00 per cent increase in East Asia by 2080. In contrast, significant losses of arable land are predicted in Northern, Southern Africa and Asian countries for increasing heat and water stress in this region. Ten to twenty per cent losses are predicted in cereal production in African countries.

FAO (2007) in a study on climate change and trans-boundary pests and diseases in India observed that dramatic effects of climate change on animals pest and diseases are likely to be seen among arthropod insects, like mosquitoes, midges, ticks, fleas and sand flies. With change in temperature and humidity levels, the population of these insects may expand their geographic range and also affect farm animal's immunity.

Gary (2008) in his study on reducing poverty and hunger in Asia in the context of climate change estimated that, the effects of climate change will exacerbate stresses on agricultural production, particularly in low and mid latitude countries. It adversely affects wheat productivity in the Indo-Gangetic Plains, will reduce rice yields due to increased night-time temperatures and will increase demand for water.

Jarvis *et al.* (2008) conducted a study on effect of climate change on crop, agriculture, ecosystems, and environment and reported that production from agriculture is projected to decline by 2030 over much of southern and eastern Australia and over parts of eastern New Zealand due to increased drought and fire.

Maitra *et al.* (2008) in their study on alerting farmers to adopt- an SMS alert system, opined that disease and pest problems are increasing day by day in the Sunderbans region of west Bengal due to changes in climate and also the study stated that rainfall intensity was also comparatively less in this region presently as compared to the actual rainfall received in earlier years.

Kavikumar (2009) in his study on climate sensitivity of Indian agriculture reported that climate change impact studies on agriculture are broadly based on agronomic-economic approach and Ricardian approach. The analysis based on four decades of data suggests that the climate sensitivity of Indian agriculture is increasing over time, particularly in the period from mid-eighties to late nineties. The climate change induced impacts are measured through changes in net revenue (-21.00 per cent) triggered by the changes in the climate variables.

Anonymous (2010) stated that the impact of climate change on livestock is a matter of serious concern as majority of livestock in India are in the hands of the resource poor. A small rise in temperature negatively impacts growth, reproduction and production. Crossbred cattle and buffaloes are likely to suffer more than Zebu cattle mainly due to difference in heat dissipation mechanisms and higher water requirements. Further, climate change is likely to cause a rise in animal diseases that are spread by insects and vectors mainly due to temperature and humidity rise that favour their spread and growth.

Chase (2010) studied the change impacts on dairy cattle and agriculture in southern United States and observed that animals have a range of ambient environmental temperatures termed the thermo neutral zone. This is the range of temperatures that are conducive to health and performance. There are number of environmental factors that contribute to heat stress. These include high temperature, high humidity and radiant energy (sunlight). Heat stress can impact animal production and profitability in dairy cattle by lowering feed intake, milk production and reproduction. There are a number of management and housing alterations that can be made to decrease the impact of heat stress.

Thus, the studies reviewed above indicated that there was considerable impact of climate change on agriculture and livestock. Studies indicated that climate change affecting agriculture and livestock in different folds, increased temperatures and variability in precipitation viz., difficulty in identifying onset of rainy season, change in starting date of rain, change in duration and change in the total number of rainy days in India. The above studies reviewed from 1991 to 2010 on effect of climate change on agriculture and livestock given a conception of varied effect of climate change from region to region.

2.4 Suggestions of the farmers and scientists to mitigate the effect of climate change

Rusten and Gold (1991) in his study on understanding an indigenous knowledge system for tree fodder via a multi-method on-farm research approach of middle hills of central Nepal reported that understanding the dynamics of indigenous resource management systems could benefit natural resource development efforts and contribute to effective on farm agro forestry research initiative.

Rosenzwing and Hillel (1993) conducted a study entitled, agriculture in green house world: potential consequences of climate change. Wide variety of adaptive actions may be taken to lessen or overcome adverse effects of climate change on Agriculture in United States. At the levels of farms, adjustment may include the introduction of later maturing crop varieties or species, switching cropping sequences, sowing earlier, adjusting timing of field operations, conserving soil moisture through appropriate tillage methods and improving irrigation efficiency.

Vernon (1994) conducted a study on agriculture, environment, climate and health: sustainable development in the 21st Century in Minneapolis and reported that the farmers have changed crop varieties, were conserving soil and water, intensified water harvesting and planting trees. Some farmers have expressed migration or shifting from crops to livestock farming. Few farmers find it relatively easy to alter planting schedules or use of different tillage methods but need to do much more such as using seed varieties designed to survive climate change.

Rosenzweig and Hillel (1995) in their study in United States on potential impacts of climate change on agriculture and food supply reported that a wide variety of adaptive actions may be taken to lessen or overcome adverse effects of climate change on agriculture. At the level of farm adjustments may include the introduction of late maturing crop varieties or species, switching cropping sequences, sowing earlier, adjusting timing of field operations, conserving soil moisture through appropriate tillage methods and improving irrigation efficiency.

Smith *et al.* (1997) in their study on corn hybrid selection and climatic variability: gambling with nature reported that there are many varieties of corn with differing suitability to climate. Canadian farmers appear to adjust their hybrid selection on the basis of the previous year's climatic conditions. Farmers are recommended to match hybrid seeds climatic requirements to 30-year climate averages at their locations but frequently choose strains above or below the averages. About 30.00 per cent of farmers said that this was because of the previous year's weather.

Darwin (1999) reported that during the past few years farmers adaptation in response to global climatic change have taken into consider. Estimates of climate-induced changes in farm real estate capture first-round adaptations by farmers. Results also indicate that changes in Ricardian rents on agricultural land are poor quantitative, but good qualitative, measures considered how global climatic change is likely to affect the welfare of agricultural landowners.

Reilly and Schimmelpfenning (1999) in their study on what does climate change mean for agriculture in Netherland and adaptation to climate change included seasonal changes and sowing dates, different variety or species, water supply and irrigation system, other inputs (fertilizer, tillage methods, grain drying, other field operations), new crop varieties, forest fire management, promotion of agro forestry, adaptive management with suitable species and silvicultural practices.

William and Stering (1999) in his study on adapting north American agriculture to climate suggested that the adaptation measures made by the farmers includes the translocation of crops across natural climate gradients, the rapid introduction of new crops such as soybeans in the USA and canola in Canada and resource substitutions prompted by changes in prices of production inputs. A wide selection of modeling studies is reviewed which suggests several agronomic and economic adaptations strategies that are available to agriculture. Agronomic strategies include changes in crop varieties and species, timing of operations and land management including irrigation. Economic strategies including

investment in new technologies, infrastructure, labour, and shifts in international trade. Over all, such agronomic strategies were found to offset either partially or completely the loss of productivity caused by climate change. Economic adaptations were found to render lowering the agriculture costs of climate change.

Berkes and Jolly (2001) in their study entitled adapting to climate change social, ecological resilience in a Canadian western Arctic community analyzed the strategies of a small community of Sachs Harbour in Canada. These local communities changed their land based activities, cultural and ecological life to cope up with climate change. This community was successful to adapt themselves against climate change by utilising their indigenous technological knowledge.

Baethgen *et al.* (2003) in their study on adaptation of agricultural production systems to climate variability said that availability of better climate and agricultural information helped farmers to make comparative decisions among alternative crop management practices and this allows them to better choose strategies that make them cope well with changes in climatic conditions.

Bradshaw *et al.* (2004) in their study on farm-level adaptation to climatic variability, crop diversification in the Canadian Prairies reported that important adaptation options in the agricultural sector includes, crop diversification, mixed crop, livestock farming systems, using different crop varieties, changing planting and harvesting dates, and mixing less productive, drought-resistant varieties and high-yield water sensitive crops.

Orindi and Eriksen (2005) conducted study on mainstreaming adaptation to climate change in the development process of Uganda. Agricultural adaptation involves two types of modifications in production systems. The first is increased diversification that involves engaging in production activities that are drought tolerant and resistant to temperature stresses as well as activities that make efficient use and take full advantage of the prevailing water and temperature conditions. Among other factors, crop diversification can serve as insurance against rainfall variability as different crops are affected differently by climate events. The second strategy focused on crop management practices geared towards ensuring that critical crop growth stages do not coincide with very harsh climatic conditions such as mid-season droughts. Use of irrigation has the potential to improve agricultural productivity through supplementing rainwater during dry spells and lengthening the growing season.

Rautela (2005) discussed the indigenous technical knowledge inputs for effective disaster management practices by the people of Himalayan terrain region. He observed that during the course of their habitation the indigenous people through experience, experimentation and accumulated knowledge devised ways of reducing their vulnerability to natural hazards. Studies showed that their understanding was fairly evolved in the areas of earthquake, landslide and drought management and had devised efficient ways of mitigating the effect of natural or climatic changes.

Wall and Smit (2005) in their study on climate change adaptation in light of sustainable agriculture in Canada identified several climate and weather risk adaptation strategies currently in use and notes their close links to sustainable agriculture practices. For example, switch on to different crops, adopting efficient irrigation systems or altering production systems.

FAO (2005) in an assessment of impact of climate change on agriculture and food security report indicated that climate change has direct effects on livestock productivity as well as indirectly through changes on the availability of fodder and pastures. Climate determines the type of livestock most adapted to different agro-ecological zones and the animals that are able to sustain rural community's rearing habits. Climate change is expected to affect livestock at the species level. For example, if the Himalayas turn warmer, the yak could be restricted to higher altitudes where grass and fodder is less available.

Nhemachena and Hassan (2007) conducted a study on various adaptation strategies used by farmers in response to changing climatic conditions in Southern Africa and indicated that less than 40 per cent of the respondent did not adopt any adaptation strategies. The result also showed that mixed crop and livestock farmers were associated with positive and significant adaptation to changes in climatic conditions and female headed households were

more likely to take up adaptation options. It is also found that households with access to electricity, tractors, heavy machines and animal power have better chances of taking up adaptation options.

Nyong *et al.* (2007) in their study entitled the value of indigenous knowledge in climate change mitigation adaptation strategies in the African Sahel and reported that local population in the African Sahel region had developed and implemented extensive mitigation and adaptation strategies through their indigenous knowledge systems that have enabled them to reduce their vulnerability against climate change.

Gahendar and Dinanath (2008) in a study on an integrated approach to climate change adaptation examined that the farmers of the Chitwan district of central Nepal has taken up number of adaptations against climate change. They constructed check dams and other infrastructures, some of them replaced rice by maize, the stream beds have risen because of deposition of debris making water inaccessible for irrigation during stress period.

Rajpal and Kumar (2008) in their study on making an opportunity in changing climate scenario, a case of Himachal Pradesh indicated that the farmers of Kullu and Lahaul valley region converted the climate change problem in to opportunity where apple farmers affected by climate change have shifted to crops like kiwi and pomegranate and getting good yield.

Ronak and Niranjana (2008) reported that in Dhola region of Rajasthan farmers have been blending traditional and improved farming practices to adapt to changes in climate they are experiencing. By including practices like mulching, new seeds or vermi composting, crop diversification, green manuring in their agriculture system.

Shiraz (2008) conducted a study on adaptive agriculture in flood affected areas in Eastern Uttar Pradesh region. Farmers undertaken many adaptive measures against climate change, some of them are crop intensification, diversification, value addition, crop cycle management i.e. pre flood cultivation, cropping with floods and post flood cultivation.

Kumar (2009) in his study on indigenous technical knowledge in agriculture published a number of indigenous technological knowledge on rain-water management, soil and water conservation, wind erosion, tillage practices, crop and cropping systems, pests and disease management, soil fertility management, farm implements, post-harvest technology, grain or seed storage, horticultural crops, veterinary and animal husbandry, fishery, ethno-botany and agro-biodiversity, weather forecasting, fuel management, thermal efficiency, waste water management, garbage disposal and management, food-product development, natural yarns, dyes, dyes and weaves, low-cost housing material and ethnic food.

Reidsma *et al.* (2010) in their study entitled adaptation to climate change and climate variability in European agriculture and importance of farm level responses analysed the adaptation of farmers and regions in the European Union to prevailing climatic conditions, climate change and climate variability in the last decades (1990–2003) in the context of other conditions and changes. They observed that management and adaptation can largely reduce the potential impacts of climate change and climate variability on crop yields and farmers' income.

Thus, the studies reviewed above indicated that farmers adopted almost all simple practices in response to changing climatic conditions. Crop diversification, mixed crop, livestock farming systems, using different crop varieties, changing planting and harvesting dates, and mixing less productive, drought-resistant varieties are the main adaptations. Differential levels of adoption were found with respect to geographical location and knowledge level of the farmers. However, not much of the studies have been conducted on suggestion of farmers to changed climate. Hence, it would be interesting to study the extent of suggestion to changed climate by farmers and recommendations by the scientists.

3. METHODOLOGY

The study was conducted during the year 2010-11 in Dharwad and Bijapur districts of Karnataka. This chapter describes the scientific procedure employed while conducting this research study and is presented under following sub headings.

- 3.1 Research design
- 3.2 Locale of the study
- 3.3 Selection of districts and taluks
- 3.4 Selection of villages and respondents
- 3.5 General description of study area
- 3.6 Selection of variables
- 3.7 Operationalisation and measurement of variables
- 3.8 Data collection
- 3.9 Statistical tools used

3.1 Research design

Since the variables selected for the study had already occurred and are established facts, Ex-post-Facto research design was followed for the conduct of the study.

3.2 Locale of the study

The study was conducted in two agro climatic zones of northern Karnataka viz., northern transitional zone and northern dry zone. One district each from these zones were selected for the study. Dharwad district from northern transitional zone and Bijapur from northern dry zone were selected, which formed the locale of the study.

3.3 Selection of taluks

Dharwad taluk from Dharwad district and Bijapur taluk from Bijapur district were selected based on the high variability in rainfall, temperature, relative humidity and sunshine in the last 2 decades. Meteorological data for the same was collected from College of Agriculture, Bijapur and College of Agriculture, Dharwad.

3.4 Selection of village and respondents

Five villages from each taluk, each representing north, south, east, west and centre location of the taluk were purposively selected to ensure better heterogeneity and representativeness. Study thus covered 10 villages. Fifteen farmers from different landholding categories from each village were randomly selected and also one of the criterions fixed for the study was that farmer should be minimum of 45 years old. This was followed to get better response towards change in climate over the years. In all, 150 farmers were selected for the study. The details of the district, taluk, villages, location and number of respondents selected for the study are given in Table 3.1.

3.5 General description of the study area

Description of Dharwad district

The study was purposively conducted in Dharwad district. It is situated in western sectors of northern part of the Karnataka state. Belgaum and Gadag districts surround it in the north, Haveri district in the south and Uttara Kannada district in the west. The district is divided into three belts geographically viz., Malnad, Transition and Dry regions. Dharwad taluk surrounds by Hubli taluk in the southeast and Belgaum district in the north (Dharwad District at a glance, 2009, Bangalore).

Table 3.1: Districts, Taluks, villages and number of respondents selected for the study

Sl. No	Districts	Taluks	Villages	Number of respondents
1.	Dharwad	Dharwad	Chikmalligewada	15
			Itagatti	15
			Kelageri	15
			Kotura	15
			Pudukalkatti	15
2.	Bijapur	Bijapur	Atalatti	15
			Arkere	15
			Hittnalli	15
			Kotyal	15
			Shivnagi	15
Total	2	2	10	150

Dharwad district has an area of 4,263 sq. kms. Dharwad taluk has an area of 1,032 sq. kms. As per 2001 census, the total population of Dharwad district was 16, 04,253. Total population of Dharwda taluk was 2,18,961. The density of population in Dharwad district is 3, 76,321 sq. kms.

The land utilization pattern of Dharwad taluk was that, the net sown area was 1, 11, 788 ha. The area under forest was 13,676 ha. The fallow land accounted for 8,046 ha. About 6,402 ha of land was found to be of available for cultivation. Soils comprised of red, medium, black and deep black however, major part of soils comprised of deep black cotton soils.

The major sources of irrigation in Dharwad district are canals, tanks and wells. However, the canal irrigation was not found in Dharwad taluk. Major sources of irrigation are bore wells and wells. The total area irrigated in Dharwad taluk was 5,915 ha.

The southwest monsoon is most crucial for Dharwad district. Average rainfall of the district was 969 mm. Dharwad taluk receives an average annual rainfall of 1,523 mm (Anon., 2009). During the beginning of the second fortnight of June the southwest monsoon occurs. Further, details of rainfall are given in Table 3.2.

There is much variation in season wise temperature. Summer season experiences high temperature while in winter there is steep fall. The mean monthly maximum temperature rises up to 33.33°C during April and minimum temperature fall up to 11.10°C during January.

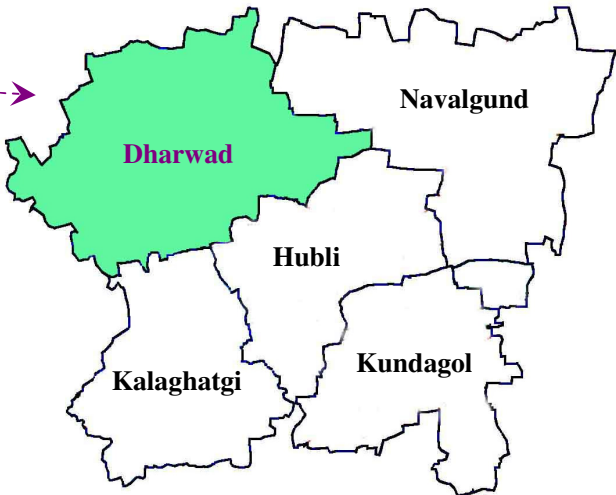
Relative humidity places a crucial role in harvesting and good crop yield during *Rabi* season. Where, in Dharwad most of the pulse crops are grown in this season. Like bengal gram, soybean, green gram, horsegram and blackgram.

Description of Bijapur district

The study is purposively conducted in Bijapur district. It is situated in northern sectors of northern part of the Karnataka state. Belgaum, Raichur, Gulbarga and Bagalkote districts surround it. The district is divided into three belts geographically viz., Malnad, Transition and Dry regions (Bijapur District at a glance, 2009, Bangalore).



DHARWAD DISTRICT



BIJAPUR DISTRICT

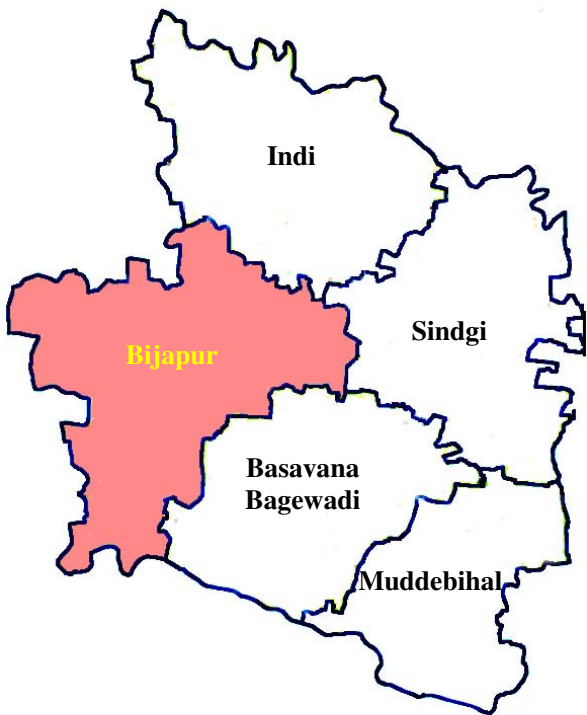


Fig. 1: Map showing the study area

Table 3.2: The season wise rainfall distribution of Dharwad taluk (2008-2009)

Sl. No.	Period	Type of rain	Rainfall (%)
1	June-Sept	Southwest	63
2	Oct-Jan	Northeast	23
3	Feb-May	Pre-monsoon	14

Table 3.3: Season-wise maximum and minimum temperatures of Dharwad (2008-2009)

Season	Period	Mean temperature for season (° C)	
		Maximum	Minimum
<i>Kharif</i>	June-Sept	33.30	17.00
<i>Rabi</i>	Oct-Jan	32.20	11.10
Summer	Feb-May	36.90	18.20

Bijapur district falls under Northern dry zone (zone III). The district which is located well in the interior of the Deccan Peninsula lies at an altitude of about 593 meters above the mean sea level. It has a cultivation area of 35,581,64 acres. The zone is having less irrigation facility. The soil type varies from medium black to deep black. Soils are fertile having high moisture holding capacity. Hence, food grain production depends only on the extent of rainfall. Major crops of the districts are cereals, pulses and oilseeds. The major crops grown in *Kharif* are Bajra and Jowar pulses like Green gram, Cowpea, Horse gram and Red gram. The major *Rabi* crops are *Rabi* Jowar, Wheat, Bengal gram and sun flower. The farmers of these areas usually possess large land holdings.

Annual rainfall ranges from 400 mm to 566 mm. The rainfall is scanty, erratic, uncertain and unevenly distributed. Contribution from the southwest is very less but northeast monsoon determines the production of food grains. The Rainy months are June, July, October and November.

The temperature ranges from 8.09°C to 42.54°C with the maximum temperature prevailing during March, April and May months and the minimum during December and January months. The hot season begins by the middle of February and extends till the end of May or beginning of June.

From beginning of June, south-west monsoon extends till the end of September with cool and moist weather. The North-east monsoon season is between October and November while the cold season is from December to middle of February.

Table 3.4: Average relative humidity of Dharwad (2008-2009)

Sl. No.	Season	Period	Mean seasonal average
1	<i>Kharif</i>	June-Sept	41.56
2	<i>Rabi</i>	Oct-Jan	32.51
3	Summer	Feb-May	25.93

Table 3.5: Decadal average climatic changes of Dharwad taluk (before 1990 to after 1990s)

Season	Comparative changes in climatic conditions before 1990s to after 1990s					
	Temperature (0c)		Rainfall (mm)		Relative humidity (total)	
	Before 1990	After 1990	Before 1990	After 1990	Before 1990	After 1990
<i>Kharif</i> (June-September)	24.13	24.73	676	698	9436	9987
<i>Rabi</i> (October-January)	20.16	22.15	271	263	7891	7823
Summer (February-May)	25.90	27.34	169	151	6311	6233

Table 3.6: The seasonwise rainfall distribution of Bijapur taluk (2008-2009)

Sl. No.	Period	Type of rain	Rainfall (%)
1	June-Sept	Southwest	74.00
2	Oct-Jan	Northeast	18.00
3	Feb-May	Pre-monsoon	08.00

Table 3.7: Season wise maximum and minimum temperatures of Bijapur taluk (2008-2009)

Season	Period	Mean temperature for season (° C)	
		Maximum	Minimum
<i>Kharif</i>	June-Sept	18.43	25.12
<i>Rabi</i>	Oct-Jan	8.09	29.33
Summer	Feb-May	26.65	42.54

Table 3.8: Average relative humidity of Bijapur (2008-2009)

Sl. No.	Season	Period	Mean seasonal average
1	<i>Kharif</i>	June-Sept	59.28
2	<i>Rabi</i>	Oct-Jan	33.54
3	Summer	Feb-May	7.18

Table 3.9: Decadal average climatic changes of Bijapur taluk (before 1990 to after 1990s)

Season	Comparative changes in climatic conditions before 1990s to after 1990s					
	Temperature (°C)		Rainfall (mm)		Relative humidity (total)	
	Before 1990	After 1990	Before 1990	After 1990	Before 1990	After 1990
<i>Kharif</i> (June-September)	21.33	22.37	476	452	6587	6312
<i>Rabi</i> (October-January)	17.26	17.56	178	145	4390	3984
Summer (February-May)	30.81	34.59	72	51	3421	3122

3.6 Selection of variables

3.6.1 Dependent variables

By considering the objectives of the study, farmer's views of climate change and effect on agriculture and livestock were considered as dependent variables.

3.6.2 Independent variables

Independent variables that were supposed to influence the dependent variables were identified by consulting scientists and reviews. Fifteen independent variables were considered for the study. They were age, education, family size, farm size, herd size, farming commitment, farming experience, annual income, cropping pattern, economic motivation, mass media exposure, risk orientation, scientific orientation, extension system link and extension contact.

3.7 Operationalisation and measurement of variables

3.7.1 Dependent variables

3.7.1.1 Farmer's views on climate change

Person's views are defined as the process by which people organize and interpret the sensory information they receive into a meaningful mental picture (Chang and Megginson, 1981). For the research purpose effort has been made to investigate the farmer's views on changes in climate, referred to its five components- rainfall, temperature, relative humidity, sunshine and wind blow as observed and experienced by them. Responses for changes in these climatic factors were sought across *Kharif*, *Rabi* and summer seasons. The responses sought were then tabulated in frequency and percentages. Besides, the extent of variations perceived by them in each of these factors from the normal was also recorded as proportion to percentage and mean value of percent variation is mentioned.

3.7.1.2 Effect on agriculture and live stock

Effect refers to an event which follows immediately from an antecedent, called the cause.

The weather conditions rainfall, temperature, relative humidity, sunshine and wind blow determines the carrying capacity of the agriculture and animal husbandry. Any short fluctuations of the climate can have dramatic effect on the agriculture productivity and performance of livestock.

Effect of climate change as perceived by the respondents was studied separately for crop husbandry and livestock practices.

Twenty eight farming practices beginning with the land preparation to post harvest operations of crop husbandry covering grains and crop residues, were enlisted. Effect of climate on each of these practices were sought as positive, negative and no effect. The responses against each of these practices were expressed as frequency and percentage. Also the extent of effect, if any, as felt by the respondents was collected and mean values were presented for interpretation.

Similarly, 25 livestock practices beginning with breed selection to fodder and feed production and utilization were enlisted and the similar method followed for crop husbandry practices was applied to seek responses and to present the results.

3.7.2 Independent variables

3.7.2.1 Age

It is operationalised as the chronological age of the respondent in completed years at the time of investigation. The age of respondents was recorded as mentioned by them and were categorized as middle (45-60 years), old (61 to 75 years) and very old (above 75 years).

3.7.2.2. Education

Education was operationalised as the number of years of formal schooling undergone by the respondents. A score of one was given for each year of schooling. The respondents were grouped into different categories based on procedure followed by Binkadkatti (2008).

Sl. No.	Categories
1	Illiterate
2	Primary school (1 to 4 th)
3	Middle school (5 to 7 th)
4	High school (8 to 10 th)
5	Pre-university (11 and 12 th)
6	Graduate (above 12 th)
7	Post graduate (master degree)

3.7.2.3 Family Size

Total number of members residing together in the family of the respondent at the time of investigation was considered to assess the family size. Families with members up to 4 were categorized as small and those with more than 4 members were considered as big. The same procedure was followed by Pushpa (2006).

3.7.2.4 Farm size

Extent of land actually possessed by the farmers at the time of investigation was recorded and this was converted into standard order based on Karnataka Land Reforms Act 38 of 1996. According to this act, one acre of garden and wet land was considered equal to 2.50 acres or 1 ha of dry land. Categorization of respondents is done in the following manner as followed by Khin Mar Oo (2007).

Farmers categories	Land holding (acres)
Marginal	up to 2.50
Small	2.51 to 5.00
Big	Above 5.00

3.7.2.5 Herd size

Herd size was expressed in terms of standard adult cattle units. Scores for calculating standard adult unit were assigned as given below.

Type of livestock	Score
Large ruminants like cow/buffaloe/bullock	1
Calves of large ruminants and small ruminants like sheep or goat	0.50
Lambs and kids of small ruminants	0.25

The scores for each respondent are totaled and categorized as small, medium and large herd size based on mean and standard deviation. The procedure followed by Pushpa (2006) was adopted for the study.

3.7.2.6 Farming commitment

This was quantified by using the scale developed by Gowda (1991). The scale consisted six statements, of which two were positive and the rest negative. The responses were recorded on five point continuum ranging from strongly agree, agree, undecided, disagree and strongly disagree with scores of 5,4,3,2,1 for positive statements and 1,2,3,4,5 for negative statements, respectively. Maximum and minimum scores obtainable by the individual on the scale were 30 and 6. Based on the scores, farmers were grouped into three categories by using mean and standard deviation as measure of check.

Category	Score
Low	Less than $(\bar{X} - 0.425 \text{ SD})$
Medium	Between $(\bar{X} \pm 0.425 \text{ SD})$
High	More than $(\bar{X} + 0.425 \text{ SD})$

3.7.2.7 Farming Experience

Experience in cultivation is referred to the years of experience of an Individual farmer in crop cultivation. Each year of experience was given one score for analysis and respondents were categorized into three groups as followed by the Sakharkar *et.al.* (1992).

Category	Farming Experience
Low	Less than 20 years
Medium	20-40 years
High	More than 40 years

3.7.2.8 Annual income

It was operationalised as the total income earned by the respondents from both agriculture and the sources other than agriculture in the previous year as expressed by the respondents in rupees. The classification was done as per the Ministry of Rural Development, GoI and the same was followed by Binkadkatti (2008)

Category	Income (in Rs)
High income	Above 51,000
Medium	34,001 to 51,000
Semi medium	17,001 to 34,000
Low	Below 17,000

3.7.2.9 Economic motivation

Economic motivation referred as the extent to which an individual is oriented towards achievement of the maximum economic ends such as maximization of profits. This was quantified by using the scale developed by Supe (1969), later followed by Padmaiah (1995). The scale consisted of six statements, of which first five statements were positive and the last one was negative. The responses for each statement were rated on 5 point continuum ranging from 'strongly agree', 'agree', 'undecided', 'disagree' and 'strongly disagree' with scores of 5, 4, 3, 2 and 1 for positive statements. The scoring was reversed for negative statements. Maximum and minimum scores an individual could obtain on this scale were 30 and 6, respectively. Further, the respondents were classified into three categories based on the mean ($\bar{X}$) and standard deviation (SD) as a measure of check.

Category	Score
Low	Less than $(\bar{X} - 0.425 \text{ SD})$
Medium	Between $(\bar{X} \pm 0.425 \text{ SD})$
High	More than $(\bar{X} + 0.425 \text{ SD})$

3.7.2.10 Mass media participation

This variable is operationalized as the exposure of an individual to different mass media channels such as newspaper, farm magazine, radio, television and his degree of participation in them. The respondent was asked to indicate whether he subscribed to or own the media as mentioned earlier. Then, the respondent was asked to indicate his degree of participation as regular, occasional and never for reading, listening and viewing habits. The responses so obtained were expressed in frequency and percentage.

3.7.2.11 Risk orientation

It is operationalized as the degree to which a farmer is oriented towards risk and uncertainty and has courage to face the various risk involved in farming. Risk orientation was measured with the help of risk orientation scale developed by Supe (1969) and as followed by Shashidhara (2003). The scale consisted of six statements, of which first and fifth statements were negative and all others were positive. The items were rated on a five point continuum ranging from 'strongly agree', 'agree', undecided', 'disagree' and 'strongly disagree' with weightages of 5, 4, 3, 2 and 1 for positive statements and 1, 2, 3, 4 and 5 for negative statements, respectively. The possible score ranged from 6 to 30.

Based on the scores, the respondents were grouped into three categories by using mean ($\bar{X}$) and standard deviation (SD) as a measure of check.

Category	Score
Low	Less than $(\bar{X} - 0.425 \text{ SD})$
Medium	Between $(\bar{X} \pm 0.425 \text{ SD})$
High	More than $(\bar{X} + 0.425 \text{ SD})$

3.7.2.12. Scientific orientation

Scientific orientation is operationalized as the degree to which farmer is oriented to the use of scientific methods in decision making in farming. It was measured with the help of a scale developed by Supe and singh (1969). The scale consisted six statements amongst which the second statement alone was negative. The items were rated on a five point continuum ranging from 'strongly agree', 'agree', 'undecided', 'disagree' and 'strongly disagree' with weightages of 5, 4, 3, 2 and 1 for positive statements and 1, 2, 3, 4 and 5 for negative statements, respectively. The possible scores ranged from 6 to 30. Higher score indicated better orientation towards scientific farming. Respondents were then grouped into different categories on the basis of mean and standard deviation.

Category	Score
Low	Less than $(\bar{X} - 1 \bar{SD})$
Medium	Between $(\bar{X} \pm 1 \bar{SD})$
High	More than $(\bar{X} + 1 \bar{SD})$

3.7.2.13 Extension participation

It refers to the extent of participation of the farmers in different extension activities like krishimela, training programme, extension meetings, group discussions, etc. Quantification of this variable was done as per the procedure followed by Shashidhara (2003). A list of 7 most relevant extension activities was presented to the respondents and responses were elicited against each activity with reference to their regularity of participation as regular, occasional and never. Responses were tabulated as frequency and percentages for each of their responses.

3.7.2.14 Extension system link

Extension contact has been operationally defined as the frequency of contact of respondents with extension personnel and extension agencies for seeking information about cultivation practices. Frequency of their contact to the enlisted 6 extension workers was obtained from the respondents and was expressed as frequency and percentage.

3.8 Data collection

Keeping in view the objectives and variables of the study, a structured interview schedule was developed by consulting with experts and referring to the relevant literature related to impact of climate change on agriculture. Pre-testing of schedule was carried out in the non-sample area for its practicability and relevancy. The final schedule was prepared by making necessary modifications, additions and deletions based on pre-testing results. Pre-tested and standardized interview schedule was used for data collection through personal interview method. Data collection was carried out in an informal atmosphere.

3.9 Statistical tools used in the study

The data were analyzed using simple statistics- frequency, percentage, mean and standard deviation.

4. RESULTS

The results of the study comprising effects of climate change on agriculture and livestock as perceived by the farmers are presented under the following major heads.

- 4.1 Socio-economic profile of the respondents
- 4.2 Farmers views on climate change
- 4.3 Reasons for climate change as perceived by the farmers
- 4.4 Effect of climate change on agriculture and livestock as felt by the farmers
- 4.5 Suggestions of the farmers to mitigate the climate change effect

4.1 Socio-economic profile of the respondents

4.1.1 Socio-economic characteristics

4.1.1.1 Age

It could be seen from Table 4.1 and Fig. 2 that, majority (66.00%) of the respondents belonged to middle age group, whereas 20.67 per cent and 13.33 per cent of them belonged to old age and very old age categories, respectively.

4.1.1.2 Education

One fourth of the respondents were illiterates (26.67%) and primary educated (25.33%), while little less than one fourth (22.00%) of the respondents received education up to middle school. Some proportion (14.00%) of the respondents received education up to PUC and 07.33 per cent of the respondents had education up to high school. Graduates accounted 04.67 per cent only (Table 4.1 and Fig. 2).

4.1.1.3 Family size

It is clear from the Table 4.1 and Fig. 2 that half (50.67%) of the respondents belonged to big family (above 4 members) and another half (49.33%) to small family (4 and below members). The mean family size was 5.51 members.

4.1.1.4 Farm size

It could be seen from Table 4.1 and Fig. 2 that 42.00 per cent of the respondents belonged to marginal land holding category, followed by small (30.00 %) and big farmers accounted for 28.00 per cent only. The mean farm size was 12.53 acres.

4.1.1.5 Herd size

Large livestock holder accounted only 02.00 per cent. Almost equal percent of the respondents had medium (50%) and small (48%) herd size (Table 4.1 and Fig. 2). The mean herd size was 4.64 ACUs.

4.1.1.6 Farming experience

More than half (56.00%) of the farmers belonged to the medium farming experience followed by high (39.33%) and low (4.67%) farming experience categories (Table 4.1 and Fig. 2). The mean years of farming experience was 39.69 years.

4.1.1.7 Annual income

It could be observed from the Table 4.1 and Fig. 3 that, 40.67 per cent of farmers had medium level of income (Rs. 34,000-51,000), 28.67 per cent had high level (above Rs. 51,000/-), 25.33 per cent had semi-medium level (Rs. 17,000-34,000) and only 5.33 per cent had low level of annual income (up to Rs. 17,000/-). The average annual income was Rs. 67, 470.

Table 4.1: Distribution of respondents according to their Socio-personal-economic characteristics

(n=150)

Sl. No.	Characters	Categories	Respondents	
			Number	Per cent
1.	Age	Middle (45-60 years)	99	66.00
		Old (61-75 years)	31	20.66
		Very old (above 75 years)	20	13.33
		Mean=58.04 S.D.=12.38		
2.	Education	Illiterate	40	26.67
		Primary school (1 to 4th)	38	25.33
		Middle school (5 to 7th)	33	22.00
		Pre-university (11 and 12th)	21	14.00
		High school (8 to 10th)	11	07.33
		Graduate (above 12th)	07	04.67
		Mean = 5.25 S.D.=4.66		
3.	Family Size	Small (1-4 members)	74	49.33
		Large (>4 members)	76	50.67
		Mean = 5.51 S.D.=2.82		
4.	Farm size	Marginal farmers (<2.5acres)	63	42.00
		Small farmers (2.5 – 5 acres)	45	30.00
		Big farmers (> 5 acres)	42	28.00
		Mean = 12.53 S.D.=23.23		
5.	Herd size (ACUs)	Small (1-4)	72	48.00
		Medium (4-10)	75	50.00
		Large (>10)	03	02.00
		Mean = 4.64 S.D.=3.32		
6.	Farming experience	Low (<20 years)	07	04.67
		Medium (20-40 years)	84	56.00
		High (>40 years)	59	39.33
		Mean = 39.69 S.D.=13.61		
7.	Annual income	Low (up to Rs. 17,000/-)	08	05.33
		Medium (Rs. 34,000-51,000)	61	40.67
		semi-medium (Rs. 17,000-34,000)	38	25.33
		High (above Rs. 51,000/-)	43	28.67
		Mean = 67470 S.D.=64037.31		

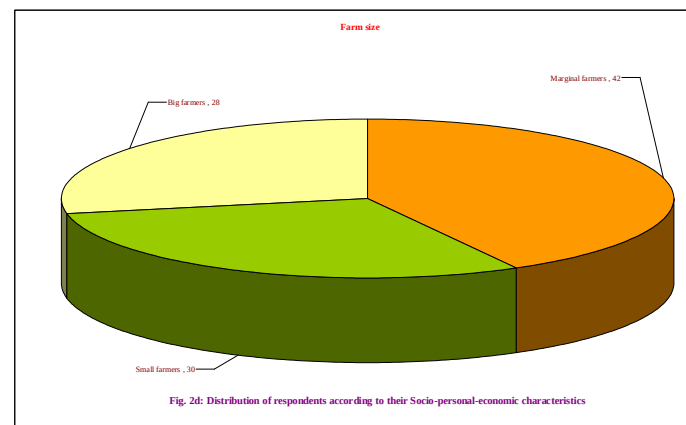
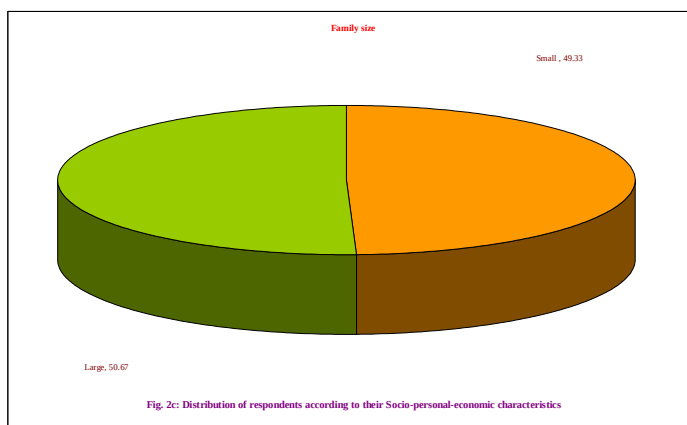
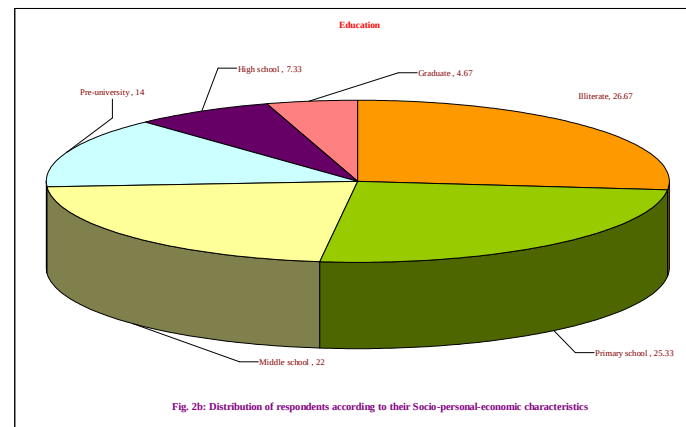
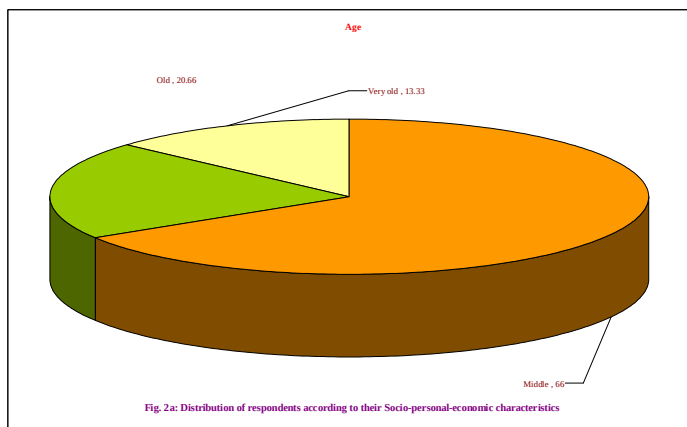
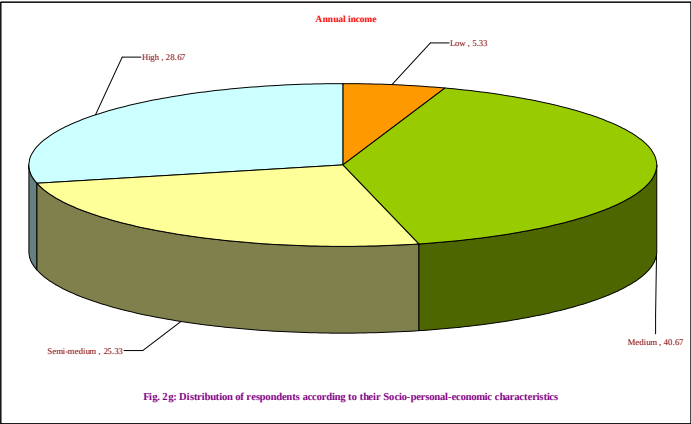
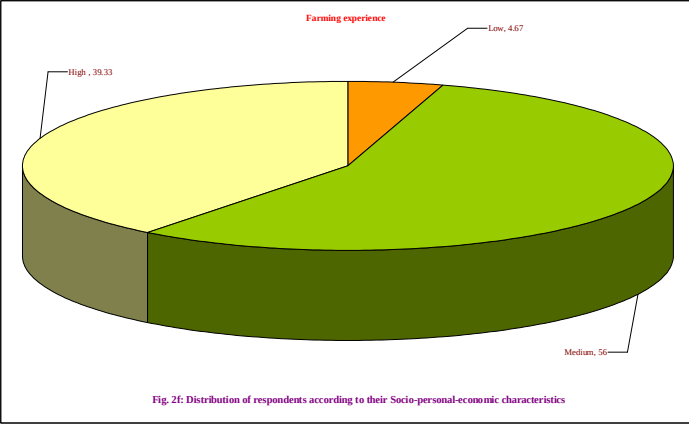
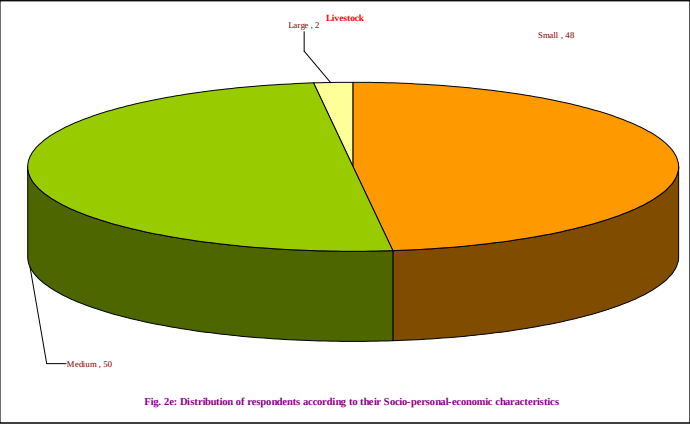


Fig. 2: Distribution of respondents according to their Socio-personal-economic characteristics



4.1.2 Psychological variables

4.1.2.1 Farming commitment

It can be confirmed from the Table 4.2 and Fig. 3 that, 60.00 per cent of the farmers had medium and 34.00 per cent had high farming commitment. Negligible (6%) per cent of the respondents had low farming commitment.

4.1.2.2 Economic motivation

It could be observed from Table 4.2 that the majority (81.33%) of the respondents had medium economic motivation. Only 10.67 per cent and 08.00 per cent had high and low economic motivation, respectively.

4.1.2.3 Risk orientation

Risk orientation of the respondents shown in the Table 4.2 indicated that majority (94.00 %) of the respondents had medium risk orientation, whereas 4.00 per cent and 02.00 per cent of the respondents had high and low level of risk orientation, respectively.

4.1.2.4 Scientific orientation

The data in Table 4.2 indicated that 91.33 per cent of the respondents had medium scientific orientation, whereas 04.67 per cent and 04.00 per cent of them had high and low level of scientific orientation.

4.1.3 Communication variables

4.1.3.1 Mass media participation

The results of mass media participation of respondents is presented in Table 4.3 and Fig. 4 and it could be observed that 44.00 per cent of the respondents subscribed newspaper. The regular reading behavior was found with 54.00 per cent respondents in case of agricultural articles and equal proportion (52.00 %) with respect to information/news and recreational articles. Farm magazine was subscribed by 12.00 per cent of the respondents only. Less proportion (12.67%) of the respondents read agricultural articles regularly and an equal percentage (14.00%) of the respondents read both news/information and recreational articles regularly. Regarding possession of radio sets, 20.67 per cent of the respondents possessed sets. The regular listening behavior was found with 38.00 per cent respondents for agricultural programmes and 39.33 per cent of the respondents listened radio for news and 40.00 per cent listened entertainment programmes.

Television sets were possessed by 94.00 per cent of the respondents. About an equal (98.00%) per cent of the respondents regularly viewed news and entertainment programmes. The occasional viewing behavior of the respondents was found with negligible percent (01.33%) of the respondents.

4.1.3.2 Extension participation

The data in Table 4.4 and Fig. 5 indicated that the majority of the respondents (66.00%) regularly participated in Krishimela. More than half of the respondents participated in training programme occasionally. While majority of participants never participated in study tours (96.67%), extension meetings (92.00%), field visits (90.00%), group discussions (54.00%) and agricultural exhibitions (53.12%).

4.1.3.3 Extension contact of the respondents

Regarding contact of farmers with extension personnel, it was observed from the Table 4.5 and Fig. 6 that during cropping season, 92.67 per cent of the respondents contacted private agency extension personnel 'whenever problems occurs' and 07.33 per cent 'never contacted' private agency extension personnel. The percentage of the respondents who contacted the Raita Samparka Kendra /Agriculture Department officials was 'never contacted' (10.00 %), 'once in a month' (22.67%), 'once in a fortnight' (22.50%), 'whenever problem occurs' (32%) and 'once in a week' (15.33%). The percentage of the respondents 'who never' contacted officials of Horticulture Department was 64.00 per cent and 'whenever problem occurred' was 36.00 per cent. It was found that all the respondents 'never' contacted the KVK officers.

Table 4.2: Distribution of respondents according to socio psychological variables

(n=150)

Categories	Frequency	Percentage
Farming commitment		
Low < ($\bar{X} - 0.425$ SD)	09	06.00
Medium Between ($\bar{X} \pm 0.425$ SD)	90	60.00
High > ($\bar{X} + 0.425$ SD)	51	34.00
	Mean=19.15 S.D.=1.59	
Economic motivation		
Low < ($\bar{X} - 0.425$ SD)	12	08.00
Medium Between ($\bar{X} \pm 0.425$ SD)	122	81.33
High > ($\bar{X} + 0.425$ SD)	11	10.67
	Mean = 20.18 S.D.= 1.17	
Risk orientation		
Low < ($\bar{X} - 0.425$ SD)	03	02.00
Medium Between ($\bar{X} \pm 0.425$ SD)	141	94.00
High > ($\bar{X} + 0.425$ SD)	06	04.00
	Mean = 10.02 S.D = 0.425	
Scientific orientation		
Low < ($\bar{X} - 0.425$ SD)	06	04.00
Medium Between ($\bar{X} \pm 0.425$ SD)	137	91.33
High > ($\bar{X} + 0.425$ SD)	7	04.67
	Mean = 10.02 S.D = 0.580	

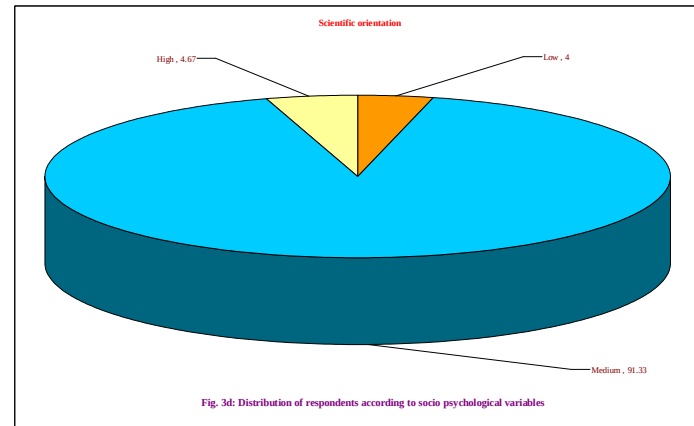
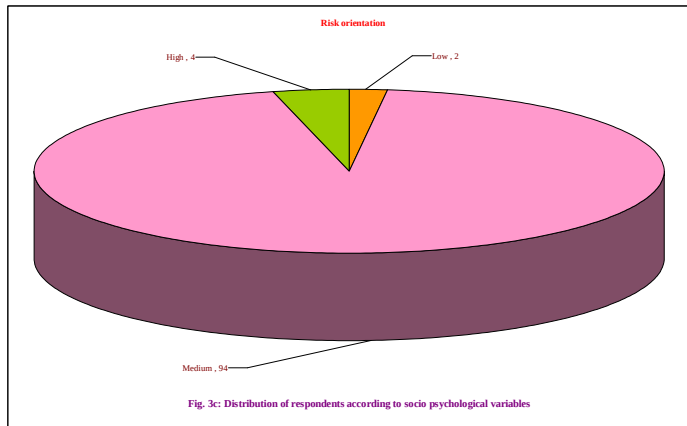
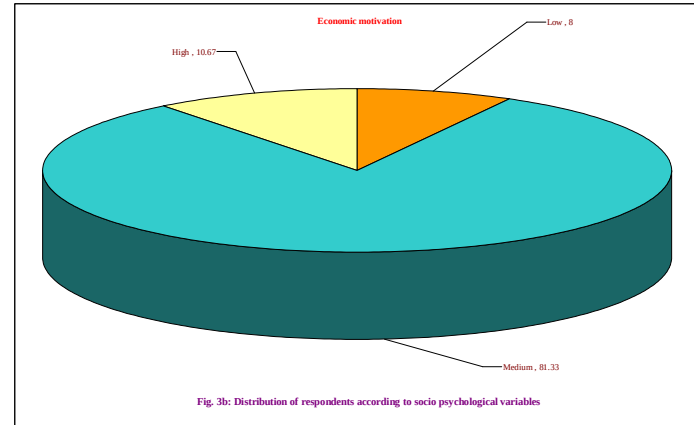
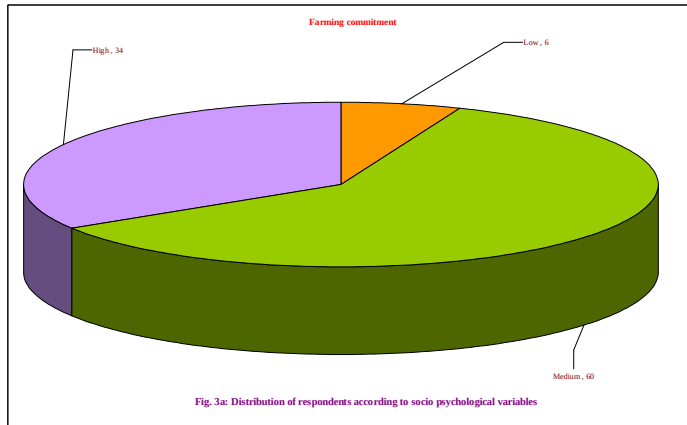


Fig. 3: Distribution of respondents according to socio psychological variables

Table 4.3: Distribution of the respondents according to their mass media exposure

(n=150)

Mass media	Subscribed/ owned	Programmes	Frequency of use		
			Regular	Occasional	Never
			f (%)	f (%)	f (%)
Newspaper	66 (44.00)	Agricultural articles	81 (54.00)	6 (04.00)	63 (42.00)
		Information/News	78 (52.00)	6 (04.00)	66 (44.00)
		Recreational articles	78 (52.00)	6 (04.00)	66 (44.00)
Farm magazine	18 (12.00)	Agricultural articles	19 (12.67)	18 (12.00)	113 (75.33)
		Information / News	21 (14.00)	6 (04.00)	123 (82.00)
		Recreational articles	21 (14.00)	6 (04.00)	123 (82.00)
Radio	31 (20.67)	Agricultural programmes	57 (38.00)	45 (30.00)	48 (32.00)
		Information / News	59 (39.33)	16 (10.67)	75 (50.00)
		Entertainment	60 (40.00)	9 (06.00)	81 (54.00)
Television	141 (94.00)	Agricultural programmes	145 (96.67)	2 (01.33)	3 (02.00)
		Information / News	147 (98.00)	0 (00.00)	3 (02.00)
		Entertainment	147 (98.00)	0 (00.00)	3 (02.00)

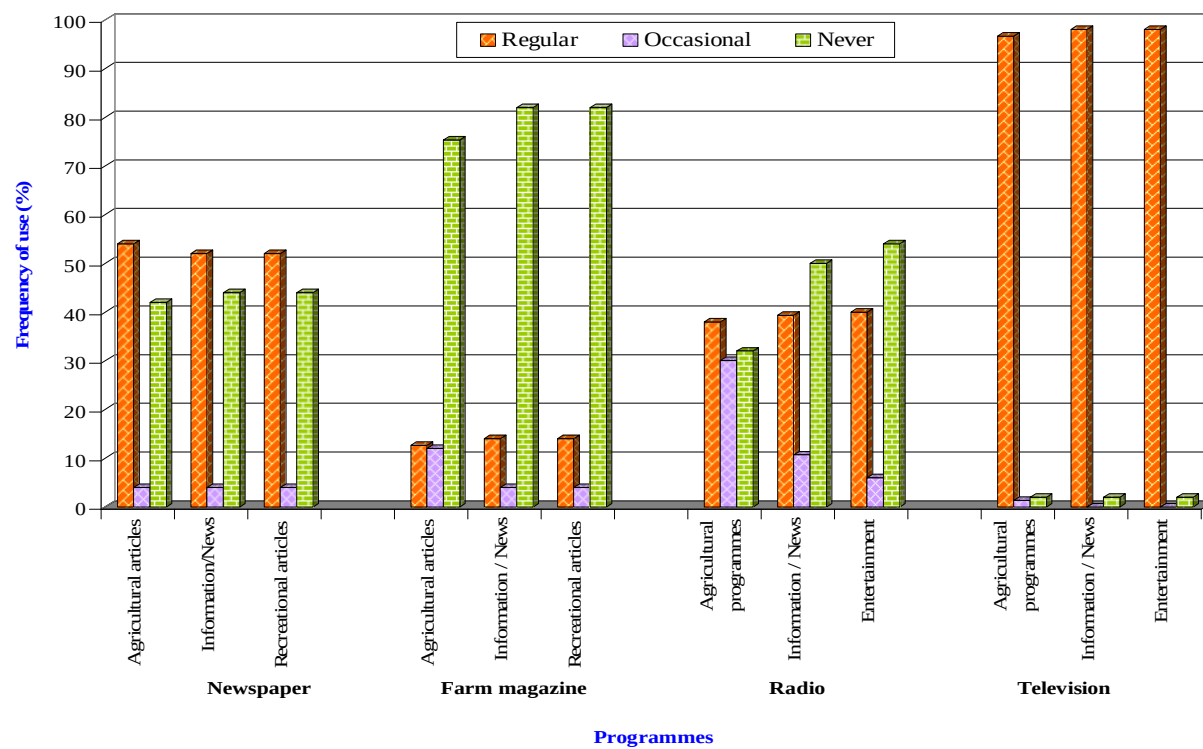


Fig. 4: Distribution of the respondents according to their mass media exposure

Fig. 4: Distribution of the respondents according to their mass media exposure

High majority (92%) of the respondent's never contacted university scientists and only 8 per cent respondents contacted them 'whenever problem occurred'. Only 4.67 per cent of the respondents 'never' contacted the Veterinary Officials, however remaining all (95.33%) contacted them 'whenever problem occurred'.

4.2 Farmers views on climate change

The results indicated (Table 4.6 and Fig. 7) that cent per cent of respondents observed changes in quantity of rainfall and 98.67 per cent noticed changes in the distribution pattern of the rains over the past 20 years. A perception of rainfall quantity and pattern is observed across three major seasons. About 90.67, 46.67 and 44.00 per cent noticed an increase in the amount of rainfall of about 23.90, 15.10 and 11.84 per cent from the normal during *kharif*, *rabi* and summer seasons, respectively. Similarly, about 9.33 per cent in *kharif* and more than half (53.33% and 56.00%) of the farmers in *rabi* and summer perceived that there was 21.60, 3.11 and 11.50 per cent decrease in rainfall quantity from the normal in the *kharif*, *rabi* and summer seasons, respectively.

About 15.33, 6.00 and 4.67 per cent of the respondents expressed that the distribution pattern of rainfall was predictable to the extent of 60, 70 and 81 per cent during *kharif*, *rabi* and summer seasons, respectively. However large majority (84.67%, 92.67%, 94.00%) of the respondents expressed that the distribution is unpredictable to the extent of 67.66 per cent, 73.39 per cent and 79.84 per cent in *kharif*, *rabi* and summer seasons, respectively.

Majority (70.67%, 83.33%, 98.00%) of the respondents mentioned that there is an increase in temperature to the extent of 16.47 per cent, 11.54 per cent and 24.25 per cent from the normal temperature during the *kharif*, *rabi* and summer seasons, respectively (Fig. 6). The results indicated that 90.67 per cent of respondents perceived that relative humidity is increasing in *kharif* of an extent of 15.75 per cent. On the other hand, almost an equal proportion of farmers (52.00% and 56%) perceived that the region is getting drier of an extent 9.03 per cent during *rabi* and 15.38 per cent in summer (Fig. 7).

Majority of farmers (98.67 %) perceived that there is an increase in scorching sunshine hours during summer season of an extent of 21.21 per cent and only one-third (33.33%) and 12.00 per cent of the farmers expressed decrease in scorching sunshine hours during *kharif* followed by *rabi* on average extent of 5.50 per cent (Fig. 6).

4.3 Reasons for climate change as perceived by the farmers

Data about the perceived reasons for climate change by the respondents is presented in Table 4.7 and Fig. 8. More than half of the respondents expressed that the reasons for climate change were deforestation (58.00%), gas emission by industries and automobiles (53.33%) and population explosion (52.00%). Less than half of the respondents quoted urbanization (42.00%), commercialization of agriculture (40.00%) and burning of farm waste (26.00%) as the reasons for climate change.

4.4 Effect of climate change on agriculture and livestock as felt by farmers

4.4.1 Effects of climate change on agriculture as perceived by farmers in the last two decades

Farmers shared some experience of changing climate and its impact on agricultural practices (Table 4.8 and Fig. 9). Responses were elicited for twenty eight farm practices. Majority of the respondents expressed that climate change has resulted in negative impacts on most of the farm practices. For some of the farm practices, no effects were observed by the respondents. Time of application of chemical fertilizer, intercultural operations, use of pesticides, overall health of the crop were the four practices in which all the respondents noticed negative impacts. However the percent variation as expressed by them for these practices varied which was 30.42 percent for time of application of chemical fertilizer, 31.42 per cent for intercultural operations, 9.50 per cent for use of pesticides and 35.25 per cent for overall health of the crop.

Table 4.4: Distribution of respondents according to their level of extension participation

(n=150)

Extension activities	Extent of participation		
	Regular f (%)	Occasional f (%)	Never f (%)
Krishimela	99 (66.00)	12 (08.00)	39 (26.00)
Training programme	13 (08.67)	84 (56.00)	53 (35.33)
Extension meetings	03 (02.00)	09 (06.00)	138 (92.00)
Group discussions	03 (02.00)	66 (44.00)	81 (54.00)
Field visits	02 (01.33)	13 (08.67)	135 (90.00)
Agricultural exhibitions	02 (01.33)	16 (10.67)	132 (88.00)
Study tour	02 (01.33)	03 (02.00)	145 (96.66)

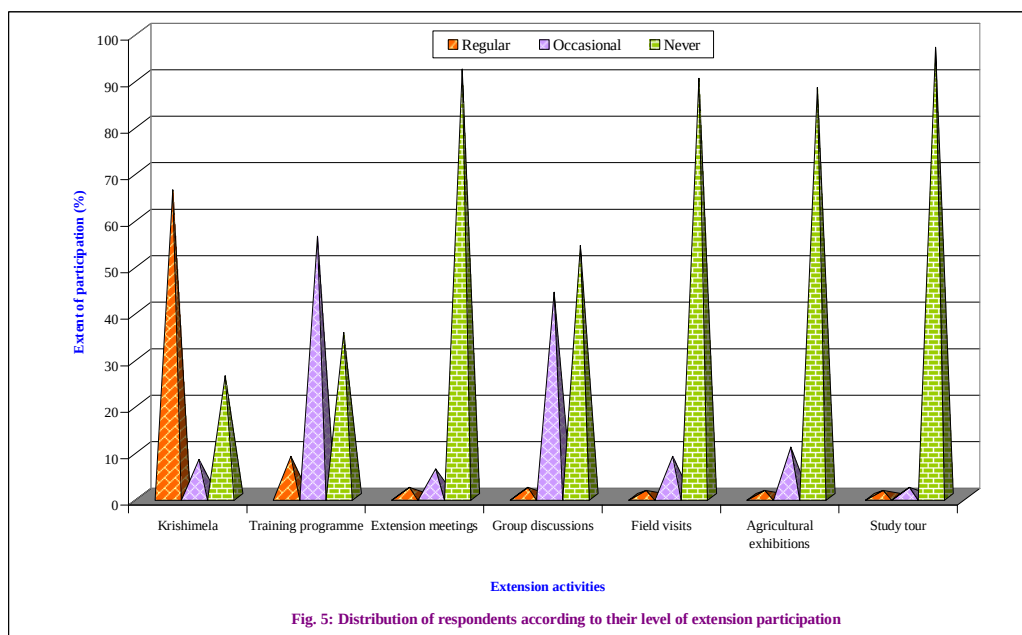


Fig. 5: Distribution of respondents according to their level of extension participation

Table 4.5: Distribution of respondents according to their level of extension contact

(n=150)

Extension workers	Once in a week f (%)	Once in a fortnight f (%)	Once in a month f (%)	Whenever problem arises f (%)	Never f (%)
RSK /Agri dept officials	23 (15.33)	30 (20.00)	34 (22.67)	48 (32.00)	15 (10.00)
Officials of horticultur dept	0 (00.00)	0 (00.00)	0 (00.00)	54 (36.00)	96 (64.00)
KVK experts	0 (00.00)	0 (00.00)	0 (00.00)	0 (00.00)	150 (100.00)
UAS scientists	0 (00.00)	0 (00.00)	0 (00.00)	12 (08.00)	138 (92.00)
Private extension agency	0 (00.00)	0 (00.00)	0 (00.00)	139 (92.67)	11 (07.33)
Veterinary Officials	0 (00.00)	0 (00.00)	0 (00.00)	143 (95.33)	7 (04.67)

RSK: Raita Samparka Kendra
KVK: Krishi Vigyan Kendra
UAS: University of Agricultural Sciences

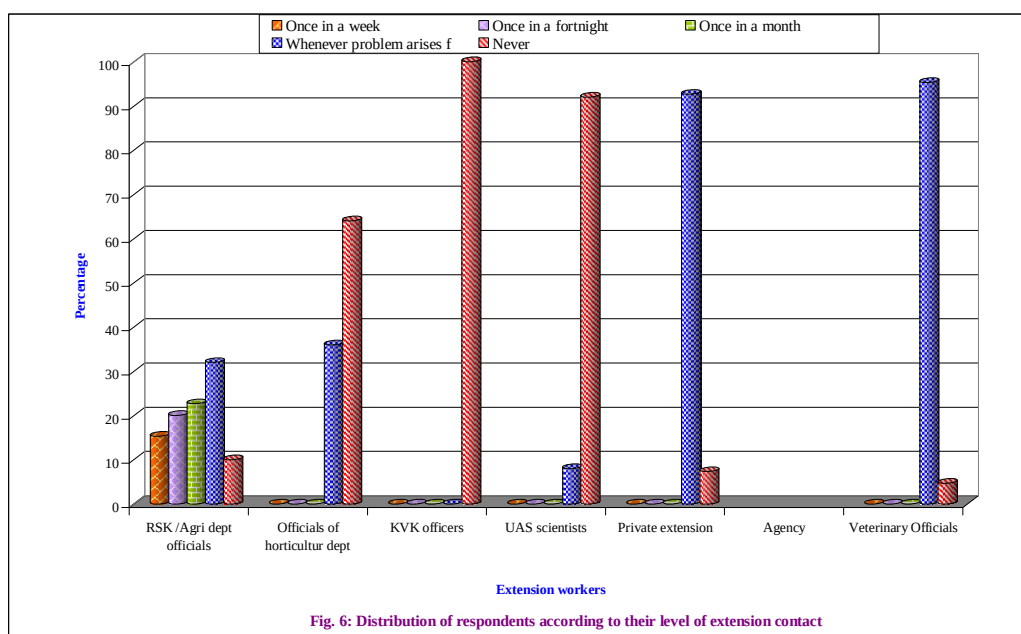


Fig. 6: Distribution of respondents according to their level of extension contact

Table 4.6: Distribution of the respondents according to their views on Seasonal variation in climate

(n=150)

Weather parameters		Seasonal variation as perceived by the farmers					
		<i>Kharif</i> f (%)	Per cent variation	<i>Rabi</i> f (%)	Per cent variation	Summer f (%)	Per cent variation
Rain fall							
a. Quantity							
i.	Increasing	136 (90.67)	23.90	70 (46.67)	15.10	66 (44.00)	11.84
ii.	Decreasing	14 (09.33)	21.60	80 (53.33)	13.11	84 (56.00)	11.50
b. Distribution pattern							
i.	Predictable/uniform	23 (15.33)	60.00	09 (6.00)	70.00	07 (04.67)	81.00
ii	Unpredictable/erratic	125 (84.67)	67.66	139 (92.67)	73.39	141 (94.00)	79.84
iii	Constant	00 (00.00)	00.00	02 (01.33)	00.00	02 (01.33)	00.00
Temperature							
a.	Increasing	106 (70.67)	16.47	125 (83.33)	11.54	147 (98.00)	24.75
b.	Decreasing	44 (29.33)	5.86	25 (16.67)	10.11	03 (02.00)	22.50
Relative humidity							
a.	Increasing	136 (90.67)	15.75	68 (45.33)	10.75	66 (44.00)	09.14
b.	Decreasing	09 (6.00)	11.67	78 (52.00)	09.03	84 (56.00)	15.38
c.	Can't say	05 (3.33)	00.00	04 (02.67)	00.00	00 (00.00)	0.00
Sunshine							
a.	Increasing	97 (64.67)	7.46	130 (86.67)	09.85	148 (98.67)	21.21
b.	Decreasing	50 (33.33)	05.60	18 (12.00)	05.42	00 (00.00)	00.00
c.	Can't say	03 (02.00)	00 (0.0)	2 (01.33)	00.00	02 (01.33)	00.00

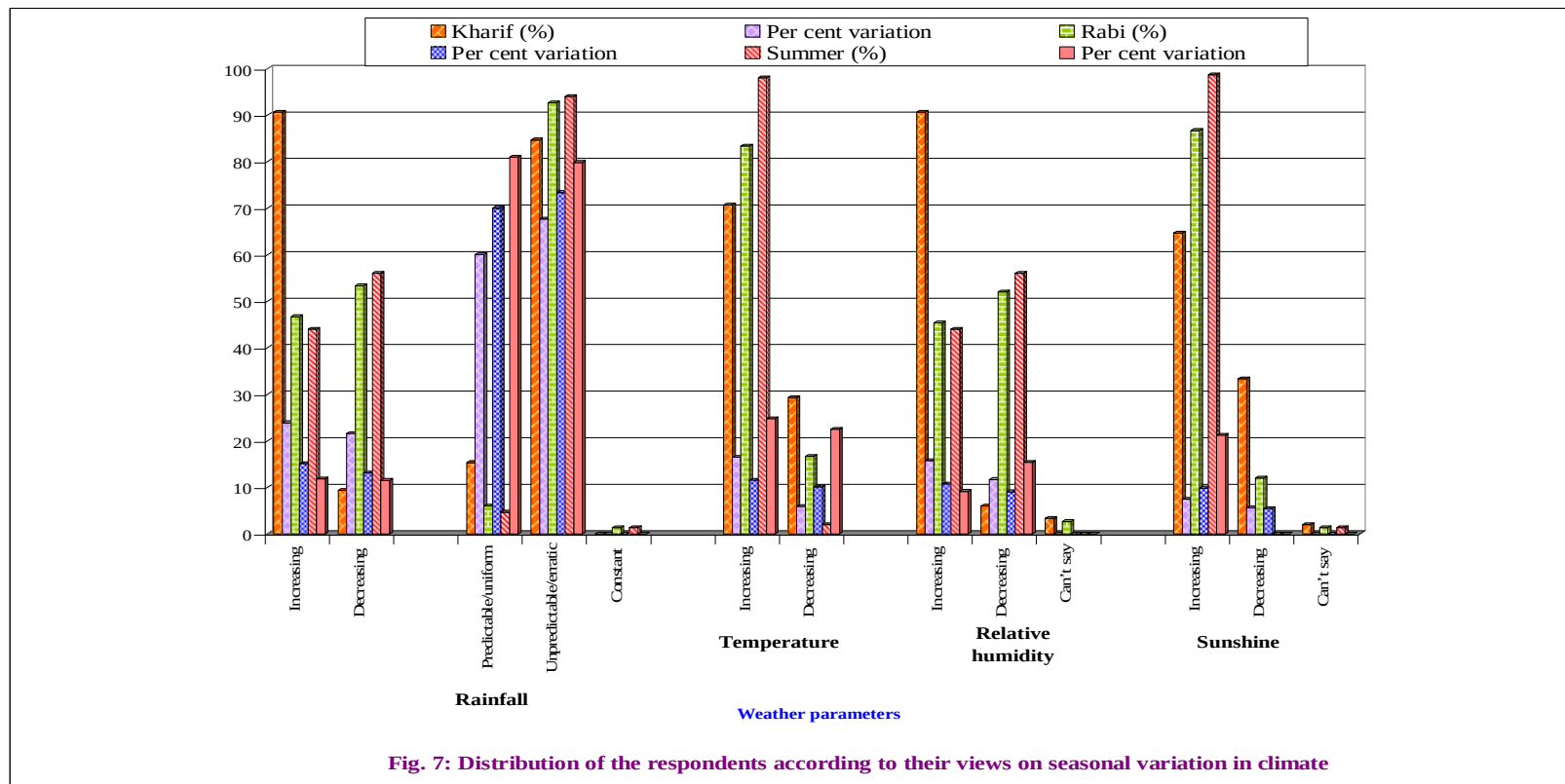


Fig. 7: Distribution of the respondents according to their views on seasonal variation in climate

Table 4.7: Distribution of the respondents according to their perceived reasons for climate change

(n=150)

Reasons	Frequency	Percentage
Deforestation	87	58.00
Gas emission by industries and automobiles	80	55.33
Population explosion	78	52.00
Urbanisation	63	42.00
Commercialisation of agriculture	60	40.00
Burning of farm waste	39	26.00

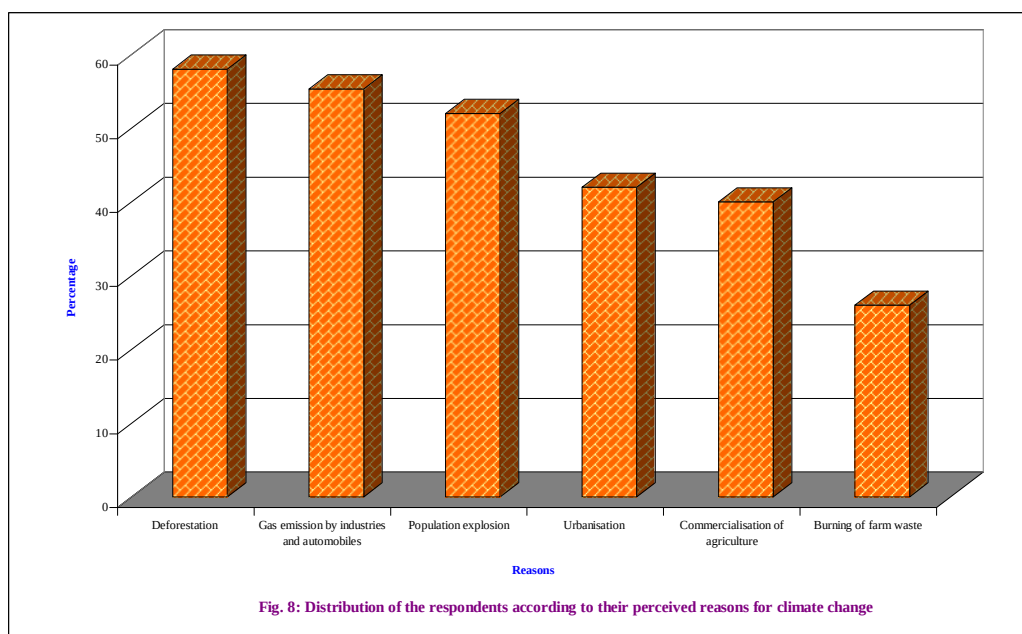


Fig. 8: Distribution of the respondents according to their perceived reasons for climate change

Table 4.8: Distribution of the respondents according to their perceived effects of climate change on agriculture in the last 2 decades

(n=150)

Sl. No.	Farming practices	Effect of climate change		Per cent variation
		Negative f (%)	No effect f (%)	
1.	Soil fertility	135 (90.00)	15 (10.00)	21.90
2.	Crops grown	145 (96.67)	05 (03.33)	39.68
3.	Cropping pattern	138 (92.00)	12 (08.00)	32.00
4.	Variety selection	80 (53.33)	70 (46.67)	90.00
5.	Land preparation	135 (90.00)	15 (10.00)	46.34
6.	Sowing time	128 (85.33)	22 (14.67)	30.50
7.	Spacing	138 (92.00)	12 (08.00)	47.57
8.	Seed rate	02 (01.33)	148 (98.67)	---
9.	Seed treatment	28 (18.67)	122 (81.33)	----
10.	FYM application	22 (14.67)	128 (85.33)	----
11.	Use of chemical fertilizer	135 (90.00)	15 (10.00)	22.98
12.	Time of application of chemical fertilisers	150 (100.00)	00 (00.00)	30.42
13.	Intercultural operations	150 (100.00)	00 (00.00)	31.42
14.	Intensity of weeds	147 (98.00)	03 (02.00)	48.05
15.	Insect, Pest infestation	138 (92.00)	12 (08.00)	21.00
16.	Disease infestation	135 (90.00)	15 (10.00)	09.50
17.	Pesticide use	150 (100.00)	00 (00.00)	09.50
18.	No .of Irrigation	134 (89.33)	16 (10.67)	15.80
19.	Harvesting	147 (98.00)	03 (02.00)	24.73
20.	Grain Yield qty	147 (98.00)	03 (02.00)	30.35
21.	Grain yield quality	140 (93.33)	10 (6.67)	29.13
22.	Straw yield obtained	132 (88.00)	18 (12.00)	26.00
23.	Storage duration	100 (66.67)	50 (33.33)	----
24.	Market price	70 (46.67)	80 (53.33)	35.28
25.	Overall health of the crop	150 (100.00)	00 (00.00)	35.25
26.	Shelf life of the crop	147 (98.00)	03 (02.00)	15.33
27.	Storage pests and diseases	105 (70.00)	45 (30.00)	---
28.	Taste of the produce	117 (78.00)	33 (22.00)	23.33

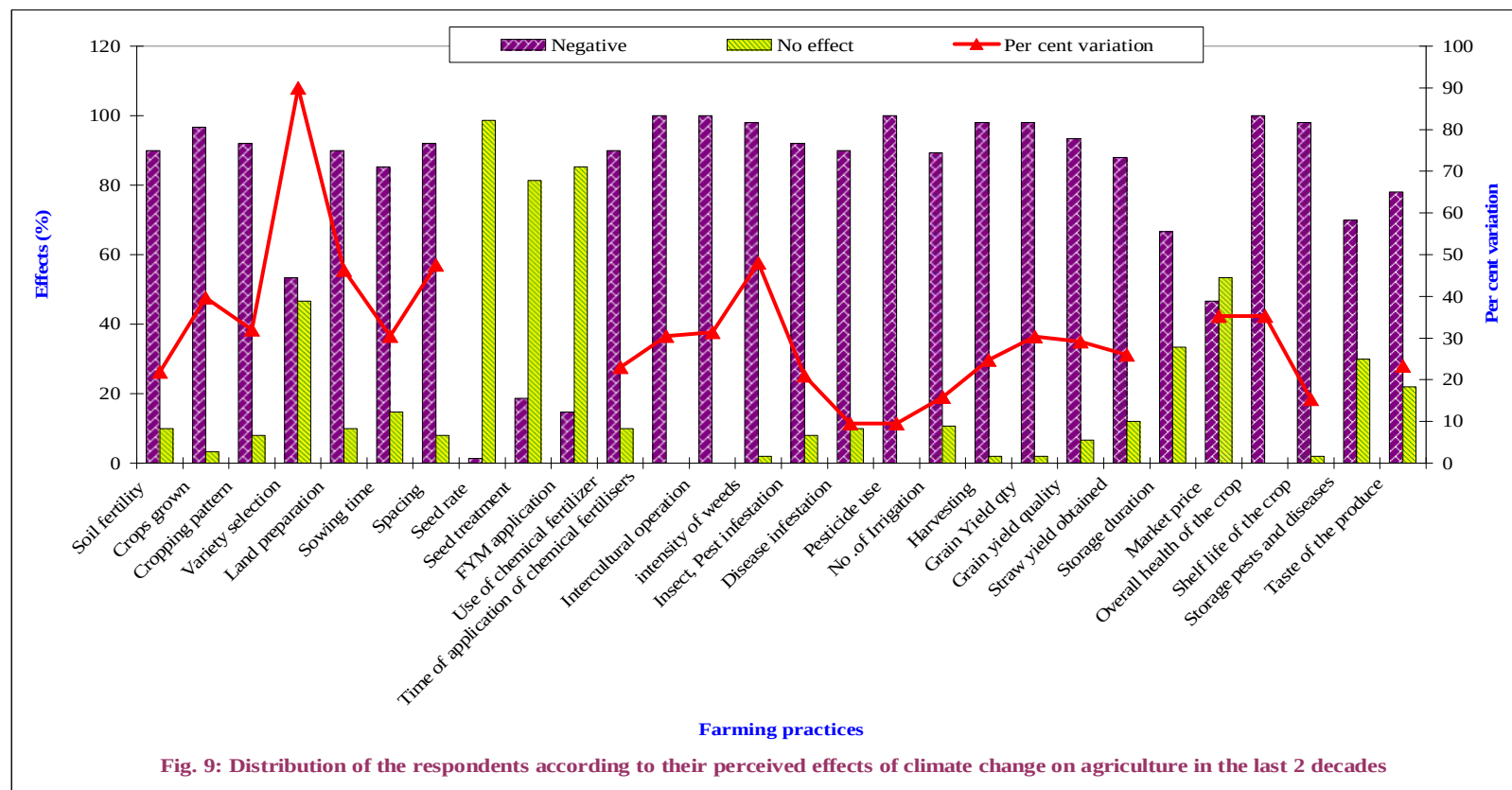


Fig. 9: Distribution of the respondents according to their perceived effects of climate change on agriculture in the last 2 decades

Closely followed by these were the practices, with negative impacts as expressed by almost all the respondents along with their percent of observed variation, such as, intensity of weeds (98%, 48.05%), harvesting (98%, 24.73%) , grain yield (98%, 30.35%) and shelf life of the crop (98%, 15.33%).

Among the remaining practices, 90 or more than 90 percent of the respondents mentioned negative impact for 9 practices. Those along with percentages of respondents and observed variation were soil fertility (90%, 21.90%), crops grown (96.67%, 39.68%), cropping pattern (92%, 32%), land preparation (90%, 46.34%), spacing (92%, 47.57%), use of chemical fertilizer (90%, 22.98%), insect and pest infestation (92%, 21%), disease infestation (90%, 9.50%) and grain yield quality (93.33%, 29.13%).

Large majority of the respondents observed negative impacts with observed percent variation for sowing time (85.33%, 30.50%), number of irrigations required (89.33%, 15.80%) and for straw yield obtained (88%, 26%).

Negative impact on the taste of the produce was expressed by 78 percent of the respondents with the observed percent variation from the normal to the extent of 23.33 percent.

Practices like variety selection (53.33%), storage duration (66.67%), storage pests (70%), market price (46.67%) received mixed responses from the respondents as almost half of them mentioning negative and the rest mentioned no impacts. However majority respondents mentioned that climate change had no effect on seed rate used (98.67%), seed treatment practices (81.33%) and FYM application (85.33%),

4.4.2 Effects of climate change on livestock as perceived by farmers in the last two decades

The impact of climate change on live stock was documented by considering the criteria of direct and indirect effects. Table 4.9 and Fig. 10 vividly explains that the negative effects of climate change on livestock as experienced by more than 90 per cent of the respondents with percent variation were hours of grazing (42%) , hours of stall feeding (22.32%), utilization of concentrate feeds (23.05%), availability of concentrate feeds (21.30%), availability of dry fodder (32.55%), extent of milk yield (14.95%), number of livestock reared (45.12%), type of livestock reared (47.10%), cost of rearing (72.95%) and cost of feeds (73.00%).

It can be seen from the table that more than 80 per cent respondents have observed negative impacts with observed percent variation on quantity of concentrate feeds (24.50%), quality of dry fodder (32.75%), utilization of dry fodder (34.04%), method of rearing livestock (39.00%) and purpose of rearing livestock (14.26%).

Large percentage of the respondents with their observed percent of variation expressed as having negative impacts on fodder utilization from common lands (78%, 26.06%), fodder availability from common lands (77.33%, 25.71%), availability of green fodder (72%, 28%) and utilisation of green fodder (74%, 26%).

Negative impact of climate change on strength of bullocks was expressed by 65.33 percent of respondents with the variation of 39 percent from the normal. However half of the respondents expressed negative impacts with observed percent variation from the normal on number of diseases to the livestock (25.62%), quality of green fodder (28%) and quality of fodder from common lands.

Livestock activities related to market linkages, however received positive impacts, though they might not be related to climate change directly but are influenced indirectly. Almost all the respondents observed positive impact on price of the milk and price of the livestock with almost equal percent of observed variation (71.14% and 71.68%).

Table 4.9: Distribution of the respondents according to their perceived effects of climate change on livestock in the last 2 decades

(n=150)

Subject	Effect of climate change			Per cent variation
	Positive f (%)	Negative f (%)	No effect f (%)	
Type of livestock reared	00 (00.00)	140 (93.33)	10 (6.67)	47.10
Number of livestock reared	00 (00.00)	140 (93.33)	10 (6.67)	45.12
Purpose of rearing livestock (milk, FYM, both, meat)	00 (00.00)	134 (89.33)	16 (10.67)	14.26
Number of diseases to the livestock	00 (00.00)	75 (50.00)	75 (50.00)	25.62
Extent of milk yield	00 (00.00)	144 (96.00)	06 (04.00)	14.95
Strength of bullocks	00 (00.00)	98 (65.33)	52 (34.67)	23.11
Method of rearing livestock	00 (00.00)	120 (80.00)	30 (20.00)	39.00
Price of the milk	144 (96.00)	00	06 (04.00)	71.14
Price of the livestock	144 (96.00)	00	06 (04.00)	71.68
Cost of rearing	00 (00.00)	144 (96.00)	06 (04.00)	72.95
Cost of feeds	00 (00.00)	144 (96.00)	06 (04.00)	73.00
Fodder availability from common lands	00 (00.00)	116 (77.33)	34 (22.67)	25.71
Fodder utilization from common lands	00 (00.00)	117 (78.00)	33 (22.00)	26.06
Quality of fodder from common lands	00 (00.00)	76 (50.67)	74 (49.33)	---
Availability of green fodder	00 (00.00)	108 (72.00)	42 (28.00)	25.90
Utilization of green fodder	00 (00.00)	111 (74.00)	39 (26.00)	27.73
Quality of green fodder	00 (00.00)	70 (46.67)	80 (53.33)	28.00
Availability of dry fodder	00 (00.00)	138 (92.00)	12 (08.00)	32.55
Utilization of dry fodder	00 (00.00)	129 (86.00)	21 (14.00)	34.04
Quality of dry fodder	00 (00.00)	125 (83.33)	25 (16.67)	32.75
Availability of concentrate feeds	00 (00.00)	141 (94.00)	09 (6.00)	21.30
Utilisation of concentrate feeds	00 (00.00)	140 (93.33)	10 (06.67)	23.05
Quality of concentrate feeds	00 (00.00)	129 (86.00)	21 (14.00)	24.50
Hours of stall feeding	00 (00.00)	147 (98.00)	03 (02.00)	22.32
Hours of grazing	00 (00.00)	150 (100.00)	00 (00.00)	42.00

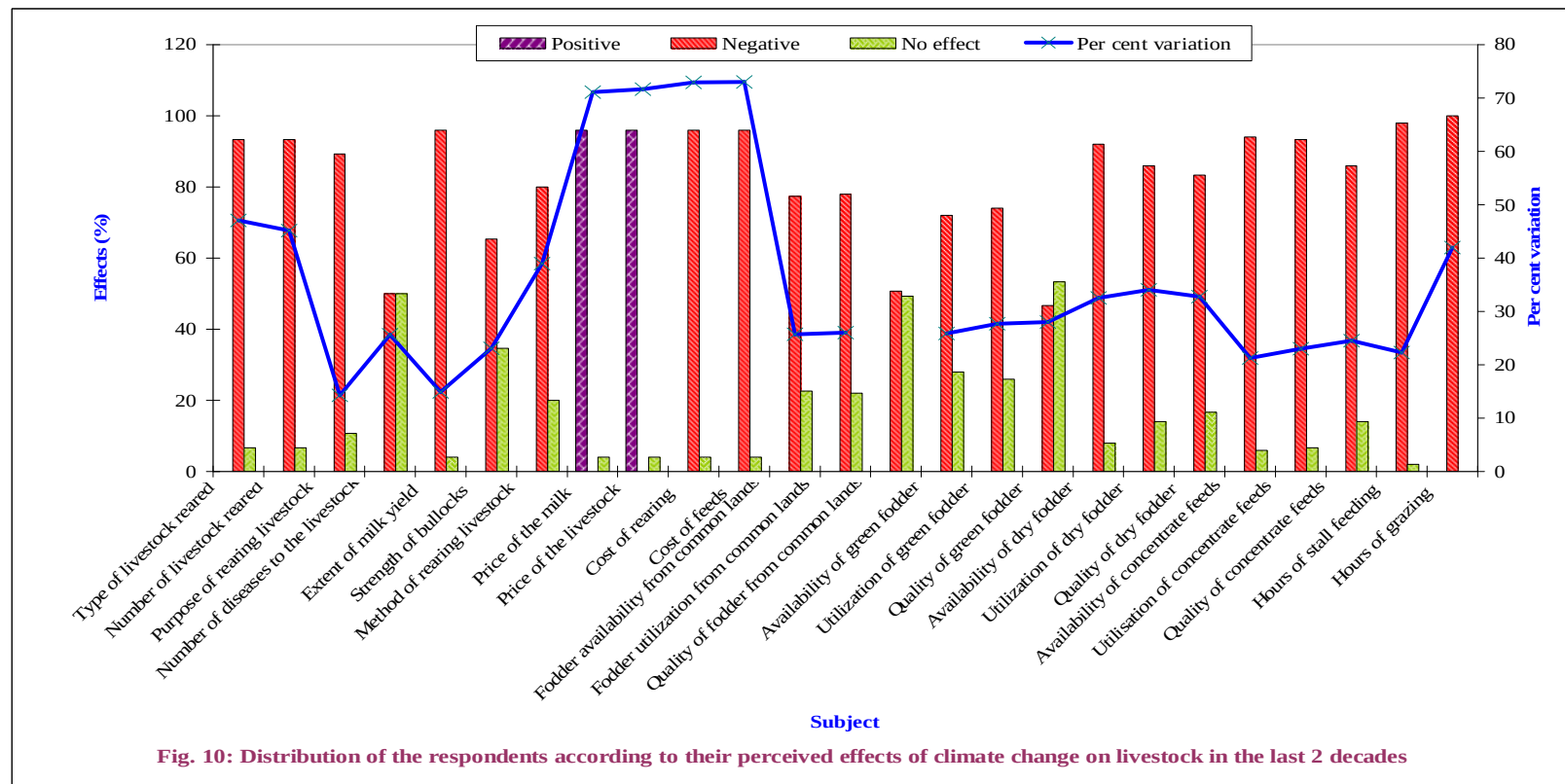


Fig. 10: Distribution of the respondents according to their perceived effects of climate change on livestock in the last 2 decades

4.5 Suggestions of the farmers to mitigate the climate change effect

4.5.1 Specific suggestions of the farmers to mitigate climatic effect on each farm practices

Farmers should be able to adapt in order to reduce negative impact of climate change. This section focuses on the various adjustments that farmers in the survey made in their farming activities to overcome changes in the climate. Different specific suggestions of the farmers to mitigate climatic effect on each farm practices followed are presented in Table 4.10.

In case of harvesting, all the farmers used to harvest crops at clear sunny days. Mulching, proper decomposing of FYM, frequent weeding and intercultivation are the practices followed by 99.00 per cent of the farmers to control weed growth. Exactly 90.00 per cent of the farmers changed their time of application of chemicals and fertilizers to evening hours and the same proportion of farmers changed number of intercultivation operations depending on the rainfall occurrence.

Majority (90.00%) of the farmers replaced traditional varieties like white sorghum, javari redgram, bengal gram and jaidhar cotton varieties (high pest incidence) with the high yielding varieties having characteristics of short duration, resistant to pests and diseases and climate resilient technologies and more than 80.00 per cent of the farmers used to apply more of FYM, chemical fertilizers and penning to reduce the loss of soil fertility.

Nearly three-fourth of the farmers kept land ready for sowing as soon as onset of rainfall and they are practicing summer deep ploughing in recent past and the same proportion of respondents applying FYM one month prior to the sowing date. Nearly two third (65.33 %) of the farmers changed their cropping pattern from mono cropping to diversified cropping pattern.

Half of the respondents used to apply fertilizers and FYM at proper moisture condition in case of lean rain fall period and make a solution of sheep pellet and cow dung, then sprayed it on the field. Compared to past two decades farmers were using higher quantity of chemical fertilizers. Less than half (44.00%) of the farmers practicing nursery preparation to cope with altered sowing dates. Farmers (42.00%) were practicing wider spacing in case of cotton, sorghum and soybean. In case of pest and disease infestation, farmers (24.67%) adapted to grow resistant varieties, applied neem and glyricidia leaves to overcome the frequency of damage. Twenty per cent of the respondents followed number of adaption strategies like pot irrigation method, sprinkler irrigation, drip irrigation and frequency of irrigation is also increased by the farmers and they used to irrigate during morning and evening hours.

4.5.2 Specific suggestions of the farmers to mitigate climatic effect on livestock management practices

Farmers are practicing some of the management practices in their farm level. Different specific suggestions of the farmers to mitigate climatic effect on livestock management practices are presented in the following paragraphs (Table 4.11).

Majority (86.00) of the farmers followed practices like more hours of grazing, growing green fodder during *kharif* and protecting straw by covering polythene to avoid shortcoming of dry fodder during offseason period. To overcome the shortage of availability of concentrate feeds, respondents (72.00%) prepared homemade concentrates by using grain husk, cereals, pulses and grain powder left out during milling. Nearly half of the farmers reduced number of livestock and are rearing high milk yielding breeds like Holstein Friesian and New Jersey. Same proportion of farmers used green fodder as a feed instead of dry fodder, smearing oil and frequent spraying of water over the body during summer to avoid reduction in milk yield. Farmers (30.00%) replaced large ruminants (buffaloes and cows) with the small ruminants (sheep and goat).

Table 4.10: Distribution of respondents on the basis specific suggestions to mitigate climatic effect on each farm practices

(n=150)		
Farming practices	Farmers Suggestions	f (%)
Soil fertility	Applying more of FYM, Penning and use of More chemical fertilizer	127 (84.67)
Variety selection	Changing from traditional varieties (white sorghum, Javari red gram, Bengal gram And Jaidhar cotton variety) to HYV	138 (92.00)
Cropping pattern	More diversified cropping pattern like Mixed cropping, inter cropping and alternate cropping	98 (65.33)
Land preparation	Keeping ready, as soon as rainfall occurs for sowing, summer deep ploughing. Digging of soil by spade or plough.	108 (72.00)
Sowing time	Crops grown in nursery, depending on rain fall occurrence.	66 (44.00)
Spacing	Wider spacing in cotton, sorgam and soyabean	63 (42.00)
FYM application	Applying one month early, spreading evenly, long term decaying. More use chemical fertilizers comparatively	114 (76.00)
Use of Chemical fertilizer	More use chemical fertilizers comparatively. Application of liquid fertilizer. Farmers used to make a solution of sheep, cow dung etc., and then sprayed it in the field	78 (52.00)
Time of application	Applying after rain fall stops or spraying during evening	135 (90.00)
Intercultural operation	Number depending on rain fall distribution	135 (90.00)
Weed growth	Frequent weeding, inter cultivation and proper sun burning of FYM and soil	99 (66.00)
Insect, Pest infestation	Growing resistant varieties	37 (24.67)
Disease infestation	Growing resistant varieties	37 (24.67)
Pesticide use	Applying after rain fall stops or spraying during evening and irrigating after spray if rain fall to occur.	45 (30.00)
No. of Irrigation	Increased no. of irrigation. Pot irrigation- keep the pot near the base of the plant making a whole at the bottom so that water can penetrate directly to root zone.	30 (20.00)
Harvesting	Harvesting at clear sunny day	150 (100.00)
Grain Yield qty	Growing HYV along with resistant variety to climatic variations	22 (14.67)
Storage pests and diseases	Smearing by red soil, neem and pongamia leaves application, foaming by burning of waste	105 (70.00)
Taste of the produce	Harvesting at appropriate time	33 (22.00)

Table 4.11: Distribution of respondents on the basis specific suggestions to mitigate climatic effect on livestock management practices

(n=150)

Livestock management practices	Farmers Suggestions	f (%)
Type of livestock reared	Rearing small ruminants like sheep and goat instead buffaloes and cow	45 (30.00)
Number of livestock reared	Rearing high milk yielding, drought resistant breeds	80 (53.33)
Extent of milk yield	Using more green fodder, smearing oil to the body and frequent spraying of water to the body during summer	75 (50.00)
Strength of bullocks	Providing additional concentrate feeds and dripping of calcium during summer	18 (12.00)
Availability of dry fodder	More hours of grazing, growing green fodder during <i>Kharif</i> and protecting straw by using polythene	129 (86.00)
Availability of concentrate feeds	Preparing at home using grain husk, cereals, pulses and grain powder left out during milling	108 (72.00)
Hours of grazing	Grazing during morning and evening hours and stall feeding in between	30 (20.00)

Table 4.12: Distribution of respondents on the basis of overall suggestions to mitigate effect of climate change

(n=150)

Sl. No.	Suggestions	Frequency	Percentage
1.	Afforestation	87	58.00
2.	Make awareness about climate change and adaptation strategies	83	55.33
3.	Decomposing of farm waste and by products instead of burning	78	52.00
4.	Control on use of farm machineries and automobiles	63	42.00
5.	Less dependency on external inputs and more on locally available resources	39	26.00
6.	Promotion of organic farming	39	26.00
7.	Efficient soil and water management strategies like mulching, contour bunds, Farm pond and drip irrigation.	33	22.00
8.	Use of renewable energy sources like solar energy, bio gas, power generation from water.	18	12.00
9.	Government intervention to reduce carbon dioxide emission	15	10.00
10.	Providing subsidies to climate proof technologies	15	10.00

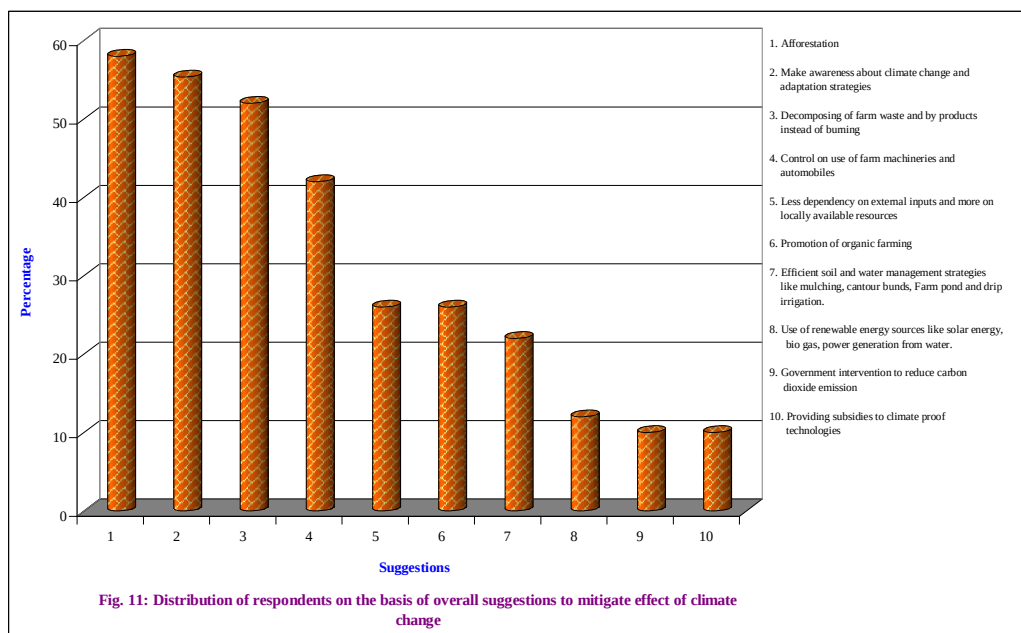


Fig. 11: Distribution of respondents on the basis of overall suggestions to mitigate effect of climate change

Grazing during morning and evening hours and stall feeding in between were the practices followed by respondents (20.00%) for avoiding grazing during scorching sunny hours. As a measure to avoid reduction in strength of bullocks 12.00 per cent of the farmers added concentrate feeds and dripping of calcium during summer season.

4.5.3 Overall suggestions of respondents to mitigate effect of climate change

The information presented in Table 4.12 and Fig. 11 mentions the overall suggestions given by the farmers to mitigate the effect of climate change. It is clear from the table that, majority (58.00%) of the respondents suggested afforestation, followed by 55.33 per cent of the respondents suggested to create awareness about climate change and adaptation strategies, 52.00 per cent of the farmers suggested decomposing of farm wastes and residues instead of burning. Further, 42.00 per cent of respondents suggested that there should be control on use of farm machinery and automobiles, followed by less dependency on external inputs and more on locally available resources (39.00%) and promotion of organic farming (26.00%).

About 22.00 per cent of the farmers expressed efficient soil and water management strategies, followed by use of renewable energy sources (12.00%) and 10.00 per cent of the respondents suggested providing subsidies to climate resilient technologies and government policy intervention to reduce carbon dioxide emission.

5. DISCUSSION

The findings of the study are discussed in this chapter under following headings. Since the research studies in this particular field were very scarce, the findings of the related studies are made use of to substantiate the results wherever possible.

- 5.1 Socio-personal-economic, psychological and communication characteristics of the respondents
- 5.2 Farmers views on climate change
- 5.3 Reasons for climate change as perceived by the farmers
- 5.4 Effect of climate change on agriculture and livestock as felt by farmers
- 5.5 Suggestions of the farmers to mitigate the climate change effect

5.1 Socio-personal-economic, psychological and communication characteristics of the respondents

5.1.1 Socio-personal-economic characteristics

5.1.1 Age

Majority (66.00%) of the respondents belonged to middle age group, followed by old and very old age categories. Middle aged farmers have not only higher perception ability, but also have higher recollecting ability of past climatic events than older respondents. They also have more responsibility towards family than older and very old age respondents. These could be the reasons for the majority respondents belonging to middle age group.

5.1.2 Education

It could be observed from the Table 4.1 that 26.67 per cent of the respondents were illiterates, while 25.33 and 22.00 per cent of the respondents received education up to primary school and middle school, respectively. Some proportion (14.00%) of the respondents received education up to PUC and 07.33 per cent of the respondents were educated up to high school. Graduates accounted 04.67 per cent only. Study made purposive selection of respondents who are above 45 years of age. Comparatively poor economic status, poor infrastructure of education facilities might have restricted education level of majority of the respondents to middle school or no schooling at all.

5.1.3 Family size

It is clear from the Table 4.1 that half of the respondents had big family (50.67%) and remaining half had small family size (49.33%). The possibilities of disintegration of joint family system, in some cases, to nuclear family system could be the reason for the present finding.

5.1.4 Farm size

It could be seen from Table 4.1 that 42.00 per cent of the respondents belonged to marginal land holding category, followed by small (30.0%) and big (28%) land holding categories. The fragmentation of ancestral land from generation to generation might have led to more number of marginal and small holdings.

5.1.5 Herd size

It could be seen from Table 4.1 that 50.00 per cent of the respondents had medium herd size and little less percent (48%) holding small herd size. Inclination to rear cross bred animal and availability of limited quantity of fodder and labour could be the reasons.

5.1.6 Farming experience

Majority (56.00%) of the farmers had 20 to 40 years of farming experience. Purposive selection of respondents of above 45 years might be the reason for the present finding. Further Nhemachena and Hassan (2007) reported that experienced farmers can perceive the things easily, effectively and have better knowledge and information on changes in climatic conditions in relation to crop and livestock management practices.

5.1.7 Annual income

It could be observed from the Table 4.1 that, 40.67 per cent of farmers had medium level of income (Rs. 34,000-51,000), 28.67 per cent had high level of income (above Rs. 51,000/-), followed by 25.33 per cent had semi-medium level of annual income (Rs. 17,000-34,000) and only 05.33 per cent of the farmers had low level of annual income (up to Rs. 17,000/-). Medium to high income groups have greater role in perception on effect of climate change on agriculture and livestock and strategies to overcome the risks (Semenza *et al.*, 2011). Good irrigation facility, high fertile soil in the farm of the respondents coupled with diversified occupation might have contributed for better economic conditions.

5.1.2 Psychological variables

5.1.2.1 Farming commitment

Sixty per cent of the farmers had medium farming commitment. The possible reason could be that due to good number of years of farm experience they might have learnt to cope up with the changing climatic conditions leading to less attrition in farming. Also their low education level and brought up in farm family since childhood might also be the reasons for the present finding.

5.1.2.2 Economic motivation

High majority of the farmers (81.33%) belonged to medium economic motivation followed by high (10.67%) and low (8.00%) economic motivation (Table 4. 2). The reason could be that high economic motivated farmers would be less vulnerable to climate induced adverse impacts. Generally such people would be engaged in high value commercial crops like vegetables, cotton, chilli etc. Therefore in the study only few of them had high economic motivation.

5.1.2.3 Risk orientation

Risk orientation of the respondents shown in the Table 4.2 indicated that majority (94.00 %) of the respondents had medium risk orientation. Medium risk bearing ability might be due to medium level of economic condition to overcome likely indebtedness by accepting only those technologies having assured income generation.

5.1.2.4 Scientific orientation

The data in Table 4.2 indicates that 91.33 per cent of the respondents had medium scientific orientation. This could be due to their level of education, extension participation, extension contacts and use of mass-media to educate themselves on new and emerging technologies. Besides, even medium level of economic condition might have also indirectly restricted them, to have orientation to try new scientific technologies.

5.1.3 Communication variables

5.1.3.1 Mass media participation

The data (Table 4.3) pertinent to mass media participation of respondents revealed that 44.00 per cent of the respondents subscribed newspaper. The regular reading behaviour was found to be 54.00 per cent in case of agricultural articles and equal proportion (52.00 %) with respect to information/news and recreational articles.

Farm magazine was subscribed by 12.00 per cent of the respondents only. Less proportion (12.67%) of the respondents read agricultural articles regularly and an equal percentage (14.00%) of the respondents read both news/information and recreational articles regularly. Reasons might be lack of awareness about availability of different farm magazines and also TV, a stronger medium was owned by almost all the respondents making it less necessary to subscribe to farm magazine. Regarding possession of radio sets, 20.67 per cent of the respondents possessed sets. The regular listening behaviour of the respondents was found to be 38.00 per cent with respect to agricultural programmes and 39.33 per cent of the respondent's listened to radio for news and 40.00 per cent account for regular entertainment programme listeners. Radio has certain advantages over Television. Farmers can listen to it while they work. This could be the reason why still one fifth of the respondent own radio and make use of it despite presence of much stronger medium.

Television sets were possessed by 94.00 per cent of the respondents. About an equal (98.00%) per cent of the members were regular viewers of news and entertainment programmes. The television viewing was also mainly used for the agricultural purposes along other programmes. The farming commitment, utility and convenient timing of the agricultural programmes could be the reasons for the present finding.

5.1.3.2 Extension participation

The data in Table 4.4 indicated that the majority of the respondents (66.00%) regularly participated in Krishimela. Krishimela is a yearly event organised in Dharwad itself, which forms the study area, with wide publicity and is much applauded in the state in terms of its vastness and coverage of subject matter of agriculture. Besides exhibitions, it provides platform for interactive sessions with scientists of varied specialisation and opportunity for the farmers to purchase reliable inputs. Due to the popularity, regularity, usefulness and vicinity majority might have had regular participation

More than half (56%) of the respondents, participated in training programmes occasionally. Training programmes are conducted by various line departments of the state to improve the knowledge and skills of the farmers. Usefulness of trainings might be the reason for more than half occasionally participating in it.

High majority of respondents never participated in study tours (96.66%), extension meetings (92.00%), field visits (90.00%), agricultural exhibitions (88%) and group discussions (54.00%) might be due to the lack of motivation and interest to participate. The result was in the line with the result of Gupta (1999).

5.1.3.3 Extension contact of the respondents

Regarding contact of farmers with extension personnel, it was observed from the Table 4.5 that during cropping season, 92.67 per cent of the respondents contacted private agency extension personnel 'whenever problems occurs' and 7.33 per cent 'never contacted' private agency extension personnel. Private agencies provide technical information while selling inputs like fertilizers, pesticides and credit facilities to farmers.

The percentage of the respondents in contact with the government agency extension personnel namely Raitha Sampark Kendra (RSK) /Agriculture department officials was 'never contacted' (10.00 %), 'once in a month' (22.67%), 'once in a fortnight' (22.50%), while 32 per cent contacted 'whenever problem occurs' and 15.33 per cent of the respondents contacted 'once in a week'. Easy accessibility as RSK is located at grassroot level (panchayat level) and regularity of staff could be the reasons.

The percentage of the respondents 'who never' contacted officials of horticulture department was 64.00 per cent. The possible reasons may be that, these offices are located at Taluka level and horticulture crops being less cultivated in the study area farmers might not felt the need to consult them.

The findings were in accordance with the findings of Kalakanavar (1999), who found that majority of the respondents had medium level of extension contact.

5.2 Farmers views on climate change

The results indicated (Table 4.6) that cent per cent of respondents observed changes in quantity of rainfall and 98.67 per cent noticed changes in the distribution pattern of the rains over the past 20 years.

A perception of rainfall quantity and pattern was observed across three major seasons. About 90.67, 46.67 and 44.00 per cent noticed an increase in the amount of rainfall of about 23.90, 15.10 and 11.84 per cent during *kharif*, *rabi* and summer seasons, respectively.

High majority (84.67%, 92.67% and 94.00%) of the respondents expressed that the distribution is unpredictable to the extent of 67.66 per cent, 73.39 per cent and 79.84 per cent in *kharif*, *rabi* and summer seasons, respectively.

The results revealed that 70.67, 83.33, 98.00 per cent of the respondents perceived long-term increase in temperature to an extent of 16.47, 11.54 and 24.25 per cent during the three distinctive seasons, respectively. Only 2.00 per cent of the respondent during summer of about an extent of 22.50 per cent noticed the contradictory, a decrease in temperature strikingly.

The results indicated that 90.67 per cent of the farmers perceived that relative humidity is increasing in *kharif* to an extent of 15.75 per cent. On the other hand, almost an equal proportion of farmers (52.00 and 56%) perceived that the region is getting drier to an extent 9.03 per cent during *rabi* and 15.38 per cent in summer seasons respectively.

Contrary to scorching summer, majority (98.67 %) of farmers perceived that there is increase in scorching sunshine hours during summer season to an extent of 21.21 per cent and only one-third (33.33%) and 12.00 per cent of the farmers experiencing decrease in scorching sunshine hours during *kharif* followed by *rabi* on average extent of 5.50 per cent.

In nutshell, large majority of the respondents mentioned increase in rainfall and relative humidity in *kharif* and increase in temperature in summer. The results of the study about climatic parameters however, appear to be in accordance with the general observations of meteorologists of the study area. The change in climate is experienced every where and so the results.

5.3 Reasons for climate change as perceived by the farmers

Data about the perceived reasons for climate change by the farmers is presented in Table 4.7. The major reasons expressed by the respondents were deforestation (58.00%), gas emission by industries and automobiles (53.33%) and population explosion (52.00%). The other reasons were urbanization (42.00%) followed by commercialization of agriculture (40.00%) and burning of farm waste (26.00%).

Respondents owing to their low education level and conscious thinking about reasons for climate change could mention only the most prominent reasons without mentioning the intricacies or more refined reasons. Many of them while conducting survey quoted 'God' for bringing changes in climate.

The data collected regarding perception is also in line with the report of India's Initial National Communication 11 (Annual report, 2009 and Sharma, M. and Amit, G., 2006), 15 sources qualify as key sources for changed climate. The key amongst is the energy and transformation industries that are power generation, which emits about 29.00 per cent of the total CO₂ equivalent emissions from India. This is followed by enteric fermentation, which contributes 15.30 per cent of the total CO₂ equivalent emissions. The rest of the key sources in the decreasing order of emissions are energy intensive industries, rice cultivation, transport, iron and steel production, residential sector using fuel for energy, biomass burnt for energy, cement production, commercial and institutional combustion, manure management, ammonia production and lastly land use, land use change and forestry sector.

The present findings are in conformity with the findings of Badami (2004), Kumar (2004), Ramesh and Purvaja (2004), Johzen (2005), Johnson *et al.* (2007) and Benedicta (2010).

5.4 Effect of climate change on agriculture and livestock as felt by farmers

5.4.1 Effects of climate change on agriculture as perceived by farmers in the last two decades

Despite technological advances, such as improved varieties, genetically modified organisms, and irrigation systems, weather is still a key factor in agricultural productivity, as well as soil properties and natural communities. The effect of climate on agriculture is related to variabilities in local climates rather than in global climate patterns. Hence climate effects on different crop production practices as perceived by the respondents were studied.

Cent percent of the respondents expressed negative effects of climate change on time of application of fertiliser, intercultural operations, pesticide use and overall health of the crop.

Application of fertiliser in relation to soil and air temperatures is important because these conditions affect plant growth and hence nutrient use. Fertiliser application should be timed to achieve maximum plant uptake, thereby reducing losses of nutrient to the environment. Consider also the amount of rainfall and/or irrigation experienced or expected. Change in climate, however, brought shift in time of application of fertiliser resulting in perceived negative impact. Robinson (1998) also reported similar results. Farmers expressed that application of fertiliser in high rainfall period as experienced by them in the last two decades resulted in leaching of nutrients applied and improper dissolution during drought period leading to the suffocation and burning impacts. Soil condition is necessary to take up intercultural operations either by bullocks or tractor. Rainfall affected this operation as farmers frequently could not get ideal soil condition to take this farm operation at right time of crop growth. MC.Clean and Colin (2005) observed increased rainfall increases pesticide cost. Empirically, they found that more rainfall increases pesticide usage costs for corn, wheat, soybeans, and potatoes while hotter weather increases pesticide costs for corn, cotton, soybeans and potatoes but decreasing the cost for wheat.

More than ninety percent of the respondents expressed negative impacts of climate change on weed growth (98%), harvesting (98%), grain yield (98%), shelf life of the crop (98%), crops grown (96.67%), quality of grain yield (93.33%), cropping pattern (92.00%), spacing (92%), insect and pest infestation (92%), land preparation (90%), soil fertility (90.00%), use of chemical fertiliser (90%) and disease infestation (90%).

Farmers perceived negative impact on weed growth as a result of increased crop weed competition compared to earlier. A very important point to consider is that weeds would undergo the same acceleration of cycle as cultivated crops, and would also benefit from carbonaceous fertilization. Since most weeds are C3 plants, they are likely to compete even more than now against C4 crops such as corn. An increase in rainfall in study areas would lead to an increase of atmospheric humidity and the duration of the wet seasons. Combined with higher temperatures, these could favor the development of insects and diseases like bugs and thrips (hard bodied), smuts, powdery mildew and downey mildew. Similarly, because of higher temperatures and humidity, there could be an increased pressure from insects and disease vectors. This finding is in agreement with the findings of FAO (2005) and Maitra *et al.* (2008). Weeds, pests and diseases are the strong reasons that directly affect the grain yield and its quality and indirectly on the shelf life of the crop. According to researchers in the US who looked at historical data on crop production and weather, climate change will reduce production of five staple crops in Sub-Saharan Africa – maize, sorghum, millet, groundnut and cassava – by a mean of between 8 and 22%. And in all cases except cassava there's a 5% chance that yields could drop by more than 27%. Negative effect on the cropping pattern might be due to variation in climate like long dry spells and sudden intensified rainfall. The similar finding was reported by Meinke *et al.* (2004). Usually 15-20 days early or delay in onset of rainfall leads to alteration in the sowing date, (to match the correspondent rainfall initiation) the finding is in concurrence with the findings expressed by Vernon (1994). Regarding quantity of grain yield farmers were observing fluctuation in year to year yield due to regular vagaries in climate. This is in concurrence with the findings expressed by Sinha and Swaminathan (1991) and Rao and Sinha (1994).

More than three fourth of the respondents expressed negative changes in number of irrigation (89.33%), withstanding water shortages of crops by evaporation and evapo transpiration there is need to aggregate intensification in number of irrigations. Farmers encountering intensification in number of irrigation as a result of increased scorching sunny hours and temperature leading to more water loss in all the stages, the finding is in accordance with the findings reported by Fischer *et al.* (2002). Straw yield (88%), taste of the produce (78%) and storage pests and diseases (70%). Negative effects of climate change on storage and market price was expressed by 66.67 per cent and 46.67 per cent respondents, respectively. These are the practices which might have affected due to climate change indirectly as farmers are growing hybrids and dwarf varieties which influence the straw yield and taste of the produce.

Farmers observing fluctuation in market price as an indirect impact of climate change, year to year vagaries in climate leading to fluctuation in production level. This is leading to fluctuation in prices. Respondents observed negative impacts of scorching sunny hours while harvesting, this has leading less efficiency of work and unanticipated rainfall during harvesting stage leading another impact on grain and straw quality, storage capacity, price and work efficiency of labour.

Neutral effect of climate change was observed for seed rate (98.67%), seed treatment (81.33%), with this regard farmers not aware about technical relevance of the practice and farmers were not giving precise importance to the above practice, so they are lack ability to observe any effects. FYM application (85.33%), farmers observed improper decomposition thereby crop is affected by spreading of weeds, pests and diseases through FYM, this is the case observing in the study area because insufficient moisture (rainfall) for decomposition and late onset of rain fall leading to germination /proliferation of weeds and pests in the established crop field. This leading farmer not to practices stale bed for submergence of weeds, pests and disease infected soil what farmers practiced in case of early onset of rainfall.

5.4.2 Effects of climate change on livestock as perceived by farmers in the last two decades

The impact of climate change on livestock was documented by considering the criteria of direct and indirect effects. The most vulnerable livestock management practices and their extent of impact relating to climate change were presented as follows.

The Table 4.9 vividly explains that the possible negative effects of climate change on livestock as experienced by more than 90.00 per cent with an extent of 42.00, 22.32, 23.05, 21.30, 32.55, 14.95, 45.12, 47.10 and 73.00 per cent on hours of grazing, hours of stall feeding, utilization of concentrate feeds, availability of concentrate feeds, availability of dry fodder, extent of milk yield, number of livestock reared, type of livestock reared and cost of rearing and cost of feeds, respectively.

It can be seen from the table that more than 80.00 per cent of the respondents have observed negative impacts on quantity of concentrate feeds, quality of dry fodder, utilization of dry fodder, method of rearing livestock and purpose of rearing livestock of an extent of 24.50, 32.75, 34.04, 39.00 and 14.26 per cent, respectively.

Farmers observed negative impacts on number and type of livestock reared. Sheep and goats are reared more specially in Bijapur district as compared to large ruminants, due to their better adaptability to climate variation. Respondents were experiencing the problem of drastic reduction in summer milk yield due to higher temperature, the result was in line with the research findings reported by Klinedinst *et al.* (1993) and Chase (2010). In case of strength of bullock, irrespective of feed intake bullocks are not working to their actual horse power because of heat stress and suffocation created inside the body, this finding is in agreement with the findings of Frank *et al.* (2001). The pests and diseases frequently proliferate at higher temperature on livestock like spots in the body, blue tongue, cattle ticks and sterility. This finding is in agreement with the that of FAO (2007). With reference to method of rearing, farmers need to rear inside the stall to avoid scorching sunshine hours during summer and also there is nothing for the animals to graze in the common lands.

Cost of rearing has increased owing to factors like decline in milk production, reduced fertility rate, frequent incidence of pest and diseases, non availability of adequate quantity of fodder, high cost of feed *etc.* The finding is in accordance with the findings expressed by Anon. (2010). Susceptibility to pests and diseases acts as a cause of increased temperature and higher relative humidity some of the farmers also opined that windblown from North West direction brings pathogens.

Farmers observed negative effects of climate change on quality of fodder. This was assessed by indirect method as they observed deterioration in the taste of meat, thickness of milk and strength of livestock in the last 20 years. Reduction in quality of fodder could also be attributed to the leaching of soil nutrients during high rainfall period. Farmers observed reduced fodder availability from common lands due to high grazing pressure, dominance of weeds and encroachment.

Reduced availability of dry fodder is the major effect. Crop loss incidences due to flooding or long dry spells in the field conditions and shift in cropping pattern as more farmers prefer to grow cotton and chilli could be the reasons. Farmers restricted grazing only during morning and evening hours to avoid temperature stress and scorching sunshine causing various impacts to herd like sterility, heat stress, suffocation, reduction in milk yield, ceiling of energy and susceptibility to pests and diseases.

In case of price of milk and livestock, farmers observed positive effects. But in true sense when compared with the cost of milk production the respondents' perception of positive effect on price of milk needs further analysis. To the changing climate compared to crops, livestock are hardier, they can be reared under harsh climatic condition and another reason might be due to livestock holding acting as a buffering to crop production losses.

5.5 Suggestions of the farmers to mitigate the climate change effect

5.5.1 Specific suggestion of the farmers to mitigate climatic effect on each farm practices

All the respondents followed the practice of harvesting crops on clear sunny days. Absence expecting clearance of cloudy weather as they were experiencing exact initiation and termination dates of rainfall previous to last twenty years. Majority (92%) of the farmers replaced traditional varieties like white sorghum, javari redgram, bengal gram and Jayadhar cotton varieties (high pest incidence) with the high yielding varieties having characteristics of short duration and resistant to pests and diseases because traditional varieties lost their crop yield potential and Jayadhar cotton variety became more susceptible to the changing climate. Farmers are using short duration varieties of soybean and bengal gram to escape from long dry spells and droughts and to perform well in moisture stress condition. Ninety per cent of the farmers changed their time of application of chemicals and fertilizers to evening hours for efficient use and to control sun burning effect to crops and the same proportion of farmers changing number of intercultivation operations depending on the rainfall occurrence. More than 80.00 per cent of the farmers applied more FYM, chemical fertilizers and penning to amend the soil fertility loss as a result of leaching out of soil nutrients during the period of heavy rainfall.

Nearly three fourth of the farmers kept land ready for sowing and are practicing summer deep ploughing to improve the water holding capacity of soil. Same proportion of respondents' applied FYM one month in advance, to the sowing date to facilitate proper decomposition. Mulching, proper decomposing of FYM, frequent weeding and intercultivation are the practices followed by 66 per cent of the farmers to control weed growth, continuous drizzling of rainfall favoured weed growth during intense rainfall period. Nearly two third (65.33%) of the farmers changed their cropping pattern from mono cropping to diversified cropping pattern to mitigate climate change. Half of the respondents applied fertilizers and FYM at proper moist condition and prepared a solution of sheep droppings and cow dung that was sprayed in the field for quick assimilation by the plants during water stress condition. Utilisation of more quantity of chemical fertilisers was also one of the practices followed by the farmers to maintain fertility of the soil. Less than half (44.00%) of the farmers expressed that they resorted to raising nurseries of the crop to match the recommended sowing date as they observed delay in onset of monsoon in the recent past. To overcome the water stress, farmers (42.00%) are practicing wider spacing in case of cotton, sorgham and soybean. In case of pest and disease infestation farmers (24.67%) adapted to grow resistant varieties, applying Neem and Glyricidia leaves to overcome the problem. Twenty per cent of the respondents followed number of adaption strategies like pot irrigation method, sprinkler irrigation, drip irrigation, frequent irrigation and irrigation during morning and evening hours to avoid water loss by evaporation and evapotranspiration.

Sustenance of life based on their own experiences has taught farmers to adapt farming practices to mitigate effects of climate change.

5.5.2 Specific suggestion of the farmers to mitigate climatic effect on livestock management practices

High majority (86.00) of the farmers followed practices like more hours of grazing, growing green fodder during *kharif* and protecting straw by covering polythene to avoid shortcoming of dry fodder during off season period. Farmers are mainly focusing on the protection of storage of straw from decaying during high rainfall period. To overcome the shortage of availability of concentrate feeds respondents (72.00%) prepared homemade concentrates by using grain husk, cereals, pulses and grain powder left out during milling. This is practice followed by farmers to avoid indirect impact of climate change because of potential reduction in crop production as a casual factor leading to rise in price. Nearly half of the farmers reduced number of livestock and are rearing high milk yielding, drought resistant breeds like Holstein Fregien and New Jersey. Good number of farmer's gradually changing type of livestock rearing to avoid susceptibility of the traditional type to extreme weather. Same proportion of farmers used green fodder as a feed instead of dry fodder, smearing oil and frequent spraying of water to the body during summer to avoid reduction in extent of milk yield. Farmers (30.00%) replaced large ruminants (buffaloes and cows) with the small ruminants (sheep and goat). Because these small ruminants are hardier compared to buffalo and cattle they can thrive in scanty rainfall and bit extreme. So, farmers are replacing this with former ones. Grazing during morning and evening hours and stall feeding in between were the practices followed by respondents (20.00%) for avoiding grazing during scorching sunny hours. Farmers observing reduction in milk yield, reduction in energy (Horse power) during summer noon hours in the recent years for avoiding this they are not practicing grazing during noon hours.

5.5.3 Overall suggestions of respondents to mitigate effect of climate change

More than half of the respondents suggested afforestation (58.00%). The importance of this practice is published by awareness campaigns, school children and advertisement by mass media and other modern medias, so most of the farmers given this suggestion. Creating awareness about climate change and adaptation strategies (55.33%), most of the farmers were not aware about phenomena of changing climate and suitable adaptation strategies to cope with this, because climate change is a recent concept. Decomposing of farm waste instead of burning (52%). Local farmers observing emission of GHG through burning of farm waste, crop residues and by-products, for controlling this source of global warming suggested decomposition of farm waste. Further, 42.00 per cent of respondents suggested that there should be control on use of farm machineries and automobiles, followed by less dependency on external inputs and more on locally available resources (39%) and promotion of organic farming (26%), About 22.00 per cent of the farmers expressed efficient soil and water management strategies and 12 percent of respondents suggested for using renewable energy sources. Only 10.00 per cent of the respondents suggested providing subsidies to climate proof technologies and government policy intervention to reduce carbon dioxide emission, higher education, cosmopoliteness, social participation and higher economic conditions are the reason for this suggestion. These are the important suggestions expressed by farmers based on their experience in farming over a long period. Development departments should think over all these suggestions of farmers in order to fulfil their needs to cope up with ill effects of climate change.

6. SUMMARY AND POLICY IMPLICATIONS

Climate change is the most serious environmental threat of the 21st century. Climate constitutes complex inter-related variables such as temperature, rainfall, wind speed and sun shine, having varied role to play. Change in one variable triggers changes in other. The increase in greenhouse concentration may lead overall increase in the rainfall of about 1.00 to 4.00 mm per day in India. It is estimated that by the end of the 21st century rainfall will increase by 15.00-31.00 per cent and the mean annual temperature will increase by 30° C to 60° C in the country. The rise in average annual temperature by 1.3° C in the state of Karnataka during 1950 to 1990 has been observed (Rajegowda *et al.*, 2009). Agriculture and food security are among the major casualties of climate change in India. Although there has been substantial growth in production, there is also substantial variability in production trend. Variability in weather and climate is regarded as the primary cause of year to year fluctuation in yields. More subtle fluctuations in weather during critical phases of crop development will also have substantial impact on yield. Average annual production of paddy, pulses, oilseeds, potato, onion and other vegetables have decreased in the state by 06.80, 56.40, 44.00, 20.70, 14.40 and 24.80 per cent respectively in the last decade (WIB, 2007). Climate change poses formidable challenge to the development of livestock sector in India. The predicted negative impact of climate change on Indian agriculture would also adversely affect livestock production by aggravating the feed and fodder shortages. There are number of changes in reproductive performance such as decrease in length and intensity of oestrous period, decreased fertility rate and decreased growth, size and it also lead to reduced disease resistant mechanism. Under the climatic stress there can be decrease in the milk production of 10.00 to 20.00 per cent in summer hot days (Madan, 2009). Some grazing lands are projected to deteriorate progressively as a result of increased temperature and reduced rain fall but this unlikely to occur until after 2030

Climate change although a global phenomena but the real cost of it is being paid by the poorest of the poor like farmers and agriculture labourers. There are number of studies made on climate change both at national and international level to understand the effect of climate change on agriculture and animal husbandry. However, very limited studies have been done to understand farmer's perspectives and experiences of climate change in crop cultivation and animal husbandry. It was felt very essential to understand their perspectives also, so that better holistic policy decisions could be made. Therefore the present study was proposed.

Keeping the above aspects in view, this study has been conducted with the following objectives.

1. to document the farmers views on climate change
2. to find out the reasons for climate change as perceived by the farmers
3. to study the effect of climate change on agriculture and livestock as felt by farmers
4. to elicit the suggestions of the farmers to mitigate the climate change

Methodology

The study was conducted during 2010-11 in Dharwad and Bijapur districts of Karnataka. Ex-post-Facto research design was followed for the conduct of the study. Based on the existence of high range of variability in rainfall, temperature, relative humidity, wind blow and sunshine (since last 20 years), one taluk will be selected from each district. Accordingly Dharwad and Bijapur taluks selected were. Five villages representing different locations (north, south, east, west and centre) were purposively selected from each taluk. Thus a total of ten villages were selected for the study. From each of the selected villages 15 farmers were selected by simple random sampling method. Thus the total sample for the present study was 150. By considering the objectives of the study farmer's views of climate change and effect on agriculture and livestock were considered as dependent variables, collected data were analyzed using simple statistics- frequency, percentage, mean and standard deviation.

Major findings of the study

- More than (66.00%) of the respondents belonged to middle age group. Half (50.67 %) of the respondents belonged to big family (above 4 members).
- One fourth of the respondents were illiterates (26.67%) and primary educated (25.33%), while less than one fourth (22.00%) of the respondents received education up to middle school. Graduates accounted 04.67 per cent only.
- Less than half (42.00%) of the respondents belonged to marginal land holding category. Almost equal per cent of the respondents had medium (50%) and small (48%) herd size. The data on annual income showed that, 40.67 per cent of farmers had medium level of income.
- High majority (81.33%) of the respondents had medium economic motivation and 60.00 per cent of the farmers had medium and 34.00 per cent had high farming commitment. More than 90.00 per cent of the respondents belonged to medium risk orientation and scientific orientation (91.33%) category.
- Regarding mass media possession, television sets were possessed by 94.00 per cent of the respondents. About an equal (98.00%) per cent of the respondents regularly viewed news and entertainment programmes.
- Two-third (66.00%) of the respondents regularly participated in Krishimela. While majority of respondents never participated in study tours (96.67%), extension meetings (92.00%), field visits (90.00%), group discussions (54.00%) and agricultural exhibitions (53.12%).
- The percentage of the respondents who contacted the RSK /Agriculture department officials was once in a month (22.67%), once in a fortnight (22.50%) and once in a week is 15.33 per cent. However, 95.33 per cent and 92.67 per cent of the respondents contacted veterinary officials and private agency extension personnel only whenever problem occurred.
- All the respondents observed changes in quantity of rainfall and 98.67 per cent noticed changes in the distribution pattern of the rains over the past 20 years.
- High majority (84.67%, 92.67%, and 94.00%) of the respondents expressed that the distribution is unpredictable to the extent of variation of 67.66, 73.39 and 79.84 per cent in *kharif*, *rabi* and summer seasons, respectively.
- Majority (70.67%, 83.33%, and 98.00%) of the respondents mentioned that there was an increase in temperature to the extent of 16.47, 11.54 and 24.25 per cent from the normal temperature during the *kharif*, *rabi* and summer seasons, respectively.
- More than 90.00 per cent of respondents perceived that relative humidity is increasing in *kharif* of an extent of 15.75 per cent and almost an equal proportion of farmers perceived that the region is getting drier of an extent 9.03 per cent during *rabi* and 15.38 per cent in summer.
- Almost all the farmers (98.67 %) perceived that there is increase in scorching sunshine hours during summer season of an extent of 21.21 per cent.
- Deforestation, gas emission by industries and automobiles and population explosion were the major reasons perceived by the farmers to the changing climate.
- Other reasons expressed by respondents were urbanization, commercialization of agriculture and burning of farm waste.
- All the respondents noticed negative impacts with regard to time of application of chemical fertilisers, intercultural operation pesticide use and overall health of the crop with perceived per cent variation of 30.41, 31.42, 9.50 and 35.25 per cent respectively.
- Negative impacts as expressed by almost all the respondents along with their percent of observed variation, such as, intensity of weeds (98%, 48.05%), harvesting (98%, 24.73%) , grain yield (98%, 30.35%), shelf life of the crop (98%, 15.33%).

- Percentage of respondents with observed variation were- soil fertility (90%, 21.90%), crops grown (96.67%, 39.68%), cropping pattern (92%, 32%), land preparation (90%, 46.34%), spacing (92.00%, 47.57%), use of chemical fertilizer (90%, 22.98%), insect and pest infestation (92%, 21%), disease infestation (90%, 9.50%) and grain yield quality (93.33%, 29.13%).
- High majority of the respondents observed negative impacts with observed per cent variation for sowing time (85.33% and 30.50%), number of irrigations required (89.33% and 15.80%) and for straw yield obtained (88.00% and 26.00%).
- High majority (90.00%) of the respondents expressed negative impact with percent variation on hours of grazing (42.00%), hours of stall feeding (22.32%), utilization of concentrate feeds (23.05%), availability of concentrate feeds (21.30%), availability of dry fodder (32.55%), extent of milk yield (14.95%), number of livestock reared (45.12%), type of livestock reared (47.10%), cost of rearing (72.95%) and cost of feeds (73.00%) , respectively.
- More than 80.00 per cent respondents have observed negative impacts with observed percent variation on quantity of concentrate feeds (24.50%), quality of dry fodder (32.75%), utilization of dry fodder (34.04%), method of rearing livestock (39.00%) and purpose of rearing livestock (14.26%).
- Majority of the respondents with their observed percent of variation expressed as having had negative impacts on fodder utilization from common lands (78%, 26.06%), fodder availability from common lands (77.33%, 25.71%), availability of green fodder (72%, 28%) and utilization of green fodder (74%, 26%).
- Almost all the respondents observed positive impact on livestock activities related to market linkages like price of the milk and price of the livestock with almost equal percent of observed variation (71.14% and 71.68%).
- High majority (90.00%) of the farmers replaced traditional varieties like white sorghum, javari redgram, bengal gram and jaidhar cotton varieties (high pest incidence) with the high yielding varieties having characteristics of short duration and resistance to pests and diseases.
- More than 80.00 per cent of the farmers applied more FYM, chemical fertilizers and penning to reduce the loss of soil fertility.
- Nearly three fourth of the farmers kept land ready for sowing and were practicing summer deep ploughing to improve water holding capacity of soil.
- Nearly two third (65.33%) of the farmers changed their cropping pattern from mono cropping to diversified cropping pattern.
- Half of the respondents applied fertilizers, FYM and solution of cow dung and sheep droppings at proper moist condition of the soil. Less than half (44.00%) of the farmers raised nursery to cope with altered sowing dates.
- To control storage pests and diseases most of the farmers (70.00%) followed practices like smearing grain by red soil, application of neem and pongamia leaves and foaming by burning of waste.
- High majority (86.00) of the farmers following practices like more hours of grazing, growing green fodder during *kharif* and protecting straw by covering polythene to avoid shortcoming of dry fodder during offseason period.
- Nearly half of the farmers reduced number of livestock and reared high milk yielding, drought resistant breeds like HF and New Jersey and same proportion of the farmers used green fodder, smearing oil and frequent spraying of water to the body during summer to avoid reduction in extent of milk yield.
- Thirty per cent of the farmers replaced large ruminants (buffaloes and cows) with the small ruminants (sheep and goat).

- Grazing during morning and evening hours and stall feeding in between were the practices followed by respondents (20.00%) for avoiding grazing during blistering sunny hours.
- Afforestation, make awareness about climate change and adaptation strategies, decomposing of farm waste and by products instead of burning, control on use of farm machineries and automobiles, less dependency on external inputs and more on locally available resources are the major overall suggestions given by respondents
- Other minor suggestions of the farmers to mitigate the effect of climate change were promotion of organic farming, Efficient soil and water management strategies like mulching, cantour bunds, Farm pond and drip irrigation, Use of renewable energy sources like solar energy, bio gas, power generation from water, Government intervention to reduce carbon dioxide emission, Providing subsidies to climate proof technologies.

Policy implications

1. The timings of the study point at several possible implications. First, it was found that farmers were observing number of reasons for changing climate in different magnitude like deforestation, gas emission by industries and automobiles, population explosion, urbanization and burning of farm waste. More effective implementation of policies already existed to combat these is crucial.
2. Furthermore, given the inadequate knowledge regarding effect of climate change on agriculture and livestock to both farmers and extension officers in the region, improving the knowledge and skills of extension personnel about climate change and adapted management strategies through training programs should be taken up.
3. Although, some proportion of farmers are aware of climate change impacts, only few seems to take steps to adjust their farming activities since low awareness about climate proof technologies and economic constraints. Government policies should therefore ensure that farmers have access to technological information and credit affordability to increase their ability and flexibility to change production strategies in response to changed climatic conditions.
4. In addition to creating awareness, there is a need to educate farmers through extension persons on appropriate varieties selection, change in cropping pattern, choice of crop, timing of irrigation, application of chemical and livestock management practices species mix including drought resistant breeds livestock management practices so as to counter adverse impact of rising temperature and reduced precipitation
5. The number of suggestions offered by the farmers to reduce pace and impact of climate change, such as, afforestation, decomposing of farm waste and crop residue instead of burning, control on use of farm machineries and automobiles, less dependency on external inputs and more on locally available resources make awareness and adaptation strategies to changing climate. These suggestions should be kept in mind before formulating the programmes and policies on climate change.

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Appendix I: Interview schedule

Perspectives of farmers on effect of climate change on agriculture and livestock

Interview schedule

Respondent No: _____

A. General information

- 1) Name of the respondent :
- 2) Village :
- 3) Taluk :
- 4) District :

B. Profile of Respondent

- 1. Age :
- 2. Education :
- 3. Family size :

Sl. No..	Name	Age	Gender	Relation with respondent	Occupation	Educational	Monthly earning (Rs.)
1							
2							
3							
4							
5							
6							
7							

4. Farm size

Type of Land	Dry land	Irrigation	Garden Land	Total
Area (acres)				

5. Farming experience_____ years

6. Herd size

Sl. No.	Herd size	Number
1	Local Cow	
2	Crossbred cow	
3	Buffalo	
4	Bullock	
5	Young ones of cow and buffalo	
6	Sheep	
7	goat	

7. Economic motivation: Please, indicate your response to the following statements
SA - Strongly agree, A - Agree, UD - Undecided, DA - Disagree, SDA - Strongly disagree

Sl. No.	Statements	Responses				
		SA	A	UD	DA	SDA
1.	A farmer should work towards larger yields and economic profits					
2.	The most successful farmer is one who makes the best profits					
3.	A farmer should try any new farming idea which may earn more money					
4.	A farmer should grow cash crops to increase monetary profits in comparison to growing of food crops for home consumption					
5.	It is difficult for the farmer's children to make a good start unless he provides them with economic assistance					
6.	A farmer must earn his living, but the most important thing in life can not be defined in economic terms					

8. Risk orientation

Please indicate your agreement or disagreement for the following statements.

Sl. No.	Statements	A	UD	DA
1.	A farmer should grow large number of crops to avoid greater risks involved in growing one or two crops			
2	A farmer should rather take more of a chance in making a big profit than to be content with a smaller but less risky profits			
3	A farmer who is willing to take greater risks than the average farmer, usually does better financially			
4	It is good for a farmer to take risks when he knows his chance of success			

Sl. No.	Statements	A	UD	DA
5	It is better for a farmer not to try new farming methods unless most other farmers have used them with success			
6	Trying an entirely new method in farming by a farmer involves, risk but it is worth			

A-Agree, UD-Undecided, DA-Disagree

9. Scientific orientation

Please indicate your choice among three alternatives for each of the following statements.

Sl. No.	Statements	Response category		
		Agree	Undecided	Disagree
1.	New methods of farming gives better results to a farmer than the old method			
2.	The way farmer's fore-fathers practiced agriculture is still the best way even today			
3.	Even a farmer with lot of experience should use new method in agriculture			
4.	Though, it takes time for a farmer to learn new methods in agriculture, it is worth the efforts			
5.	A good farmer experiments with new ideas in agriculture			
6.	Traditional methods in farming have to be changed in order to raise the level of living of a farmer			

10. Farming commitment

Sl. No.	Statements	Responses				
		SA	A	N	D	SD
1.	If I am given a job in city, I quit farming					
2.	I feel that simply talk of farming, farming problems they forget that everything depends on how they manage it					
3.	I am not willing to take a great deal of effort to develop my farm					
4.	I am prepared to face any problems to stay permanently in farming					
5.	I wish my children to be government employees rather than farmer like me					
6.	There is not much to be gained by sticking to farming permanently					

11. Extension system link

Please indicate the frequency of contact with extension agency.

Sl. No	Extension workers	Once in a week	Once in a fortnight	Once in a month	Whenever problem arises	Never
1.	RSK / Agri dept officials					
2.	Officials of horticulture depr					
3.	KVK officers					
4.	UAS scientists					
5.	Private agency extension officer					
6.	Veterinary Officials					
7.	Any other (Specify)					

12. Extension participation

Please, indicate your response to the following statements

Sl. No.	Extension activities	Subject matter	Organised by whom	Extent of participation		
				Regular	Occasional	Never
1.	Krishimela					
2.	Training programme					
3.	Extension meetings					
4.	Group discussions					
5.	Field visits					
6.	Agricultural exhibitions					
7.	Study tour					
8.	Any other specify					

13. Mass media participation

Please, indicate your response to the following statements

Sl. No.	Mass media	Subscribed/ owned	Programmes	Frequency of use		
				Regular	Occasional	Never
1.	Newspaper		Agricultural articles			
			Information/News			
			Recreational articles			
2.	Farm magazine		Agricultural articles			
			Information / News			
			Recreational articles			
3.	Radio		Agricultural programmes			
			Information / News			
			Entertainment			
4.	Television		Agricultural programmes			
			Information / News			
			Entertainment			

14. What are your views on climate change?

a. Seasonal and annual variation of weather parameters.

Sl. No.	Weather parameters		Seasonal variation as compared to last 2 decades(before 1980's)						
			Kharif	Extent (in%)	Rabi	Extent (in%)	Summer	Extent (in%)	Total
1.	Rain fall								
	a. Quantity								
	i	Increasing							
	ii	Decreasing							
	iii	Don't know							
	b. Distribution pattern								
	i	Predictable/uniform							
	ii	Unpredictable/erratic							
	iii	Constant							
2.	Temperature								
	a.	Increasing							
	b.	Decreasing							
	c.	Don't know							

3.	Relative humidity								
	a.	Increasing							
	b.	Decreasing							
	c.	Don't know							
4.	Sunshine								
	a.	Increasing							
	b.	Decreasing							
	c.	Don't know							

15. What are the reasons for change in climate?

1.

2.

3.

4.

16. What are the likely effects of climate change on agriculture as experienced by you in the last 2 decades?

Sl. No.	Farming practices	Effect of climate change			Per cent variation	Strategies ,if any
		Positive	Negative	No effect		
1	Soil fertility					
2	Crops grown					
3	Cropping pattern					
3	Variety selection					
4	Land preparation					
5.	Sowing time					
6.	Spacing					
7.	Seed rate					

8.	Seed treatment					
9.	FYM application					
10.	Use of Chemical fertilizer					
11.	Time of application					
12.	Intercultural operation					
13.	Weed growth					
14.	Insect, Pest infestation					
15.	Disease infestation					
16.	Pesticide use					
17.	No .of Irrigation					
18	Harvesting					
19	Grain Yield qty					
20.	Grain yield quality					
21	Straw yield					
22	Storage					
23	Market price					
24	Overall health of the crop					
25	Shelf life of the crop					
26	Storage pests and diseases					
27	Taste of the produce					
28	Any other					
29	Any other					

17. What are the likely effects of climate change on livestock as experienced by you in last 2 decades?

Sl. No..	Types	Effects			Per cent variation	Strategies, if any
		Positive	Negative	No effect		
a	Type of livestock reared					
b	Number of livestock reared					
c	Purpose of rearing livestock (milk, FYM, both, meat)					
e	Number of diseases to the livestock					
f	Extent of milk yield					
g	Strength of bullocks					
h	Method of rearing livestock					
i	Price of the milk					
j	Price of the livestock					
k	Cost of rearing					
l	Cost of feeds					
m	Fodder availability from common lands					
n	Fodder utilisation from common lands					
o	Quality of fodder from common lands					
p	Availability of green fodder					
q	Utilisation of green fodder					
r	Quality of green fodder					
s	Availability of dry fodder					
t	Utilisation of dry fodder					
u	Quality of dry fodder					
v	Availability of concentrate feeds					

w	Utilisation of concentrate feeds					
x	Quality of concentrate feeds					
y	Hours of stall feeding					
Z	Hours of grazing					
aa	Any other					
Ab	Any other					

18. Give your suggestions to mitigate effect of climate change on different aspects of life

i.

ii.

iii.

iv.

v.

vi

PERSPECTIVES OF FARMERS ON EFFECT OF CLIMATE CHANGE ON AGRICULTURE AND LIVESTOCK

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**2011 DR. NAGARATNA BIRADAR
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ABSTRACT

The study was conducted in Dharwad and Bijapur districts of Karnataka state during 2011. Ex-post-Facto research design was followed for the conduct of the study. The total sample for the present study was 150. The study was conducted with the objectives of documenting farmers views on climate change, to find out the reasons for climate change and to study the effect of climate change on agriculture and livestock as felt by farmers. Frequency, percentage, mean and standard deviation were the statistical tools employed for the present study.

High majority (81.33%) of the respondents belonged to medium economic motivation. All the respondents observed changes in quantity of rainfall and 98.67 per cent noticed changes in the distribution pattern of the rains over the past 20 years. Large majority (84.67%, 92.67%, and 94.00%) of the respondents expressed that the distribution is unpredictable to the extent of variation of 67.66, 73.39 and 79.84 per cent in *kharif*, *rabi* and *summer* seasons, respectively. High majority (90.00%) of the respondents expressed negative impact with percent variation on hours of grazing (42.00%) and hours of stall feeding (22.32%), respectively. High majority (90.00%) of the farmers replaced traditional varieties like white sorghum, javari redgram and jaidhar cotton varieties with high yielding varieties having characteristics of short duration and resistance to pests and diseases. Nearly two third (65.33%) of the farmers changed their cropping pattern from mono cropping to diversified cropping pattern.

High majority (86.00) of the farmers following practices like more hours of grazing, growing green fodder during *kharif* and protecting straw by covering polythene to avoid shortcoming of dry fodder. Nearly half of the farmers reduced number of livestock and reared high milk yielding and drought resistant breeds. Thirty per cent of the farmers replaced large ruminants (buffaloes and cows) with the small ruminants (sheep and goat).