Global Water Partnership
South Asia
India Water Partnership

Water & Climate Resilience Programme *(WACREP), India*
(October, 2013 – March, 2015)

Report on Vulnerability Assessment to Climate Change Impact on Agriculture, Animal Husbandry & Water Management and Development of Adaptation Framework for the Region

Activity No. 3.7.1.C (Work Package-7): *Assessment of vulnerability to climate change on water resources, commons, agriculture system and animal husbandry in Sinhar watershed in Bhinder Block in Udaipur district of Rajasthan*

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WATER AND CLIMATE RESILIENCE PROGRAMME (WACREP)

Water and Climate Resilience Programme (WACREP) is an innovative initiative of Global Water Partnership (GWP) South Asia devised to improve the climate resilience of South Asian countries to withstand the impact of climate change. The major objectives of the programme are; (a) Develop and integrate 'no regrets' water security and climate resilience investments into their development plans, budgets and programs; (b) Identify solutions to address critical water security challenges to enhance climate resilience of countries and communities; (c) Build knowledge and capacity to enhance water security and climate resilience; and (d) Operationalize the GWP network with strategic allies and stakeholders to integrate water security and climate resilience in the development processes. More than 40 climate resilience interventions are planned for the first phase (October, 2013 to March, 2015) of the programme. On successful completion of first phase, a set of new activities will be taken-up during the second phase.

The WACREP was launched at the India Water week in April 2013 by GWP-South Asia to improve the climate resilience of South Asian countries to withstand the impact of climate change through the implementation of 8 work packages aligned with GWP strategic goals. The programme is being implemented by the Country Water Partnerships of GWP-South Asia namely; Bangladesh, Bhutan, India, Nepal, Pakistan and Sri Lanka with the support of national and regional partners. The programme is also having synergies with Regional Institutions and initiatives on on-going climate change projects to ensure its effectiveness. The first Phase of WACREP Programme started in October 2013 and continued until March 2015. This programme under second phase will take up new set of activities. In India, WACREP Phase-I was implemented

Under Work Package-7 of WACREP, India Water Partnership (GWP-India) with support of **Action for Food Production (AFPRO)** undertook vulnerability assessment on agriculture, animal husbandry and water

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Preface

Climate change and increasing climate variability are likely to aggravate the problem of future water and food security by exerting pressure on natural resources. However, there are lot of uncertainties about the assessment of impact, adaptation and mitigation of climate change on agriculture, livestock and rural livelihood. The impact can be worse in areas prone to natural calamities like flood, drought etc. The low capacity of the people to adopt remedial measures due to financial , institutional and technological constraints make it necessary to identify cost effective and social friendly interventions.

Researchers follow different methodologies and arrive at contrasting results making it difficult to reach a logical conclusion and develop policy actions. There is a need to develop and apply a standard methodology across the board for various studies related to climate change, water in relation to agriculture and livestock. The report covers impacts of climate change on agriculture, water resources and livestock by developing inventories of water sources and analyzing the vulnerabilities and mitigation options in a tribal dominant region where agriculture and livestock are the major sources for food, nutritional and livelihood security.

The present report describes the methodology for vulnerability assessment in a simple and lucid way so that a researcher can adopt it while conducting such studies. The analysis and application of the results are also illustrated. An effort has been made to consolidate all the efforts carried out so far in this field and serve as a ready reference for further work in the field. The report has been prepared jointly by **India Water Partnership (GWP-India)** and **Action for Food Production (AFPRO)** under **Water and Climate Resilience Program of GWP-South Asia**.

I am sure this report will prove to be an invaluable source of reference for the researchers, scientists and students engaged in climate change related studies, research and development programs. Moreover, the outcomes of this study and the suggestive adaptation measures can be applied in a similar agro-climatic region under any Govt schemes or by other funding organizations, which might be taken forward to policy formulation.

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Acknowledgement

Climate change is likely to impact on the whole world, while the poor countries and the weaker sections within a country are the most vulnerable ones; causing inequalities in health and wealth of common people. Food security, clean water and eco-friendly environment are the basic need of the people. The ever increasing population and developmental interventions make this task a tedious one.

The reports on climate change present data on increasing global average temperature of air and ocean, wide spread melting of snow and ice and global rising of ocean level which is attributable to emission of green house gases mainly due to burning of fossil fuels including increased pressure on land due to agriculture, livestock and human population. Agriculture and livestock continue to be the major source of income and employment for rural masses in general and the tribal community in particular. Therefore an effort was made to assess the vulnerability to climate change in the context of agriculture, animal husbandry and water resources in a tribal belt of southern Rajasthan.

The present study was taken up in cluster of 10 tribal villages under Sinhar watershed (Vallabhnagar Tehsil), of Udaipur district which falls in sub-humid southern plain and Aravali hill region of Rajasthan. The study under **Water and Climate Resilience Program** of **GWP-South Asia** was taken up by **Action for Food Production (AFPRO)** through its Regional office at Udaipur. It was sponsored and supported by **India Water Partnership (IWP)** which is a part of **Global Water Partnership (GWP)**. We are highly thankful to **IWP**, **GWP** and **GWP-South Asia** for the encouragement, guidance and financial support given by them.

The study was based on analysis of secondary data, collection and analysis of primary data and under taking Participatory Rural Appraisal (PRA) and focus group discussions held with the local community in the study area. We are grateful to all of them who were always ready with a positive guidance and support in conducting the study, providing the climate related data as well as in preparation of the said report throughout the study period.

AFPRO would also like to convey its special thanks to **Dr. K. A. Verghese**, Retd. Professor & Head, Dept. of Agriculture Economics & Statistics, Rajasthan College of Agriculture, MPUAT, Udaipur and **Dr. J. C. Dubey**, Sr. Geologist (Retd), Govt. of Rajasthan for their whole hearted cooperation and support to AFPRO for an in-depth interpretation and analysis of various data and also for their help in finalizing the said study report.

Along with AFPRO, the field level information and data were collected by **Apna Sansthan** Udaipur. We are highly grateful to the entire team of Apna Sansthan for all their support and services.

Last but not the least; we would also like to convey our sincere gratitude and thank to all the farmers of the selected 10 villages for their cooperation and support and extending a helping hand at every juncture of need during the study and for the purpose of this study.

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Abbreviations

AFPRO	Action for Food Production
ARIS	All India Rainfall Series
AS	Apna Sansthan
AWP	Area Water Partnership
BCM	Billion Cubic Meters
CBO	Community Based Organization
CO_2	Carbon Dioxide
CWP	Country Water Partnership
DNWP	Draft National Water Policy
GCM	General Circulation Models
GDP	Gross Domestic Production
GHG	Green House Gases
GWP	Global Water Partnership
Ha	Hectare
HH	House Hold
IPCC	Intergovernmental Panel on Climate Change
IWP	India Water Partnership
IWRM	Integrated Water Resources Management
Kg	Kilogram
MM	Millimeter
NAP	National Action Plan
NAPCC	National Action Plan on Climate Change
NGO	Non-Governmental Organization
NOAA	National Oceanic and Atmospheric Administration
OBC	Other Backward Class
pH	potential of Hydrogen
PPP	Public-Private Partnership
PRA	Participatory Rural Appraisal
PRI	Panchayati Raj Institutions
Qt.	Quintal
RAPCC	Rajasthan Action Plan on Climate Change
SC	Schedule Caste
SDC	Swiss Development Cooperation
SRES	Special Report on Emissions Scenarios
ST	Schedule Tribes
T_{max}	Temperature Maximum
T_{mean}	Temperature Mean
T_{min}	Temperature Minimum
TSP	Tribal Sub Plan
ULB	Urban Local Bodies
UNICEF	United Nations International Children's Emergency Fund
V&A	Vulnerability & Adaptability
WACREP	Water and Climate Resilience Program
WAPCOS	Water and Power Consultancy Services
ZWP	Zonal Water Partnerships

Executive Summary

The study on **"Vulnerability assessment to climate change impact on agriculture, animal husbandry and water management and development of adaptation frame work"** on these sectors for the region under **Water and Climate Resilience Program (WACREP)"** was taken up in a cluster of 10 villages under Sihnar watershed (Vallabhnagar tehsil) of Udaipur district. The study area falls under sub – humid southern plain and Aravali hills (Zone IVA) of Rajasthan. Udaipur district is characterized by relatively large forest cover and low area under plough. Maize and gaur in *kharif* and wheat, gram and mustard in rabi seasons are the major crops. Goat, cattle and buffalo are the major livestock reared in the district. Irrigation is mostly through wells which depend on rainfall in the district.

The land area in selected cluster covers private and Government waste land followed by rainfed and irrigated cultivated land and pasture land. The cropping pattern and livestock composition in the study area are similar to that of the other parts of the district.

The rainfall pattern in the study area indicated more quantum of rains occurred during last two decades compared to the previous two decades. The number of rainy days has also gone up in the later period with less inter year variability in rainy days.

The seasonal analysis of rains indicated that during the later period (during 1972 – 2013 Period) the increase in the rainfall was during south west monsoon period (June to September). There was substantial decrease in the south east monsoon (October to January) and intermediate rains (February to May). The increase in the quantum of rains during south west monsoon coupled with reduction in the south east and intermediate rains call of effective water management strategies to conserve rainwater and also to minimize wastage of run off during monsoon season. There is some forward shift in the onset of monsoon also, especially during the second half of the total period which has implication for Kharif sowing period and crop duration which in turn will have effect in Rabi sowing. The maximum, minimum and mean temperatures were found to slightly decrease during the later period. The decrease in minimum temperature was recorded mostly in the month of May and minimum temperature in the month of January.

The analysis of base line survey data indicated that agriculture and livestock are the major sources of employment and livelihood for the people in the study area. For drinking water there is more dependency on hand pumps and less dependency on common and private wells. Large numbers of open wells are unprotected, unlined and lying defunct in the area for various reasons.

The crops are grown in both Kharif and rabi seasons. The Kharif crops are mostly rainfed and rabi crops are irrigated. Maize in Kharif and wheat in rabi are most important crops which meet the food security of the people and fodder requirement of animals. Goat, cattle and buffalo constitute the major livestock reared on farms by the households. There is reduction in the number of animals per household over the years. The household income is generated through livestock and crop production. Migration, both within and outside state, also is followed by some households. Community Pasture land is used mostly for open grazing.

The outcome of PRA exercise conducted in each of the 10 villages in the selected cluster has been in conformity with the baseline survey. Over the years the millet crops have been replaced by cereals, pulses, oil seeds and other crops. The sown area has gone up, but soil fertility has come down over the years. The input cost of cultivation has increased with use of chemical fertilizers and plant protection measures. In livestock composition there is substitution of large animals with small ruminants, especially goat. Heavy rains in few years and frequent drought in the subsequent years were the major climate havocs in the area. The reduction in the span of rainy season (No of rainy days) and changes in temperature were also observed.

The vulnerability of climate change and especially the Climate variability was assessed by analyzing the economic activities like crop production, animal husbandry and basic resources like land, water and associated factors.

In Kharif season maize dominated production system suffers due to water logging in heavy rainfall years, late sowing during delayed monsoon followed by disease and pest problems. It leads to household food and fodder insecurity as well as increased cost of cultivation. The intervention like water conservation at upper ridges of pasture land and introduction of moisture tolerant, late sown and short duration maize varieties advocated. In rabi season wheat is the dominant crop to support household food and fodder security. It generally suffers due to late sowing after harvest of late sown maize, due to fluctuation in temperature during flowering time of wheat leading to low yield. Introduction of late sown, short duration and heat tolerant seeds of wheat is also suggested and advocated.

The livestock production system is dominated by goat, cattle and buffalo. The herd size and composition have undergone changes over the time. The low productivity of livestock leads to low profitability, mainly due to fodder shortage. Breed improvement and ensured fodder supply from local sources with development of pasture lands are suggested.

The pasture area with low productivity of both with private ownership and government lands are available in the area. Over exploitation of grazing land due to open grazing practice not only leads for loss of biodiversity, loss of rootstocks but to shortage of fodder availability. Protection of grazing land with low cost materials and joint farmer group management practices of grazing land are proposed and practiced on pilot basis.

The water resources in the area largely depend on rain which is stored in wells and tanks and surplus water goes as runoff which is stored through anicuts at palaces. The potential agricultural areas are not being covered under *rabi* crops due to shortage of water. The water management practices to minimize losses due to evaporation, leakage & breakage of irrigation channels, ensure storage capacity in wells and tanks through de-silting and enhancement of storage capacity is suggested.

The wells going out of use due to depleting of ground water table and for those wells under use, increased operational expenditures on one hand and higher cost of production of irrigated crops on the other hand are matters of concern. Working adults are forced to migrate to other places in search of livelihood. Intervention for increased ground water recharge and reduction in wastage of runoff, deepening of wells, de-silting, lining of water courses and other water management /conservation measure assume great importance.

The seasonal and permanent migration of family workers faces problem for existing farming systems. Promotion of rural livelihood based on available resources and refinement of integrated farming system practices are strongly advised.

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1. Introduction

1.1 About Global Water Partnership and India Water Partnership

The **Global Water Partnership (GWP)** was founded in 1996 to foster **Integrated Water Resources Management** (IWRM) which is defined as the coordinated development and management of water, land, and related resources in order to maximize economic and social welfare without compromising the sustainability of vital environmental systems. GWP was founded by the World Bank, the United Nations Development Program (UNDP) and the Swedish International Development Cooperation Agency (SIDA) to foster integrated water resource management (IWRM). IWRM is a process which promotes the coordinated development and management of water, land and related resources in order to maximize economic and social welfare without compromising the sustainability of ecosystems and the environment. The Global Water Partnership's vision is for a water secure world and its mission is to support the sustainable development and management of water resources at all levels.

The **GWP** has 85 Country Water Partnerships in 13 regions in the World having its headquarters at Stockholm, Sweden that provide a neutral and multi-stakeholder platform for dialogue and facilitating change processes. Regional and Country Water Partnerships manage and govern themselves, and convene stakeholders to address specific issues. They bring about solutions that are both tailored to local conditions and informed by local experiences and good practices from across the network.

India Water Partnership (IWP), established in **2001,** is a non-profit organization with a goal of promoting Integrated Water Resources Management (IWRM). It has been accredited by the Global Water Partnership (GWP) as Country Water Partnership of GWP and IWP fall under South Asia Region of GWP.

IWP is active in promotion of Integrated Water Resource Management (IWRM) principles and practices through its network partners to support national development priorities. Some of the core priority areas are; promoting IWRM approach effectively through workshops and consultations to address adaptation to climate change with the support of zonal water partners across the country; encouraging use of innovative low cost water saving technologies by the farming communities; sustainable natural resource management; integrated domestic water management; promoting Area Water Partnership (AWP) for river basin management; conflict resolution on water sharing; inter-state trans-boundary water sharing issues; gender mainstreaming etc.

1.2 About Water and Climate Resilience Program (WACREP)

South Asia is endowed with vast water resources, which are essential for basic human needs, agriculture, hydropower, industries and to sustain aquatic environment. South Asia Regional Water Partnership comprises of six Country Water Partnerships (CWPs), Bangladesh, Bhutan, India, Nepal, Pakistan, and Sri Lanka. Within the framework of CWPs, there are Area Water Partnerships, Zonal Water Partnerships and Local Water Parliaments which serve as ground level mechanism for multi-stakeholder dialogue.

Water and Climate Resilience Program (WACREP) is a regional program that is being implemented by CWPs in Bangladesh, Bhutan, India, Nepal, Pakistan and Sri Lanka. Concept of this project was initiated at the Country Chairs' Meeting held in November 2012 in New Delhi, India. As per the milestones agreed at the said meeting, countries submitted their scoping papers or Country Consultation Reports to the GWP South Asia Regional Office, Colombo, followed by the program launching at India Water Week in April 2013.

In broad terms, this program will address the task of improving the resilience of South Asian countries to withstand the impacts of climate change through the implementation of 8 work packages aligned with GWP's strategic goals. This program aims to support countries and regional organizations to integrate water security and climate resilience programming at trans-boundary, national and local levels through policy dialogues and participatory approaches.

The program intends to enhance Water security & climate resilience through better water resources management in South Asia. It also aims to boost the capacities of partnership, institutes and stakeholders to integrate water security and climate resilience in development planning and decision making process leading to local climate resilience investment program and plans.

- Countries and regions support to develop and integrate 'no regrets' water security and climate resilience investments into their development plans, budgets and programs
- Solutions is in place for addressing critical water security challenges to enhance climate resilience of countries and communities
- Knowledge and capacity developed for enhancing water security and climate resilience
- Operationalize the GWP network working with strategic allies and stakeholders to integrate water security and climate resilience in the development process.

1.3 Background of initiating the WACREP Project in Rajasthan:

Rajasthan is geographically the largest and the eighth most populous state of India. Eighty per cent of the population depends on agriculture and 19 per cent on animal husbandry for their livelihood. Over two million families live below the poverty line. Rajasthan has barely 1.16% of the water resources of the country as against its share 11% in total geographical area. Average annual rainfall ranges from 150 mm in north-west part to 900 mm in south-east. Due to scarcity of surface water, agriculture production to a great extent in Rajasthan is critically dependent on the vagaries of monsoon and ground water resources. Land, human resources, crop and livestock activities are highly integrated and more or less cyclic in nature.

The National Action Plan on Climate Change (NAPCC) came in force to address the challenges posed by climate change along with the imperatives of poverty alleviation and economic growth for India. The focus of NAPCC is to improve the understanding of climate science, adaptation, mitigation, energy efficiency and natural resource management & conservation. Similarly, as a follow-up, like other few states in India, the state of Rajasthan also developed RAPCC (Rajasthan Action Plan on Climate Change). As per RAPCC documents climate change scenarios for India and Rajasthan includes following specific manifestations:

- Rise in annual mean surface air temperature for all parts of India. Temperatures are likely to rise by 2°C - 5°C and 2.5°C - 4°C in A2 and B2 IPCC SRES emission scenarios by the end of 21st century (2071-2100), with warming more pronounced over the northern parts of India.
- The warming is also expected to be relatively greater in winter and post-monsoon seasons than in the summer monsoon season. Spatial pattern of rainfall change estimates a 20% rise in all India summer monsoon rainfall for the future in both A2 and B2 scenarios as compared to present (SDC V&A Program, 2009).
- Maximum 1-day rainfall is expected to increase by 20 mm, and maximum 5-day rainfall by 30 mm in the period 2071-2100 (SDC V&A Program, 2009).

Annual Rainfall Variability

As indicated above, we can summarize that major facets of climate variability and climate changes in the area are: delay in the onset of monsoon, failure of monsoon, variability of monsoon rainfall, long break in monsoon and a real difference in the perseverance of monsoon. All these changes will impacts on various sectors such as agriculture, water resources, forestry & biodiversity, human health, energy and infrastructure. All together one finds that climate change is likely to further exacerbate the already strained conditions for agriculture in Rajasthan. Diverse impacts on agriculture require constant adaptation in order to maintain yields. Any change in climatic determinants can not only lead to adverse impacts on food security and nutrition but also essentially affect well being of the population deriving livelihood and income from agriculture a high risk activity in the state.

Climate stress:

Delay in the onset of monsoon or failure of monsoon causing drought situation, variability of monsoon rainfall, long break in monsoon and a real difference in the perseverance of monsoon.

Based on the findings and the experience of previous project/study on Livestock, pasture land and climate change adaptation, **AFPRO** submitted a project proposal to GWP through IWP for assessing the vulnerability due to climate change for improving the livelihood condition of rural poor living in the semi-arid region of Rajasthan state through a program on "**Water and Climate Resilience Program**" (**WACREP**) under climate change scenario which has been subsequently approved by **GWP/IWP** for implementation on ground.

Project Location:

Total **10 villages** under Sinhar Watershed (Vallabhnagar block) of Udaipur District (Rajasthan) were selected for conducting this study. The selected villages fall under Jaisamand catchment area which is mainly characterized by undulating terrain with larger parts lying unused due to degrading conditions. About 70% of total population is belongs to schedule tribe (ST) called Rawat meena in these villages. Livestock and Agriculture are main livelihood source of the community, seasonal migration to urban area also found among them for alternative income source for family survival.

1.4 Project Goal and Objectives

In line with the vision of **RAPCC** "*Achieve sustainable development by reducing vulnerability to climate change impacts and enhancing resilience of ecological, economic and social systems in Rajasthan"*, the ultimate goal of this project under WACREP was evolved as "**To Improved Community Resilience against climate change in Semi-Arid region of South Rajasthan**" and to achieve this goal the following specific project objectives were finalized as:

- To conduct a scientific study to evolve a suitable knowledge products to promote climate resiliency and to develop an adaptation framework in existing water and agriculture sector.
- Promote science uptake for efficient practices and technologies as adaptation approach to evolve models suited in Hilly regions
- Establish participatory system of learning and documentation for replication to benefit wider community through policy and advocacy

2. Climate Change, Impacts and Initiatives

In this section, efforts have been made to review the issue of climate change, its impact and initiatives at **National level**.

2.1 Climate Change

Climate change is one of the biggest issues facing the world today it is not a new phenomenon in the Earth's history. Climate Change refers to a significant variation in either the mean state of the climate or in its variability, persisting for an extended period, typically, decades or longer. Studies indicate that the decade (1990-2000) across the globe recorded the warmest years during the past century, the three years. viz. 1997, 1998 and 1999 recording more warmer conditions, increasing in sequence. Summer, 2002 and 2003 were declared as warmest year during current century on record by National Oceanic and Atmospheric Administration (NOAA) especially in the Asian Sub Continent and in Europe, where the temperatures remained extremely high for long periods resulting in death of large number of human population in Europe alone. It is evident that there was, there is and there will be climate variability at global, regional and local levels. Since, climate is closely related to human activities and economic development including agricultural system, there is a serious concern about its stability (Sinha et al., 2000).

Burning of fuel, deforestation, various agricultural systems and industrial practices are altering the composition of the atmosphere and contributing to it. These human activities have led to increased atmospheric concentration of a number of greenhouse gases, including carbon dioxide, methane, nitrous oxide, chlorofluorocarbons, and tropospheric ozone in the lower part of the atmosphere. Just a few degrees increase in the earth's temperature can cause droughts and crop failures, ecosystem imbalances as well as melting ice caps causing sea levels to rise.

The temperature record is not the only indication of a changing climate. There are many other indicators such as the substantial retreat of mountain glaciers in many locations around the world, decreased snow cover in the Northern hemisphere, decreased tropical precipitation, increased mid-to-high latitude precipitation, sea level rise, increase in extreme events, decreased extent of Arctic ice and thinning of Arctic ice. All these proved that global climate is changing. At this point, it is to note that water vapor is the single most powerful greenhouse gas in the atmosphere. Water vapor has approximately twice the effect of the second most powerful greenhouse gas—carbon dioxide. Human activities do not have any significant direct impact on the level of water vapor in the atmosphere. However, as a result of global warming it is likely that human activities will have a significant indirect impact on the level of water vapor in the atmosphere. Water vapor is the most important greenhouse gas and the development of a better understanding of the effect of global warming on atmospheric water in all its forms (solid, liquid, and gas) is of critical importance.

Studies indicate that if no corrective measures are taken, the atmospheric temperatures may increase by 1.4 to 5.8 °C by the year 2100 (IPCC 2001). This will have serious impacts on day to day life. Some of the projected impacts made are as follows:

Inundation of coastal areas and seashore recession due to rise in sea level

- Disruption of ecosystem complexes
- Shifts in rainfall pattern and length of growing season
- Shifts in cropping pattern, geographical crop preferences
- High evapotranspiration rates

2.2 Global Scenario

Weather observations indicated that the global average surface temperature has increased by 0.6 ^{0}C since the 19th century (IPCC, 2001). The rate of warming is faster than at any other time, during the past 100 years, which is attributed to the increase in the proportion of carbon dioxide and other greenhouse gases in the atmosphere over the last century. Observations also indicated that all the warmest years during the past century across the globe occurred in the last two decades. Increasing concentrations of greenhouse gases are likely to accelerate the rate of climate change. Model output estimates that the average global surface temperature could rise 0.6 to 2.5 °C in the next fifty years and 1.4 to 5.8 ^{0}C in the next century, by doubling the concentrate of CO_2 with significant regional variation. The expected rise in temperature at higher latitudes will be much more than at equatorial regions.

Other than the changes in air temperature, global warming has potential impact on global precipitation patterns and the frequency of droughts and flood. Many researchers are of the opinion that an increase in temperature could lead to a more intensive use of water. The rates of evaporation from soils and water as well as transpiration from plants could increase.

Other impacts of global warming include mean sea level rise as a result of thermal expansion of the oceans and the melting of glaciers and polar ice sheets. The global mean sea level is projected to rise by 0.09 to 0.88 meter over the next century. Due to global warming and sea level rise, many coastal systems can experience increased levels of inundation and storm flooding, accelerated coastal erosion, seawater intrusion into fresh groundwater and encroachment of tidal waters into river systems. Climate change and global warming also affect the abundance, spawning, and availability of commercially important marine fisheries. Increase in sea surface temperature adversely affects coral and coral associated flora and fauna.

2.3 Earlier Initiatives

Through the first half of the 20th century, when global warming from the greenhouse effect was only a speculation, the handful of scientists who thought about it supposed any warming would be for the good. Svante Arrhenius, who published the first calculations, claimed that nations like his native Sweden "may hope to enjoy ages with more equable and better climates". In any case, nobody worried about the impacts of climate change that scientists expected would only affect their remote descendents, several centuries in the future, if it happened at all. A few scientists took a closer look in the late 1950s, when they realized that the level of carbon dioxide gas in the atmosphere might be rising suggesting that the average global temperature might climb a few degrees Celsius before the end of the 21st century. Roger Revelle, the most senior of these researchers, publicly speculated that in the 21st century the greenhouse effect might exert "a violent effect on the earth's climate" (as Time magazine put it). He thought the temperature rise might eventually melt the Greenland and Antarctic icecaps, raising sea level enough to flood coastlines.

2.4 Climate Changes in India

Confirmative evidences of climate variability and change are difficult to obtain, as often the signals are confusing. However, few evidences are available, which need further critical analysis for their confirmation. The All India Rainfall Series (AIRS) has to be considered as an overall generalization of rainfall over India as it does not reflect the year to year fluctuations for all the areas because the geophysical area of India is too large and it cannot be regarded as a single unit (Normand, 1953). Rainfall variability and trends over India show a high temporal and spatial characteristic of rainfall over India. Analysis of the long term changes in rainfall quantum across individual meteorological sub divisions indicate that not only there are regions which have recorded increase or decrease of annual rainfall on a long term basis (1871 -1999) but also there has been southward shift in the surplus rainfall zones, when one compares the last four decade means with the long term means (Schaefer, 2001).

A comparison of the mean monthly distribution of rainfall between 1972 and 1990 with that during 1990 - 2000 indicates that the July rains have decreased from 114 mm to 73 mm, while the August rains increased from 109 to 179 mm. This shift influence the sowing of crops adversely as the crop now experience delay in the availability of assured moisture regime for their establishment as June and July rains are more suitable for land preparation and seedling establishment. Also a shift in the peak rains is observed. The peak earlier observed in September rains indicate a decline by 17 mm while October rains (227 mm) indicate a substantial increase of 92 mm along with a corresponding increase in rainy days. Though the period of analysis is short to draw any firm conclusions, the pattern implies a shift in rainfall pattern by 2 to 3 weeks. Similarly, trends of decreasing pattern in pre monsoon rainfall were observed in some parts of Chhattisgarh region in the months of May and June, proving detrimental to pre sowing operation of rice crop (Sastri and Urkurkar, 1996). Many parts of Chhattisgarh also recorded continuously below normal rainfall during the last decade.

2.5 National Initiatives:

The need to address both climate change and energy security has given rise to prime ministerial directive called the **National Action Plan** (NAP) which identifies eight area or "mission" for focused energy and climate policy interventions. These include solar energy, energy efficiency, sustainable habitat, water, Himalayan ecosystems, sustainability agriculture, strategic knowledge for climate change and a

"Green India". Each of these mission will processed under Public, Private and People (PPP) partnership which bring together central and state government, business, civil society and community organizations to create an effective and really strategy for implementation of the eight mission.

2.6 General Impacts of Climate Change

Climate change impacts can be broadly divided into two groups biophysical and socio-economic as under:

1. Biophysical impacts

a. Physiological effects on crops, pasture, forests and livestock
b. Changes in land, soil and water resources
c. Increased weed and pest challenges
d. Shifts in spatial and temporal distribution
e. Sea level rise, changes to ocean salinity
f. Sea temperature rise causing fish to inhabit different ranges

2. Socio-economic impacts:

a. Decline in yields and production
b. Reduced marginal GDP from agriculture
c. Fluctuations in world market prices
d. Changes in geographical distribution of trade regimes
e. Increased number of people at risk of hunger and food insecurity
f. Migration and civil unrest.

2.7 Review of Studies on Impact of Climate Change on Agriculture

The projected global climate change by several researchers due to warming of the atmosphere as a result of increased presence of green house could lead to a threat to future food security and natural resources directly or indirectly through anomalies in weather patterns particularly in fragile arid eco systems. The impact of projected climate change is more likely in arid ecosystem than in semi arid or sub humid regions of India by end of 21st century.

Agriculture has always been dependant on the variability of the climate for the growing season and the state of land at the start of the growing season. A temperature rise extends the growing season and the farmable area; it causes earlier maturity of grain and open up for the growing of new crops. While the temperature rise is beneficial to some crops, the extra heat also affects weeds, pests and insects tend to get better living conditions under high temperatures.

Several predictions have been made on the possible changes in climate due to increased concentrations of green house gases (GHG) and their impacts on agriculture. The general circulation models (GCM*)* indicate that doubling of CO_2 concentration by 2030 will increase average global temperature by 1-3 ^{0}C, which may result in decrease in cereal production and increase in tropical cyclonic activity, posing serious flood damages along their tracks (Govinda Rao et al, 1994).

The effect of temperature rise will lead to an increase in biological activity as well as the physical and chemical processes. Increase in CO_2 concentration can lower pH, thereby, directly affecting both nutrient availability and microbial activity. Climate Change is also expected to bring about the changes in the amount, intensity and distribution pattern of rainfall. The changes in the crop yield depend not only on the change in rainfall but also on the changes in CO_2 concentration. Rosenzweig and Parry (1994) estimated that the net effect of climate change may lead to reduce global cereal production up to 5 per cent. They further indicated that production in the developed world would increase while it may decline in developing countries. Doubling of CO_2 concentration may increase the photosynthetic rates by as much as 30-100 percent. C3 plants will become more water efficient as they quickly grow. However, the response in C4 plants may not be spectacular (IPCC, 1992). The effect of increased CO_2 and temperature on Indian agriculture was reported by Aggarwal and Sinha (1993) and predicted a shift in wheat production belt.

The average temperatures are expected to increase more near poles than equator, the shift in climatic zones will be more pronounced in the higher latitudes. These projections indicate that increased temperature resulting from global warming is likely to reduce the profit from wheat cultivation and will compel farmers of lower latitudes to opt for maize and sorghum which are better adapted to higher temperature. Morey and Sadaphal (1981) reported a decrease of wheat yield by 400 kg ha-1 for unit increase of 1°C maximum temperature and 0.5 hr sunshine. In similar studies, Ramakrishna et al. (1996) have estimated a fall in productivity of pearl millet in Rajasthan by 10-15 per cent due to increase in temperature by 2 °C.

Global warming will affect the scheduling of the cropping season as well as the duration of the growing period of the crop in all the major crop producing areas of Asia. In general, areas in mid and high latitudes will experience increase in crop yields, while yields in areas in the lower latitudes will decrease. In India while the wheat crop is found to be sensitive to an increase in maximum temperature, the rice crop is vulnerable to an increase in minimum temperature. The adverse impacts of likely water shortage on wheat productivity could be minimized to a certain extent under elevated CO_2 levels. The impact of rise in temperature and increases in atmospheric carbon dioxide on rice production in Bangladesh, Indonesia, Malaysia, Myanmar, Philippines, South Korea, and Thailand suggest that the positive effects of enhanced photosynthesis due to doubling of CO_2 are canceled out for increases in temperature (Mavi and Tupper, 2005).

Studies of Lai et a/. (1998) concluded that acute water shortage conditions combined with the thermal stress would adversely affect both the wheat and more severely the rice productivity in north-west India, even under the positive effects of elevated CO_2 levels in future. Likely impacts of climate change on agricultural productivity in India is causing a great concern to the scientists and planners as it can hinder their attempts for achieving household food security. Food grain requirement in the country (both human and cattle) would reach about 300 million tons in 2020. **The**

question that is of great concern is that, with the alarming increase, will it be possible to achieve the targeted production?

2.8 Impact of Climate Change on Livestock

Climate change may influence livestock systems directly by its effects on animal's health, growth, and reproduction, and indirectly through its impacts on productivity of pastures and forage crops. African cattle are mostly more heat tolerant than European cattle. In extremely hot areas, even the African breeds are beyond their thermal optimum. Under global warming, meat and milk production decline largely because the animals remain in the shade instead of grazing. Though the breed of animals are more tolerant to extreme climatic condition, the indirect impact through fodder availability due to climate change will be more in Rajasthan.

2.9 Impact of Climate Change on Disease and Pest of Crops

Most literature on effect of climate change on disease development and management involves only one of the several environmental factors, such as CO_2 concentration, temperature, or relative humidity conducted under controlled environments, which may not be applicable under field conditions. Results obtained so far indicate that climate change can alter stages and rate of pathogen development. Modify host resistance, change the physiology of host-pathogen interaction and this can be different in different patho-systems and locations, and thus no generalization can be made.

Low temperatures are often more important than high temperatures in determining global geographical distribution of insect pests and diseases. Therefore, for species, which are currently limited by low temperature, increasing temperatures may result in a greater ability over winter at higher latitudes, and may increase the pest's chances of extending its range. Spatial shifts in the distribution of crops may also occur under changing climatic conditions. Changes in the distribution of insect pests and pathogens will be greatly influenced by changes in the range of host crops because of distribution of a pest is also dependent on the availability of a host. However, whether or not a pest would move with a crop into a new area would depend on other environmental conditions such as the presence of overwintering sites, soil type, and moisture, e.g., populations of the corn earworm *[(Heliothis zea (Hubner*)] in the northern America could reach higher levels, leading to greater damage in maize and other crops. For all the insect species, higher temperatures, below the species upper lethal limit, could result in faster development rates and therefore more rapid increase of pest populations as the time to reproductive maturity is reduced. In addition to the direct effects of temperature changes on development rates, increases in food quality as a result of plant stress may result in dramatic increases in the development rate of pest populations. Thus, pest outbreaks are more likely to occur with stressed plants because under such circumstances, the plants defensive system is compromised and the resistance to pest infestation is lowered. Global warming will lead to earlier infestation of soybean by *H. zea*, with potentially significant levels of economic loss.

Rising temperatures are likely to result in the availability of new pests and pest niches. An increase of 3°*C* in the mean daily temperature would cause the carrot fly

(*Delia radicum*) to become active a month earlier than at present. An increase of 2°C will reduce the time from birth to reproductive maturity of the bird cherry aphid (*Rhopalosiphum path*) by varying amounts dependent upon the mean temperature. An increase of 1 and 2°C in daily maxima and minima will cause codling moth (*Cydia pomonella*) to become active about 10 to 20 days earlier than expected. For the summer fruit tortrix (*Adoxophyes orana*), increasing daily temperatures by 1°C would cause adult moth activity and larval emergence to occur about 10 and 25 days earlier, respectively, while temperature increases of 2°C would bring both adult activity and larval emergence forward by 10 days and the pest would complete 3 generations. There will be increased dispersal of airborne pest species in response to atmospheric disturbances. Many insects are migratory, and therefore may be well adapted to exploit new opportunities by moving rapidly into those areas, which become increasingly favorable as a result of climate change. Thus, climate changes may lead to:

- Extension of geographical range and increased risk of pest out breaks.
- Rapid population growth and more number of generations.
- Changes in insect —host synchrony and availability of alternate hosts.
- Changes in activity and abundance of natural enemies
- Reduced effectiveness of different pesticides.

2.10 Impact of Climate Change on Biodiversity

There is firm evidence of biological responses to climate change such as changes in flowering dates, arrival of migrating birds and fish; these and other phenol-logical mismatches may disrupt ecosystems. There is strong evidence that the distribution of many species has responded to climate change. Very many species, however, are unable to disperse rapidly to adapt to climate change in this way, especially in systems with low connectivity. There is evidence of changes in the composition and structure of communities and habitats, and in the habitat requirements of some species, including some protected species, pests and disease vectors. Ecosystem processes and services are probably also alter in as a direct result of climate change. Other drivers of biodiversity loss may exaggerate the rate and extent of these alterations and their reduction would offer the possibility of adaptation strategies. Climate change may therefore, stop one reaching site, regional, national and international conservation objectives. Furthermore, ecosystem goods and services, and their socio-economic benefits, will be put increasingly at risk.

2.11 Research Based Adaptation and Mitigation Strategies

Agriculture productivity is sensitive to two broad classes of climate induced effects (i) Direct effects from changes in temperature, precipitation or carbon dioxide concentrations and (ii) Indirect effects through changes in soil moisture and the distribution and frequency of infestation by pests and diseases. **Rice and wheat yields could decline considerably with climatic changes (IPCC, 2001).** Simple research and adaptation strategies, such as change in planting dates and varieties could help in reducing impacts of climate change to some extent (Aggarwal, 2008). Projected priorities for research, adaptation and mitigation strategies are discussed below:

(i) Agronomic Manipulations: Small changes in climate parameters can often be managed reasonability well altering dates of sowing, plant population, weed management, use of bio regulators crops or cultivars more adapted to changed environment can further ease the pressure. Further research is needed on these aspects.

(ii) Genetic Improvement in Crops and Livestock: It is reported that grain production in the world has stabilized slightly over 1800 million tons between 1996 and 2003. However, during last four years of this period followed declining trends of grain production. One of the reasons for stagnation/declining trends of production was rise in temperature due to climate change. Hence, research is needed for genetic manipulation in the cultivars and livestock's in such a way that they can tolerate the thermal stress and other changes in climate and sustain production under changed climatic conditions. Development of new genotypes to sustain or enhance productivity of crops is required. The need of the time is to conduct sincere research on marker aided sections and development of trans-genes for stress management.

(iii) Development of Resource Conserving Technologies: Recent researches have shown that surface seeding or zero tillage establishments of upland crops after rice gives similar yields to when planted under normal conventional tillage over a diverse set of soil conditions. This reduces costs of production, allows earlier planting and thus higher yields, results in less weed growth, reduces the use of natural resource and shows improvements in efficiency of water and fertilizers. In addition, such resource conserving technologies restrict release of carbon thus mitigating increase of CO_2 in the atmosphere. Global environmental changes including climatic variability may further increase the costs of production of crops due to its associated increases in nutrient losses, evapotranspiration and crop weed interactions. Suitable actions such as accelerated evolution of location specific fertilizer practices, improvement in extension services, fertilizer supply and distribution and development of physical and institutional infrastructure can improve efficiency of fertilizer use.

(iv) Improved Land Use and Natural Resource Management: Another important aspect of adaptation is strategic development of new land use system. The role of agro forestry and allied activities needs to be focused. Adaptation to environment change could be in the form of social aspects such as crop insurance, subsidies and pricing policies related to water and energy. Necessary provisions need to be included in the research and development plans to address these issues of attaining twin objectives of containing environmental changes and to enrich organic matter in the soil and thus improve soil health. Research on conservation of natural resources like land, water etc. is needed to mitigate the adverse effect of climate change.

To mitigate the effect of climate change much more emphasis should be given on land and water management practices. In India about two third agricultural lands are rainfed which are totally dependent on vagaries of monsoon. Under such conditions in-situ moisture conservation techniques followed by rainwater harvesting is only an alternative to save the crop under adverse climatic conditions. Scientific rainwater harvesting, watershed management, water storage and conservation practices with active community participation shall be a befitting answer on which a sound research plan should be prepared and executed for enhancing agricultural production and also to mitigate severity of drought.

In rainfed areas research priorities should be focused on rainwater harvesting, multiple use of harvested water and increasing water use efficiency. The specific research area in context of climate change is as under:

- River basin approach for sustainable management of surface water and ground water resources.
- Watershed planning and management strategies in rainfed areas.
- Impact of climate change on agricultural productivity and socio-economic status of people in the selected areas.
- Impact, outcome and adaptation strategies to climate change and globalization.
- Regional climate change prediction models based on long term data of rainfall, temperature, humidity etc.
- Impact on climate change on rainfall, evapo-traspiration and surface runoff
- Capacity building of farmers to cope with rainfall variability and water.

Research on impact of climate change will strengthen the overall socio- economic condition of the country. India is having well established network of regional and local organizations that can play a lead role in regional capacity building and research on impact of climate change on water. This will help to understand its regional obligations regarding water resources.

(v) Improved Risk Management though Early Warning System: Improved weather forecasting and management services can help a great deal in planning against cold waves, drought, flood, diseases and insect pest outbreak. In this respect short, medium and long range forecasts can be of great help. Development of contingency plans against temperature and rainfall etc are possible only through this. To transform weather information into operational researches needed. The increasing probability of floods and droughts; and other uncertainties in climate may seriously increase the vulnerability of eastern India and resource poor farmers to global climate change. In view of these climatic change and the uncertainties in future agricultural technologies and trade scenarios, it will be very useful to have an early warning system of environmental changes and their spatial and temporal magnitude.

(vi) Mitigation Options of GHG in Agriculture: Research on approaches to increase soil carbon such as organic manures, minimal tillage and residue management should be encouraged. These have synergies with sustainable development as well. Changing land use by increasing area under horticulture, agro forestry could also mitigate GHG emissions. Improved efficiency of energy use in agriculture by using better designs of machinery, improved management of rice fields for water and fertilizer use efficiency could reduce emissions of GHGs. Use of nitrification inhibits and fertilizer placement practices need further consideration for GHG mitigation. Improved management of livestock population and its diet could also assist in mitigation of GHGs.

3. Study Area

The present study area falls in Udaipur District of Rajasthan state, which is prone to the vagaries of nature in a big way. The state itself is, agro-climatically, a diverse region.

3.1 State of Rajasthan

The state of Rajasthan lying in the north western part of India is the largest state of India covering about 10.4 percent geo-graphical area of the country. The state of Rajasthan accounts for 5.7 percent of human population and 10.7 percent livestock population of the country. The Aravali range of hills starting from Gujarat and passing through the state from south west to north east and going up to Haryana divides the state in to two physiographic divisions. The regions lying north of Aravili range is mostly desert in nature. The region in south and south-east of Aravali is a diversified region for agricultural purposes. For the purpose of developing location specific agricultural technologies, the state is divided into ten agro-climatic regions as per details given in Table-1:

Table-1: Agro-climatic regions of Rajasthan

Zone No.	Zone	District	Coverage of Tehsils	Annual average Rain fall (mm)	Temperature maximum °C	Temperature minimum °C
IA	Arid western plain	Barmer, Jodhpur,	All Part (5)	200-370	40.0	8.0
IB	Irrigated north western plain	Shri Ganganagar Hanumangarh	All All	100-350	42.0	4.7
IC	Hyper arid western plain	Bikaner Jaisalmer Churu	All All Part (3)	100-350	48.0	3.0
IIA	Transitional plain of inland Drainage 5	Nagaur Sikar Jhunjhnu Churu	All All All Part (3)	300-500	39.7	5.3
IIB	Transitional plain of Luni basin	Jalore Pali Sihorhi Jopdhpur	All All Part (3) Part (2)	300-500	38.0	4.9
IIIA	Semi arid and eastern plain	Ajmer Jaipur Dosa Tonk	All All All All	500-700	40.6	8.3
IIIB	Flood prone	Alwar	All	500-700	40.0	8.2

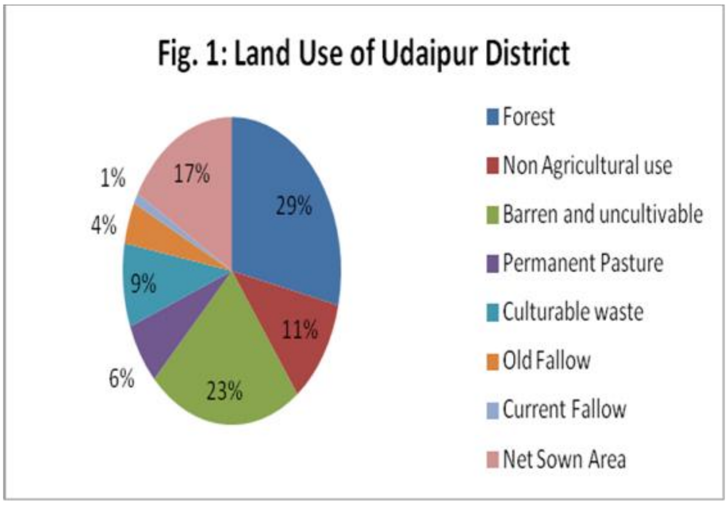
Zone No.	Zone	District	Coverage of Tehsils	Annual average Rain fall (mm)	Temperature maximum °C	Temperature minimum °C
	eastern plain	Bharatpur Dholpur Karoli Swaimadhopur	All All All Part (5)			
IVA	Sub-humid southern plain and Aravali hills	Bhilwara Rajsamand Chittprgarh Udaipur Sirohi	All All Part (9) Part (7) Part (2)	500-900	38.6	8.1
IVB	Humid southern plain	Banswara Dungarpur Pratpgarh Chittorgarh Udaipur	All All All Part (4) Part (2)	500-1100	39.0	7.2
V	Humid south eastern plain	Bundi Jhalawar Kota Baran Swaimadhopur	All All All All Part (2)	650-1000	42.6	10.6

Note:-Figures in parentheses indicate number of tehsil of the district that fall in a particular zone.
Source: -Rajasthan Agricultural Statistics at a Glance- Directorate of Agriculture, Government of Rajasthan

3.2 District of Udaipur

The Study area forms part of Udaipur district which falls in zone IV A, Sub-humid Southern Plain and Aravali Hills. Udaipur district, before the formation of Rajsamand district in 1991, was one of the largest district of southern Rajasthan. When a new district – Pratapgarh was formed in 2008 again some part of Udaipur district was merged with Pratapgarh. Hence it is different to get meaningful time series data for Udaipur district. The major part of present Udaipur district falls under IV A and remaining under zone IVB. The major area of Udaipur district falls under **Tribal Sub Plan (TSP).**

3.2.1 Land Use Pattern of Udaipur District



Udaipur district has geographical area of 13.88 lacs hectares out of which 28.6 percent is under forest, 11.2 percent under non-agricultural uses, 22.8 percent under barren and uncultivable land, 6 percent under permanent pasture and grazing land, 8.8 percent under culturable waste, 4.4 percent under old fallow, 1.1 percent under current fallow and 16.6 percent under net sown area. ***Here it is worth mentioning that the***

share of net sown area to geographical area of Udaipur district is one of the lowest for any district of the state. Details are given in Fig. -1.

3.2.2 Cropping Pattern of Udaipur District:

The gross cropped area of the district is 3.23 lacs hectare out of which 2.24 lacs hectare under Kharif crop and remaining 0.98 lacs hectares under Rabi crops during 2010-2011. The major kharif crops is Maize sharing about 55% and Major Rabi crop is wheat sharing about 17% of gross cropped area. The area under specific crops could be seen from Fig.-2 and Table 2 respectively.

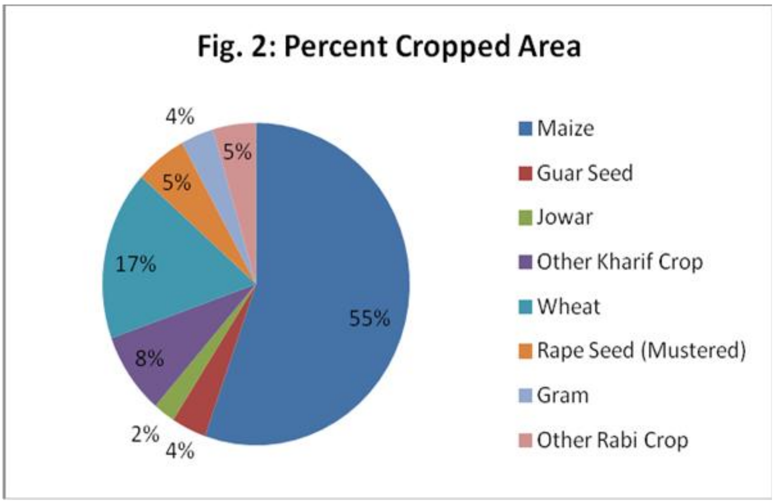


Table-2: Cropping pattern of Udaipur District

Name of crop	Area of crop(hectares)	Irrigated area of crop (Hectares)	Irrigated Area in Percent
Paddy	4881	5	0.10%
Sorghum	7477	0	0.00%
Maize	179380	30	0.02%
Small Millet	1086	11	1.01%
Arhar	3355	0	0.00%
Other Kharif Pulses	7462	0	0.00%
Sisimam	2612	0	0.00%
Ground nut	3176	0	0.00%
Soybean	1802	4	0.22%
Cotton	973	903	92.81%
sugarcane	293	290	98.98%
Guar Seed	11888	0	0.00%
Chilies	847	8	0.94%
Wheat	55118	54205	98.34%
Barley	7529	6553	87.04%
Gram	11157	905	8.11%
Other Rabi Pulses	857	830	96.85%
Rape seed (Mustered)	17541	9342	53.26%
Taramira	5249	35	0.67%
Seed species	250	250	100.00%
Other species	260	260	100.00%
Ajwine	608	0	0.00%
Total	**323801**	**73631**	**22.74%**

Source: -Rajasthan Agricultural Statistics at a Glance- Directorate of Agriculture, Government of Rajasthan

Only 22.74 percent of cropped area is irrigated in the district.

3.2.3 Demographic Features

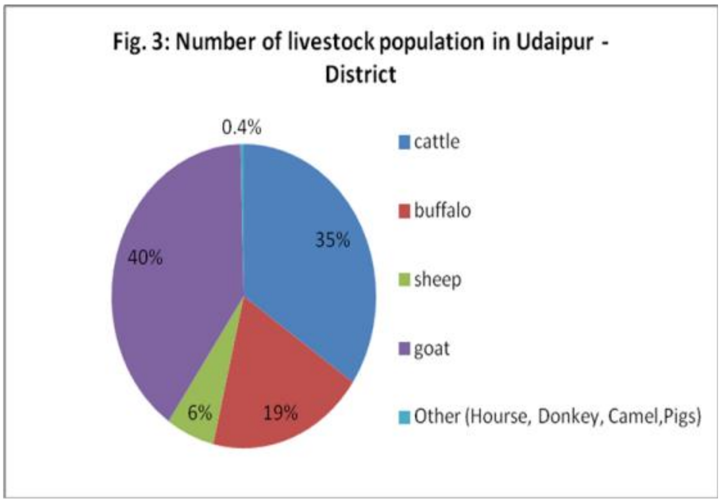
According to 2011 Census, the human population of Udaipur district has been 3.07 million, which is about 4.47 percent of total population of the state. During the period 2001-2011 the population of the district has grown by 23.63 percent against 21.44 at state level. Presently, out of the total population, 80 percent is rural and 20 percent is urban. The literacy is 62.7percent with rural literacy of 55.8 percent compared to 67.06 percent and 62.34 percent respectively at state level.

3.2.4 Livestock Population

Udaipur district has 27.36 lacs livestock population for the year 2007, the category wise breakup of different livestock could be seen from Fig.-3 and Table 3 respectively.

Table-3: Detail of Livestock Population of Udaipur District

Type	no.
Cattle	946318
Buffalo	523712
Sheep	161769
Goats	1093432
Horse	673
Donkey	3298
Camel	5522
Pigs	1330
Total	**2736054**



Water Resources

The Annual normal rainfall of Udaipur district is 645 mm. Major chunk of rainfall is received through south west monsoon from June to September. The source wise gross and net irrigated area of the district for 2008-2009 is as given in Table 4 and Fig. -4.

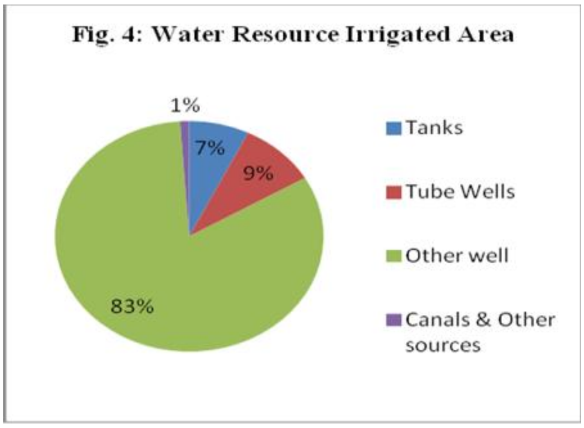


Table-4: Details of water resource

Source	Irrigated Area (Ha.)		Irrigated Area in Percent	
	Gross	**Net**	**Gross**	**Net**
Canals	493	493	0.80	0.82
Tanks	4482	4438	7.23	7.41
Tube Wells	5777	5577	9.32	9.31
Other well	51065	49184	82.37	82.15
Other sources	181	181	0.29	0.30
Total	61998	59873	100	100

Source: -Rajasthan Agricultural Statistics at a Glance- Directorate of Agriculture, Government of Rajasthan

Out of 3.23 lacs hectare gross cropped area only 0.62 lacs hectares is irrigated and the remaining is rain-fed or un-irrigated

3.2.5 Selected Study Area:

Udaipur district consists of 11 Tehsils, 12 panchyat samities and 467 Gram panchyats. The cluster of 10 selected villages for the purpose of present study falls under Bhinder block of Vallbhnagar tehsil which has a common boundary with Mavali at north, Girva at west, Darayawat at south and Chittorgarh district at eastern part as shown in Fig. 5.

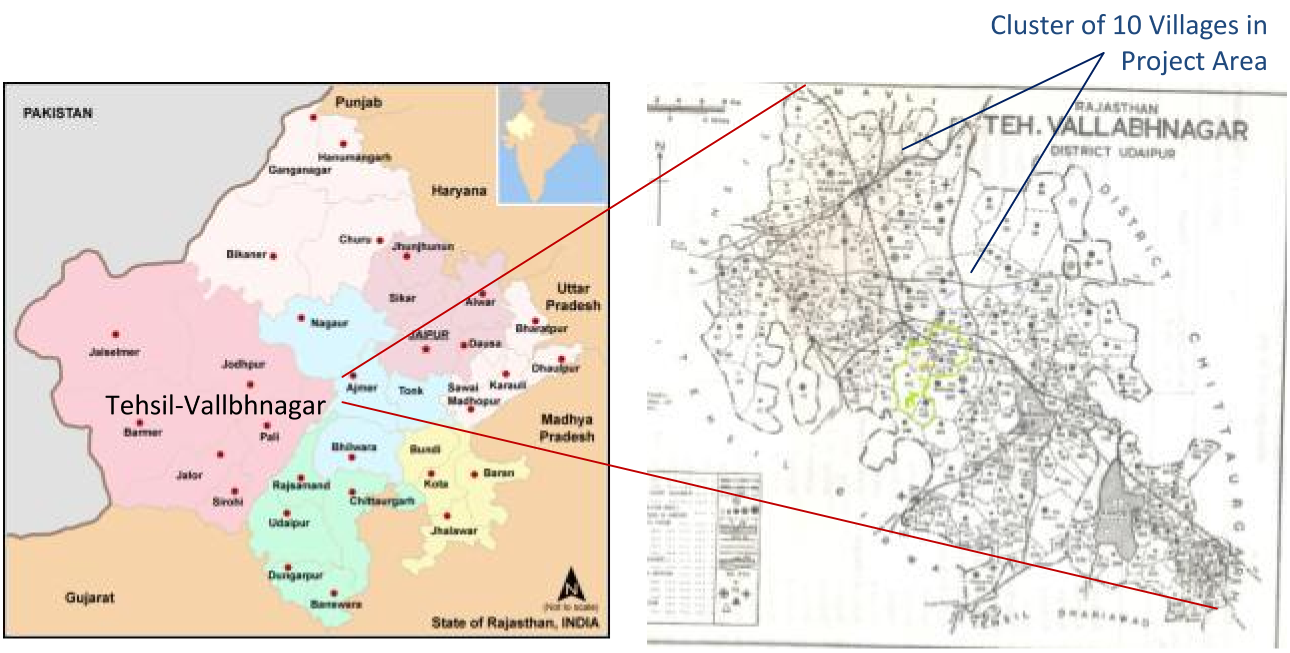


Fig. 5: Location Map of Study Area

3.2.6 Selected Villages and Profile:

The Water and Climate Resilience Program (WACREP) in collaboration with India Water Partnership (IWP) was taken up by AFPRO Udaipur in association with Apna Sansthan Udaipur during October-2013 to March -2015 in a cluster of 10 villages in Vallbhnagar tehsil of Udaipur district. The land profile of these villages is given in Table 5.

Table-5: Selected Villages and Profile

(Area in hectare)

Name of Villages	Forest	Pasture	cultivable	Govt. Waste land	Pathways drainage	Private waste land	Total	Irrigated
Beripura	0	9	10	0	3	22	44	6
Bhopa kheda	0	17	155	18	2	77	269	55
Dhawadia	0	141	98	185	13	177	614	30
Gajpura	0	0	14	16	6	45	81	6
Kapario ka kheda	0	0	22	334	1	14	371	12
Khera phala	0	0	33	43	1	104	181	16
Nagaliya	353	0	79	427	55	382	1296	18
Paitya	0	0	14	15	3	50	82	10
Phoosariya	0	7	107	49	2	208	373	22
Rayla	0	22	33	3	2	72	132	20
Total	**353**	**196**	**565**	**1090**	**88**	**1151**	**3443**	**195**

Source: Village Record of Patwari

The households in the selected cluster of villages mostly fall under scheduled caste and scheduled tribe communities who are resource constrained group of people. In terms of farm size these families fall under small and marginal class of farmers with average size of 1.23 hectare per house hold out which 38.3 percent irrigated. 16.2 percent rainfed, 42.4 percent pasture and 3.1 percent under non agriculture use.

The house hold in selected villages follow farming as the major source of livelihood These farmers , by and large, follow integrated farming system of practices with different combinations of crops and livestock activities. The village wise major crops and livestock activities are as given in Table 6.

Table-6: Major crops and livestock in selected villages

S. No.	Name of Village	Major crops	Major livestock
1	Beripura	Maize, wheat , mustard, and fodder	Cattle , buffalo, goat,
2	Bhopa kheda	Maize, Soybean, wheat , mustard, opium	Cattle , buffalo, goat, sheep
3	Dhawadia	Maize, Wheat	Cattle , buffalo, goat, sheep
4	Gajpura	Maize ,Jawar, Urad, wheat	Cattle , buffalo, goat
5	Kapario ka kheda	Maize , wheat. Barley	Cattle , buffalo, goat, sheep
6	Khera phala	Maize, Jawar, wheat, mustard	Cattle , buffalo, goat

S. No.	Name of Village	Major crops	Major livestock
7	Nagaliya	Maize ,wheat, Barley, Mustard	Cattle , buffalo, goat, sheep
8	Paitya	Maize, Jawar, Soybean, Guar, wheat , mustard, and Isabgol	Cattle , buffalo, goat
9	Phoosariya	Maize, Soybean, Jawar, Urad, wheat , Barley, mustard	Cattle , buffalo, goat
10	Rayla	Maize , Urad, wheat , barley	Cattle , buffalo, goat, sheep

Source: Household Survev

Almost every house hold grows maize in kharif and wheat in rabi season. Depending upon land size other crops are also grown by the households. On an average 6-7 animals are maintained on each farm out of which 55 percent is goat followed by 28 percent cattle , 15 percent buffalo and remaining other animal like sheep, donkey etc.

4. Climate Change in Selected Study Area

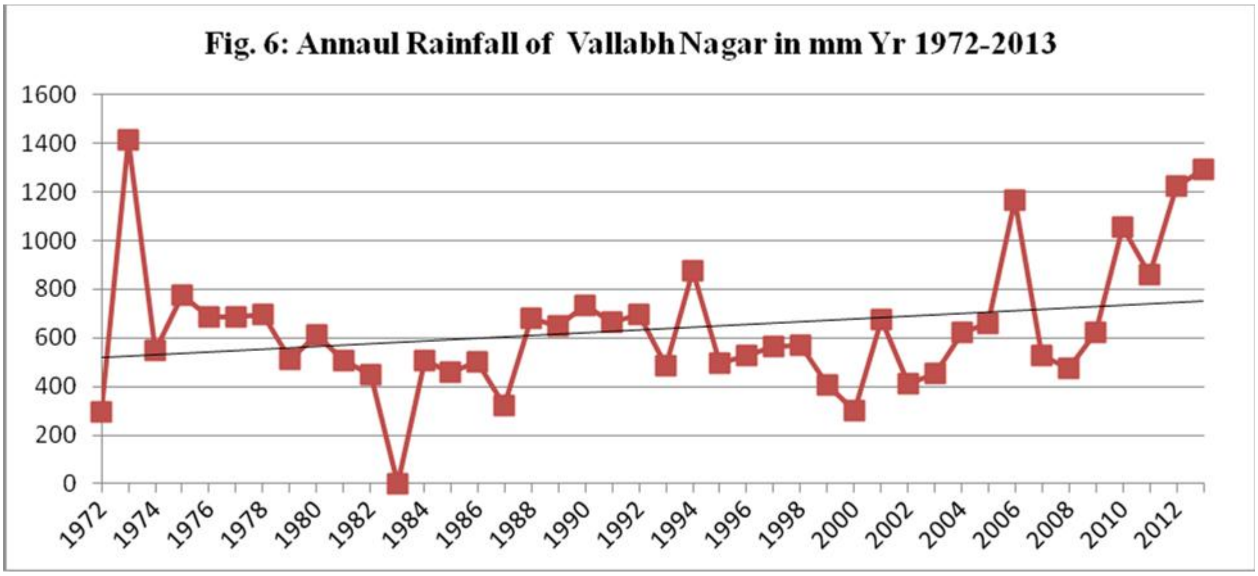
4.1 Rainfall

The analysis of annual rainfall data for the period 1972-2013 recorded in the meteorological observatory at Vallbhnagar (catchment no. 406) was done for the pooled period as well as split period 1972-1992 and 1993-2013. The quantum of average annual rainfall during 1993-2013 showed substantial increase over 1972-1992 (679.05 mm and 589.73 mm respectively). The trend pattern has been positive for the pooled and lateral period and negative for former period 1972-1992. The coefficient of variation is being 43.37 percent for pooled period, 44.39 percent for former period and 42.29 percent for lateral period as given in Table 7. The annual rainfall pattern of the region could be seen from Fig. 6.

Table 7: Rainfall Pattern in Study area

Period	Mean Rainfall (mm)	standard deviation in Rainfall (mm)	Coefficient of variation (in %)	Trend equation
1972-2013	634.39	275.15	43.37	Y_t = 512.58+5.6654t
1972-1992	589.73	261.79	44.39	Y_t = 670.78-7.3681t
1993-2013	679.05	287.20	42.29	Y_t = 379.95+27.191t

Source: Indian Metrological Department (imd.gov.in)

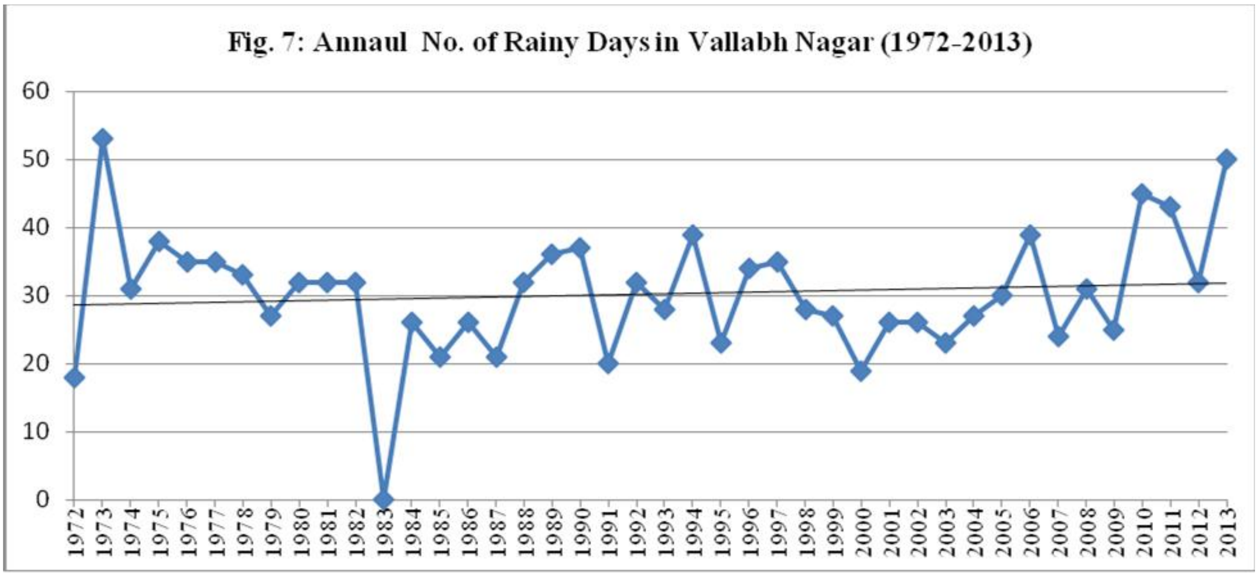


Source: Indian Metrological Department (imd.gov.in)

The positive shift in rainfall over the years has impact on land use as well as agricultural and livestock systems in the area.

4.1.1 Rainy Days

Analysis of annual rainy days indicated increase in number of rainy days in second period compared to first period. The low coefficient of variation in second period indicates less variability in rainy days during this period. It shows more concentration of rainy days within rainfall seasons as shown in Table 8. The pattern of rainy days could be seen from **Fig. 7.**



Source: Indian Metrological Department (imd.gov.in)

Table 8: Annual mean rainy days

Period	Mean (days)	standard deviation in Rainfall (mm)	Coefficient of variation (in %)	Trend equation
1972-2013	30.26	9.16	30.27	Y_d = 28.542+ 0.08d
1972-1992	29.38	10.24	34.85	Y_d = 33.681-0.3909d
1993-2013	31.11	8.1	26.01	Y_d = 25.343+0.5273d

Source: Indian Metrological Department (imd.gov.in)

4.1.2 Seasonal Rainfall

The season wise rainfall for pooled, first and second period could be seen from **table 9.** During 1972-1992, though rainfall was less, it was more spread over the south-west, south east and intermediate rainfall seasons. During 1993-2013 the south west monsoon was found to be much higher compared to that in 1972-1992. It is worth noting that south east and intermediate rains were much less in second period compared to first period. It is pointed out that the highest rainfall in a day was 190 mm in year-2012 and the lowest rainfall in a day was 36 mm in year-1972.

Table 9: Season wise rainfall in study area

S. no.	Period	South west monsoon (June-Sept.) in mm	South East monsoon (Oct-Jan) in mm	Intermediate Rains (Feb-May) in mm	Total Rainfall (in mm)
1.	1972-2013	588	31	16	635
2.	1972-1992	536	37	17	590
3.	1993-2013	642	24	14	680

The increase in quantum of rains through south west monsoon coupled with reduced quantum of rains in other season's calls for water management strategies to conserve rain water and to minimize wastage of precious water resources in the study area.

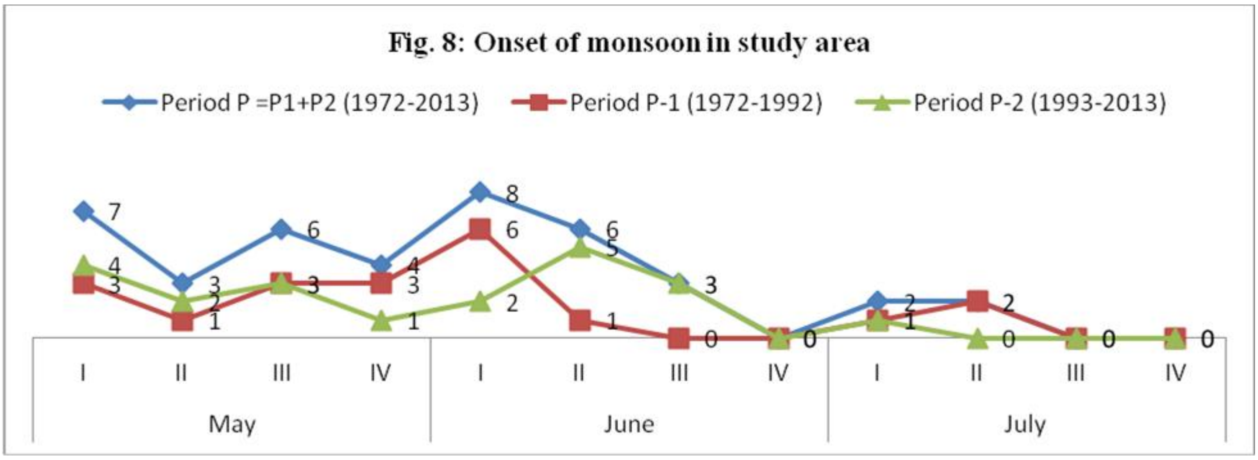
4.1.3 Onset of Monsoon

The details of onset of monsoon in the study area are given in **table 10** and **Fig. 8**.

Table 10: Frequency of onset of monsoon in different weeks in the study area during the periods

Month	Week	Period P =P1+P2 (1972-2013)	Period P-1 (1972-1992)	Period P-2 (1993-2013)
May	I	7	3	4
	II	3	1	2
	III	6	3	3
	IV	4	3	1

Month	Week	Period P =P1+P2 (1972-2013)	Period P-1 (1972-1992)	Period P-2 (1993-2013)
June	I	8	6	2
	II	6	1	5
	III	3	0	3
	IV	0	0	0
July	I	2	1	1
	II	2	2	0
	III	0	0	0
	IV	0	0	0



The frequency of weeks for onset of monsoon has been different for the first and second period. From May first week to third week over the year there was no significant difference in the frequency of weeks, however from May third week to June first week the frequency was more for first period and less for second period which changed from June second week to fourth week. In other words there is an indication of shifting onset of monsoon forwarded during the second period. This shift in monsoon days has also implication for sowing of kharif crops

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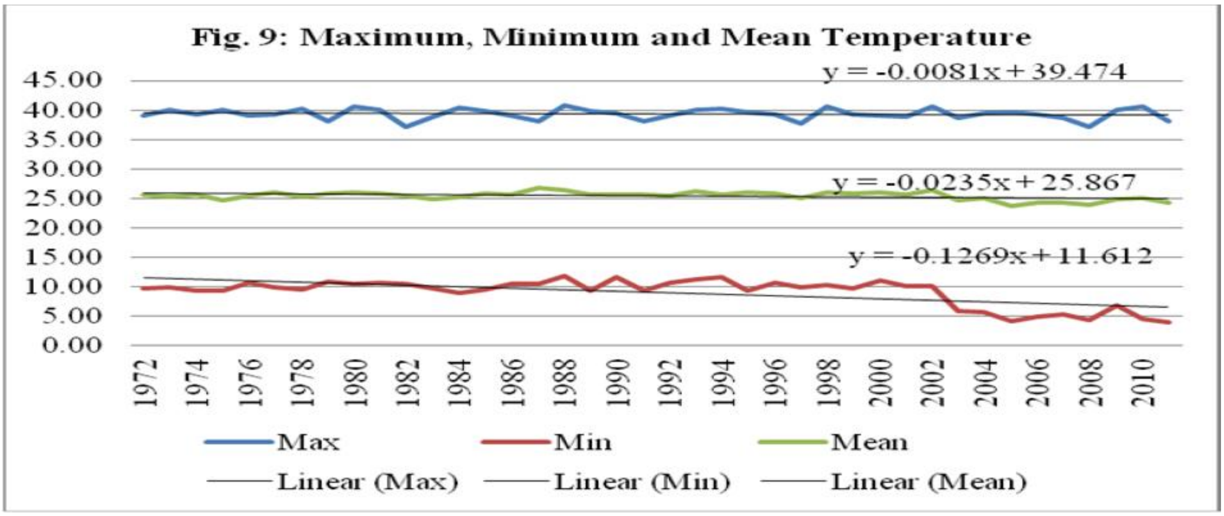
4.2 Temperature (1972- 2011)

The estimated trend equations for maximum, minimum and mean temperature are as under in Fig. 9.

$T_{max} = 39.474-0.0081C$

$T_{min} = 11.612-0.1269C$

$T_{mean} = 25.867-0.0235C$



Source: Indian Metrological Department (imd.gov.in)

The maximum, minimum and mean temperatures are found slightly decreasing over the period. The minimum temperature is found to decrease at a faster rate compared to maximum temperature. The number of years in which maximum and minimum temperature recorded in different months could be seen from table 11.

Table : 11 Number of years in which max and min temperature recorded in different months

Temperature in °C	Month	Frequency
Maximum	March	0
	April	3
	May	35
	June	2
Minimum	Nov	0
	Dec	4
	Jan	32
	Feb	4

Source: Indian Metrological Department

The maximum temperature was recorded mostly in the month of May and minimum temperature in the month of January.

4.3 Base Line Survey

4.3.1 Sample Households

Base line survey was conducted in 400 households in a cluster of 10 selected villages as per details given below in **Table: 12.**

Table: 12 Number of Total and Sample Household in Selected Villages

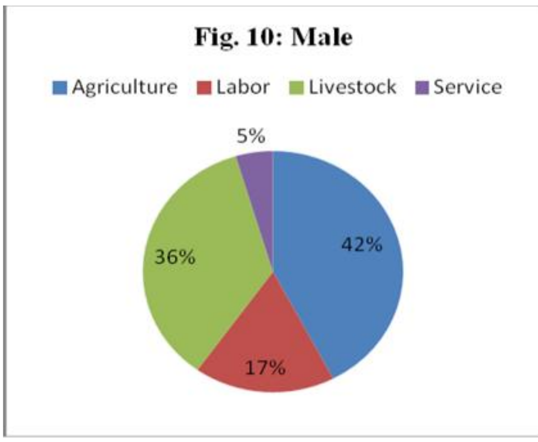
S. No.	Name of Village	Panchyats	Total HH	Sample HH	% Sample HH with Total HH

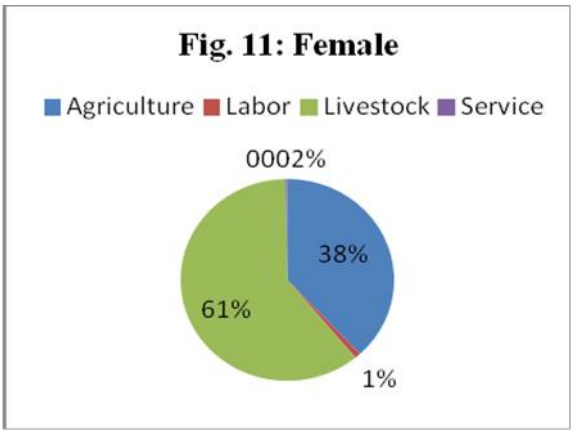
S. No.	Name of Village	Panchyats	Total HH	Sample HH	% Sample HH with Total HH
1	Beripura	Bhopakheda	65	35	53.85
2	Bhopa Kheda	Bhopakheda	164	27	16.46
3	Dhawadiya	Dhawadiya	303	84	27.72
4	Gajpura	Amarpura	57	10	17.54
5	Kapario ka Kheda	Amarpura	157	38	24.2
6	Khera phala	Dhawadiya	209	54	25.84
7	Nagaliya	Dhawadiya	197	43	21.83
8	Patiya	Amarpura	58	11	18.97
9	Phoosariya	Bhopakheda	258	21	8.14
10	Rayla	Bhopakheda	129	77	59.69
	Total		**1597**	**400**	**25.05**

A well structured schedule was used for collection of household level information. The data was collected though personal interview of respondents. The type of data collected included respondent's identification information, family size, work force, education, drinking water facility, details of wells, land use pattern, livestock composition, crop and crop production, source of household income, migration of family members, fodder availability, pastureland management and so on. The summary of finding of the base line survey is given below:

4.3.2 Family Adults and Work Force:

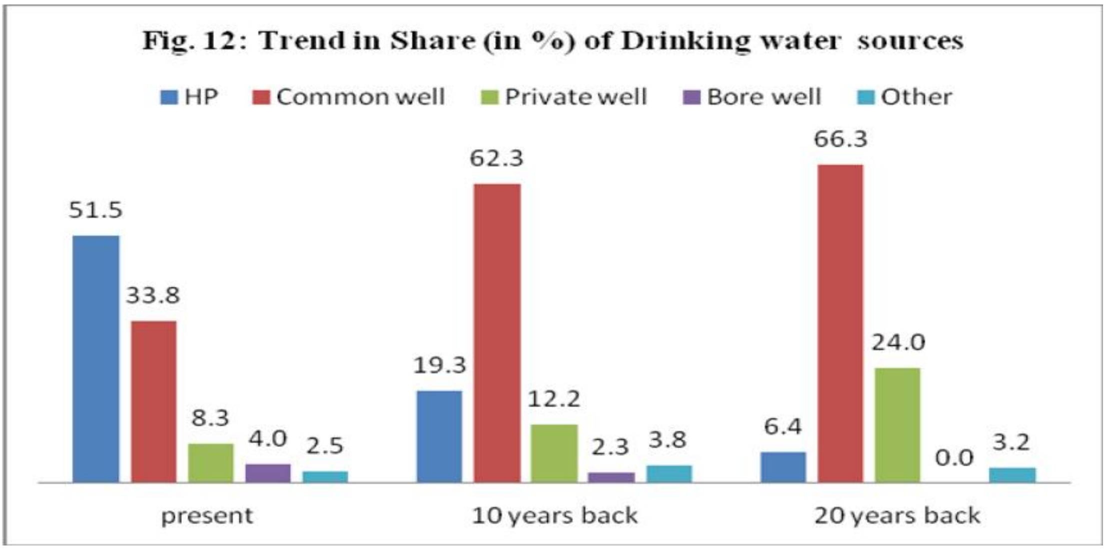
- In all there were 411 adult male members out which 174 in agriculture, 72 as laborers, 146 in livestock and 19 in service.
- In all there were 336 adult female numbers out of which 128 in agriculture, 3 as laborers, 204 as livestock and one in service.
- Agriculture and livestock were major sources of employment followed by labor work for both male and female workers. Work force of male and female are engage in different occupation are given in **fig. 10 & 11**.





4.3.3 Drinking Water Facilities

- Presently about 206 households depended on hand pumps, 134 on common wells, 33 on private wells, 16 on bore wells and 10 on other sources for drinking water purposes.
- Ten years back 76 households depended on hand pumps, 245 on common wells, 48 on private wells, 9 on bore-wells and 15 on other sources.
- Twenty years back 20 households depended on hand pumps, 207 on common wells, 75 on private wells and 10 on other sources.
- There is increased dependence on hand pumps and decreased dependence on private wells for drinking water.
- As the ground water level goes down, there is more dependence on hand pump as the private wells become unused. Trends of share of drinking water given in **fig.12.**



4.3.4 Wells and Water Bodies

The details of wells and other water bodies in selected villages are given in Table 13 and 14 respectively.

Water resource data collection during survey of irrigation wells in the project area

Table: 13 Number of wells and bore wells in different villages

S. No	Name of village	Number of wells			Number of bore wells
		Total	Functional	defunct	
1	Beripura	7	6	1	0
2	Bhopa kheda	63	37	26	10
3	Dhawadia	75	41	34	0
4	Gaipura	11	9	2	3
5	Kapario ka kheda	44	23	21	1
6	Khera phala	20	16	4	0
7	Nagalya	53	41	12	1
8	Patiya	14	12	2	14
9	Phoosariya	82	40	42	7
10	Rayla	44	23	21	0
Total		413	248	165	36

Source: Household survey

Out of 413 wells in the villages, 248 are functional and 165 are non functional.

Table 14: Surface water bodies in project villages

S. No.	Village	Details of Water Bodies					Structure details
		Anicut	Talab/nadi	Water availability in months	Submergence (ha)	Uses	
1	Beripura	-	1	3	0.35	For livestock	Construction by AS in 2010 under FFCD
2	Bhopa Kheda	-	2	3	2.34	For livestock	Constructed more than 100 years
3	Dhawadia	-	-	-	-	-	-
4	Gajpura	-	1	3	0.47	Recharge of groundwater	The village is also benefited by Patiya anicut
5	Kapario ka khera	1	1	6	0.7	6 ha irrigation by lift	By pnchayat
6	Khera phala	-	-	-	-	-	-
7	Nagaliya	3	-	12	2.8	For livestock	Construction by WRD
8	Patiya	1	-	3	0.93	Recharge of groundwater	Constructed by Panchayat
9	Phoosariya	1	1	4	1.17	livestock	Constructed by Panchayat
10	Rayala	3	-	5	3.74	2.5 ha irrigation	Constructed by Panchayat

Source: Household Survey

In all there are 9 anicut and 6 Ponds. Except 3 anicuts, all water basins are seasonal for 3-6 months.

4.3.5 Land Use

- Presently area under kharif crop per household is 0.41 hectares, rabi crop is 0.37 hectares and zaid is 0.01 hectares
- 20 years back, per house hold area under kharif crop was 0.34, rabi crop 0.29 and zaid 0.05 hectares.
- 40 years back per house hold area under kharif crop was 0.22 and rabi crop 0.15 hectares
- Per household area under khari and rabi crop increased over the years.

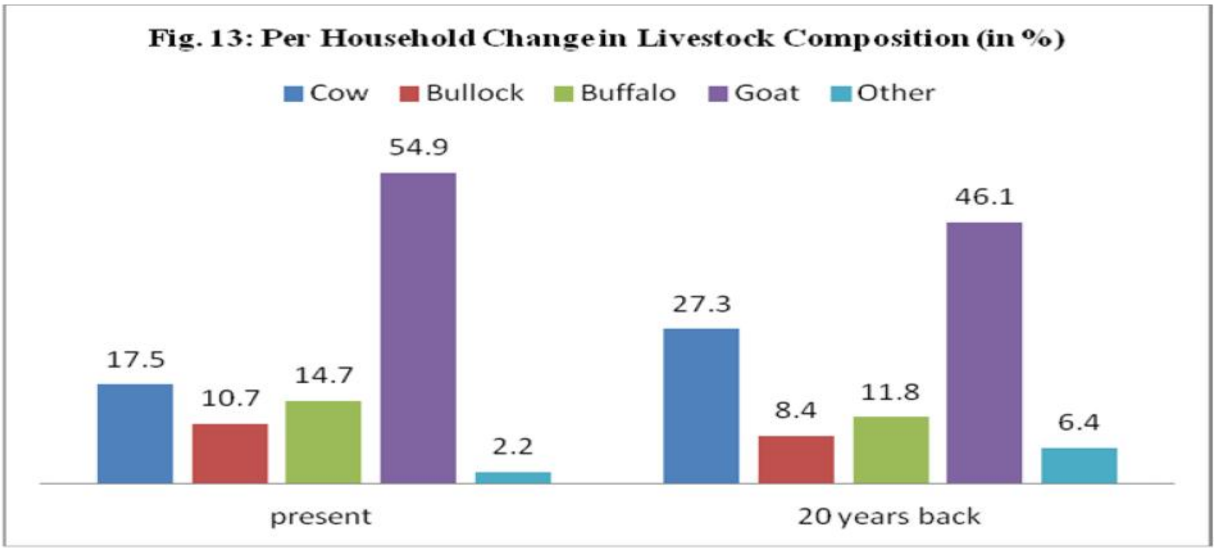
4.3.6 Cropping Pattern and Crop Production

- Maize in kharif and wheat in rabi continued to be major crops in study area.
- The present productivity of maize is 11.73 qt/ ha against 11.3 qt/ha 20 years back and 6.30 qt/ ha 40 years back
- The present productivity of wheat is 18.11 qt/ha against 17.60 qt/ha. 20 years back and 4.50 qt/ha 40 years back
- Though productivity maize and wheat over the years has increased, it is still very low in the study area.

4.3.7 Livestock Composition

- Presently per household number of livestock comes to 6.44 out of which cow is 1.13, bullock is 0.69, buffalo is 0.95, goat is 3.54 and others 0.14 respectively.
- Per household livestock 20 years back was 9.70 out which cow 2.66, bullocks 0.82, buffalo 1.15, goat 4.49 and others 0.62 respectively.
- The total and species wise number of animal per house hold has come down over the years probably due to fodder problem given in **fig.13.**

Low milk productive Indigenous breed of Cow in Project area



4.3.8 Source of Household Income

- The major sources of household income included activities like livestock, labor work, crop production, business and so on.

4.3.9 Migration Pattern

- Out of 400 sample households, migration of family members was reported in 43 (10.8%) households, out of which 14 within district, 7 within state and 22 outside states.
- Out of 43 migrations 22 (51%) were permanent 21 (49%) were seasonal.

4.3.10 Fodder Availability

- The present dry fodder production per household is 11.78 qt against 7.98 qt in 10 years back and 8.71 qt 20 years back. The availability of most of the fodder requirement are met from private and common pastures and partially purchased from outside by few families.

4.3.11 Pastureland and Management

- Out of 3443 hectare area of sample villages 33.30 percent comes under private pasture and grazing land 3.82 percent under panchyat level pastureland.
- Major part of private pastureland is used for open grazing and in some cases such lands are managed jointly by group of farmers.

Survey of pastureland in village - Kamliya under Participatory technology development approach

4.4 Participatory Rural Appraisal (PRA)

In each village PRA was conducted with a view to assess the overall situation of the village including local resource mapping, hazard mapping, identification of problems and perception of people about possible remedial measures related to climate change, crop production, livestock production and so on. The details of PRA and summary of findings are as under:

4.4.1 Participants:

Included selected Cluster Core group members, Women, Village elders, Panchayat leader (Sarpanch), Village youths, Farmers, Livestock keepers, Field associates, NGO representatives, etc.

4.4.2 Schedule of PRA Exercise:

The schedule of PRA in each village followed a sequence as under:

- Introduction of participants.
- Film entitled *Dharti ki Odhani* (Climate Vulnerability and Adaptation initiatives) linking Water and climate Resilience Programme.
- Brief Introduction of WACREP – IWP initiatives in the project.
- Community perception on climate change and its impact.
- Objectives and Methodology of PRA exercise.
- Group Exercise for Village Resource Mapping (Land, Water and Vegetation) Livelihood pattern (Agriculture, Livestock, Pasture, etc.) and Climate change scenario in the area and village transect walk.

The PRA exercise was organized to collect primary information of each village. The women and men from village were involved to conduct the exercise. The representation of 2 persons from each hamlet was ensured for participation in PRA. The village was divided in mainly 2 parts geographically covering natural water resources. The Resource map was drawn on ground showing natural and common property resources available in village. The different colors were used to show resources on ground involving each participant. The map was also drawn on paper parallel for reference and further use for documenting village information.

4.4.3 Major outcomes of PRA:

- **Mapping of the Resources (Land, Water and Vegetation):** The land was categorized in mainly three parts –Agriculture, Non cultivable and common land. The natural water resources like talab (pond), anicut, other water body, open wells, bore wells, hand pump including irrigation and drinking water facilities in village were made on map. The vegetation available on agriculture land and private pasture area has been shrinking due to destructive

Resource mapping by the community during PRA exercise in Village - Dhawadiya harvesting for fodder, fuel and timber / non timbers needs. Many invasive species replaced the important timber and fodder species which was having great economic value for the communities.

- **Previous and Existing Agriculture pattern:** Previously 50 years ago, the traditional crops cultivated mainly included millets like *Kuri, Batti, Hamo, Kangani, Jwar, Jow,* etc. Presently, cropping pattern is changed by cultivating mainly cereals, legumes, oil seed crops, cash crops, etc. The area of cultivation has increased but gross productivity is decreased due to fertility loss, top soil erosion, water scarcity etc. There is also increased input cost in agriculture by using chemical fertilizers, pesticides, hybrid seeds, etc. Several pests is also affected the crops during past 30 -40 years of period which has resulted in crop loss and decreased productivity. Pest, locally called *Rolee,* and has termites in soil were found since many years. About 50 years ago, paddy was cultivated along the streams in villages.
- **Previous and Existing Livestock status:** Livestock composition has changed and its productivity affected due to changing feeding practices and inadequate nutritional requirement to productive animals. Comparatively the number of animals has decreased. The large ruminants like cow, buffaloes, bullocks were replaced by small ruminant like goat, due to inadequate fodder availability and limited adaptive capacity of tribal community in the village. Due to climate change impacts livestock were affected by some diseases causing losses to livestock population and their health. The diseases are in Goat like *Dastan* (calf scour) and in cow/buffaloes like *Galghontu* (Hemorrhagic septicemia) found during these days due to impact of changing climate and animal feeding practices. Many of important grass species like Heran *(Sehima nervosum)* has been disappeared from the local vegetation, such species played a major role in the past to meet fodder requirements of animals.
- **Extreme Climate events in the area:** Frequent drought occurred in the area. At every 3-4 years drought situation arise which and affected natural resources and associated livelihood sources. During last 30 years, the climate hazards accrued are listed as below **Table 15.**

Table 15: Major Climate Hazards in Study Area

Year	Climate Event	Impacts
1977	Heavy Rains	- Loss of livestock population with diseases and many animals dead due to flood in the area - Loss of buildings and destroyed due to heavy rain
1983	Drought	- Loss of Agriculture production. - Sold the livestock due to fodder scarcity - Freely released the livestock for grazing - Migration to urban areas for wage employment - Most of open well dried
1987	Drought	
1992	Drought	
2004	Drought	
2006	Heavy Rain	Crop was lost due to heavy rains in monsoon season
2010 -11	Heavy Rain	Inadequate fodder available for animal Most of the rainwater flowed through small and big streams in

Year	Climate Event	Impacts
		Jaisamand lake Soil erosion along with streams

Source: Base Line Survey & PRA

- **Rainfall:** The rainy season was previously for about 4 months therefore is called chomasa (four months) but since past few years it has been reduced up to 2 months even some time only 1 month. The scanty rainfall mostly occurs in the area. This year 2013 – 14, post monsoon rain has been affected the loss of harvested crops and fodder from pastures.
- **Temperature:** Since last 30 years, the temperature has changed in summer and winter seasons. The intensity of heat has been increased in summer and colder days in winter. The year 2013 – 14 has been coolest year in winter in last 15 years as shared by village elders. During these winter, due to *Daaha* (frost), the tree Khakhra *(Butea monsoperma)* was affected. The leaves of this tree are being used as fodder during dry summer season. 15 years ago such event had happened and crops were pre-harvested which made great loss to productivity in agriculture and affected food fodder availability during the period.
- **Watershed Hazard Mapping:** Water hazard map was drawn on resource mapping sheet which was copies from map drawn on ground by community.

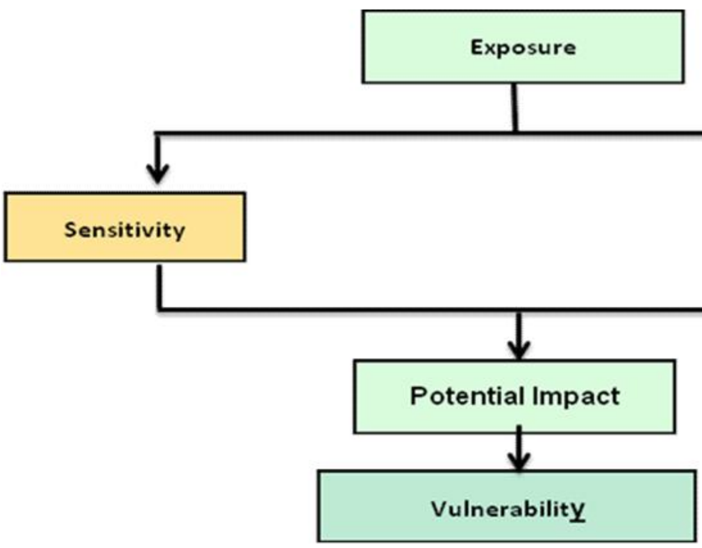
5. Vulnerability Assessment and Adaptation Strategies

5.1 General Analytical Frame Work

The vulnerability of climate change in the rural agricultural system was perceived on the basis of following parameters and as shown in **Fig. 14.**

- Nature and type of climate change in the region (exposure)
- Characteristics of agriculture system (sensitivity)
- Impact on the system
- Ability of the system to face the challenges (adaptive capacity)

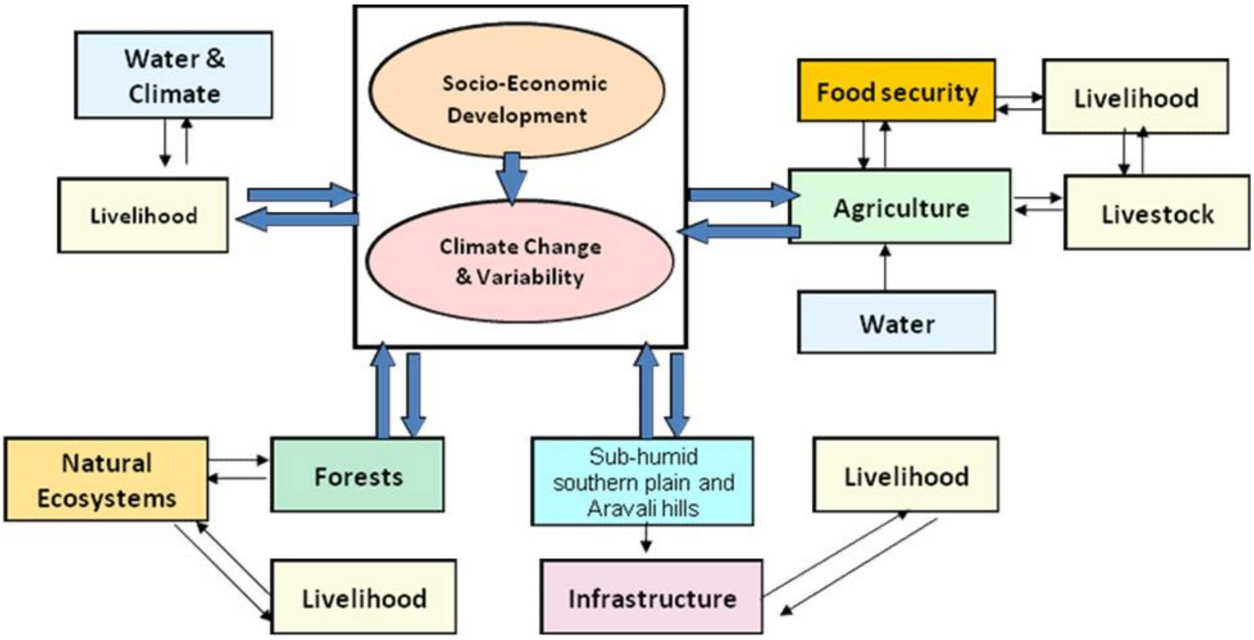
Fig. 14: climate change and vulnerability in a system



5.2 Area Specific Analytical Framework

The impact of climate change on agriculture, livestock, water resources and livelihood can be better perceived for the study area according to **Fig. 15**.

Fig. 15: Development-Climate change – livelihood linkages

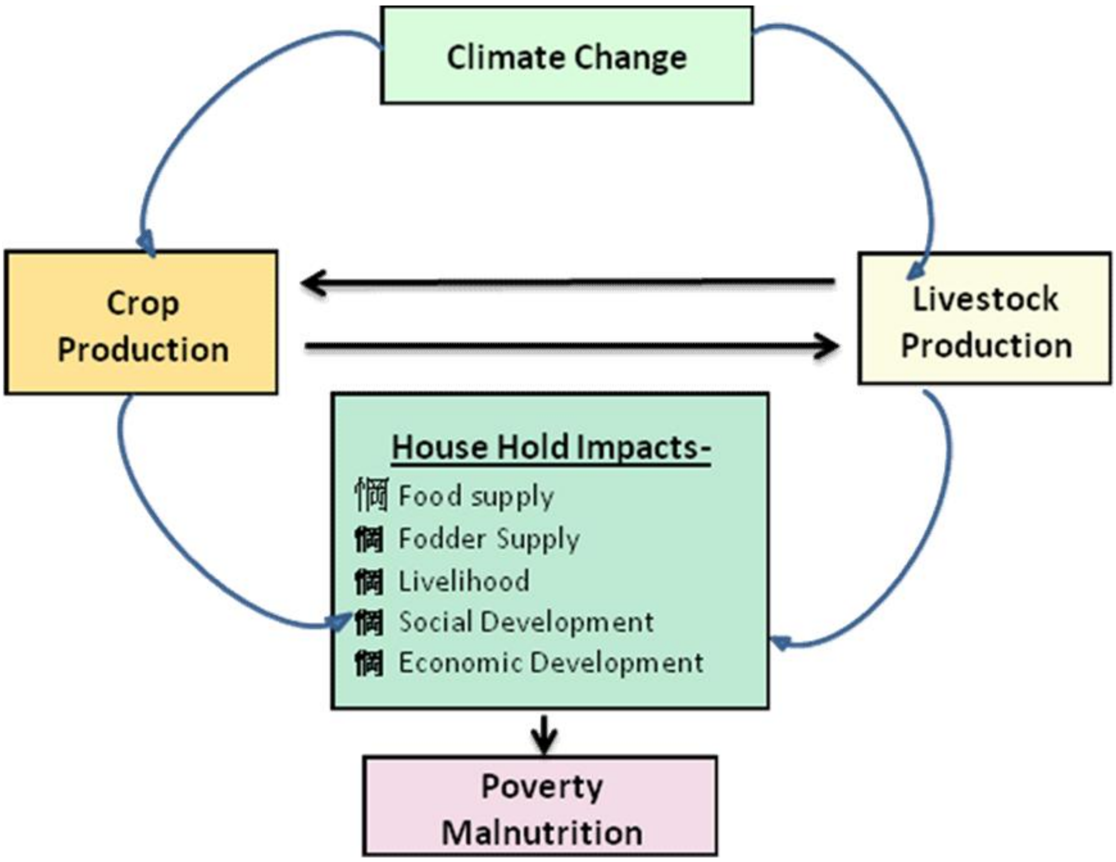


The development Interventions generally lead to climate change. The interventions included digging and deepening of wells, shift in cropping pattern, changes in livestock composition, and deforestation for wood requirement and so on. All these interventions imparted on livelihood through natural eco-system, infrastructural development, crop production and livestock rearing and ultimately through water and climate change as shown in **Fig. 15.**

5.3 Stakeholder Framework

Keeping in view the conceptual Fig. 15 and major finding of analysis of climate data, participatory rural appraisal made with stockholder farmers and outcome of sample base line survey efforts have been made to access the status, impact of climate change, it's consequences and also to draw mitigation strategies for each of the crucial parameter covered under the study. The details are given in **Fig. 16**.

Fig. 16: Stakeholder Implication to Climate Change



The impact of climate change on land and water resources as well as crop and livestock activities in the study area is summarized below **table 16**.

Table 16: Status Impact and consequences of climate change and mitigation strategies

Component	Status	Impact	consequences	Mitigation/ Adaptation strategies
Cultivated land	Rainfed	Water logging due to heavy rains	Increase Stalinization	Water conservation at upper ridge (pastureland)
Kharif crop	Maize dominated production system	1. Crop failure due to water logging 2. Late sowing of maize due to delayed onset of monsoon 3. Diseases and pest problems	1. House hold food and fodder security due to low production 2. Increase in cost of cultivation and less profitable	1. Water conservation at upper ridge (pastureland) 2. Introduction of moisture tolerant crop varieties and short duration maize varieties
Rabi crop	Wheat dominated production system	1. Delayed sowing of wheat due to late harvest of maize	1. Low yield of wheat 2. Household food and fodder security	1. Introduction of short duration / late sown variety of wheat
Livestock	Goat, cattle and buffalo dominated	1. Decrease in number over the years 2. Less profitability	1. Reduced income from livestock 2. Problem for	1. Ensured fodder supply round the year from local

Component	Status	Impact	consequences	Mitigation/ Adaptation strategies
	system with low productivity		household nutritional security	resources 2. Breed improvement
Pastureland	Private and government pastureland availability with low productivity	1. Over exploitation of grazing land due to open grazing 2. Loss of bio-diversity	1. Shortage of fodder supply round the year	1. Protection of grazing land with stone / vegetative / protection trenches 2. Joint farmer group management practices
Surface water resources (Anicut and Tanks)	Water availability in 9 Anicut and 6 tanks in study area is for 3-4 month	1. Use of surface water during off season not possible	1. Reduced scope to take-up irrigated crops	1. Minimize loss through infiltration and evaporation in existing structure 2. Improve storage capacity through new structure and de-silting of existing structure
Wells	Out of 413 wells only 248 are used and 165 are unused	1. Waste of investment made to dig well in the case of unused wells 2. For used wells operational expenditure increase as water level decreases	1. Cost of production of crops goes up 2. Uneconomical crop production makes people to leave cultivation and migrate to other places for livelihood.	1. Intervention for ground water recharge and reduction of waste of runoff required 2. Deepening /de-silting / lining of parapet wall to avoid collapses
Migration of work force	Permanent and seasonal migration	1. Lack of attention to house hold crop and livestock activities	1. Adverse impact on family development 2. Un economical crop and livestock activity	1. Promotion of rural livelihood system based on local resources and integrated farming system practices

6. Conclusion and Recommendation

The vulnerability of climate change was assessed by analyzing the economic activities like crop production, animal husbandry and basic resources like land, water and associated factors. Based on the analysis of secondary and primary data, PRA and Focus group discussion, the conclusions and recommendations emerged are as follows:

- In Kharif season maize dominated production system suffers due to water logging in heavy rainfall years, late sowing during delayed monsoon followed by disease and pest problems. It leads to households food insecurity as well as increased cost of cultivation. The intervention like water conservation at upper ridges of pasture land and introduction of moisture tolerant, late sown and short duration maize varieties advocated.

- In rabi season wheat is the dominant crop to support household food and fodder security. It generally suffers due to late sowing after harvest of late sown maize leading to low yield. Introduction of late sown and short duration wheat is advocated.

- The livestock production system is dominated by goat, cattle and buffalo. The herd size and composition have undergone changes over time. The low productivity of livestock leads to low profitability, mainly due to fodder shortage. Breed improvement and ensured fodder supply from local sources are suggested.

- The pasture area with low productivity of private and government lands is available in the area. Over exploitation of grazing land due to open grazing practice not only leads for loss of biodiversity but to shortage of fodder availability. Protection of grazing land with low cost materials and joint farmer group management practices of grazing land are proposed.

- The water resources in the area largely depend on rain which is stored in wells and tanks and surplus water goes as runoff which is stored through anicuts at places. The entire potential area is not covered under rabi crops due to shortage of water. The water management practices to minimize losses due to evaporation, it is recommended to enhance storage capacity of wells and tanks through de-silting.

- The wells going out of use due to falling down of water table and for those wells used, increased operational expenditures on one hand and higher cost of production of irrigated crops on the other hand are matters of concern. Working adults are forced to migrate to other places in search of livelihood. Intervention for increased ground water recharge and reduction in wastage of runoff, deepening of wells, de-silting, lining of water courses and other water management /conservation measure assume great importance.

- The seasonal and permanent migration of family workers faces problem for existing farming systems. Promotion of rural livelihoods, based on available resources and refinement of integrated farming system practices are strongly recommended.

Annexure: Base Line Survey Format

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orZe ku										
20 lky igys										
40 lky igys										

dq, ekfyd dk uke --- [kljk ua- ------------------------------

(dqavk & nks)

o"kZ	dqy xgjk bZ	ikuh dh xgjk bZ	dq, dh yEck bZ	dq, dh Pkk SM+ kbZ Z	iDd k@ dPp k	Hkkx hnkjk sa dh la[;k	flafpr {ks= Qy	ikuh fudkyus ds lk/ku		
								fo|q r eks	M+h ty bZtu	ikjEifjd lk/ku

								Vj		
orZeku										
20 lky igys										
40 lky igys										

tehu dh tkudkjh ¼ch?kk esa ½

o"kZ	[ksrh ;ksX;			[ksrh ds v;ksX; tehu			dqy
	flafpr	ckjkuh	iM+r	chM+k	edku	vU;	
orZeku							
20 lky igys							
40 lky igys							

i'kq lalk?ku ¼la[;k½

		ns'kh xk;	ladj xk;	Hksal	cdjh	HksaM	Xk/kk	mWV	eqxhZ	cSy
orZeku	nq/kk: i'kq									
	cNM+h									
	vkS"kr okf"kd vk;									
	vkS"kr okf"kd [kpkZ									
	ifjorZu dk dkj.k									
20 o"kZ igys	nq/kk: i'kq									
	cNM+h									
	vkS"kr okf"kd vk;									
	vkS"kr okf"kd [kpkZ									
	ifjorZu dk dkj.k									

d'f"k mRiknu

le;	Ekksle	Qly dk uke	{ks=Qy ¼ch?kk½	vkS"kr mRiknu ¼fDo- @ ch?kk½		vkS"kr [kpkZ ¼izfr fc?kk½	vkS"kr vk; ¼izfr fc?kk½	cktkj nj izfr fDo-
				nkuk	Hkqlk			

orZeku	[kfjQ							
	jch							
	tk;n							
20 lky igys	[kfjQ							
	jch							
	tk;n							
40 lky igys	[kfjQ							
	jch							
	tk;n							

vk; ds L=ksr ¼okf"kZd½

dza la-	fooj.k	fdl lnL; ls	dqy vk;	dqy [kpZ
1	d`f"k ls			
2	d`f"k etqnwjh ls			
3	Izokl			
4	izfrfnu etnwjh ls			
5	i'kqikyu ls ¼cdjh] HksM½			
6	O;olk; ls			
7	etnwjh ¼ujsxk½			
8	uksdjh			

	¼fuft@ljdkjh½			
9	x‘g m|ksx			
10	taxy mit ls			

etnwjh ds fy, izokl gkW ;k ugh

;fn gkW rks foLr‘r tkudkjh --

----

izokl dksu djrk gSa o;Ld] cPps] iwjk ifjokj] dsoy iq:"k]

izokl dgkW djrs gSA ---

--

izokl dk le; --- ls ---------------------------------------

--rd

izokl ds nkSjku fdl izdkj dk dke djrs --

----

vkS"kr vk; ---

----

vxzhe vko’;drk ds le; iSlk dgkW ls ysrs gSA

lkekftd lqj{kk dh ;kstukvksa ds ckjs es tkudkjh --

----

isU’ku] lkoZtfud forj.k iz.kkyh ds ckjs es tkudkjh --------------------------------------

----

izoklh lnL; dk oxZ	izokl dk le;	dgkW ij izokl djrs	dksu izokl djrk	fdrus fnu izokl djrs	izfrfnu fdrus ?k.Vs dke djrs	vks"kr vk;

Hkqfeghu						
efgyk						
iq:"k						
cPps						
fdlku						
vU;						

pkjs dh miyC/krk
pkjs dh Qlyksa ds uke --

?kkl ds uke - --

>kfM+;ksa ds uke --

	Qly ls mRiknu fDo-			fuft chM ls	Lkew fgd chM ls	[ksr dh ikyh ls	dqy mRik nu	[kfjn cktkj nj	vkS" kr [kpZ okf"k Zd
	[kfjQ	jch	Tkk; n						
orZeku									
10 lky igys									
20 lky igys									
cnyko dk dkj.k									

lkewfgd pjkxkg ij yksxksa dh Hkkxhnkfjrk gkW @ ugh
pjkxkg dk izcU/ku
orZeku es

----
10 lky igys

---------------------------- --
----

20 lky igys

Partnership in community Pasture land (Yes/ NO) …………..
lk[k dh miyC/krk   gkW @ ugh
jk'kh -- + _.k ds L=ksr ------------------------
---------------- C;kt nj -------------- izfr'kr
_.k ysus dk dkj.k ---

_.k ysus okys ,oa nsus okys ds chp es fdl izdkj dh cgl gksrh --------------------
----
----

gLrk{kj fdlku   gLrk{kj lk{kkrdkj djus okys

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