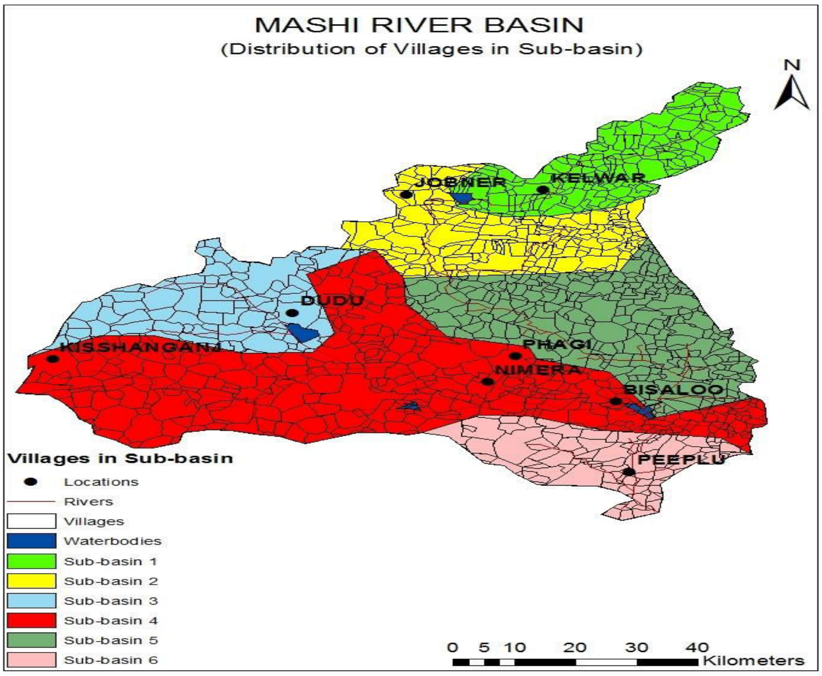
CLIMATE RESILIENT DEVELOPMENT
A CASE STUDY OF MASHI SUB BASIN IN RAJASTHAN



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Centre for Environment and Development Studies
B-92, Nityanand Nagar, Gandhi Path, Queen's Road
Jaipur 302 021
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Dr. M. S. Rathore
Director, CEDSJ

CONTENTS

ABBREVIATIONS AND ACRONYMS

AR5-Fifth Assessment Report
BGC- Banded Gneissic Complex
CAZRI-Central Arid Zone Research Institute
CC- Climate Change
CEDSJ-Centre for Environment and Development Studies Jaipur
CCAR – Climate Change Agenda for Rajasthan
DFID- Department for International Development
DPSIR- Driving forces – Pressure – State – Impact – Response
EC- Electric Conductivity
ENSO- El Niño-Southern Oscillation
EU- European Unions
EU-SPP- European Unions State Partnership Programme
FAO- Food and Agriculture Organization
GEF- Global Environment Facility
GIS-Geographic Information System
GoR-Government of Rajasthan
GP- Gram Panchayat
GP-IWRM- Gram Panchayat - Integrated Water Resources Management
GLR- Ground Laval Reservoir
GWL- Ground Water Levels
GVNML- Gramin Vikas Navyuvak Mandal Laporia
GVS- Gram Vikash Sansthan
GWD-Ground Water Department
GSS- Gramodaya Samajika Sansthan
IFAD- International Fund for Agricultural Development
IOC-UNESCO-
IPCC- Intergovernmental Panel on Climate Change
IRBM- Integrated River Basin Management
IWRM- Integrated Water Resources Management
JRM- Joint Review Mission
LDCs- Least Developed Countries
MEA- Millennium Ecosystem Assessment
MLA- Member of Legislative Assembly
MTEF- Medium-Term Expenditure Framework
NGOs- Non Governmental Organization

O&M- *Operation and Maintenance*

PHED- Public Health and Engineering Department

PR&RD- Panchayati Raj and Rural Development

PRIs- Panchayati Raj Institutions

PSR -Pressure-State-Response

RDPRD- Rural Development and Panchayati Raj Department

RIICO- Rajasthan State Industrial Development & Investment Corporation Limited

RUDA- Rajasthan Urban Development Authority

SC-Schedule Caste

SEZ- Special Economic Zone

SHG- Self Help Groups

SLF- Sustainable Livelihood Framework

SPP- State Partnership Programme

ST-Schedule Tribes

SWRPD- State Water Resources Planning Department

TA- Technical Assistance

TNA- Training Needs Assessment

UNEP –United Nations Environment Programme

UN- United Nations

VDC- Village Development Committee

VWSC- Village Water and Sanitation Committee

VWHSC- Village Water, Health and Sanitation Committee

WRCs- Water Resource Committee

WRD- Water Resource Department

CHAPTER I

INTRODUCTION

1.0 Introduction

Understanding climate change in the local context and plan action to mitigate or facilitate adaption of its negative impacts is a real challenge. Climate change is double edge phenomenon as it is triggered by activities related to economic development mostly anthropogenic and on other side it triggers many parameters of economic development and affect them in positive and negative ways. However, the local experience is that in short run Climate Variability poses greater risks to economic development than Climate Change[1].

Water resources and agriculture are the most vulnerable to climate change/variability and consequently affects livelihood of large population in India. Any adverse impact on water availability due to climate change/variability is manifested through occurrence of drought or flood consequently threatens food security and livelihood of rural households. Further it also affects the development and achievements of vital national sectoral development goals, such as, energy, health, industry, infrastructure investments, etc. Hence, building knowledge about climate change/variability, understanding and make understand the stakeholders and incorporating in planning and policy to adequately respond, i.e., climate change adaptation to the reality of a changing climate process is a major objective to attain water and food security. This knowledge will also help addressing the issues of growing vulnerabilities and livelihood security of poor and marginalized section of population. In order to achieve this, all the stakeholders, particularly decision makers first need to understand the nature and impact of climate change/variability on different parameters and overall economic development.

IPCC reports are the most researched, authoritative, and authentic documents providing knowledge about climate change. The information in these reports mostly relates to global and regional aspects, which broadly guide global and regional policy formulation. What is needed is information on impact of climate change at local level where actual action takes place and affects the lives of stakeholders and parameters of economic development.

As per the Climate Change Agenda for Rajasthan (CCAR)-(2010–2014) seven Task forces were setup to address the risks posed by climate change issues within its developmental

[1] The rainfall pattern in Rajasthan shows that in the last 100 years around 50 years were drought years and in the remaining years there was partial drought in one or more districts in the state, i.e. there is always drought in the state except in only few very good rainfall years. For more details see Rathore, M. S. (2006)Droughts and the State Failure: Unwilling to learn and Unwilling to Distribute, *Water Nepal* 12(1/2):261-280.

agenda. Though it is claimed that each Task force is supported by policy, regulatory measures and research and development needs and followed up by a detailed areas of action. However, in practice particularly at ground level hardly any changes in the working or action of line departments were observed. Line Departments have their independent programs/projects and implementing strategies with least integration with other departments resulting in insensitivity to the climate change issues. Though independently their programs/projects might be useful in climate resilient development by providing support to people in adapting to climate change yet there is lack of conscious effort to strategize for climate resilient development. In case of water resources the Action Plan suggests setting up of state-level multi-disciplinary, basin/sub-basin wise organization and in this regard the major action taken is promulgation of the Rajasthan River Basin & Water Resources Planning Act, 2015. However, it is only at the state level, the river basin level organizations are yet to be established. This study will provide agenda or a working guideline for such River Basin/sub-basin organizations.

The State CCAR also addresses agriculture and livestock sector by emphasizing on promotion of dryland agriculture recommending adoption of newly developed agriculture techniques such as low/zero tillage, in-situ soil moisture conservation, raised bed, ridge furrow, mulching etc. Developing energy efficient farm machinery to reduce emissions, i.e. use of solar pumps and micro irrigation to save water resources is also suggested. In livestock sector, development of pasture lands and fodder stocks to reduce pressure on agriculture lands and also reducing the climatic risk. The most effective program of risk management in agriculture is crop insurance along with long term risk reduction strategies. The specific area of action for the state includes; enhancing livelihood support by providing alternative livelihood generation options to communities dependent on farm based incomes; diversification of crops and promotion of alternative cropping patterns, such as, agro-forestry, horticulture, mixed cropping and high value crops. Implementation of above listed action plans mostly depend on the efficiency of state agriculture extension services. Beside state agencies the NGOs in the state have also undertaken some of these activities independently of state and have achieved good results.

Review of current status of climate change adaptive planning at the national and state level shows that though the National Action Plan on Climate Change and State Action Plans on Climate Change were prepared but they failed to change the status in absence of little or no participation of line departments and people at large. Development policies, plans and projects currently do not take climate change into account due to lack of awareness and clarity on how to effectively develop and integrate adaptation options, hence missing the opportunity to make more climate resilient development investments. On the other hand NGOs or Civil Society organisations have made significant contribution in economic development of unreached neglected areas and population by undertaking livelihood and capacity building activities without linking them to climate change or vulnerability. Their interventions were effective in strengthening climate change resilience or strengthening the adaptation strategies of the poor and marginalized population. Hence it is for this reason that in this report aspects related to both climate change/variability and livelihood are discussed at length.

Impact of climate change in most significant way is manifested in variability in rainfall and consequently affecting the availability of water resources. Therefore, the major focus of this study is management of water resources. NGOs have made interventions in rural areas of Rajasthan and more specifically in the Mashi River Basin in the field of natural resource management, mainly land, water and vegetation. Were these interventions helpful in addressing the emerging climate change issues, was the question bothering us time and again? Hence it was decided to commission a systematic study on the subject. The objective was not to indulge in the scientific debate of quantifying carbon sequestration or emission of CO_2 in the Mashi Basin villages and measure changes in these because of past interventions. Rather the idea was to know how far the NRM related interventions helped adaptation to climate variability at the first stage, and secondly in mitigation or adaptation of impacts of climate change. The interventions made by few NGOs namely GVNML, GVS, etc., were more from the point of view of providing sustainable livelihood to the rural population, yet directly indirectly they were addressing the emerging challenges of climate change. Therefore, review of their interventions was undertaken with the following objectives;

1.1 Objectives

- Review State government policies and programs, NGOs interventions and analyze them from the point of view of climate change and/or climate variability.
- To assess how these works enabled the society to cope with or adapt to the impact of climate variability/ change, particularly in the context of climate resilient development.
- To list possible effects of Climate Change/Variability on agriculture and animal rearing sector or livelihood of the people (in the Mashi sub Basin area).
- To generate information needed for preparation of IWRM plan for the sub Basin

1.2 Methodology

People based on their long experience have developed strategies to address the risk caused by climate variability, which vary by size of farm, social aspects and area. While the NGOs interventions/actions were mostly addressing the climate variability issues affecting the livelihood of rural population but the interventions were not directly designed from climate change perspective. This study is an ex post analysis of people, NGOs and government interventions to know that whether these interventions addressed the issues of adaptation or mitigation of the impact of climate change and provide input in implementation of IWRM in the Mashi Basin. For this study range of tools were used, such as, desk review, collection of primary data by organizing village surveys (by designing appropriate questionnaire), focused group discussion with key informants and other stakeholders, and direct observations. In order to know the impact of interventions on the livelihoods of beneficiaries few households were randomly selected from the sample villages for detailed survey. Study was conducted by adopting participatory approach and had consultations also with PRI representatives.

Review of Sustainable Livelihood Framework (SLF) was undertaken to understand the relationship between SLF and the strategies of people to cope with or adapt or mitigate the impact of climate variability or change. Also relate the interventions planned by NGOs to the people's adaptation practices and how far these interventions helped in strengthening the coping or adaptations of the rural community. A brief review of SLF is given in Annexure 1.

The NGOs activities/interventions were analysed based on the SLF review. Both frameworks, namely SLF and modified SLF make it clear that there are four types of livelihood strategies and they are governed by internal and external factors. In the external factors climate variability and/or change plays a significant role in shaping these strategies. It is also important to note that the context in which the livelihood strategies are framed has to be well understood. The context can be physical, economic, social, political and environmental conditions specifically prevailing in the study area and overall in the state and country. Building understanding about the physical conditions in the area detail information was obtained on the physical and environmental features such as geology, geo-hydrology, groundwater and its quality, geo-physical survey to plan future action, etc. Use of remote sensing data procured from NRSC, Hyderabad to delineate the Mashi Sub-basin area, its drainage system, topography and number of other parameters relevant to understand the likely impact of climate change on water resources and how to plan water resources management using IWRM approach.

1.2.1 Impacts of Climate Change

As the understanding on global climate and its change, mostly human induced, increased over the time, one could see an increasing number of scientists and administrators accepting it as happening. It has also been agreed that the climate change vulnerabilities are related to the developmental state of a country, as indicated by the differential impacts of climate change on countries at different developmental levels. A country's vulnerability to climate change is decided by the presence of appropriate mitigation and adaptation options. Climate change also demands that the current vulnerabilities need to be looked from a different perspective. Within climate change adaptation community, there is a common assertion that if we could cope better with the present climate risks, possibly we could significantly reduce the impacts of future climate change. There are views that the adaptation to short-term climate variability and extreme events serves as a starting point for reducing vulnerability to longer-term climate change.

In the last decade, a number of studies have been carried out on climate change impacts, vulnerability and adaptation measures in developing countries. The most damaging impacts of climate change predicted for all South Asian countries is on water resources and agriculture, and through natural disasters, such as floods, droughts and glacier lake outbursts on the poor section of the population. These events in regular intervals drastically affect the livelihood of people residing in South Asia almost every year.

As regards the water related impacts of climate change is concerned some climate models predict an increase in frequency and intensity of droughts, increase in rainfall intensity, which may increase runoff, enhance soil erosion on cleared land and accelerate sedimentation in the existing water supplies or reservoirs. Not only will this reduce the potential of a catchment to retain water, but it will also cause water quality to deteriorate.

Under a severe climate change scenario the expected potential shortfall in cereals and other crop production will range between 30 to 70%. Even under a moderate climate change scenario the crop loss due to salinity intrusion could be 0.2 Mt annually. The anticipated drop in agricultural production, when coupled with losses in other sectors, will have a deep impact on the development prospects, severely threatening food security. The ultimate impact of loss of food grain production would be increase in food imports. The agricultural sector is the major source of employment in India and will remain so in the coming decades. Loss of both agricultural land and production will adversely affect people's livelihoods, especially among the rural poor.

The views of few other scientists are that there will be some positive impacts on agriculture from climate change and its causes, such as increased temperatures and higher carbon dioxide levels. While these may have positive impacts on crop yields, this is only where moisture is not a constraint. It is feared that moisture stress would be more intense during the dry season, which might force farmers to reduce area under cultivation of certain crops. Warmer temperatures may also increase the occurrence of extreme events or pests, again offsetting any potential benefits. Both crops and livestock would be affected by an increase in disease or alien/invasive pests. An increase in temperature, despite a reduction in humidity, can reduce the ability of farmers to work. As a result, low income rural populations that depend on traditional agricultural systems or on marginal lands are particularly vulnerable to climate change and livelihoods will be at risk.

The overall impacts of climate change will be far-reaching. The goal to reduce the number of people living below the poverty line by 50%, as stated in Millennium Development Goals. Climate change will jeopardise this noble ambition unless realistic adaptation measures are devised. Moreover, climate change may have other, more indirect consequences. Following past extreme events, the poverty driven rural population has migrated to urban centres. Such large-scale inter and intra state migration is likely to increase social unrest and exacerbate existing conflict situations[2].

The IPCC's Third and Fifth Assessment Report (AR5) Assessment Reports predicted that climate change would impose significant stress on resources throughout Asia. The considers new evidence of climate change based on many independent scientific analyses from observations of the climate system, paleoclimate archives, theoretical studies of climate processes and simulations using climate models and suggested the following about climate change and its impact on Dry Regions and Drought Affected Regions as follows;

a) For dry regions at mid-latitude and in the dry tropical areas, some of which are water stressed: the predicted impact is decrease in annual average river run-off and water availability.
b) For Drought affected areas: there will be increase in the extent and frequency of heavy precipitation events.

Rajasthan is categorized both as Dry Region and Drought affected areas. If the above predictions are accepted then it is likely that in future Rajasthan State will receive less rainfall and the frequency and intensity of droughts is going to increase. Analysis of last 112 years of rainfall data reveals that 50 percent years were drought years and the intensity and

[2] For more details on climate change related human migration see Rathore (2009) and Rathore et al. (2011)

frequency of occurrence is increasing. It is also known that the nature of climate change, besides change in large macro complex parameters, at micro level can be observed by picking up at least two important parameters, namely temperature and rainfall. Increase in average temperatures across the globe and also at micro level in Rajasthan is being observed. While in case of rainfall the observations confirms increase in its variability in occurrences across the globe (both cases of high rainfall and scarcity/droughts) and declining trend in the Mashi Basin. The changes in these parameters will be observed in the study area.

The impact of increase in temperature on water, land, agriculture, biomass, and social aspects, which directly affects the livelihoods of people in rural areas, as expected to be is shown in the box below.

Box 1: Impact of change in Temperature

WATER	AGRICULTURE	SOCIAL
Evaporation losses ⇧ Water availability ⇩ Groundwater recharge ⇩ Groundwater exploitation ⇧	Food insecurity ⇧ Fodder insecurity ⇧ Change in cropping pattern/system Increase use of insecticides /pesticides Change in livestock population	Livelihood insecurity ⇧ Diversification of occupation Nonfarm Activity ⇧ Migration ⇧
LAND	BIOMASS	
Soil moisture deplition ⇧ Soil erosion ⇧ Cgange in land use pattern	Productivity ⇩ Biodiversity ⇩ Ecosystem services ⇩	

The rise in temperature is going to affect both surface and ground water availability in terms of increase in scarcity, increase in evaporation losses, decline in groundwater recharge consequently more exploitation of groundwater resource, etc. These factors will be analysed for the study area. People may respond to these changes by adopting coping strategies/adaptation measures to augment supply of water by creating new rainwater harvesting structures, recharge structures or manage demand for water, both in domestic and agricultural sector.

The expected impact of CC on agriculture will be on food and fodder security, cropping pattern, lifecycles of insect and pastes, and composition of livestock population. Peoples' responses are likely to be adjustment in cropping pattern, new combinations of crop, livestock, horticulture, medicinal plants, other types of tree plantations to evolve farming system, and developing new crop technologies to counter the likely shortages in food and fodder production. As rise in temperature will create favourable environment for germination of insects and pastes affecting crop production it is likely that there is increase in use of insecticides and pesticides resulting in some environmental problems. All these factors will be studied by selecting sample villages and households for detailed study.

The social impact of rise in temperature can be many folds. Increase in climatic risk will force farmers and other population in the rural areas to search for alternative livelihood options, particularly in the nonfarm sector. Farmers may try to diversify their cropping pattern from crop husbandry to livestock based enterprises, mix-farming system, horticulture, cultivation of high value crops, particularly medicinal plants, etc. As a last option people will draw a migration plan to move within or outside state for employment. Households strategies will be studied keeping these points in focused group discussions with key informants and other stakeholders.

The biomass productivity, biodiversity and ecosystem services are likely to decline with the rise in temperatures.

The impact of increase in rainfall variability on land, water availability, biomass, livestock, livelihood of rural population, etc. will be complex and will depend on the nature of rainfall variability. Some of the broad impacts of change in rainfall variability are listed below.

Box 2: Impact of increase in rainfall variability

- Increase or decrease in rainfall affecting total availability of water
- Increase or decrease in the rainy days will through new challenges for rain water harvesting in small or large structures.
- Change in the nature of rainfall – wide spread to sporadic rainfall will increase agricultural risks and affect present cropping practices.
- Change in runoff affecting the economic viability of the Dams.
- Shift in time of seasonal rains – delayed or early rainfall will affect crop calendar.

In the IPCC Round V the Table SPM.3, the approaches for managing the risks of climate change through adaptation are listed. These approaches should be considered overlapping rather than discrete, and they are often pursued simultaneously. Examples are presented in no specific order and can be relevant to more than one category. These are also kept in mind while designing the field survey in the Mashi Sub Basin.

Overlapping Approaches	Category	Examples
Vulnerability & Exposure Reduction through development, planning & practices including many low-regrets measures **Adaptation** including incremental & adjustments Transformation **Transformational**	Human development	Improved access to education, nutrition, health facilities, energy, safe housing & settlement structures, & social support structures; Reduced gender inequality & marginalization in other forms.
	Poverty alleviation	Improved access to & control of local resources; Land tenure; Disaster risk reduction; Social safety nets & social protection; Insurance schemes.
	Livelihood security	Income, asset & livelihood diversification; Improved infrastructure; Access to technology & decision-making fora; Increased decision-making power; Changed cropping, livestock & aquaculture practices; Reliance on social networks.
	Disaster risk management	Early warning systems; Hazard & vulnerability mapping; Diversifying water resources; Improved drainage; Flood & cyclone shelters; Building codes & practices; Storm & wastewater management; Transport & road infrastructure improvements.
	Ecosystem management	Maintaining wetlands & urban green spaces; Coastal afforestation; Watershed & reservoir management; Reduction of other stressors on ecosystems & of habitat fragmentation; Maintenance of genetic diversity; Manipulation of disturbance regimes; Community-based natural resource management.
	Spatial or land-use planning	Provisioning of adequate housing, infrastructure & services; Managing development in flood prone & other high risk areas; Urban planning & upgrading programs; Land zoning laws; Easements; Protected areas.
	Structural/physical	***Engineered & built-environment options: Sea walls & coastal protection structures; Flood levees; Water storage; Improved drainage; Flood & cyclone shelters; Building codes & practices; Storm & wastewater management; Transport & road infrastructure improvements; Floating houses; Power plant & electricity grid adjustments.***
		Technological options: New crop & animal varieties; Indigenous, traditional & local knowledge, technologies & methods; Efficient irrigation; Water-saving technologies; Desalinisation; Conservation agriculture; Food storage & preservation facilities; Hazard & vulnerability mapping & monitoring; Early warning systems; Building insulation; Mechanical & passive cooling; Technology development, transfer & diffusion.
		Ecosystem-based options: Ecological restoration; Soil conservation; Afforestation & reforestation; Mangrove conservation & replanting; Green infrastructure (e.g., shade trees, green roofs);

		Controlling overfishing; Fisheries co-management; Assisted species migration & dispersal; Ecological corridors; Seed banks, gene banks & other ex situ conservation; Community-based natural resource management.
		Services: Social safety nets & social protection; Food banks & distribution of food surplus; Municipal services including water & sanitation; Vaccination programs; Essential public health services; Enhanced emergency medical services.
	Institutional	***Economic options: Financial incentives; Insurance; Catastrophe bonds; Payments for ecosystem services; Pricing water to encourage universal provision and careful use; Microfinance; Disaster contingency funds; Cash transfers; Public-private partnerships.***
		Laws & regulations: Land zoning laws; Building standards & practices; Easements; Water regulations & agreements; Laws to support disaster risk reduction; Laws to encourage insurance purchasing; Defined property rights & land tenure security; Protected areas; Fishing quotas; Patent pools & technology transfer.
		National & government policies & programs: National & regional adaptation plans including mainstreaming; Sub-national & local adaptation plans; Economic diversification; Urban upgrading programs; Municipal water management programs; Disaster planning & preparedness; Integrated water resource management; Integrated coastal zone management; Ecosystem-based management; Community-based adaptation.
	Social	***Educational options: Awareness raising & integrating into education; Gender equity in education; Extension services; Sharing indigenous, traditional & local knowledge; Participatory action research & social learning; Knowledge-sharing & learning platforms.***
		Informational options: Hazard & vulnerability mapping; Early warning & response systems; Systematic monitoring & remote sensing; Climate services; Use of indigenous climate observations; Participatory scenario development; Integrated assessments.
		Behavioural options: Household preparation & evacuation planning; Migration; Soil & water conservation; Storm drain clearance; Livelihood diversification; Changed cropping, livestock & aquaculture practices; Reliance on social networks.
	Spheres of change	***Practical: Social & technical innovations, behavioural shifts, or institutional & managerial changes that produce substantial shifts in outcomes.***

		Political: Political, social, cultural & ecological decisions & actions consistent with reducing vulnerability & risk & supporting adaptation, mitigation & sustainable development.
		Personal: Individual & collective assumptions, beliefs, values & worldviews influencing climate-change responses.

In order to understand household strategies and the NGOs interventions in the context of Climate Change in Mashi River Basin region of Rajasthan three NGOs namely, GVNML, GVS, and Prayas were selected and also 10 sample villages were selected from the six watersheds in the basin. From these 10 villages in total 100 households were randomly selected for detailed study. The details about the sample villages are given in Table 1.1.

Table 1.1: Sample villages and households.

Village	District	Tehsil	No. of Sample household
Pachar	Jaipur	Jhotwara	10
Begas	Jaipur	Jhotwara	10
Jhag	Jaipur	Dudu	10
Mangalwara	Jaipur	Dudu	10
Shankar pura	Jaipur	Phagi	10
Kagya	Jaipur	Phagi	10
Shri Ramganj	Jaipur	Phagi	10
Mala	Ajmer	Kishangarh	10
Ajmeri	Tonk	Malpura	10
Sandera	Tonk	Peeplu	10
Total			100

1.3 Layout of the Report

The report is organized in a following manner: The first chapter provides introduction, objectives and methodology. The second chapter presents the physical and social environment that shapes the strategies to address the impact of climate change. NGOs and state interventions are discussed in chapter three. Water being the most important resource shape livelihood strategies the review of different approaches and the new approach to manage in the Mashi Basin is discussed in fourth chapter. The fifth chapter provides details on geophysical assessment conducted in the Mashi Basin to understand the specific groundwater problem identified during the field work. The last chapter provides summary and touches upon some lessons learned and insights for the development of effective ways forward.

CHAPTER II

PHYSICAL AND SOCIAL ENVIRONMENT

The resilience of people to address the shocks of climate variability/change depends on physical and environmental factors[3]. Knowledge about these factors provide scope for future action/intervention to mitigate or adapt to the environmental changes. As this study will be used as base for preparing IWRM plans for the Mashi Sub-Basin there is need to study the physical, socio-economic and environmental factors more deeply and extensively, also to prepare stakeholders capacity building modules and action plan. Hence this chapter covers details on physical and environmental parameters at three levels; first, river basin level, i.e., Banas River Basin, having eleven sub-basins and Mashi Sub-basin is one of them located at the middle of the Banas River. The larger picture of basin is important while planning water resources as there may be need for inter sub-basin transfer of water resources. Second, Sub-basin level and information was obtained using GIS and remote sensing techniques for generating maps and other relevant information. In case of groundwater, aquifer level/block level information was obtained. Third, District, Tehsil and village level, information was collected from secondary and primary sources. Most of the published socio-economic information is never reported river basin or sub-basin wise, therefore, the secondary information was to the extent possible regrouped at basin level. The overall objective of this chapter is to understand the physical and environmental features of the project area, map the resource availability and study the state, NGOs and peoples interventions/coping strategies.

I. PHYSICAL ENVIRONMENT

2.1 Physical and Climatic context

Rajasthan climate encompasses a wide range of altitudinal zones and micro-climatic conditions. The State is divided into two meteorological sub-divisions, namely West and East Rajasthan. West Rajasthan has a climate: Tropical desert, Arid-hot (BWb). The southern part of the State have a climate type marginally varying between the types Tropical Savanna-Hot, seasonally dry (AW) and Interior Mediterranean, Mild winter; dry summer; Hot Summer (Csa). The remaining part of the State belongs to the climate type: Tropical Steppe, semi-arid; Hot (Bsh) (Mashi River Basin area lie in it).

[3] Land use pattern and availability of water resources determines the livelihood options, such as, availability of CRPs determine the composition of livestock and diversification of occupation of people dependent on land and water resources. Similarly, availability of groundwater serves as buffer in coping with frequent droughts and also help ensuring food security.

The study area falls in three districts namely; Jaipur, Ajmer and Tonk districts. The physical and environmental features of these areas are as follows:

2.1.1 General Features of Mashi Sub Basin

Mashi Sub Basin is part of the larger River Basin called Banas River Basin, which is located in the middle of the Rajasthan. There are 11 sub basins in Banas River Basin namely; Banas (1,174,039 ha), Dain (306,138.4 ha), Gudia (92,038.56 ha), Kalisil (62,308.94 ha), Khari (639,052.9 ha), Kothari (229,852.1 ha), Mashi (647,615.8 ha), Morel (572,250.7 ha), Sodra (151,942.2 ha) and Berach (830,788.6 ha). The catchment area including all upstream Major/Medium projects is 5,872.0 Km^2 where as the differential catchment area (area excluding upstream catchment areas of Major/Medium projects) is 3,641.4 Km^2 and falls in Tonk District.

The Mashi River Basin area falls in three districts namely Jaipur, Ajmer and Tonk Districts. The two main tributaries of Mashi River are, namely Bandi and Mashi, which originates from the hills of Samod and Ajmer district respectively. Mashi River originates from the Silora hills about 6 kilometers south of Kishangarh Town in Ajmer district and passing through Phulera tehsil in Jaipur district. It flows initially in an eastward direction and then towards south for about 96 km in partly hilly and partly plain areas along the borders of Jaipur and Tonk districts between the tehsil of Malpura and phagi until it turns south to join the Banas River at Galod village near Tonk. The catchment of the Mashi River is located between latitudes 26°11 and 26°16’ and longitudes 74°48’ and 75°54’. It has got one tributary called Bandi. Bandi River the tributary of Mashi River originates from hills located in the North-West of Jaipur and passes through Kalwar town near Jobner and meets Mashi near Madhorajpura. These tributaries are fed by large number of small rivulets originating from the plains of tehsil Sanganer, Dudu, Chaksu, Malpura, etc. All of them are non-perennial rivulets.

The Figure 1 shows the exact location of the Mashi Sub Basin and its drainage system while the automatically delineated catchment of Mashi Sub Basin is shown in Figure 2. Figure 3 and 4 shows the Village Boundries in Mashi Basin and Watershed and Village Boundaries in the Mashi Basin respectively.

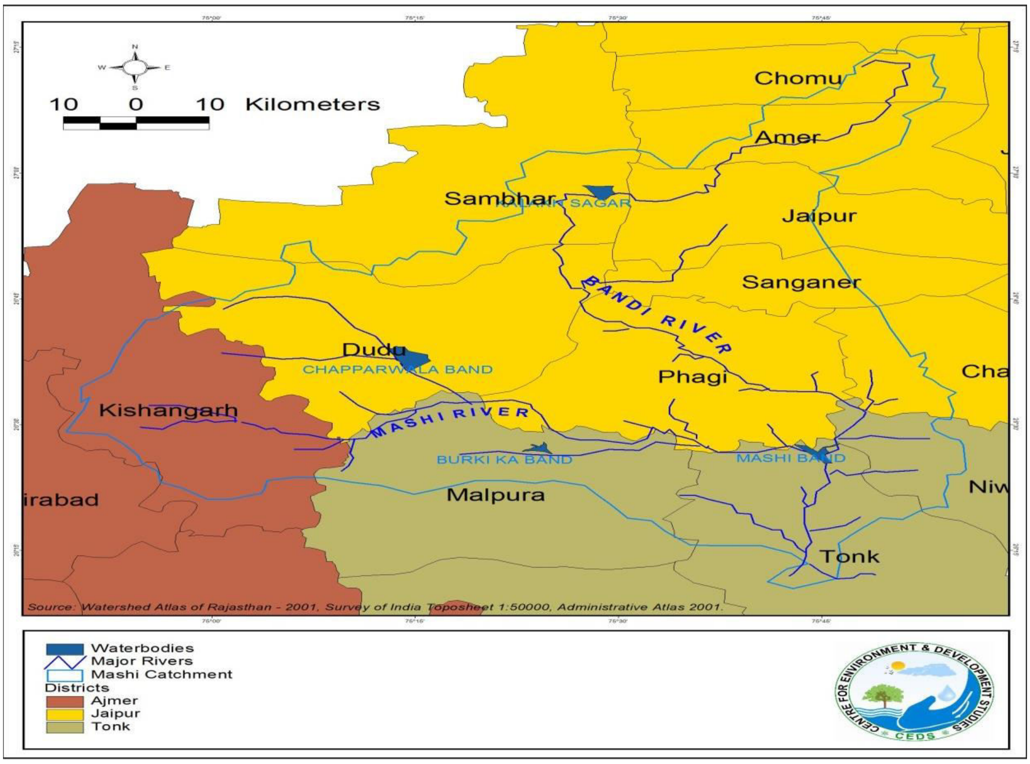


Figure 1: Boundary of Mashi sub Basin in the three Districts.

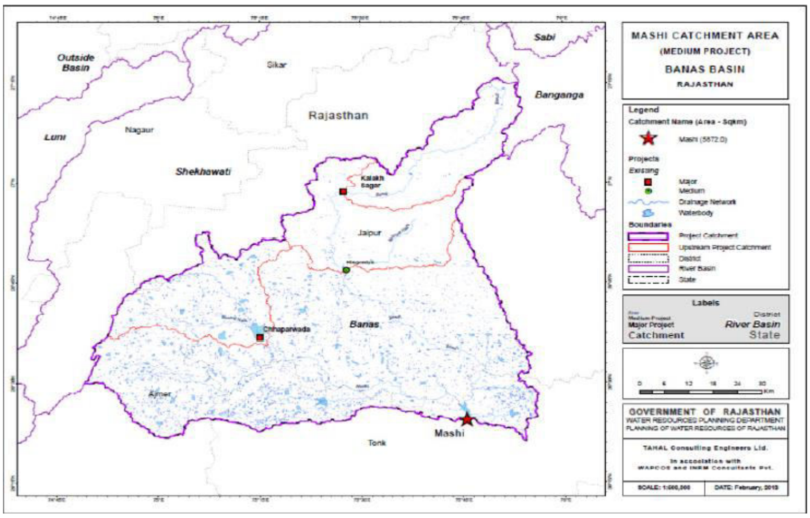


Figure 2: Automatically delineated catchment of Mashi Sub Basin

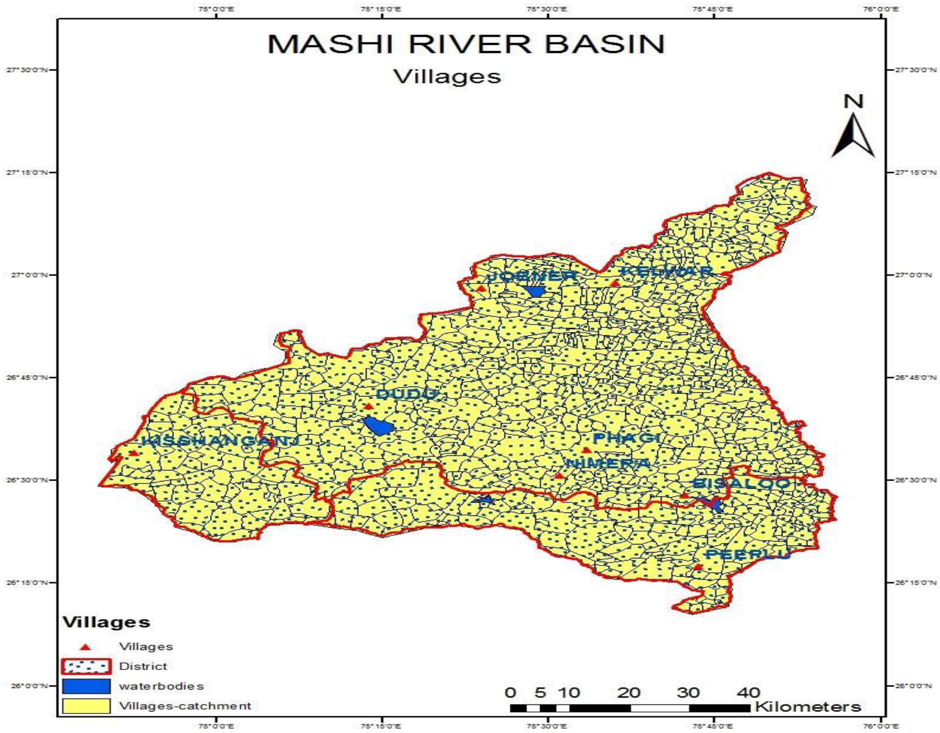


Figure 3: Village Boundries in Mashi Basin

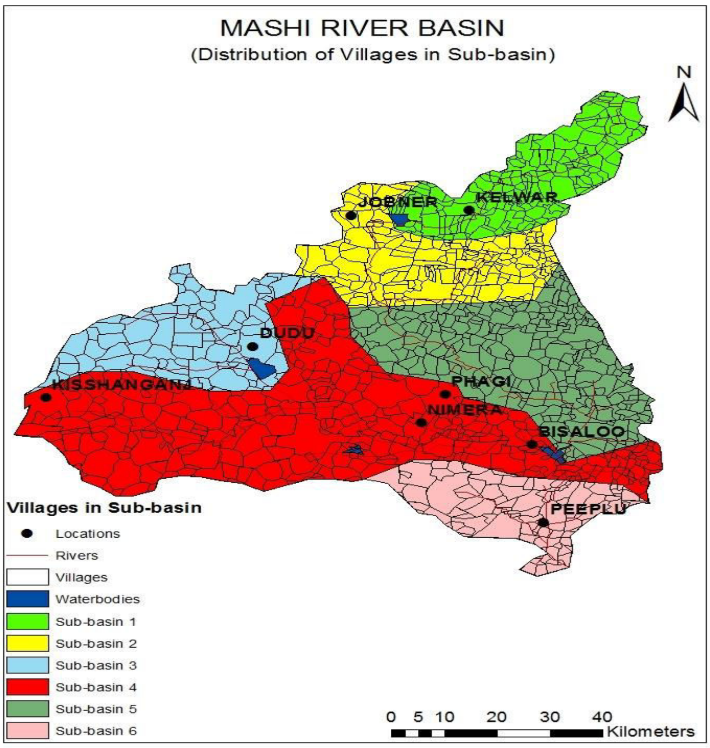


Figure 4: Watershed and Village Boundaries in the Mashi Basin

2.1.2 Climate

The weather parameter statistics of Mashi Sub Basin catchment are shown in Table 1. The average rainfall is 503 mm and 92% of it occurs in the four months of monsoon season.

Table 1: Weather Parameter Statistics for Mashi Sub Basin Catchment

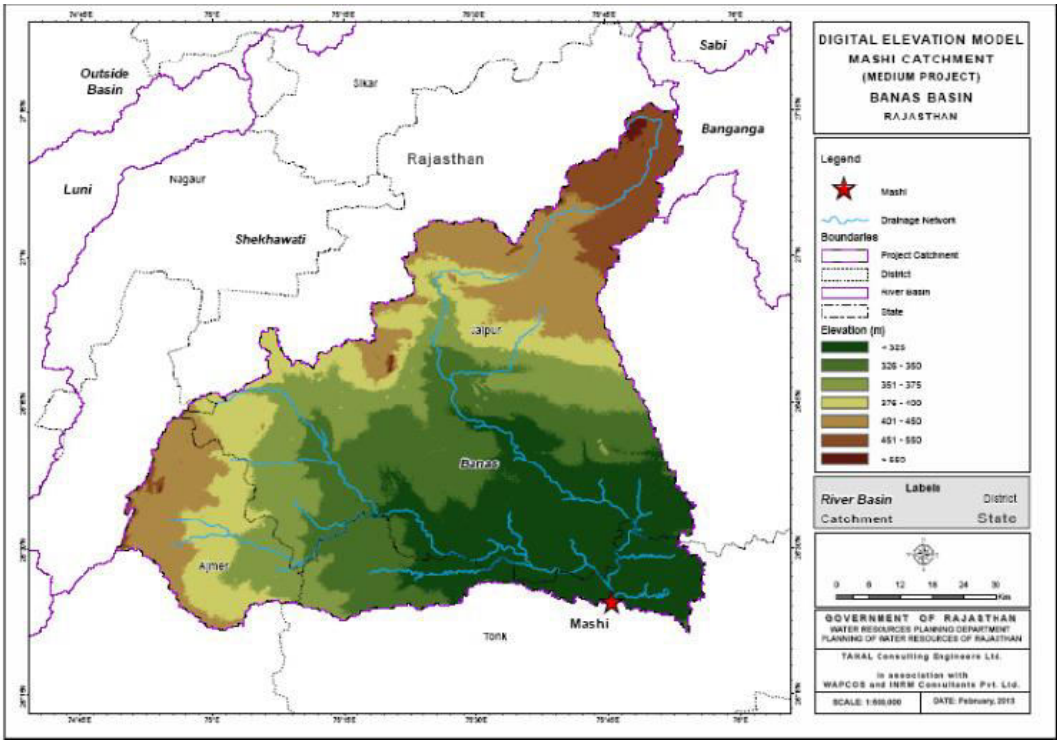
Parameter	Values
Mean Maximum Temperature, ^0C	32.4
Highest Maximum Temperature, ^0C	45.0
Mean Minimum Temperature, ^0C	19.3
Lowest Minimum Temperature, ^0C	3.5
Average Rainfall, mm	503.0
Monsoon Rainfall (Jun-Jul-Aug-Sept), mm	462.0

2.1.3 Topography

The elevation of Mashi Sub Basin catchment is shown in Figure 5 and the topographic statistics of elevation of the Mashi Sub Basin catchment is given in Table 2. The Elevation varies between the minimum of 253 m amsl to 787 m amsl with a mean of 366 m amsl. Figure 6 and 7 shows the cross section of elevations North- south and West-East respectively. It shows that the ultimate slope is towards south and the river meets Banas River at Galod village.

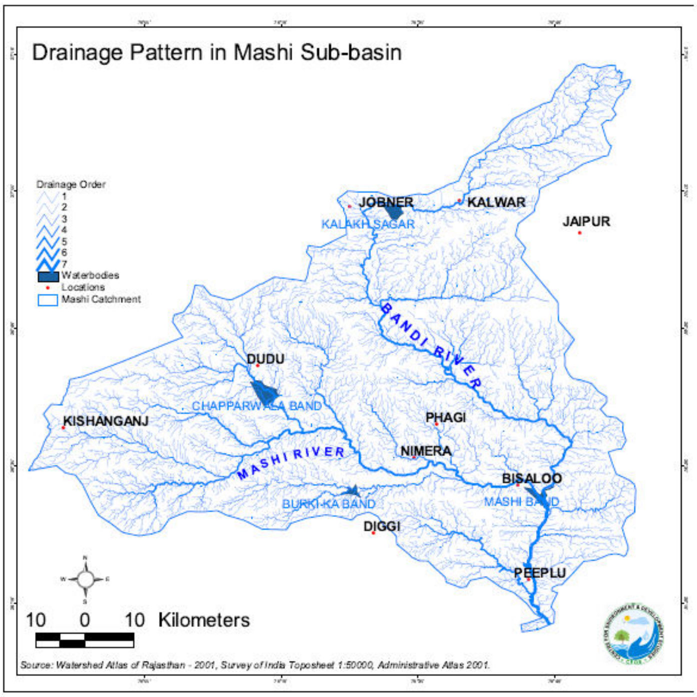
Table 2: Elevation Summaries – Mashi Project Catchment

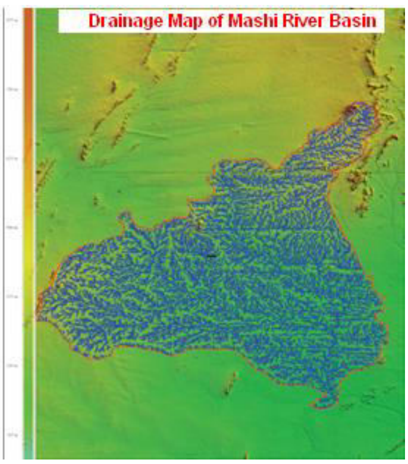
Parameter	Elevation (m amsl)
Minimum Elevation	253.0
Maximum Elevation	787.0
Mean Elevation	366.6



Source: SRTM DEM, of 90 m resolution http://srtm.csi.cgiar.org

Figure 5: Topography of Mashi Sub Basin Catchment





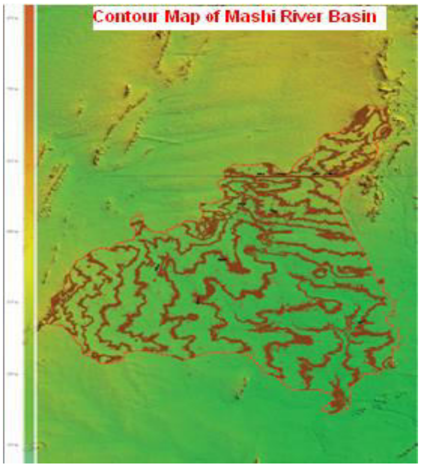


Figure 6: Mashi Basin: Elevation crossection from North to South.

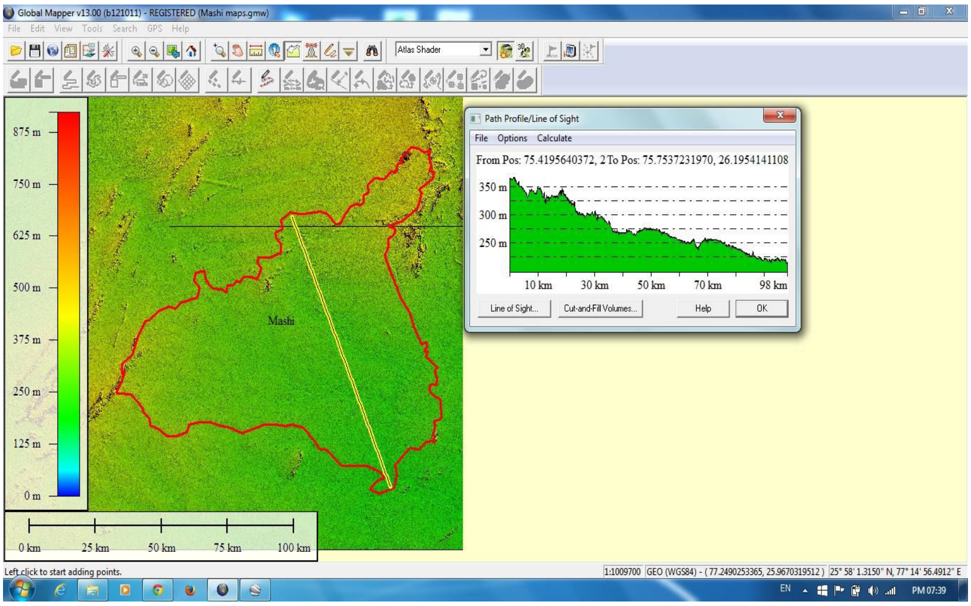
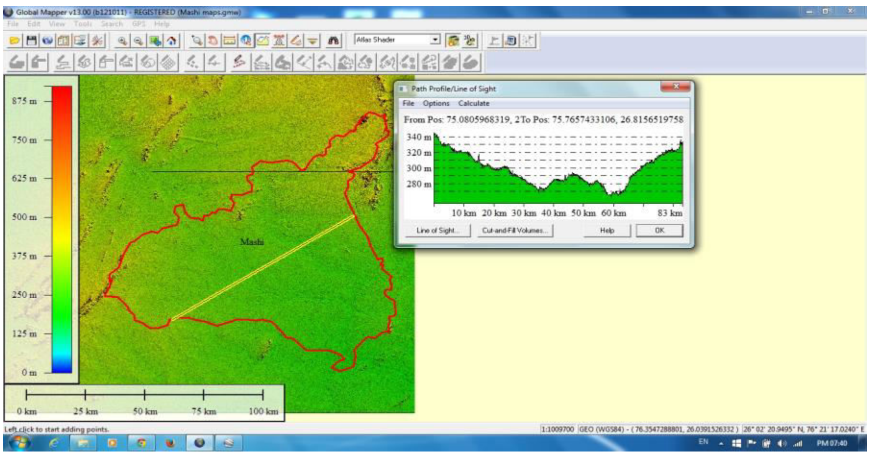


Figure 7: Mashi Basin: Elevation crossection ranging from West to East.



2.1.4 Geology

Geology of the region has a dominant role in geomorphic evolution of any area and also plays an important role in controlling groundwater conditions with cumulative factors as lithology, structural geometry, mineral composition, soil texture etc. Therefore, study of geology (including physiographic or geomorphic assessment) of the region forms one of the essential aspects of groundwater investigation. Geological formation, their lithology and chronological age are given in following table.

Age	Formation	Lithology
Quaternary	Unconsolidated	Recent & old alluvial and Aeolian(clay, silt, sand, pebble, gravel), Calcareous older alluvium(clay, silt, sand, pebble, gravel), laterite, lithomargic clay, ferruginous concretions
Cainozoic, Mesozoic	Consolidated Effusive	Basalt with/ without intertrapeans
Cainozoic, Mesozoic, Upper Palaeozoic	Semi-Consolidated	Sandstone, Shale, Limestone & Conglomerates
Cainozoic, Proterozoic	Consolidated Intrusive	Granite, Ultramafics & Dolerite
Cainozoic, Proterozoic	Sedimentary and Meta Sedimentary	Shale, Quartzite, Slate, Sandstone, Phyllite, Schist
Proterozoic	Sedimentary and Meta Sedimentary	Limestone & Dolomite
Proterozoic,Azoic	Meta Sedimentary	Schist, Phyllite, Slate, Gneiss, Marble
Proterozoic,Azoic	Meta Sedimentary	Charnockite, khondalite
Azoic	Basal Crystalline	Granite- Gneiss- complex

It is this formation that determines the location and size of water harvesting and groundwater in the Mashi Sub Basin.

2.1.5 Geomorphology

Geomorphology can be described in terms of several components, such as landforms, their nature, characteristics and stability, which constitute some of the basic parameters essential for hydrogeological investigation. Geomorphic history of the area helps in proper evaluation of surfacial material and the configuration of the bedrock profile. Relevant geomorphic and hydrogeological parameters have been integrated to evaluate the groundwater regime and the changes during last few years.

2.1.6 Regional Physiography

The Physiography of Rajasthan is the result of complex erosional and deposition processes operative during the geological history, mainly during the Late Tertiary and Quaternary periods. viz. the western sandy plains, Aravali range and the hilly region, the eastern plains and the south-eastern Rajasthan Pathar. These divisions are based on the existing relief features and provide a basis for the study of geomorphic evolution of the terrain, which has been sculptured through a number of erosional cycles, represented by various peneplained surfaces. Lithology and structure have essentially played a dominant role in carving out the present configuration of the landforms as is evident from their spectacular correlation.

The area consists of fairly open undulating plains, with hillocks in the western and north eastern parts. A wide spectrum of geomorphic features is seen in the area due to dominant fluvial and aeoalian activities. Different geomorphological units of alluvial terrain comprise of Older and Younger alluvial plains of Bandi River, blown sand, abandoned channel courses etc. Bandi and Mashi and their tributaries, which are ephemeral in nature, mainly drain the area.

2.1.7 Soil Profile

The soils of the region suffer variously in the different soil regions from excessive drainage, low water retentive capacity, moderate erosion by wind, and low fertility mostly in the upper northern part of the basin. Salinity, alkalinity, poor drainage accompanied moderate to severe erosion are the problem of soil in Naraina to Dudu, Chandrana-Padasoli and Chandran-Bandikui associated areas. Fast flowing nallahs and rivers during the rainy season cause erosion of soils near their banks. Occasionally flooded river inundate areas and silting is caused by flood channels and drainage.

Geologically the soils in the region have been derived from older alluviums of recent and sub-recent origin. On the basis of sub-soil characteristics, the soils have been classified into fallowing categories: Naraina- Dudu-Association, Chandrana-Padasoli Association and Padasoli-Phagi Association.

The soil types in this region are quite variable in their colour, texture and composition. Sand dunes occupy mainly the north western part of the area while the central part is sandy loam. Clay loam soil is present along the eastern margin and the western and south western parts of region are characterized by calcareous sands. Different types of soil in the area are listed and described as below:

a) Sand to sandy loam

b) Sandy and clay loam

c) Sandy clay

d) Clay

e) Clay loam

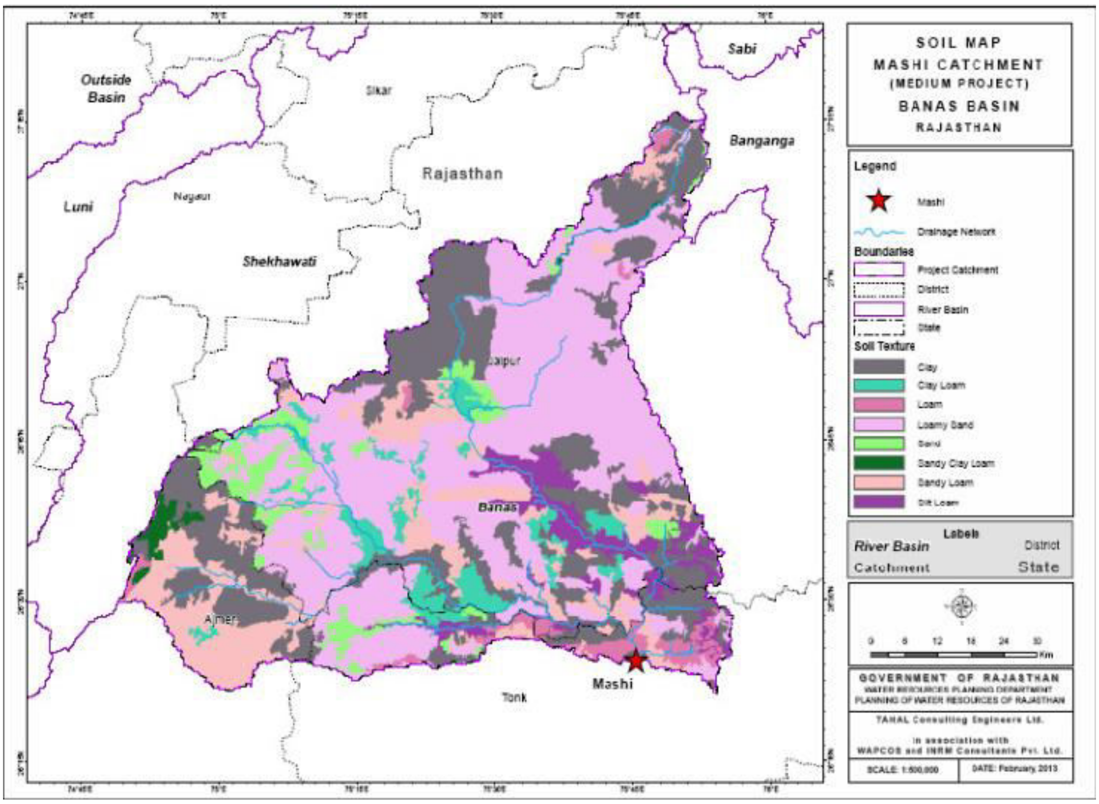
f) Loam

The soil profile in the Mashi Sub Basin catchment is reported in the Table 4. Table shows the area under each of the soil texture class found in the Mashi Sub Basin catchment. The soil map is shown in Figure 8. The Table 3 shows that predominantly Loamy Sand covers 40 percent of the area, Clay 25.9%, and Sandy Loam 14.8%, rest of the area account for around 19 percent of total area.

Table 3: Soil Profile in the Mashi Sub Basin Catchment.

Soil Texture	Area (Km^2)	Percentage of Catchment Area
Clay	1,521.7	25.9
Clay Loam	313.8	5.3
Loam	165.4	2.8
Loamy Sand	2,359.7	40.2
Sand	282.8	4.8
Sandy Clay Loam	59.8	1.0
Sandy Loam	863.0	14.8
Silt Loam	305.8	5.2
Total	5,872.0	100.0

Source: SRSAC, DST, Jodhpur



Source: Soil Resource Atlas Rajasthan (2010), SRSAC, DST, Jodhpur

Figure 8: Soil Map of Mashi Project Catchment

What emerges out of the above description is that there are inherent physical limitation of the soils in the area therefore while planning NRM interventions, such as, water harnessing structures, soil conservation works, plantations, etc. these constraints have to be kept in mind.

2.1.8 Hydrogeology

Ground water in the area generally occurs under water table in Quaternary sediments and weathered/ fissures, fractures of crystalline rocks. The alluvium is the main water bearing formation of the area. Topographic/physiographic features and lithology significantly control the occurrence and movement of ground water.

The ground water occurs in the pore spaces and interstitial openings of Quaternary alluvium while its occurrence and movement in quartzite, schist, granite, and gneisses is mainly controlled by fissures and fractures planes. Five hydrogeological formations viz; ***Younger Alluvium, Older Alluvium, Phyllite & Schist, Quartzite and BGC (Banded Gneissic Complex)*** are the main water bearing formation (aquifer) in this region. Quaternary sediments as older alluvium and Aeolian sand, gravel mixed with varying amount of clay and kankar covering north east part of basin area in Jaipur and Tonk. The Phyllite, Schist and

Quartzite of Delhi Super Group occupy the parts of Jaipur and Tonk. Banded Gneissic Complex occupies western and southern part of the basin area. BGC is the main aquifer with Mashi River and Older Alluvium is the main aquifer with Bandi River area.

2.1.9 Rainfall: There is high rainfall variability in the Basin. Occurrence of drought of high and moderate intensity is a common phenomenon. Average rainy days in the study area are 32 with rains of 450 to 650 mm a year. Figure 9 and 10 shows the mean annual rainfall and mean monsoon rainfall in Mashi River Basin.

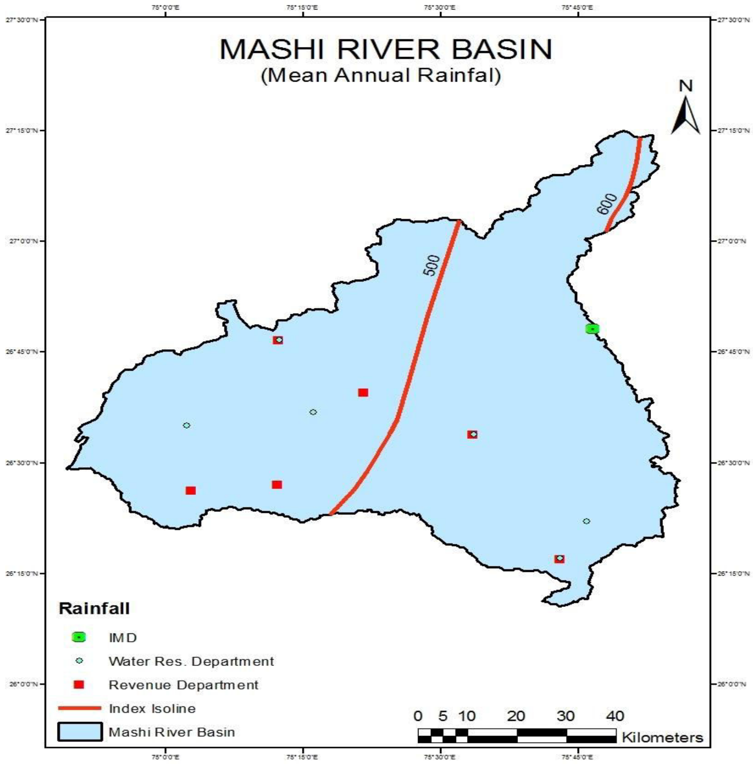


Figure 9: Mean Annual rainfall in Mashi River Basin

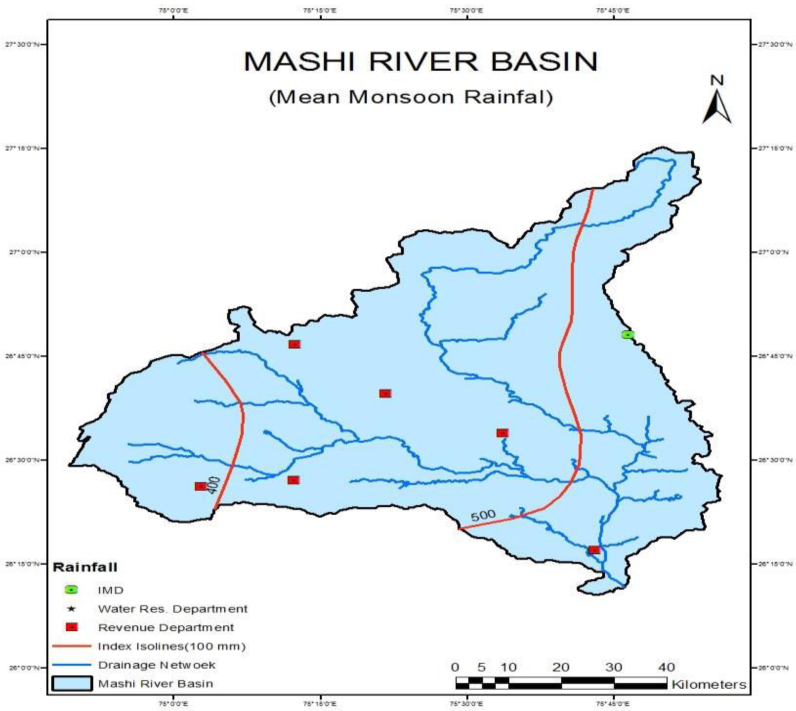
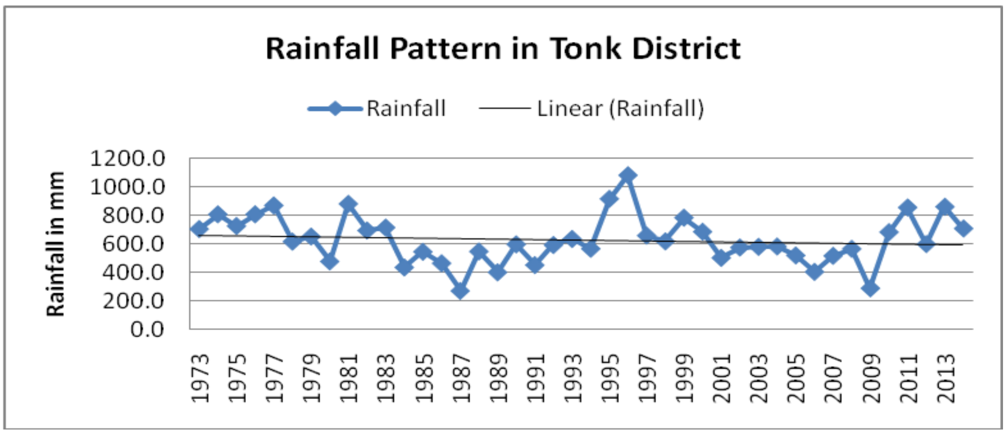
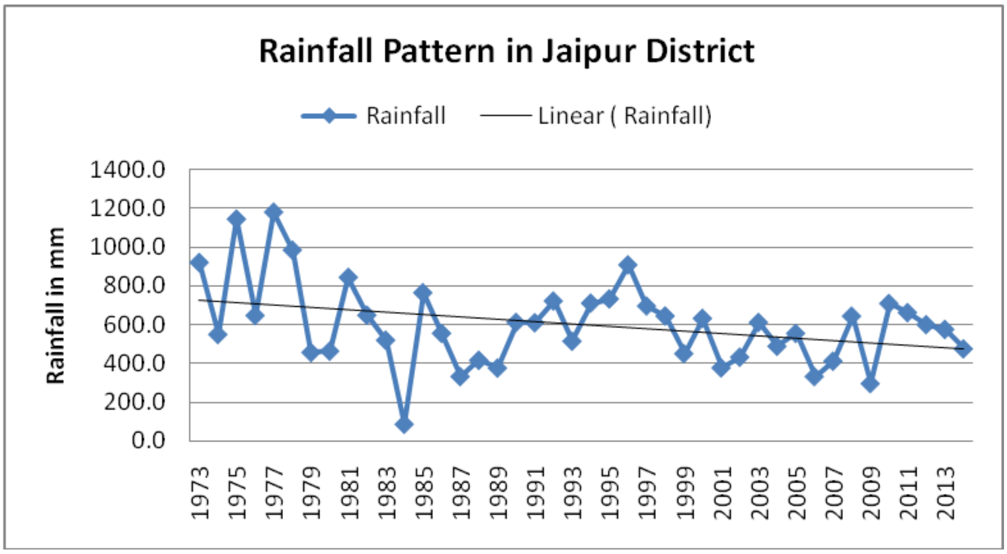
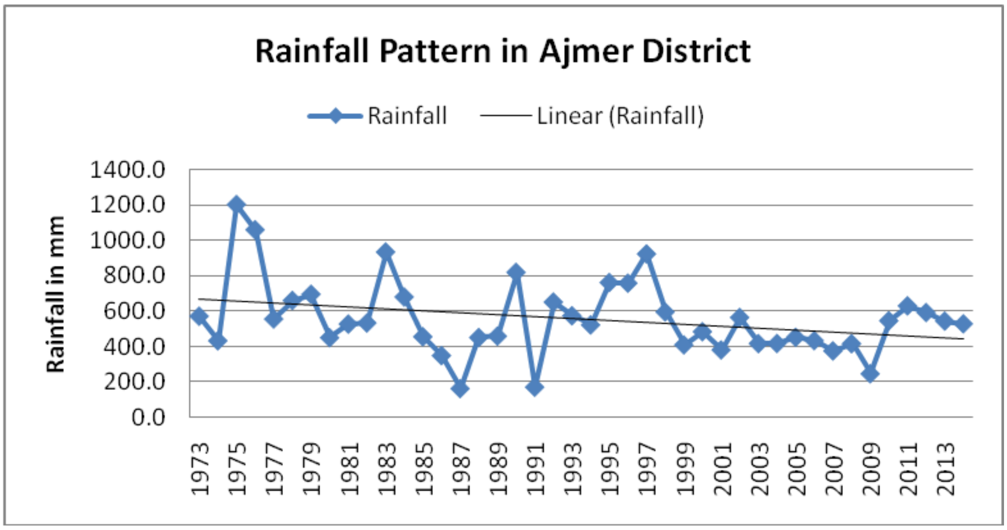


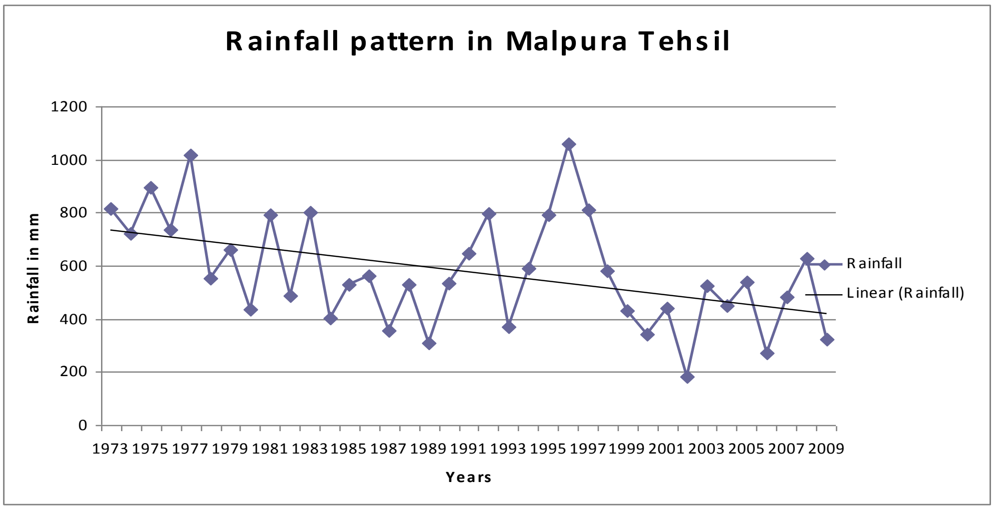
Figure 10: Mean Monsoon Rainfall in Mashi River Basin

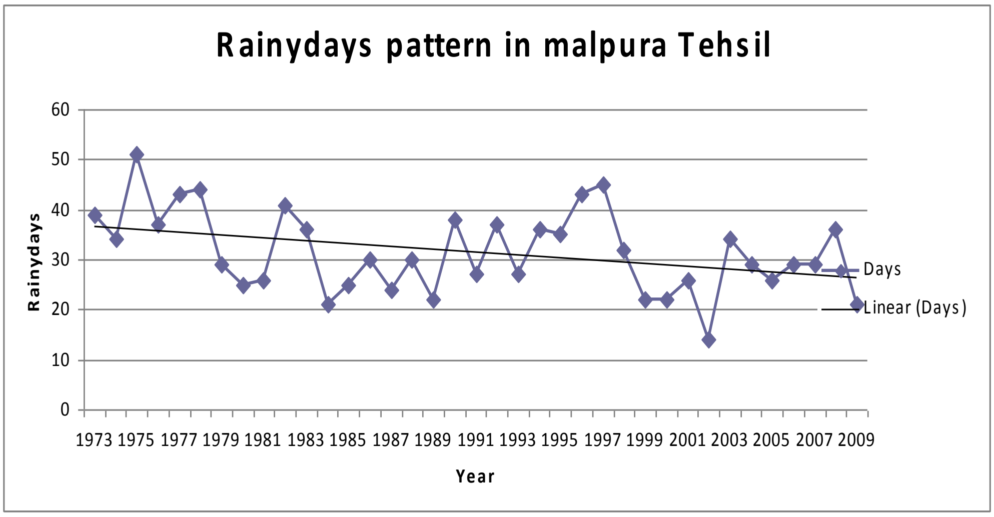
The variability in rainfall and rainy days in the three districts related to Mashi basin is shown in the following graphs. These graphs reveal that rainfall is declining in all the Districts and same is the trend in rainy days. There is sharp decline in the rainfall in Jaipur and Ajmer Districts and in Dudu and Malpura tehsils. Is this because of climate change or part of climate variability has to be established. However, this changing rainfall phenomenon is a challenge before the people and NGOs, as how to augment water supply and provide secure drinking water and meet the agricultural demand in the area.

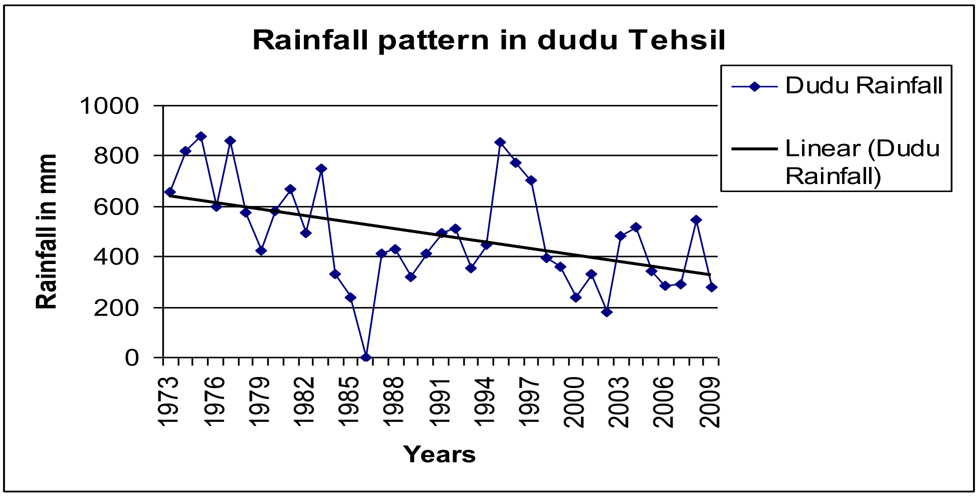


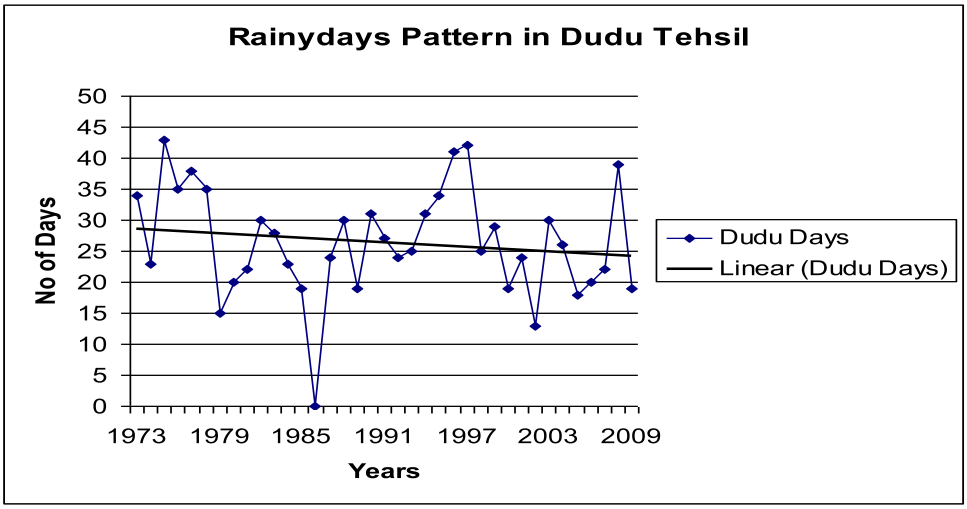

Rainfall Pattern in Jaipur District
Rainfall
Linear (Rainfall)
Rainfall in mm
1400.0
1200.0
1000.0
800.0
600.0
400.0
200.0
0.0
1973 1975 1977 1979 1981 1983 1985 1987 1989 1991 1993 1995 1997 1999 2001 2003 2005 2007 2009 2011 2013


Rainfall Pattern in Ajmer District
Rainfall
Linear (Rainfall)
Rainfall in mm
1400.0
1200.0
1000.0
800.0
600.0
400.0
200.0
0.0
1973 1975 1977 1979 1981 1983 1985 1987 1989 1991 1993 1995 1997 1999 2001 2003 2005 2007 2009 2011 2013

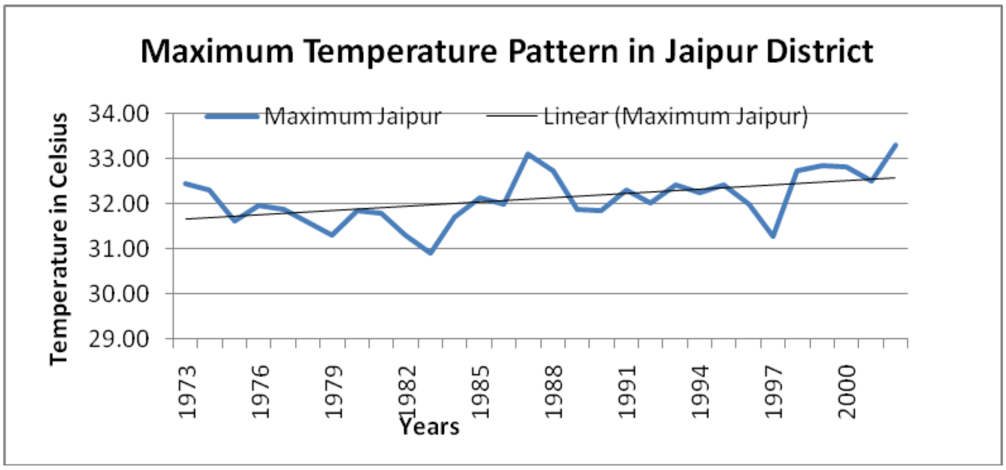

Rainfall pattern in Malpura Tehsil
Rainfall in mm
1200
1000
800
600
400
200
0
Rainfall
Linear (Rainfall)
1973 1975 1977 1979 1981 1983 1985 1987 1989 1991 1993 1995 1997 1999 2001 2003 2005 2007 2009
Years

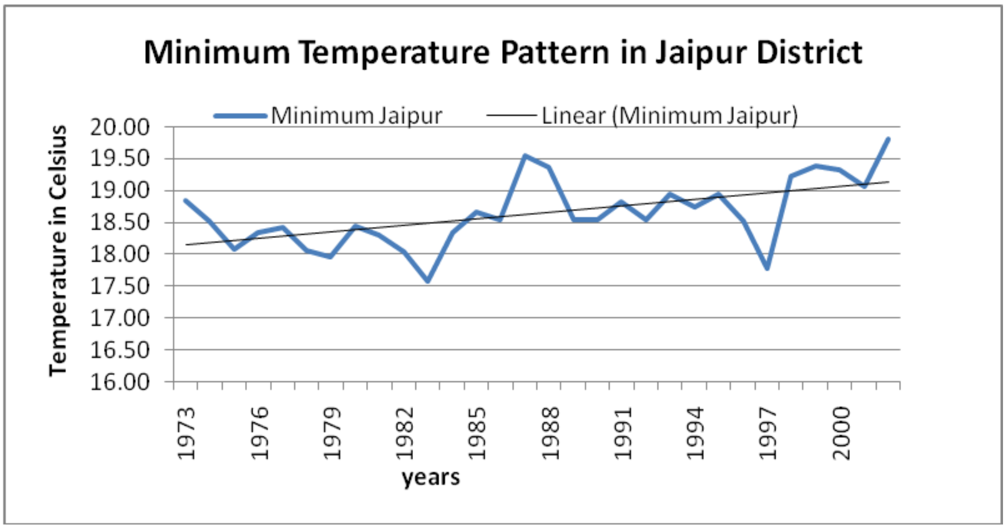

Rainydays pattern in malpura Tehsil
Rainydays
Year
Days
Linear (Days)
60
50
40
30
20
10
0
1973 1975 1977 1979 1981 1983 1985 1987 1989 1991 1993 1995 1997 1999 2001 2003 2005 2007 2009

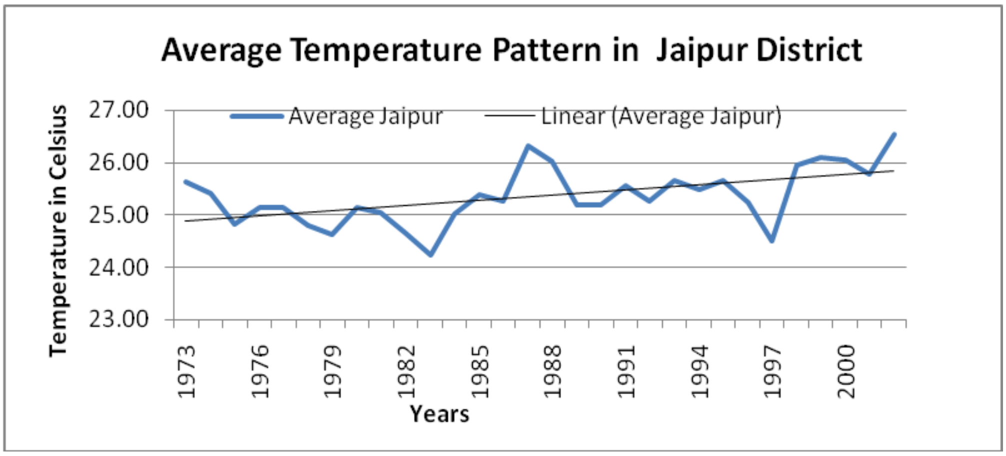

Rainfall pattern in dudu Tehsil
Rainfall in mm
Years
Dudu Rainfall
Linear (Dudu Rainfall)
1000
800
600
400
200
0
1973 1976 1979 1982 1985 1988 1991 1994 1997 2000 2003 2006 2009

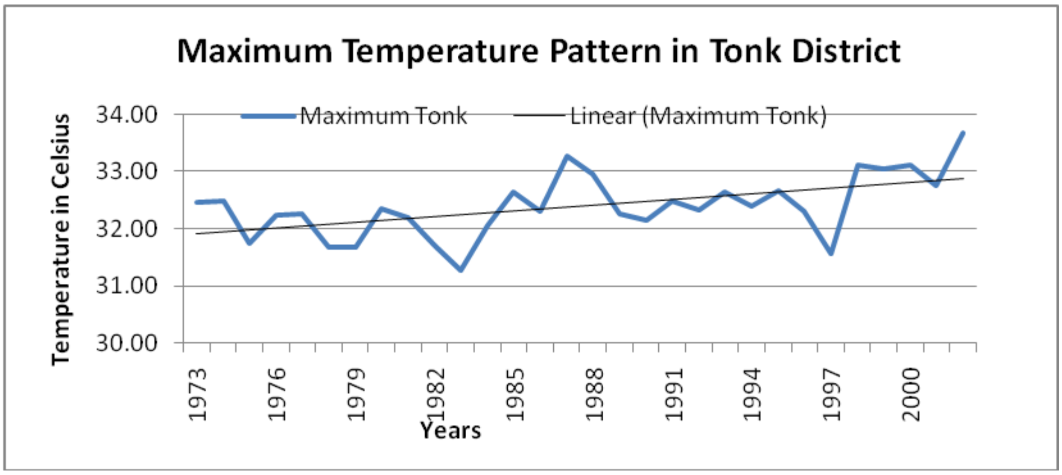

Rainydays Pattern in Dudu Tehsil
No of Days
Years
Dudu Days
Linear (Dudu Days)
50
45
40
35
30
25
20
15
10
5
0
1973 1979 1985 1991 1997 2003 2009

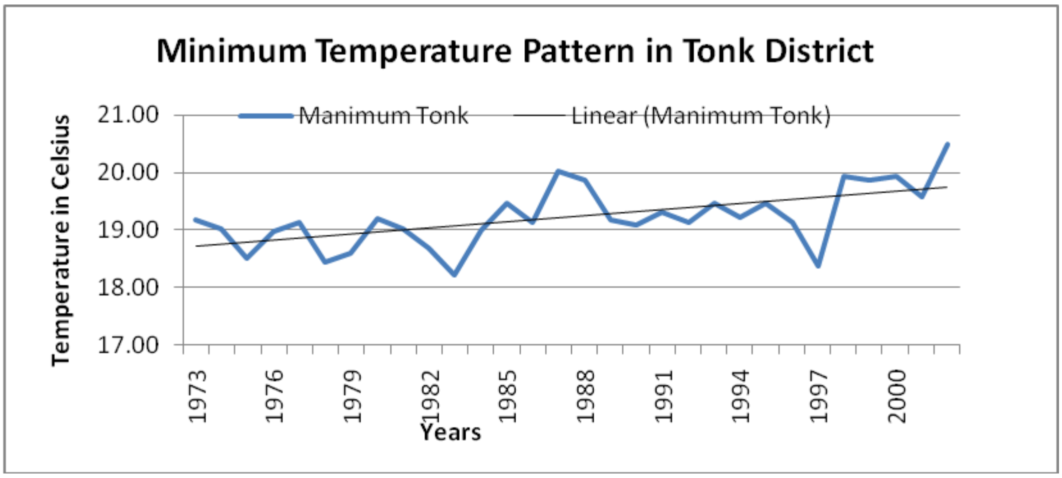
2.1.10 Temperature: Temperature affects people, agriculture, livestock and biomass in many different ways and is the most prominent parameter of climate change. May-June is the hottest part of the year in the project area. Day temperature varies between 25.8^{o}C to 45^{o}C and some time even 48^{o}C. Setting of south- west monsoon takes place after the middle of June and withdrawal of monsoon by mid-September. January is the coldest month the day temperature varies between minimum of 8.3^{o}C to 22^{o}C. The pattern of average temperature of Jaipur and Tonk districts is shown in figures below. The figures show that the average, minimum and maximum temperatures have raisin by almost one degree centigrade in last 30 years. The impacts of raising temperature on surface and ground water and agriculture in the study area needs to be analysed while working on the water balance model.

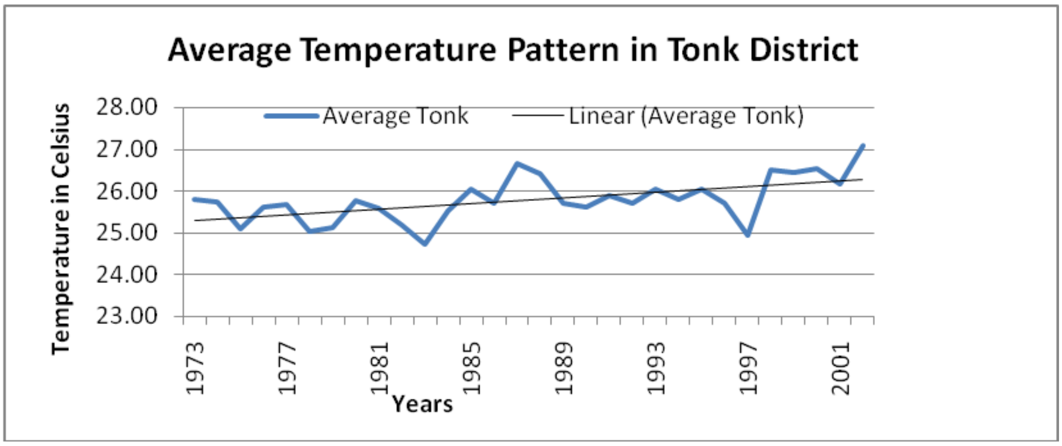


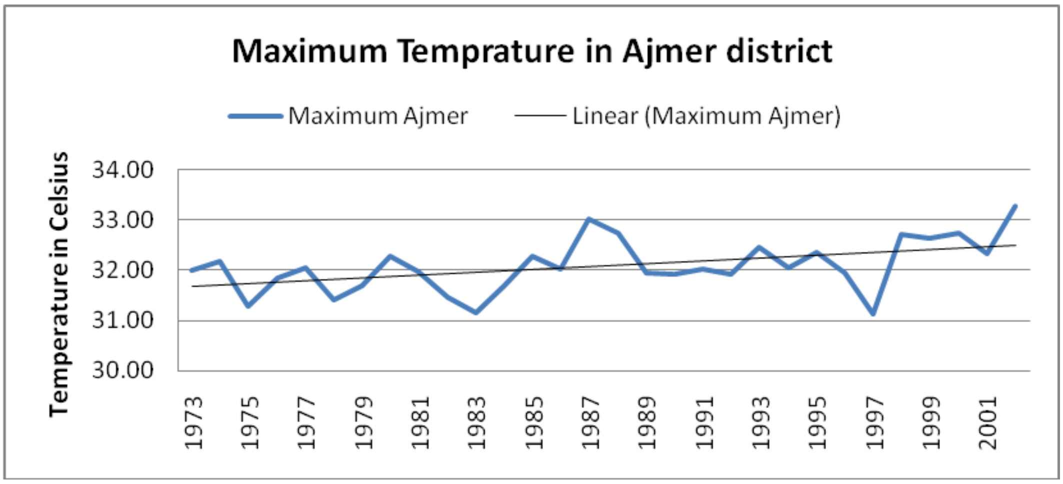


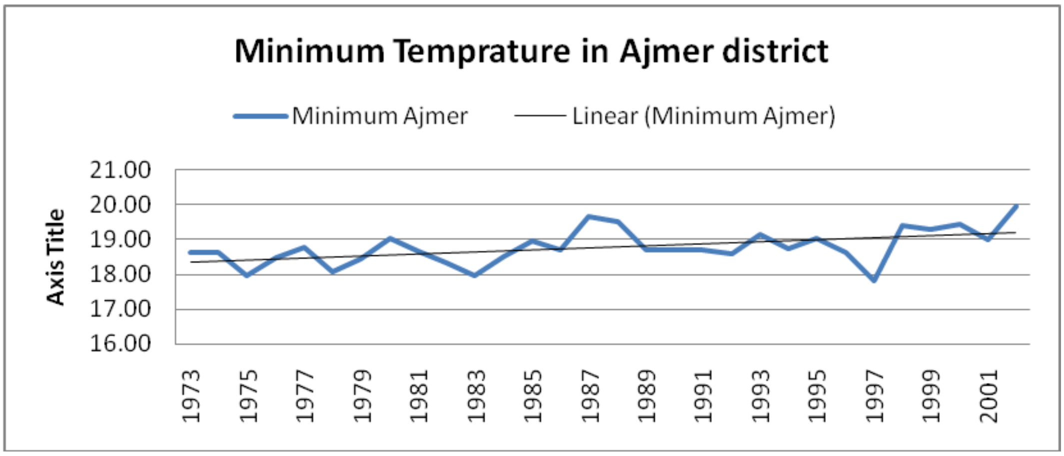

Average Temperature Pattern in Jaipur District
Average Jaipur
Linear (Average Jaipur)
Temperature in Celsius
27.00
26.00
25.00
24.00
23.00
1973
1976
1979
1982
1985
1988
1991
1994
1997
2000
Years


Maximum Temperature Pattern in Tonk District
Maximum Tonk
Linear (Maximum Tonk)
Temperature in Celsius
34.00
33.00
32.00
31.00
30.00
1973
1976
1979
1982
1985
1988
1991
1994
1997
2000
Years


Minimum Temperature Pattern in Tonk District
Manimum Tonk
Linear (Manimum Tonk)
Temperature in Celsius
21.00
20.00
19.00
18.00
17.00
1973
1976
1979
1982
1985
1988
1991
1994
1997
2000
Years


Average Temperature Pattern in Tonk District
Average Tonk
Linear (Average Tonk)
Temperature in Celsius
28.00
27.00
26.00
25.00
24.00
23.00
1973
1977
1981
1985
1989
1993
1997
2001
Years


Maximum Temprature in Ajmer district
Maximum Ajmer
Linear (Maximum Ajmer)
Temperature in Celsius
34.00
33.00
32.00
31.00
30.00
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001


Minimum Temprature in Ajmer district
Minimum Ajmer
Linear (Minimum Ajmer)
Axis Title
21.00
20.00
19.00
18.00
17.00
16.00
1973
1975
1977
1979
1981
1983
1985
1987
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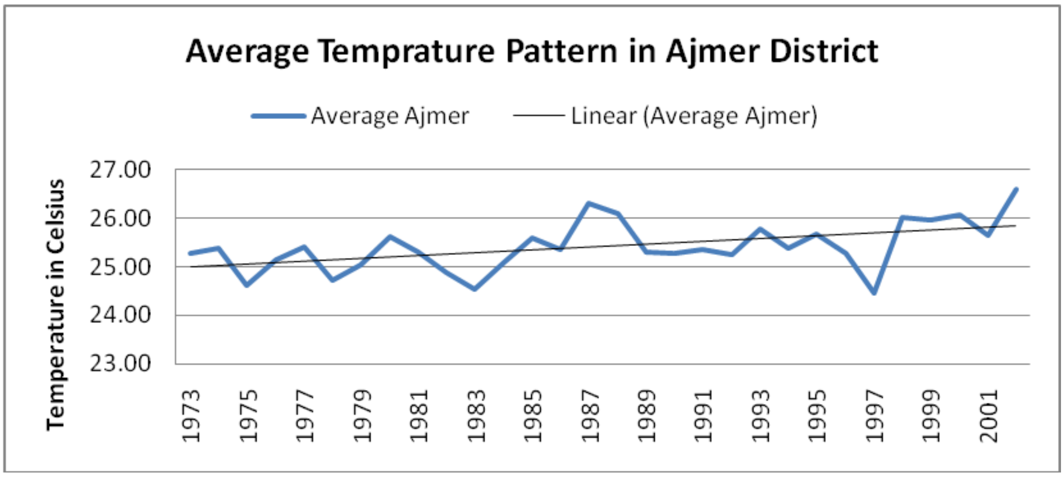
1991
1993
1995
1997
1999
2001



2.1.11 Humidity: During the brief south west monsoon the relative humidity is generally over 60 per cent. In the rest of year the air is dry. In the summer season, which is also the driest part of the year, afternoon humidity is as low as 15 to 20 percent.

2.1.12 Land Use

Land use / Land cover maps will be prepared for the study area using spectral analysis of the LISS IV satellite images and visual characteristics of the images. The land use map consists of various land use classes representing the towns, village, water bodies, forest, types of land cover etc. These categories are delineated using interpretation key elements. Remaining features like road, river and railway were captured through head-on digitization from the satellite image. All the layers are overlaid and verified with the field check to prepare the final land use / land cover map.

Sl.	Description-1	Description-2	Classes
1	Builtup	Urban	Residential, Mixed builtup, Public / Semi Public, Communication, Public utilities / facility, Commercial, Transportation, Reclaimed land, Vegetated Area, Recreational, Industrial, Industrial / Mine dump, Ash / Cooling pond
		Rural	Rural
		Mining	Mine / Quarry, Abandoned Mine Pit, Land fill area
2	Agriculture	Crop land	Kharif, Rabi, Zaid, Two cropped, More than two cropped
		Plantation	Plantation -Agricultural, Horticultural, Agro Horticultural
		Fallow	Current and Long Fallow
		Current Shifting cultivation	Current Shifting cultivation
3	Forest	Evergreen / Semi evergreen	Dense / Closed and Open category of Evergreen / Semi evergreen
		Deciduous	Dense / Closed and Open category of Deciduous and Tree Clad Area
		Forest Plantation	Forest Plantation
		Scrub Forest	Scrub Forest, Forest Blank, Current & Abandoned Shifting Cultivation

		Swamp / Mangroves	Dense / Closed & Open Mangrove
4	Grass/ Grazing	Grass/ Grazing	Grassland: Alpine / Sub-Alpine, Temperate / Sub Tropical Tropical / Desertic
5	Barren/ unculturable/ Wastelands	Salt Affected Land	Slight, Moderate & Strong Salt Affected Land
		Gullied / Ravinous Land	Gullied, Shallow ravine & Deep ravine area
		Scrub land	Dense / Closed and Open category of scrub land
		Sandy area	Desertic, Coastal, Riverine sandy area
		Barren rocky	Barren rocky
		Rann	Rann
6	Wetlands / Water Bodies	Inland Wetland	Inland Natural and Inland Manmade wetland
		Coastal Wetland	Coastal Natural and Coastal Manmade wetland
		River / Stream / canals	Perennial & Dry River/stream and line & unlined canal/drain
		Water bodies	Perennial, Dry, Kharif, Rabi &Zaid extent of lake/pond and reservoir and tanks

The information on land use generated from remote sensing data is reported in three maps for the years 2006, 2010 and 2014 and data in Table 4. It shows that the Mashi River sub basin is covering an area of 6476 Km^2 extending to three districts. The Cultivated area (including current and permanent fallow lands) accounts for 78.16 percent of total geographical area of the Basin. The forest area is around 3.66 percent and Barren/ un-culturable/ Wastelands 14.55 percent. Other categories are covering less than 5% area. The five categories of wastelands (Barren / Outcropped, Built-up, Crop Land, Dry River bed &Water bodies) shows trend of increase in area over last 8 years. The area under Built-up category has increased significantly. Major decline is reported in fallow land, land with scrub and land without scrub.

Table 4: Land use Pattern in Mashi Sub Basin Catchment.

Land Use/ Land Cover Class	**2006 to 2010**		**2010 to 2014**		**2006 to 2014**	
	Area	**%**	**Area**	**%**	**Area**	**%**
Forest Land	129.92	2.01	139.89	2.16	129.05	1.99
Forest Open Veg.	106.86	1.65	96.89	1.5	117.9	1.82
Land with Scrub	400.28	6.18	308.74	4.77	296.83	4.58
Land without Scrub	344.65	5.32	317.4	4.9	242.51	3.74
Barren / Outcropped	197.33	3.05	220.65	3.41	247.72	3.83
Built-up	142.77	2.2	220.69	3.41	261.24	4.03
Dry River bed	38.72	0.6	44.02	0.68	43.92	0.68
Crop Land	2823.4	43.6	2870.13	44.32	2968.74	45.84
Fallow	2238.23	34.56	2191.5	33.84	2092.88	32.32
Water body	53.85	0.83	66.08	1.02	75.21	1.16
Total area	**6476**	**100**	**6475.99**	**100**	**6476**	**100**

There is some difference between the tables based on data from remote sensing and land revenue records and it is partly because of the district wise data, which is not for the same geographical area and also the time of satellite picture used for analysis is for the period when there is more fallow lands. However, from water resource planning and management point of view revenue records data will be more meaningful as the demand and supply for water will be based on the revenue records.

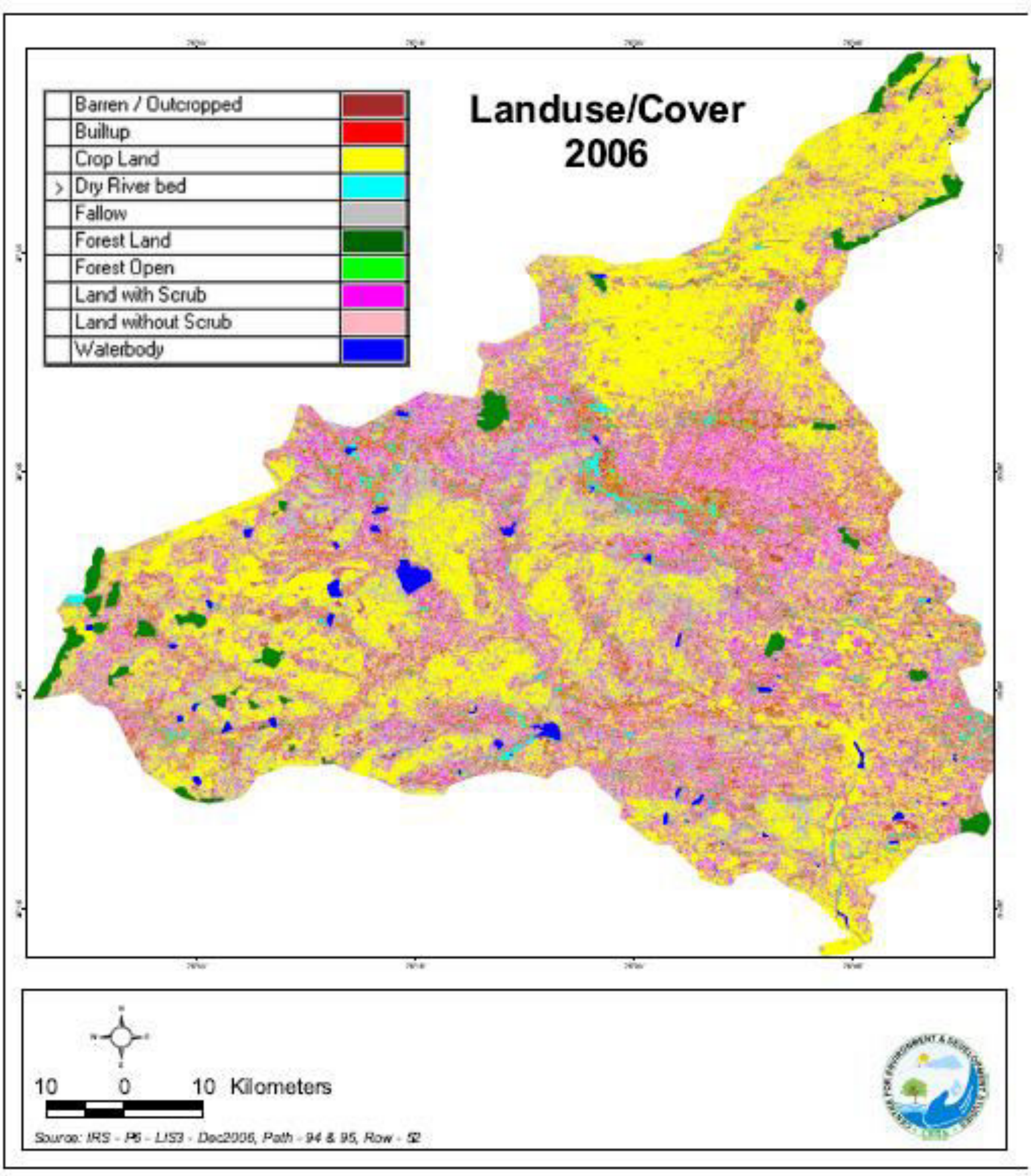


Figure 11: Land use Map of Mashi Sub Basin Catchment-2006

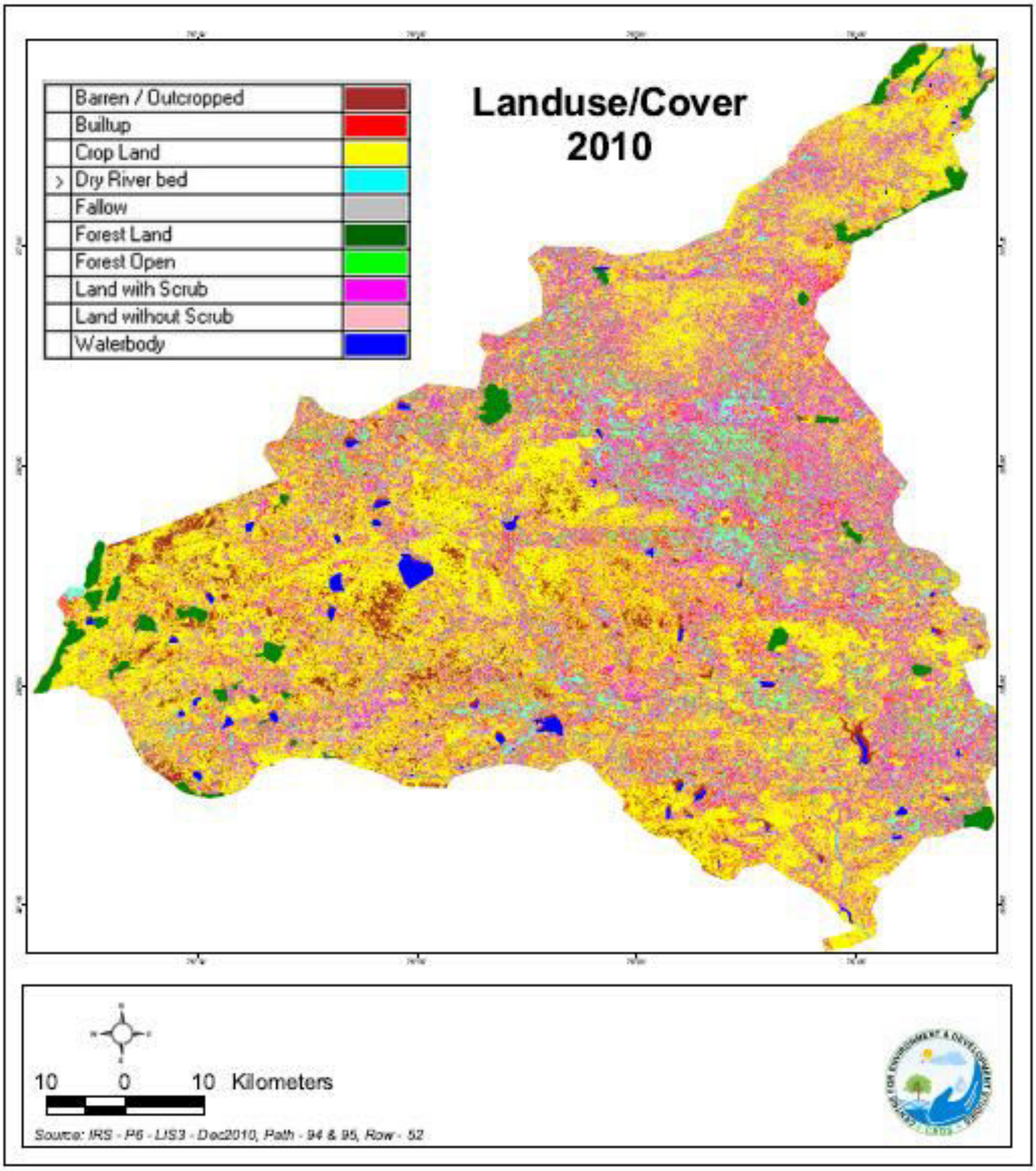


Figure 11(a): Land use Map of Mashi Sub Basin Catchment-2010

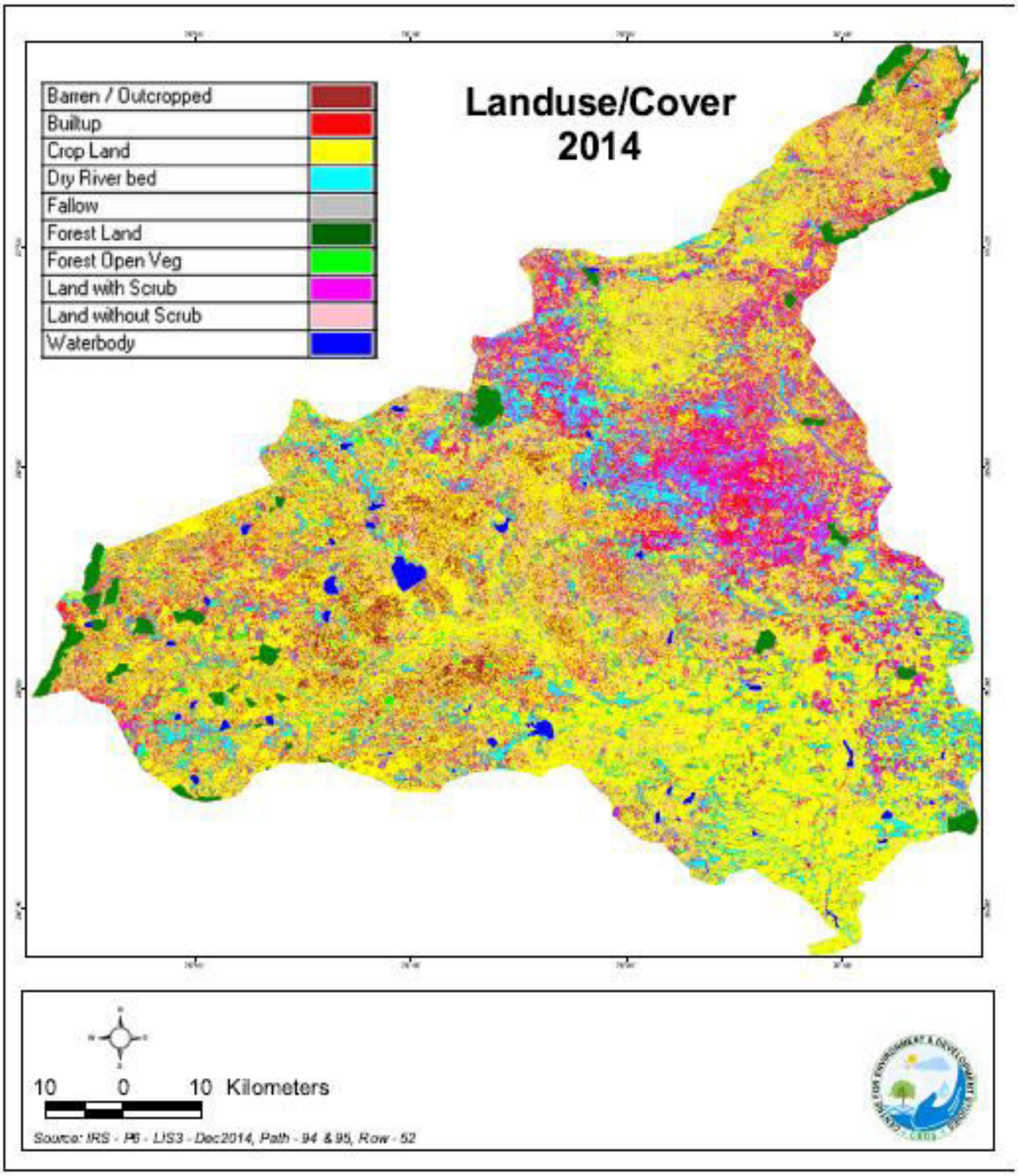


Figure 11(b): Land use Map of Mashi Sub Basin Catchment- 2014

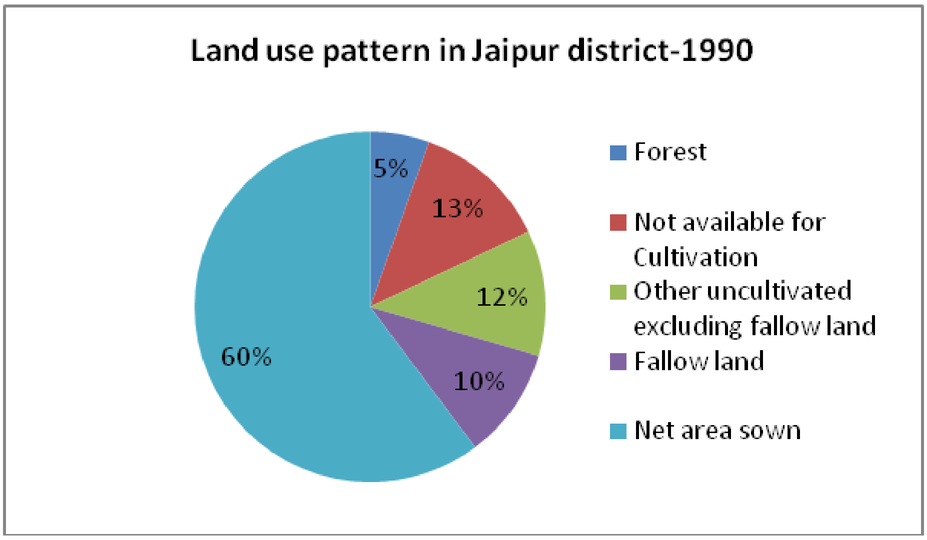
Land use pattern in the three districts falling under Mashi river basin at three time period, that is, 1990, 2005 and 2011 is shown in diagrams below.

Jaipur District: The area under Forest has increased from 5% in 1990 to 8% in 2011. The area categories Not Available for Cultivation and Other uncultivated Lands has slightly declined. While the Net Area Sown that was 56% in 1990 increased to 66% in 2011 and this change came because of decline in the area under Fallow Lands, which was 15% in 1990 has declined to 8% in 2011.

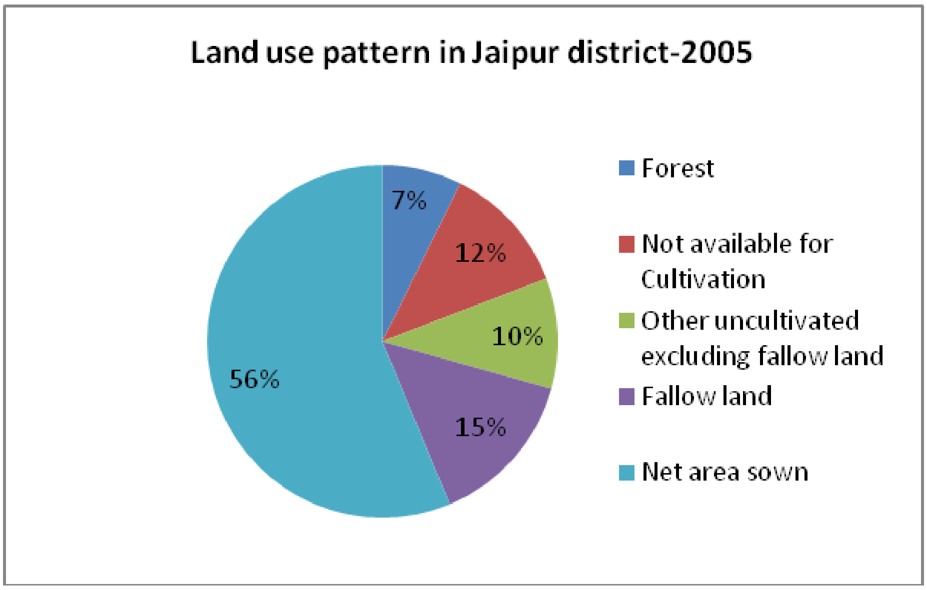
Tonk District: The forest cover has increased by one percent since 1990. The area under category 'Not Available for Cultivation' declined by one percent. The Net Sown area in the district accounts for 66% of total geographical area marginally increased with no change in the area under Fallow Lands.

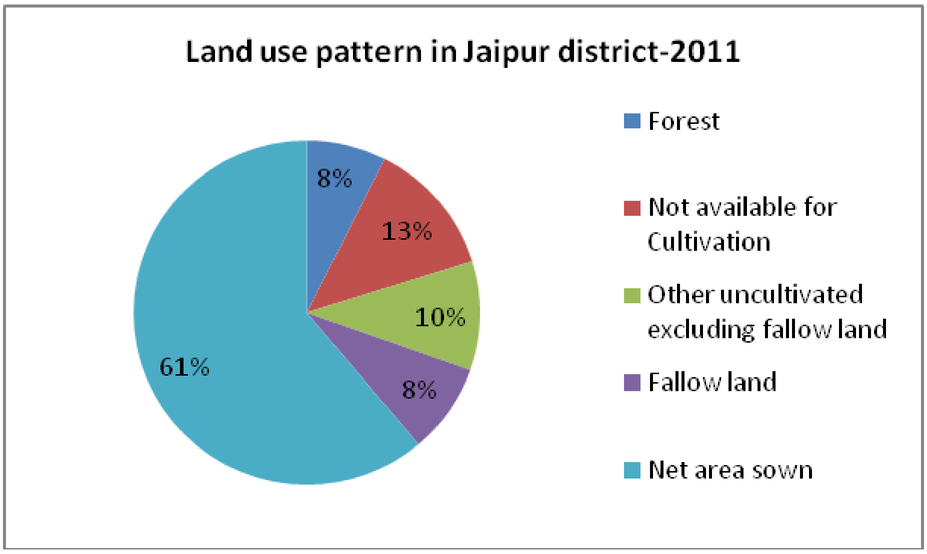
Ajmer District: The share of forest lands in total area of the Ajmer District increased by 2% since 1990. The area categories Not Available for Cultivation declined by one percent while area of 'Other uncultivated Lands' remained same. The share of Net Sown Area increased from 49% in 1990 to 53% in 2011 and this increase in area came from decline in the area under category Fallow lands.

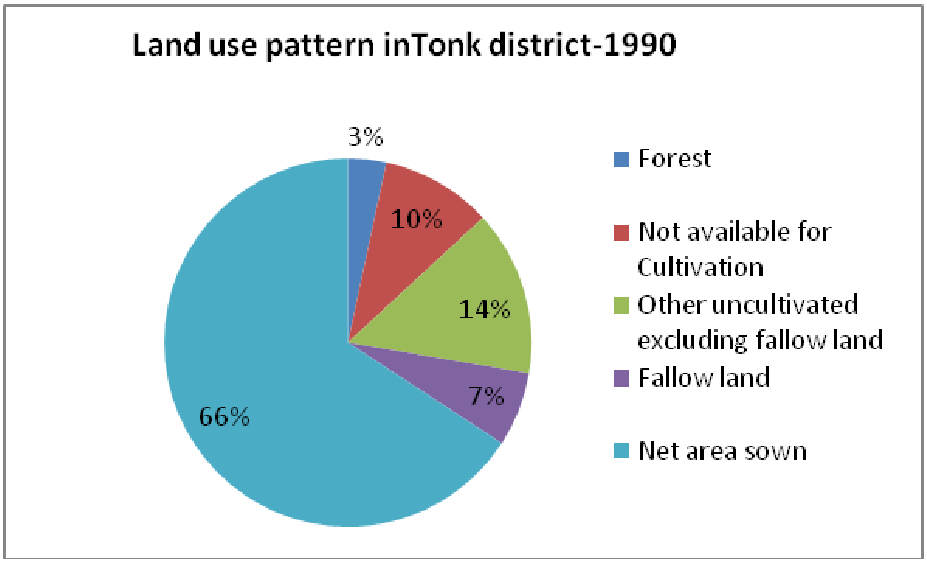
Since the major water demand comes from agriculture sector the above discussed changes in the land use pattern will affect the total demand and through new challenges for water resource management in the basin. The area categories Not Available for Cultivation and Other uncultivated Lands are the areas acting catchment area for surface water structures and groundwater recharge, therefore, these changes have to be analysed carefully.

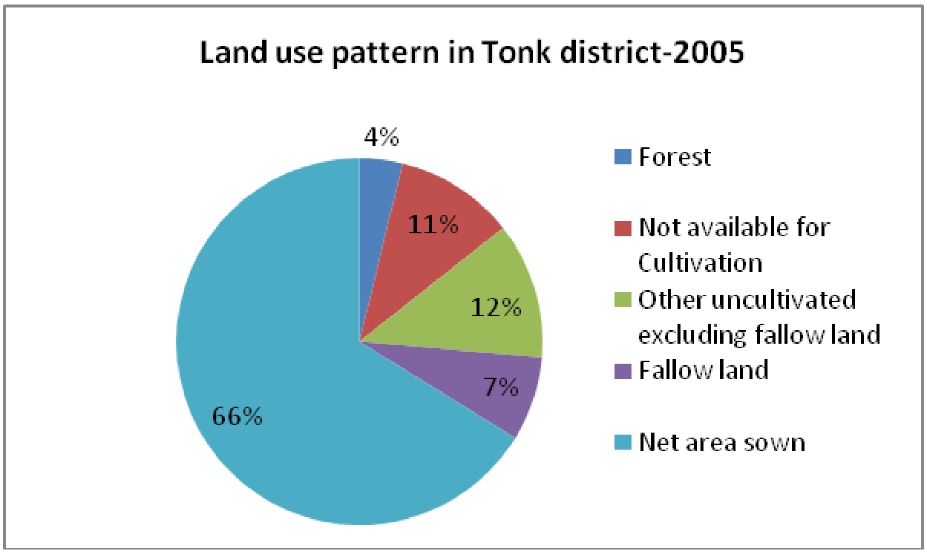


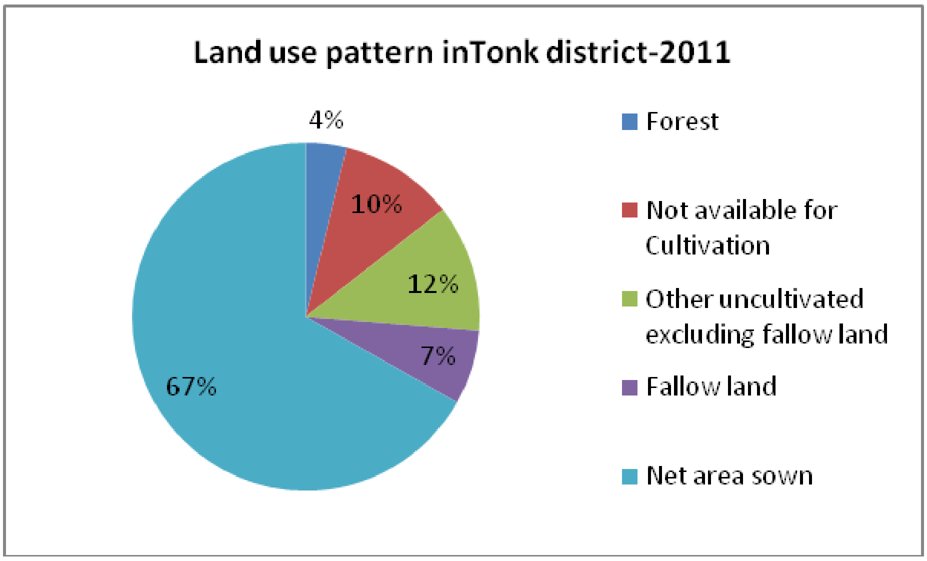
Source: Land Use Pattern In Rajasthan, Directorate of Economics and Statistics, 1970 and DECNET Project, Min. of Agriculure, GOI, Directorate of Economics and Statistics.

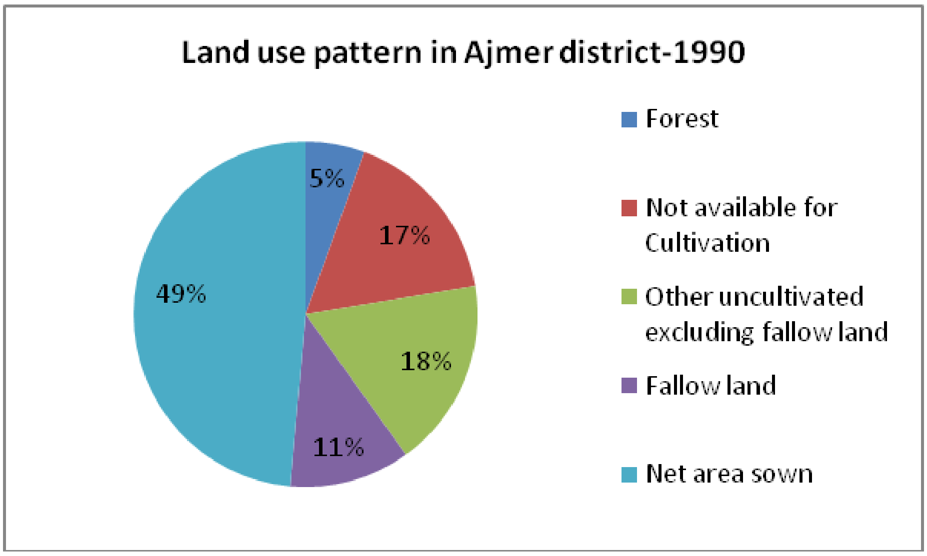

Land use pattern in Jaipur district-2005
7%
12%
10%
15%
56%
Forest
Not available for Cultivation
Other uncultivated excluding fallow land
Fallow land
Net area sown

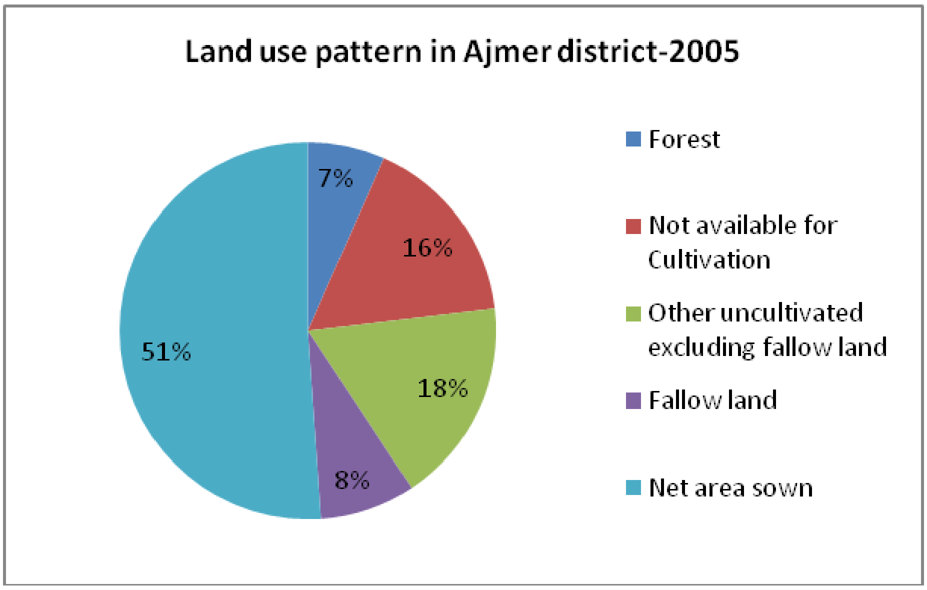

Land use pattern in Jaipur district-2011
8%
13%
10%
8%
61%
Forest
Not available for Cultivation
Other uncultivated excluding fallow land
Fallow land
Net area sown

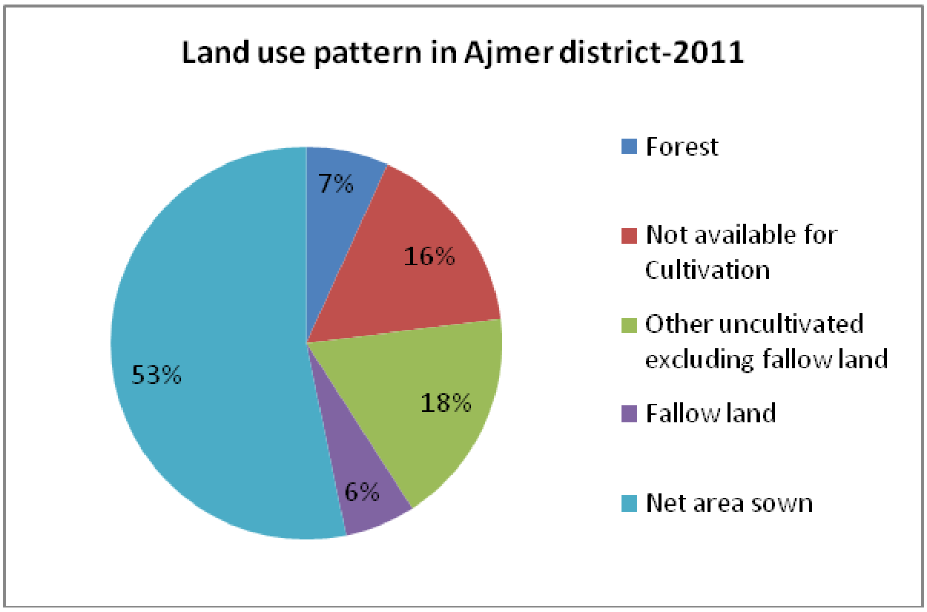

Land use pattern inTonk district-1990
3%
10%
14%
7%
66%
Forest
Not available for Cultivation
Other uncultivated excluding fallow land
Fallow land
Net area sown


Land use pattern in Tonk district-2005
4%
11%
12%
7%
66%
Forest
Not available for Cultivation
Other uncultivated excluding fallow land
Fallow land
Net area sown


Land use pattern inTonk district-2011
4%
10%
12%
7%
67%
Forest
Not available for Cultivation
Other uncultivated excluding fallow land
Fallow land
Net area sown


Land use pattern in Ajmer district-1990
5%
17%
18%
11%
49%
Forest
Not available for Cultivation
Other uncultivated excluding fallow land
Fallow land
Net area sown





2.2 Water Resources

2.2.1 Surface Water

Total number of water bodies (excluding Major/Medium/Minor projects) in Mashi Sub Basin catchment is 3,718 with a total water holding capacity of 132.58 Mm^3. Given the rainfall pattern and average rainfall in the Basin the number of Water Harvesting Structures (WHS) constructed in with differential catchment is 3,087 with total water holding capacity is 112.23 Mm^3. Actual mean annual water yield to the sub basin is computed to be 203.95 Mm^3 (with all interventions). Flow dependability with respect to four levels i.e. 25, 50, 75 and 90% of dependability is shown in Table 5.

Table 5: Water yield and flow dependability in Mashi.

Dependability Level (%)	Water Yield (Mm^3)
25	200.7
50	59.6
75	6.4
90	0.0

Rainfall occurs mainly during the monsoon season in Mashi Project catchment therefore, major portion of stream flow occurs only during these months. From Table 6, it is evident that annual dependable water yield at 50% is 59.6 Mm^3, while water yield at 75% dependability is 6.4 Mm^3 (13.3% of gross storage capacity). The mean annual virgin flow at different level of dependability is shown in the Table 6 and simulated flow in the Figure 8.

Table 6: Mean Annual Virgin Flow Dependability in Mashi Sub basins and Banas River Basin.

Sub Basins (All Flows in Mm^3)	Dependability in (Percentage)					
	10	25	50	75	90	95
Mashi	**1583.10**	**1022.00**	**472.3**	**173.6**	**71.8**	**30.2**
Banas Basin	8864.9	7256.6	4805.1	3482	693.7	1529.9

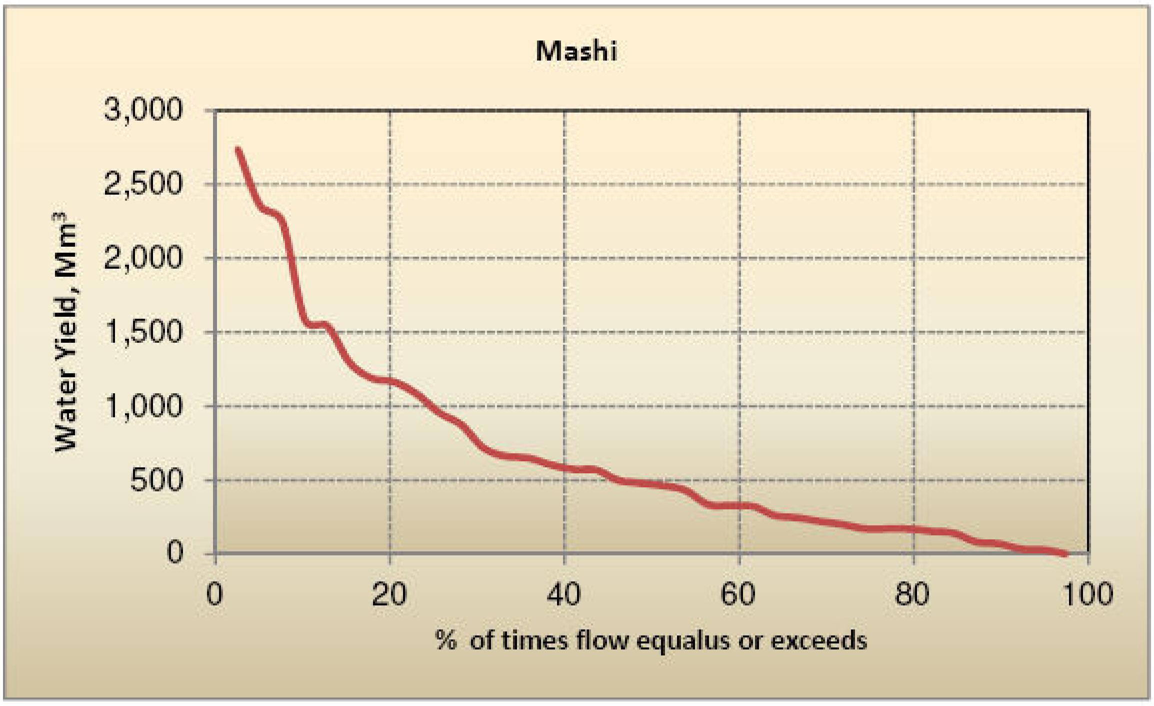


Figure 8: Simulated Flow Duration Curves for Mashi Sub-basin of Banas River Basin

Irrigation Projects in the Basin: a) Major and Medium Projects: There are 3 upstream projects in Mashi sub basin catchment. Table 7 gives the details of the existing upstream project in the Mashi Sub Basin catchment.

Table 7: Upstream project details in Mashi Sub Basin

Name	Type	Live Storage (Mm^3)	Gross Storage (Mm^3)	Data Availability	Catchment Area (Km^2)
Chhaparwada Project	Major	53.20	53.20	1996-2010	746.6
Hingonia Project	Medium	7.50	7.50	1996-2010	1,484.1
Kalkh Bund Project	Major	20.66	20.66	1996-2010	669.9

b) Minor Projects: There are 97 Minor projects in the catchment area of Mashi Sub Basin with total live storage capacity of 90.64 Mm^3. While in differential catchment area total number of minor project is 79 with total live storage capacity of 70.44 Mm^3. There are large numbers of minor projects constructed in the catchment of Mashi Dam capacity of which exceeds its design yield which may have substantial impact on inflow to project.

2.2.2 Groundwater:

(A) ***Aquifer Units and Characteristics*: ** The main aquifer units occurring in Mashi sub basin are Younger and Older alluvium, Tertiary sandstone, Bhander sandstone and Limestone, Shale, Quartzite, Phyllite, Schist, Deccan trap and BGC. The geographic area occupied by different units is shown in Table 8.

Table 8: Aquifer Units in the Mashi Sub Basin

Hydro geological Unit	Unit Area (km^2)
B.G.C.	2637.90
Older Alluvium	3021.66
Phyllite & Schist	744.82
Quartzite	6.41
Younger Alluvium	65.37
Mashi Total	6476.16

The alluvium consists of aeolian sand, gravel mixed with varying amount of clay and kankar occupies an area 3021.66 km^2. The groundwater occurs mainly in joints and fissures of rocks.

The Phyllite, schist and quartzite of Delhi Super Group occupy very large area of about 744.82 km^2 in the basin covering entire Udaipur, Chittoragarh, Bhilwara districts and parts of Jaipur, Dausa and Tonk districts. The Banded Gniessic Complex occupies western and southern parts of the basin with an area 18011.79 km2. A very small area of 62.56 km2 is occupied by Deccan traps. Table 9 shows the hydrological characteristics of Mashi Basin.

Table 9: Hydrological Characteristics of Mashi Sub Basin

Aquifer Units	Aquifer Depth (m)			SWL* (m), bgl			Discharge (lps)		
	Min	Max	Avg.	Min	Max	Avg.	Min	Max	Avg.
B.G.C.	40.00	162.00	89.12	3.00	30.15	16.64	0.13	12.60	2.23
Older Alluvium	19.90	207.00	80.40	3.25	54.00	23.26	0.10	25.00	4.54
Phyllite & Schist	50.00	155.45	93.23	6.20	16.50	12.25	0.19	5.00	1.95
Younger Alluvium	200.00	200.00	200.00	16.40	16.40	16.40	10.00	10.00	10.00
B.G.C.	8.60	35.00	16.42	0.05	0.58	0.20	-	-	-
Older Alluvium	0.90	30.60	10.27	0.04	15.22	1.42	0.68	849.00	154.55
Phyllite & Schist	17.95	17.95	17.95	0.08	0.08	0.08	-	-	-
Younger Alluvium	200.00	200.00	200.00	16.40	16.40	16.40	10.00	10.00	10.00

Source: CGWB and RGWD, * Static Water Level is based on the data from 1963 to 2010.

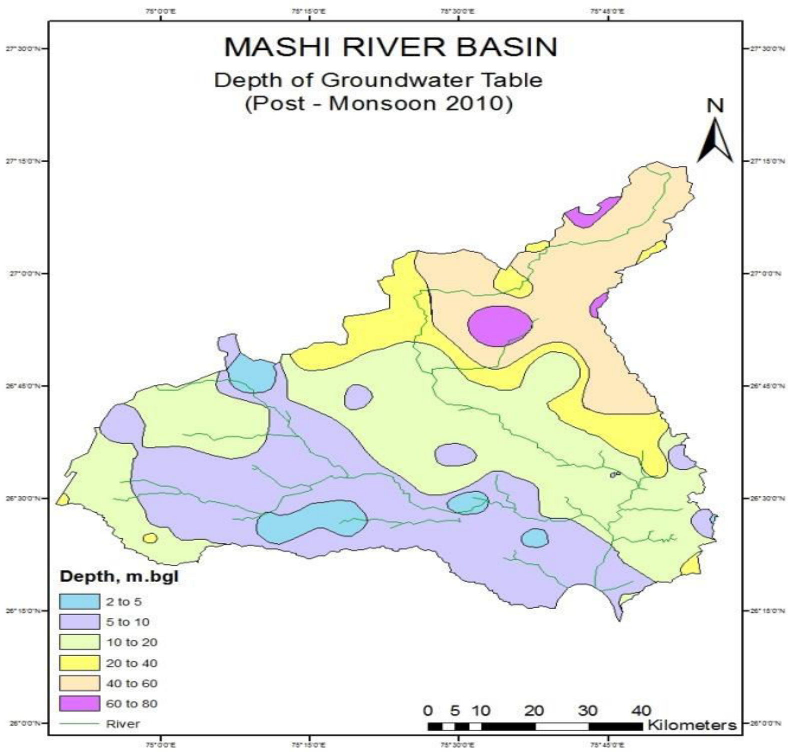
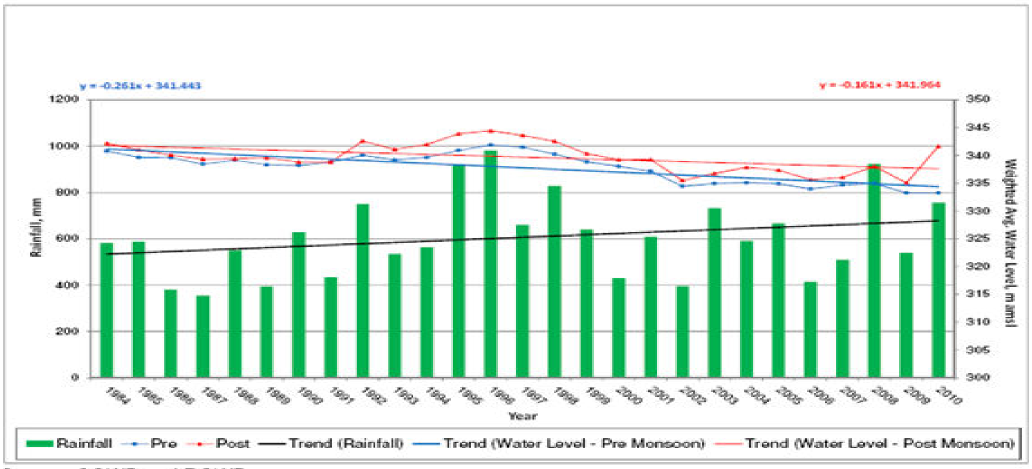


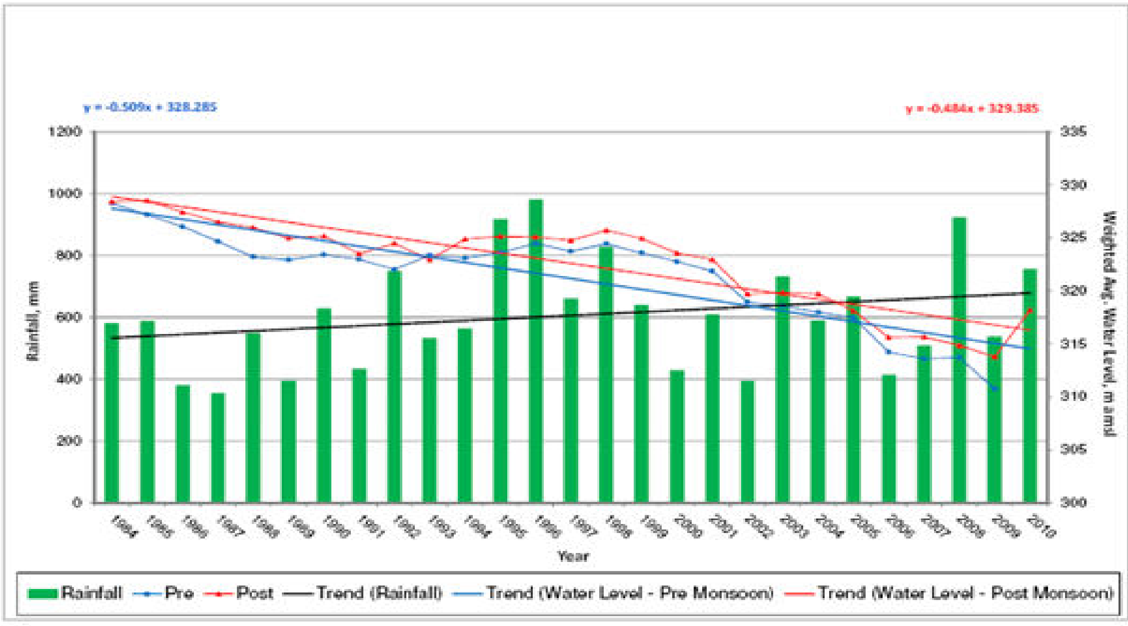
Figure 12: Depth of groundwater table- Post Monsoon

This sub-basin comprises two sub-sub-basins, namely: Mashi with B.G.C as the main aquifer and Bandi with the Older Alluvium being the main aquifer. Groundwater levels in the entire sub-basin are decreasing constantly over the years. However, the two sub-sub-basins present significantly different trends, which are being presented below (Figures 13 and 14).



Source: CGWB and RGWD

Figure 13: Long-term Groundwater Level Trend in Mashi Sub-basin Main Aquifer: B.G.C.



Source: CGWB and RGWD

Figure 14: Long-term Groundwater Level Trend in Mashi Sub-basin Main Aquifer: Older Alluvium

Groundwater levels in Mashi sub-sub-basin declined during pre-monsoon records (1984-2009) from 341 m amsl to 333 m amsl, a total of 8 m in 26 years. According to post-monsoon measurements, groundwater levels dropped from 342 m amsl to 335 m amsl, a total of 7 m in 26 years. The average declining rate of the water table varied from -0.16 m/yr (post-monsoon) to -0.26 m/yr (pre-monsoon).

Groundwater levels in the Bandi sub-sub-basin declined during pre-monsoon records (1984-2009) from 328 m amsl to 311 m amsl, a total of 17 m in 26 years. During post-monsoon measurements, the groundwater levels dropped from 328 m amsl to 314 m amsl, a total of 14 m in 26 years. Accordingly, rates in this sub-sub-basin are significantly higher: being -0.48 m/yr to -0.50 m/yr for post- and pre-monsoon, respectively.

The reason for the differences between the rates in these two sub-sub-basins might be related to the pumping potential from the alluvial aquifer, which is much higher than in the hard rocks.

In both sub sub-basins, there is a good correlation between pre-and post-monsoon data. Both seasons exhibit similar long-term trends as well as annual fluctuations. The water table difference between the seasons is similar throughout most of the period of measurements. Fairly good correlation to rainfall can be suggested from the graphs (Figures 13 and 14).

The draft values in Mashi Sub-basin are relatively high compared to other sub-basins, which may explain the extensively dropping water table.

Assuming that precipitation and drafts trends will prevail during future years, groundwater wells will continue to become dry within the next few decades. It is estimated that in case of continuation of current groundwater level trends, ~38% of the wells will be dry by the year 2020, ~72% of the wells will be dry by the year 2040 and ~76% of the wells by the year 2060 (pre-and post-monsoon dryness; (Table 10). These estimates are the highest in the entire Banas Basin.

The post-monsoon (2010) water level map of Mashi basin is depicted in Figure 15. The deeper groundwater level of 40 to 80 m is in the northern part of the basin, covering the sub-basins of Bandi correspond with levels of pre-monsoon 2010. The central part ranges between 10 to 20 m bgl, and southern parts have registered shallow groundwater levels of 5 to 10 m bgl. There are few pocket of very shallow groundwater levels ranging 2 to 5 m bgl in the sub-basin.

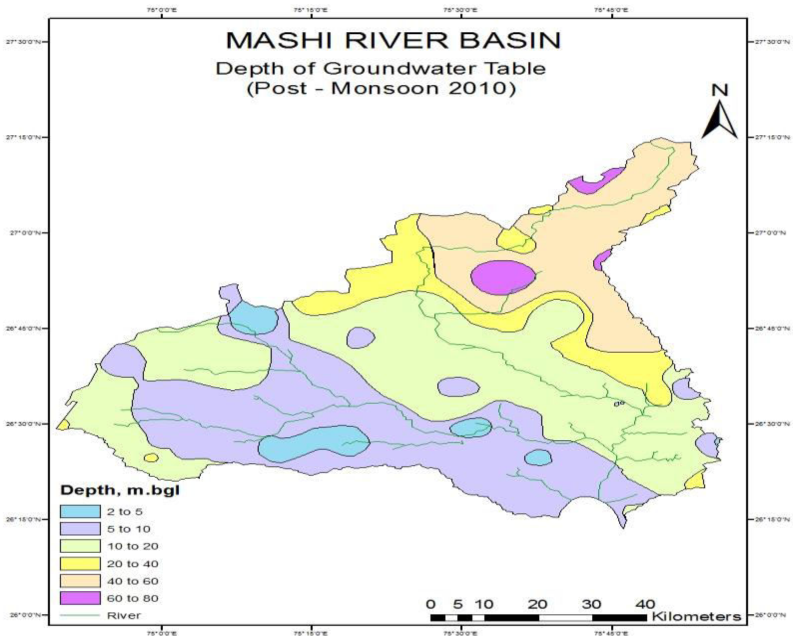


Figure 15: Current Depth to Groundwater Table (2010)

(B) Groundwater Level Fluctuation: Sub-basin and Aquifer-wise Fluctuation in Groundwater Levels (GWL) is shown in Table 10.

Table 10: Sub-basin and aquifer unit-wise fluctuation in groundwater levels in Mashi Sub Basin.

Sub-Basin	GWL Min (m)	GWL Max (m)	GWL Average (m)
Mashi	-3.05	9.80	3.73
B.G.C.	0.30	9.60	5.09
Older Alluvium	-3.05	8.88	1.64
Phyllite & Schist	1.30	9.80	6.48
Younger Alluvium	0.50	0.50	0.50

(C) Groundwater Quality

The groundwater quality in the Mashi Sub Basin has been reported with reference to selected parameters, namely:

- Concentration of Chloride (Cl) ion in water samples
- Concentration of Fluoride (F) ion in water samples;
- Concentration of Nitrate (NO_3) ion in water samples
- EC value in water samples.

Occurrence of Chloride**:** As shown in Table 11 and Figure 16 the average chlorides concentration was relatively stable and ranges from a minimum of 175 mg/l to a maximum of 474 mg/l during the period of 1984 - 2010. The concentration rose from a value of ~249 mg/l during 1984 to a value of ~452mg/l during 2010, a total rise of ~82% within 27 years.

Table 11: Aquifer-wise Levels of Chloride in Groundwater of Mashi Sub Basin.

(Percent Area)

Hydro geological Unit	< 250 mg/l	250 -1,000 mg/l	> 1,000 mg/l	Total
B.G.C.	17	69	14	100
Older Alluvium	67	26	8	100
Phyllite & Schist	25	66	9	100
Quartzite	100	0	0	100
Younger Alluvium	91	9	0	100
Mashi Total	**42**	**47**	**10**	**100**

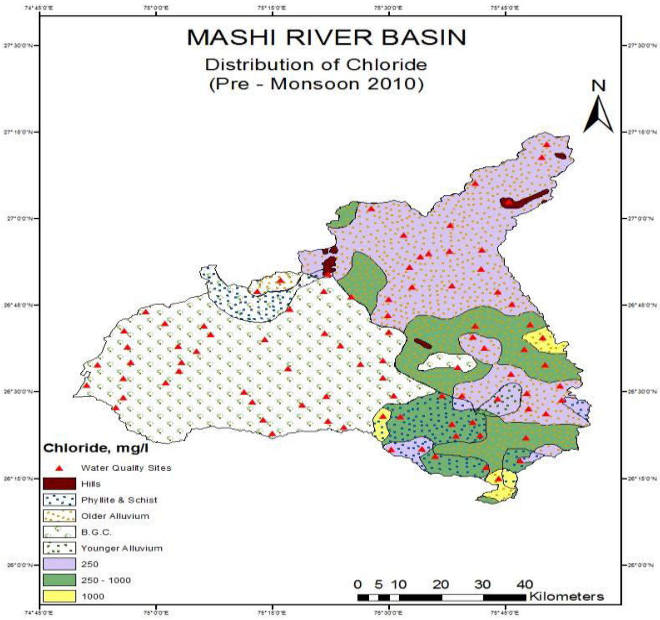


Figure 16: Location of Chloride in groundwater in Mashi Bub Basin

It is reported that about 49% area of Banas basin contains chloride levels up to 250 mg/l, the limit of usability of water for drinking purposes. 90 to 100% area of Gudia and Kalisil sub-basins bear potable quality groundwater. Poor quality groundwater, in general, relate to BGC and phyllite/schist units in sub-basins of Sodra, Kothari, **Mash**i, Banas, Dain and Berech.

Occurrence of Fluoride in Groundwater**:** The Table 12 and Figure 17 show the fluorides concentrations in Mashi Sub basin. The table revels that fluoride concentrations are above the upper permissible limit for drinking water in most of the basin's area. Significantly lower long trend concentrations were measured at the southern part of the basin. This area is mainly characterized with fluorides concentrations that are lower than the desirable limit throughout the study period.

The percent area occupied by various fluoride level ground water in different aquifer units of basin are given in Table 12.

Table 12: Aquifer-wise Fluoride Levels in Mashi Sub Basin. (Percent Area)

Hydro geological Unit	**< 1.0 mg/l**	**1.0 -1.5 mg/l**	**> 1.5 mg/l**	**Total**
B.G.C.	13	17	71	100
Older Alluvium	43	18	39	100
Phyllite & Schist	6	24	70	100
Quartzite	0	0	100	100
Younger Alluvium	45	17	38	100
Mashi Total	26	18	55	100

Source: CGWB and RGWD

The 100% non-potable water area belongs to quartzite aquifer unit in Mashi sub basin.

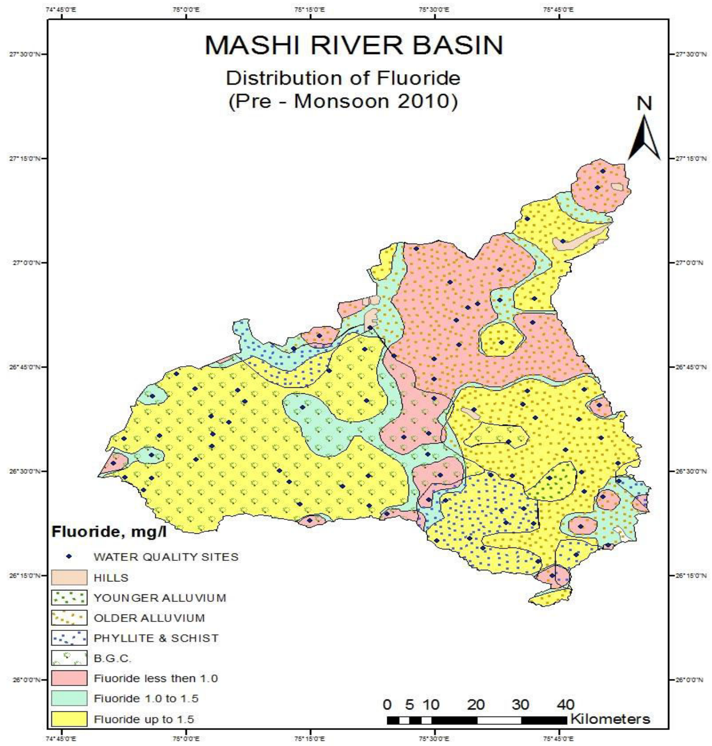


Figure 17: Location of Fluoride in groundwater in Mashi Sub Basin

Occurrence of Nitrates in Groundwater: The Table 13 and Figure 18 show the location of Nitrates in the groundwater in the Mashi Sub basin. The average nitrates concentration ranges from a minimum of ~25 mg/l to a maximum of ~267mg/l during the aforementioned time period 1984 – 2010.

The concentration rose from a value of ~41mg/l during 1984 to a value of ~100mg/l during 2010, a total rise of ~144% within 27 years. The average nitrate concentration is between the desirable and maximum allowed concentrations for drinking water (45 mg/l and 100mg/l, respectively); nevertheless, the last average value (2010) is very close to the maximum allowed limit. Most of the area in the basin is affected by nitrates ion concentrations above permissible concentrations. The average nitrates concentration is relatively high with a long-term average of ~ 90mg/l. In fact, during almost half of the studied period (1988, 1990, 1991, 1992, 1993, 1996, 1997, 1999, 2001, 2005, 2006 and 2007) the concentration had exceeded the upper allowed concentration limit for nitrate.

The maximal values in the basin vary between 100 and 300 mg/l with the higher figures suspected as measurement errors.

Table 13: Aquifer wise level of Nitrate in Mashi River Sub Basin (in mg/l)

(Percent Area)

Hydro geological Unit	< 45 mg/l	45– 100 mg/l	> 100 mg/l	Total
B.G.C.	62.0	31.7	6.3	100.0
Older Alluvium	59.6	32.2	8.2	100.0
Phyllite & Schist	59.0	22.3	18.7	100.0
Quartzite	100.0	0.0	0.0	100.0
Younger Alluvium	22.1	77.9	0.0	100.0
Mashi Total	**60.3**	**31.3**	**8.5**	**100.0**

Source: CGWB and RGWD

The 100% safe groundwater with <45 mg/l of NO3 content is found in Bhandar sandstone and quartzite aquifer units of Banas, Gudia, **Mashi** sub basins.

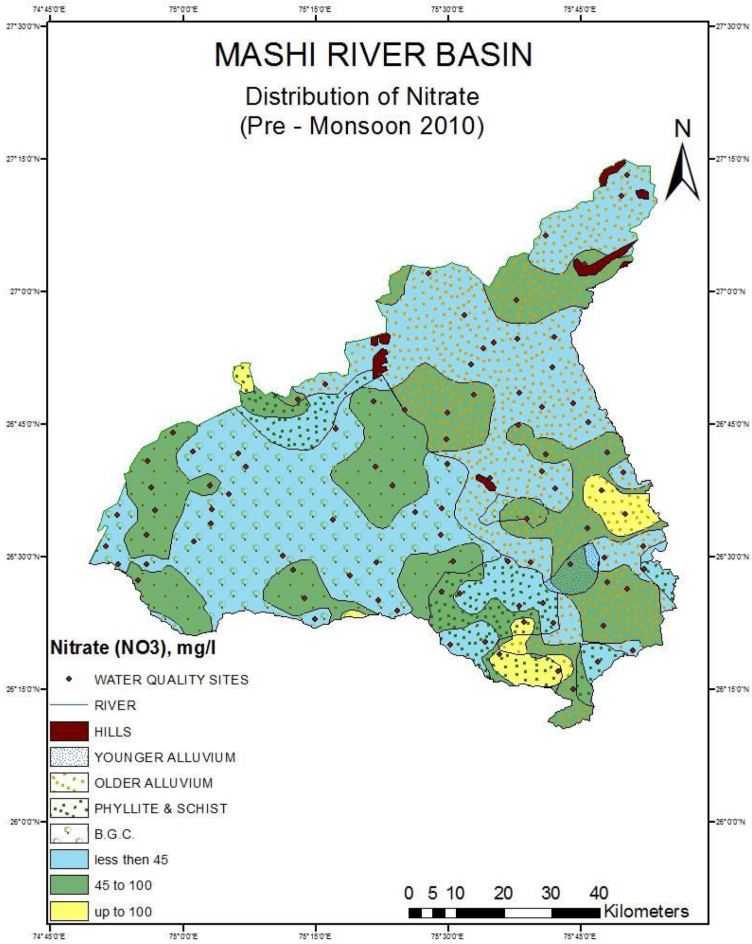


Figure 18: Location of Nitrate in groundwater in Mashi Sub Basin

Occurrence of EC in Groundwater: The current distribution of Electric Conductivity (EC), an index of salinity level in shallow groundwater in quartzite and phyllite/ Schist aquifer unit of Mashi sub-basin is shown in Table 14 and Figure 19.

Table 14: Aquifer-wise Distribution of EC of Groundwater in Mashi Sub Basin.

(Percentage Area)

Hydrogeological Unit	<750 µS/cm	750-2,250 µS/cm	2,250-5,000 µS/cm	>5,000 µS/cm	Total
B.G.C.	4.5	38.7	47.5	9.4	100.0
Older Alluvium	20.3	57.9	16.8	5.0	100.0
Phyllite & Schist	2.4	50.7	41.5	5.4	100.0
Quartzite	0.0	32.5	67.5	0.0	100.0
Younger Alluvium	54.5	43.2	2.3	0.0	100.0
Mashi Total	12.3	49.0	31.9	6.8	100.0

Source: CGWB and RGWD

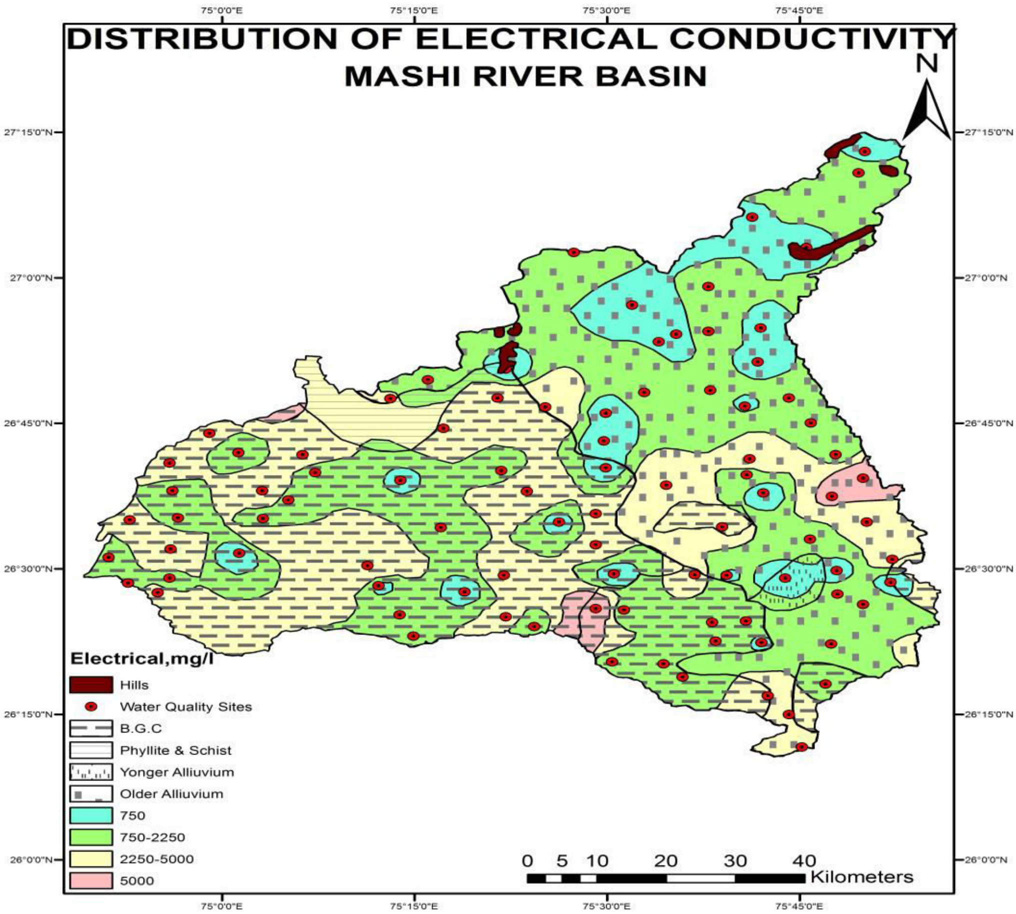


Figure 19: Distribution of EC of Groundwater in Mashi Sub Basin.

(D) Groundwater Drafts Mashi Sub-basin

The draft values during the examined period are high compared to other sub basins and have nearly linear rising rate. In 1995 total draft in the sub-basin reached 382 Mm3 and increased to 563 Mm3 until 2009, a total rise of ~181 Mm3 in 15 years. The average annual rising rate was 13 Mm3/yr with a relative increase of 48%.

Current Groundwater Draft: The groundwater draft in the Mashi Sub Basin is reported in the Table 15.

Table 15: Sub-basin Groundwater Draft in the Mashi Sub Basin.

Hydro geological Unit	**Irrigation Draft (Mm^3)**
B.G.C.	85.69
Older Alluvium	379.90
Phyllite & Schist	28.48
Quartzite	0.14
Younger Alluvium	4.50
Mashi Total	498.72

(E) Groundwater Resources Availability

The groundwater in the Mashi Sub Basin is of two type, i.e., Saline and Non Saline and it varies across the Basin. The details on these are as follows:

Non- Saline Dynamic Groundwater Availability: The non-saline dynamic net annual groundwater sources assessed for basins is 2586.29 Mm^3, the details are given in Table 16.

Table 16: Non- Saline Dynamic Annual Groundwater Availability in Banas Basin.

Sub-basin	**Net Annual GW Available, (Mm^3)**	**Existing GW Draft for All Uses, (Mm^3)**	**Stage of GW Development (%)**	**Category**
Mashi	385.62	517.70	134.25	Over Exploited

Saline Dynamic Groundwater Draft: The saline dynamic net annual groundwater sources assessed for basins is 285.66 Mm3, the details are given in Table 17.

Table 17: Saline Dynamic Annual Groundwater Availability in Mashi Sub Basin.

Sub-basin	**Net Annual GW Available, (Mm^3)**	**Existing GW Draft for All Uses, (Mm^3)**	**Stage of GW Development (%)**	**Category**
Mashi	108.14	36.56	33.81	SAFE

Non- Saline Static Groundwater Availability: The Aquifer Unit-Wise Non-Saline Static Groundwater Resources in the Mashi Sub Basin is 591.18 Mm3. Large resources of the order of 571.22 Mm3 occur in older alluvium unit in Mashi sub-basin. Sub-basin and aquifer unit-wise static groundwater resources are given in Table 18.

Table 18: Aquifer Unit-Wise Non-Saline Static Groundwater Resources in Mashi Sub Basin.

Hydro geological Unit	Pot. Zone Area (km^2)	Static Groundwater Resources (Mm^3)
B.G.C.	2278.50	10.70
Older Alluvium	**2664.25**	**571.22**
Phyllite & Schist	628.61	3.54
Quartzite	2.37	0.01
Younger Alluvium	13.95	5.71
Mashi Total	5587.67	591.18

Saline Static Groundwater Assessment: The total assessed saline static groundwater resources of Banas basin is 198.76 Mm3.

Table 19: Aquifer Unit-Wise Saline Static Groundwater Resources in Mashi Sub Basin

Hydro geological Unit	Potential Zone Area (km^2)	Static GW Resources (Mm^3)
B.G.C.	350.18	1.55
Older Alluvium	344.28	72.92
Phyllite & Schist	115.88	0.43
Quartzite	4.04	0.01
Younger Alluvium	51.42	13.35
Mashi Total	865.81	88.27
Banas Total	2,152.92	198.76

(F) Assessment of Groundwater Availability

Groundwater availability for long-term exploitation, clear of any current state of overdraft is the basic element. Since it is a derivative of rainfall, the dependability level of such rechargeable 'dynamic' groundwater availability relies on the statistic occurrence of precipitation. The total net annually assessed groundwater resource in the Mashi Basin is 2586.29 Mm^3 and groundwater draft 3497.64 Mm^3. The stage of groundwater development in the basin is 135.24 % and the basin is categorized as overexploited basin.

In short what emerges from the information in section 2.1 and 2.2 in the context of climate resilient development is as follows; the details on geographical features ravels that there are two different set of areas. First, the Mashi River area with shallow soils with hard rock below with no scope of groundwater recharge. Surface water storages of different types/size are the only option given the limited groundwater and that too of poor quality. Construction of appropriate type of rainwater harnessing structures will be one of the options. Rainfed agriculture in the area is vulnerable to high climatic risk and also the scope for commercial agriculture is very limited. Diversification of agriculture by adopting mixed farming system is a must. Low quantity with high variability of rainfall indicates use of water saving technology in agriculture can be a better strategy to cope with climate change. Livestock based livelihood options can support provided the productivity of forest, barren, and waste lands is increased/restored.

The second area is the catchment of Bandi River. The geo-formation of the area is such that groundwater availability is much better than Mashi River catchment, as it is reflected in presence of tubewells and more area under irrigated agriculture. Use of new crop technology including Polly Houses providing higher income and employment were observed during the field visits. Agriculture occupation as sustainable source of livelihood is possible with some corrective measures. State policies can play significant role in climate resilient development provided the hydrological system in the basin is undisturbed by urban and industrial development activities.

In the light of these observations the interventions of NGOs, people and government line departments will be analysed as how they could address challenges of climate change.

In the above section on water resources we have tried to generate information on availability of surface water, groundwater and its quality in the Mashi Basin. The main purpose was to look for the information to be used for preparing IWRM plan for the basin. The most important feature of IWRM is participatory approach. Real participation takes place when stakeholder's are part of the decision making process. Participation occurs only when participants have the capacity to participate. It implies that, first build the capacity of the stakeholders, particularly women and marginalized social groups. This may not only involve awareness building but confidence building and educating all stakeholders about the physical features and availability and status of surface and groundwater in the Basin. Community participation requires a significant degree of trust among stakeholders, requiring transparent and widely available data for decision making in a disintegrated form at local level, which they can comprehend and use as per their need. User participation requires a degree of hydrogeological education, still absent in India. Such education must involve politicians, water decision makers, users and general public. Demystification of knowledge, gathering of data at the appropriate scales and free-flow of data, information and capacities is fundamental requirement. In the above section we have tried to gather the relevant information on the desired parameters to address all these issues. This information will be used in the Second Phase of the project to prepare capacity building modules for the stakeholders. However, it is also important to understand the social environment in the basin to design appropriate strategies and model to bring people together and achieve the dream of Participatory Community Management of River Basin. The next section deals with the social environment in the Mashi Sub Basin.

II. SOCIO-ECONOMIC CONTEXT

In Rajasthan the regions, namely Tribal (Mewar), Desert (Marwar), Shekhawati, Dundhad and Hadoti regions, significantly differ in cultural and socio-economic environment and conditions. The relevance, effectiveness and outcome of rural development interventions by the State or NGOs are largely based on socio-economic context of the area.

After the Independence, particularly the transition period 1950 to 1960, there was shift from feudal control over natural resources to almost no controls. It was that period people took liberty to cut forests, village vegetation, uncontrolled grazing, etc. Also it was the period when traditional institutions of village common property resource management systems broke down. Within few years natural resources started depleting and degrading. Then came the Panchyat Raj regime, a mix of new and old management systems but by that time it was too late and also the democratic management was less effective in controlling the over exploitation of resources. The shifts in the mentality/perceptions of people from community management of resources to privatization of resources troughs a big challenge/threat for the future management of community resources.

Population growth rate as shown in Table 20 increased at much higher rate than the national average, resulting in increase in pressure on all the natural resources, i.e., land, water and biomass. Density of population increased many fold consequently decline in the size of holdings and increase in unemployment in the districts.

As regards the social composition of the population, the age old social classification of Hindu society based on Varnashram Dharma is still visible in the area. Hindus are divided into numerous castes and sub-castes. The social values were changing fast. Caste based reservations in government jobs, caste wise polarization of people during assembly election and others rural development activities had fractured the community based system in villages. With increase in literacy rate people started joining non-farm employment stream.

Table 20: Deicidal growth of population in Jaipur, Tonk & Ajmer Districts of Rajasthan

District /Year	Male	Female	Total	Difference in 10 years	% Growth	Density
Jaipur						
1931	551458	493732	1045190			93.8
1941	621803	567934	1189737	144547	13.83	106.8
1951	794665	729838	1524503	334766	28.14	136.8
1961	1006134	895622	1901756	377253	24.75	170.7
1971	1313618	1168767	2482385	580629	30.53	222.8
1981	1814657	1621515	3436172	953787	38.42	308.4
1991	2055259	1832636	3887895	451723	13.15	348.9
2001	2768203	2482868	5251071	1363176	35.06	471.2
2011	3490787	3173184	6663971	1412900	26.91	598.0
Tonk						
1931	155210	142065	297275			41.3
1941	173309	156481	329790	32515	10.94	45.8
1951	211336	195585	406921	77131	23.39	56.6
1961	260589	237140	497729	90808	22.32	69.2
1971	327806	298024	625830	128101	25.74	87.0
1981	406530	377105	783635	157805	25.22	108.9
1991	506928	468078	975006	191371	24.42	135.5
2001	626436	585235	1211671	236665	24.27	168.4
2011	729390	692321	1421711	210040	17.00	168.4
Ajmer						
1931	311764	281576	593340			70.0
1941	358503	323460	681963	88623	14.94	80.4
1951	425906	394071	819977	138014	20.24	96.7
1961	510446	466101	976547	156570	19.09	115.1
1971	600762	546967	1147729	171182	17.53	135.3
1981	749362	691004	1440366	292637	25.50	169.8
1991	901361	827846	1729207	288841	20.05	203.9
2001	1129920	1051750	2181670	452463	26.17	257.2
2011	1325911	1259002	2584913	403243	18.48	304.8

The official caste classification and distribution of rural population in the Districts covered under the Mashi Basin for the census year 2001 and 2011 is reported in Table 21. As per the 2001 Population Census of the total rural population the SC and ST population account for less than 28.6, 35.1, and 19.2 percent in Jaipur, Tonk, and Ajmer districts respectively. And that has changed to 29.3, 37.9 and 19.7 respectively in the districts in ten years as reflected in the Census 2011.

Table 21: Caste composition of rural population in the Mashi Basin Districts.

Districts	SC	ST	Others	Rural Population
	2001			
Jaipur	16.6	12.0	71.4	100.0 (2659000)
Tonk	20.2	14.9	64.9	100.0 (959000)
Ajmer	16.1	3.1	80.8	100.0(1306994)
	2011			
Districts	SC	ST	Others	Rural Population
Jaipur	16.8	12.5	70.7	100.0 (3154331)
Tonk	21.4	15.8	62.9	100.0 (1103603)
Ajmer	16.6	3.1	80.3	100.0(1547642)

Note: Figures in parenthesis are numbers. Source: Census of India 2001 and 2011.

The occupation structure of workers in the three districts falling under Mashi Basin is shown in the Table 22. The percent share of main workers in the total workers is 83.6% in Jaipur district, 78.5 in Ajmer and 76.3% in Tonk District. Agriculture was considered to be the major employer of rural work force and that has changed as shown in the Table 22. In Ajmer district cultivators account for only 28.4%, Jaipur 30.2% and in Tonk 50.2%. Large percent of population has diversified their occupation as the percent share in the category of 'Others' is much higher than cultivators. The diversification of occupation is higher in case of Jaipur district as 60.8% workers are in Others category followed by 54.4% in Ajmer and 29.8% in Tonk district.

Table 22: Occupation structure of working population in the districts of Mashi Basin.

(Year 2011)

District	**Jaipur**	**Ajmer**	**Tonk**
Total Workers (Number)	**2464893**	**1053722**	**649161**
Main worker	2060010	827181	495197
%	83.6	78.5	76.3
Marginal workers	404883	226541	153364
%	16.4	21.5	23.6

Total (%)	100	100	100
Total Worker (Number)	**2464893**	**1053722**	**649161**
Cultivator	744374	298856	326083
Percent of total main workers	30.2	28.4	50.2
Agriculture labour	131523	145523	113426
%	5.3	13.8	17.5
Household Industries	91011	35603	16004
%	3.7	3.4	2.5
Others	1497985	573741	193648
%	60.8	54.4	29.8
Total (%)	**100**	**100**	**100**

Source: Census of India 2011

Land ownership shapes livelihood of people in rural areas. Distribution of land by type of ownership under different categories is reported in Table 23. The numbers of individual holdings account for 65.3% of the total holdings, Joint holdings 34.3% and Institutional holdings only 0.4 %. The distribution of holdings by size shows that 55.9% of the holdings are of size less than 2 hectares, i.e. marginal and small holdings. If we look at the holdings above 10 hectares, generally called large holdings are only 3.3% of the total holdings. Given the human population growth rate and increasing number of households there will be further sub division of land holdings and the number of holdings below 2 hectares is further going to increase. This change will have serious implication on the economics of crops and livelihood of people.

Table 23: Distribution of number of landholdings by ownership and size in Mashi River Basin

(2010-11)

Size of Holding (in ha.)	Individual Holdings		Joint Holdings		Institutional Holdings		Total Holdings	
	Number	%	Number	%	Number	%	Number	%
0.5	13509	13.21	5605	10.44	84	12.44	19198	12.26
0.5 - 1.0	17635	17.24	5836	10.87	106	15.70	23577	15.05
1.0 - 2.0	26030	25.45	10274	19.14	117	17.33	36421	23.26
2.0 - 3.0	15259	14.92	7843	14.61	92	13.63	23194	14.81
3.0 - 4.0	10064	9.84	6057	11.28	69	10.22	16190	10.34
4.0 - 5.0	5666	5.54	3789	7.06	35	5.19	9490	6.06
5.0 - 7.5	7487	7.32	5968	11.12	56	8.30	13511	8.63
7.5 - 10.0	3246	3.17	3197	5.96	27	4.00	6470	4.13

10.0 - 20.0	3006	2.94	4110	7.66	43	6.37	7159	4.57
20.0 & above	363	0.35	995	1.85	46	6.81	1404	0.90
All Classes	102265	100	53674	100	675	100	156614	100

Source:http://agcensus.dacnet.nic.in/tehsilsummarytype.aspx

The Table 24 provides details on area of holdings by ownership and size. It shows that the share of area of individual holdings in the total area is 54.3%, joint holdings 44.9% and institutional holdings 0.8%. If analysed by size of holding then the area owned by holdings less than 2 hectare is 19.8% and holdings above 10 hectare have 17.9% of total area. The medium size of holdings, i.e., 2 to 5 hectares are 30 % in number and own 35.6% of area. It is this category of holdings that will after sub division will add to the category of small and marginal farmers/holdings and then the existing number of 55% will significantly increase and will have long term policy implication on the profitability/viability of agriculture as sustainable livelihood option.

Table 24: Area of landholdings by ownership and size in Mashi River Basin (2010-11)

Size of Holding (in ha.)	Individual Holdings		Joint Holdings		Institutional Holdings		Total Holdings	
	Area	%	Area	%	Area	%	Area	%
0.5	3897	1.42	1370	0.60	21	0.52	5288	1.05
0.5 - 1.0	12813	4.68	4319	1.90	78	1.92	17212	3.41
1.0 - 2.0	37588	13.73	15006	6.62	177	4.36	52775	10.46
2.0 - 3.0	37348	13.64	19292	8.51	226	5.57	56865	11.27
3.0 - 4.0	34987	12.78	21142	9.32	241	5.94	56370	11.17
4.0 - 5.0	25208	9.21	16934	7.47	158	3.89	42299	8.38
5.0 - 7.5	44958	16.42	36521	16.11	346	8.52	81824	16.22
7.5 - 10.0	27806	10.16	27538	12.14	235	5.79	55579	11.02
10.0 - 20.0	38825	14.18	55210	24.35	556	13.69	94592	18.75
20.0 & above	10296	3.76	29429	12.98	2021	49.78	41746	8.27
All Classes	273727	100	226761	100	4060	100	504549	100

Source:http://agcensus.dacnet.nic.in/tehsilsummarytype.aspx

The above discussed features of land ownership and its distribution at district level was further confirmed by conducting a survey by selecting sample villages in the Mashi River Basin and the results are presented in the Tables 25 and 26. The Table 25 shows that average size of holdings comes out to be 2.59 hectares of which 2.58 is cultivated and 1.46

hectares (56.6%) is irrigated land and remaining 1.07 hectares as unirrigated land. The size of land owned varies across the sample villages in the basin.

Table 25: Land owned per household in sample villages.

(Hectares)

Village	Total land owned	Cultivated land	Irrigated land	Un irrigated land
Pachar	1.65	1.65	1.52	0.13
Begas	2.00	2.00	2.00	0.00
Jhag	2.18	2.18	1.29	0.89
Kagya	2.78	2.78	1.27	1.52
Mala	2.53	2.53	0.25	2.28
Mangalwara	3.16	3.16	2.18	0.84
Ajmeri	3.01	2.95	2.52	0.43
Sandera	2.75	2.70	2.24	0.00
Shankarpura	4.53	4.53	0.00	4.53
Shriram Ganj	1.35	1.35	1.30	0.05
Overall	2.59	2.58	1.46	1.07

The social caste wise ownership and size of land owned in the sample villages is shown in Table 26. The size of land is higher in case of general caste category and lowest of SC category. Also the proportion of irrigated holding is also lowest of SC category households. Irrigation facility provides better opportunity to a household to respond to climate variability or change. Lower the proportion of irrigated land more vulnerable is the household to climate variability.

Table 26: Caste wise per household land owned in sample villages

(Hectares)

Caste	Total land owned	Cultivated land	Irrigated land	Un irrigated land
SC	0.77	0.77	0.16	0.61
ST	2.28	2.28	2.28	0.00
OBC	1.96	1.96	1.24	0.69
General	3.74	3.72	1.97	1.64
Overall	2.59	2.58	1.46	1.07

Ownership of assets brings credibility of households in market and also social status. It ultimately helps in credit worthiness during bad years. A household survey was conducted to know the assets owned and their present market value in the sample villages in Mashi basin. Table 27 shows the type of assets owned and their share in the total value of household assets. Land is the major asset and account for 95.2 % of total value of assets. The other assets and their share is Household asset 3%, Agricultural assets 1.1% and livestock 0.8%. On an average household owns assets worth Rs. 163,37,999 in the Mashi River basin.

Table 27: Assets owned per household in sample villages.

Village	Household Assets	Agricultural Assets	Land Assets	Livestock Assets	Total Assets (in Rs.)
Pachar	2.5	1.0	96.1	0.4	100 (23202760)
Begas	2.4	0.8	96.3	0.5	100 (38361900)
Jhag	1.4	0.4	97.6	0.5	100 (21460880)
Kagya	2.7	0.9	95.9	0.5	100 (16684420)
Mala	3.4	1.7	92.4	2.5	100 (11907390)
Mangalwara	2.6	0.7	96.2	0.4	100 (213007300)
Ajmeri	15.9	3.7	72.7	7.7	100 (1960780)
Sandera	15.6	7.1	73.5	3.8	100 (2593700)
Shankarpura	1.9	0.7	96.7	0.8	100 (18513860)
Shriram Ganj	7.5	3.2	88.8	0.6	100 (7393570)
Overall	**3.0**	**1.1**	**95.2**	**0.8**	**100 (163,37,999)**

Note: *** Figures in parenthesis are total value of assets owned by sample households in Rupees.**

Availability and use of credit facilities shape the household strategies to respond to the climate variability or change. State government and NGOs provide financial support to farmers through various formal and informal credit institutions. Household survey in the sample village about financial liabilities was conducted and the results are reported in Table 28. It shows that 56% of the sample households availed credit facilities and on an average had a loan amount of Rs. 2,24,132. It is good to note that the outstanding amount is only 5.7% of the principle amount.

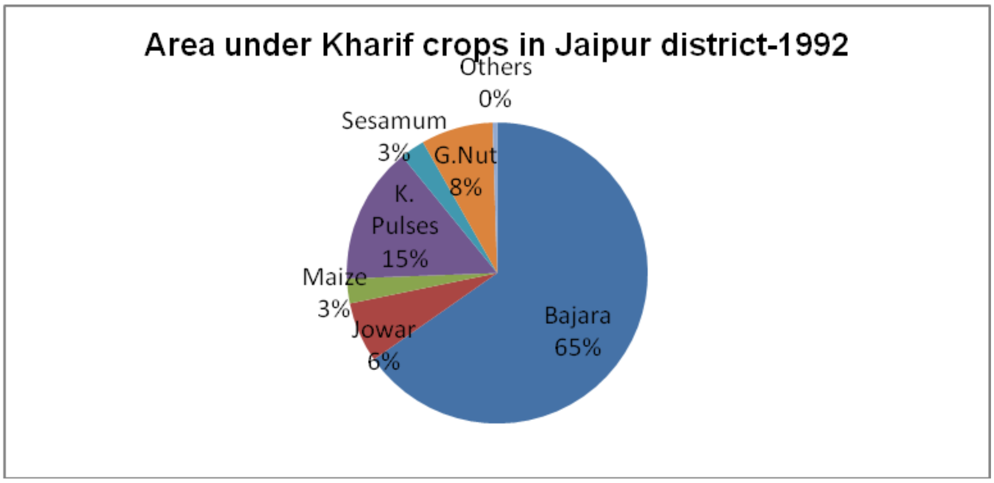
Table 28: Liabilities per household in sample villages.

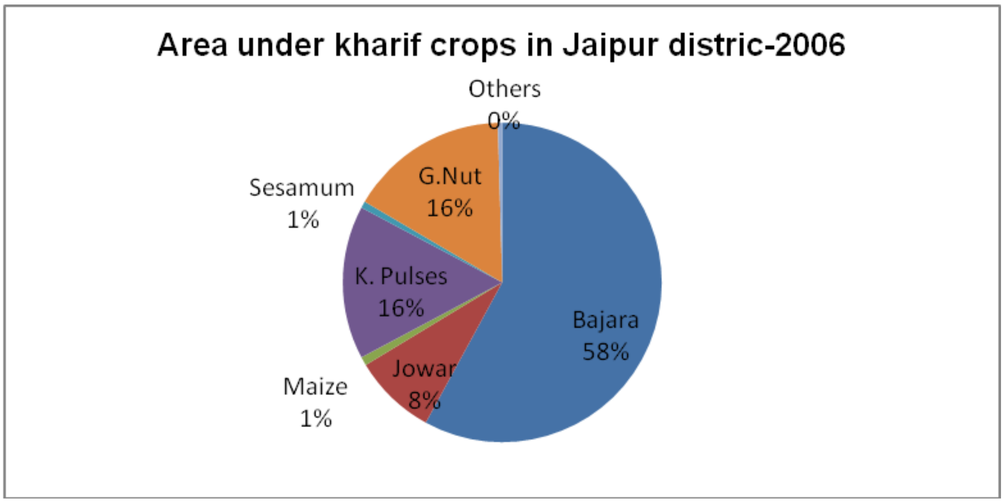
Sample Village	Borrower households (%)	Principal Amount (Rs.)	Amount outstanding (Rs.)	Outstanding as % of principle amount
Pachar	20	250000	17500	7.0
Begas	60	425000	18350	4.3
Jhag	60	177500	13267	7.5
Kagya	50	176000	5460	3.1
Mala	70	232714	11080	4.8
Mangalwara	50	278000	19420	7.0
Ajmeri	60	180000	7217	4.0
Sandera	70	168343	13559	8.1

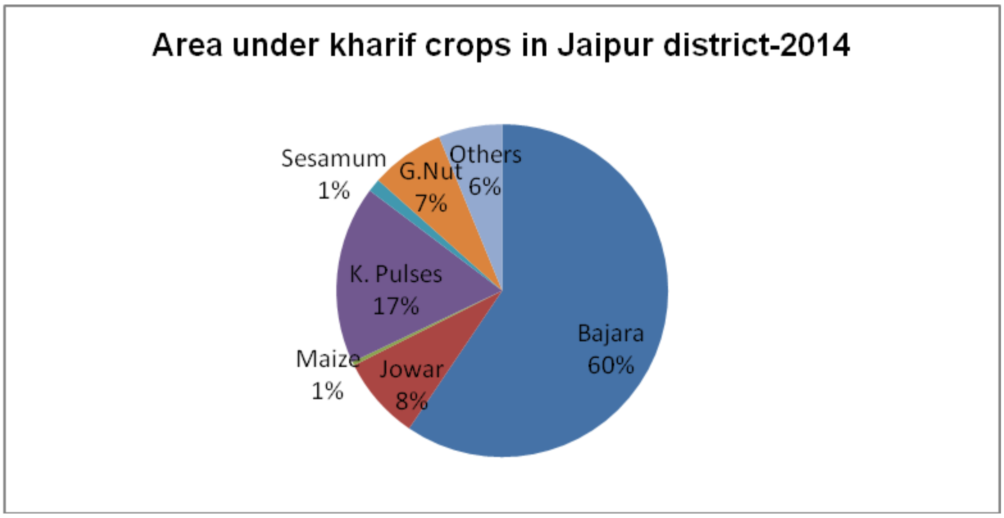
Shankarpura	70	260571	17789	6.8
Shriram Ganj	50	91000	5716	6.3
Overall	56	224132	12821	5.7

Cropping Pattern: Agriculture is most affected by climate change as the variability in availability of water resources are affected also the agriculture sector water demand is highest among all other usages. Agriculture cropping pattern ultimately tell us how much water is being used. The analysis of cropping pattern practiced in the three districts of Mashi Basin and how it is changing over time will help understanding the impact of climate variability/change in the Basin. Figures shows allocation of area under different crops in the kharif and rabi season and changes over 1992 in the three Mashi districts.

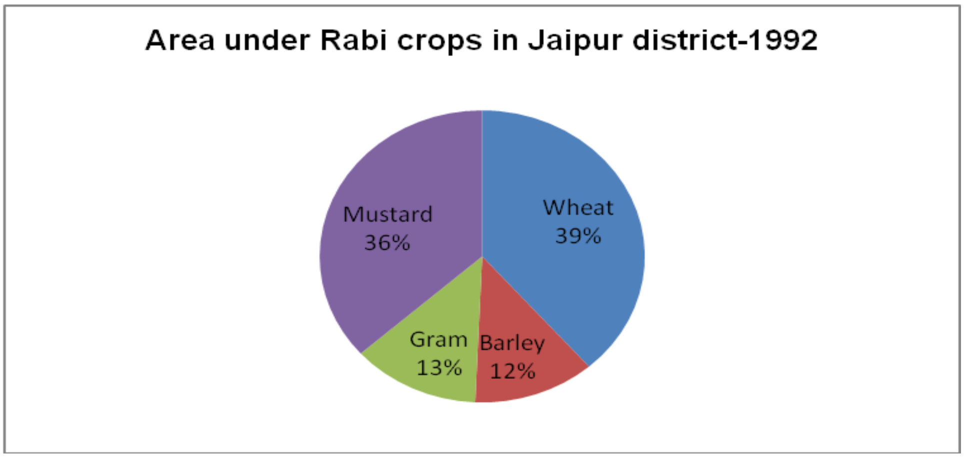
Jaipur District: the Jaipur district area largely falls under the catchment area of Bandi River and the region is better off in ground and surface water compared to other two districts. Bajra (Pearl Millet) is the main rainfed kharif crop covers 60% of area and in case of low rainfall year life saving irrigation is also given. Groundnut a high water demanding crop suitable for sandy soil is grown covering 8% area in 1992. The area increased to 15% in 2006 and then declined to 7% in 2014. The decline is mainly because of overexploitation of groundwater that has led to severe depletion and categorized as Dark Zone. Kharif pulses cover 15 to 17% area and mostly are rainfed short duration crop.

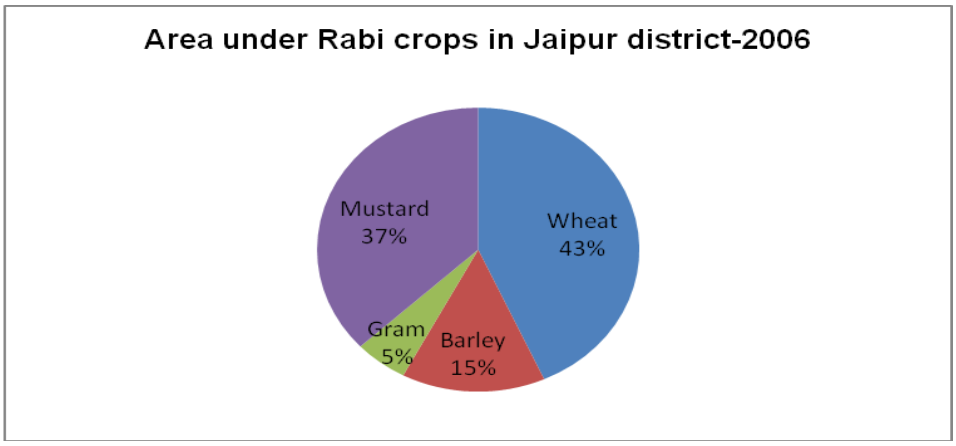


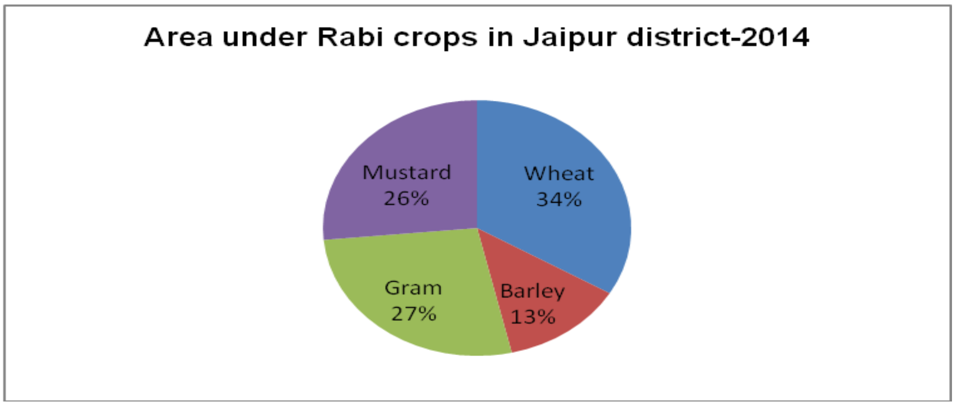




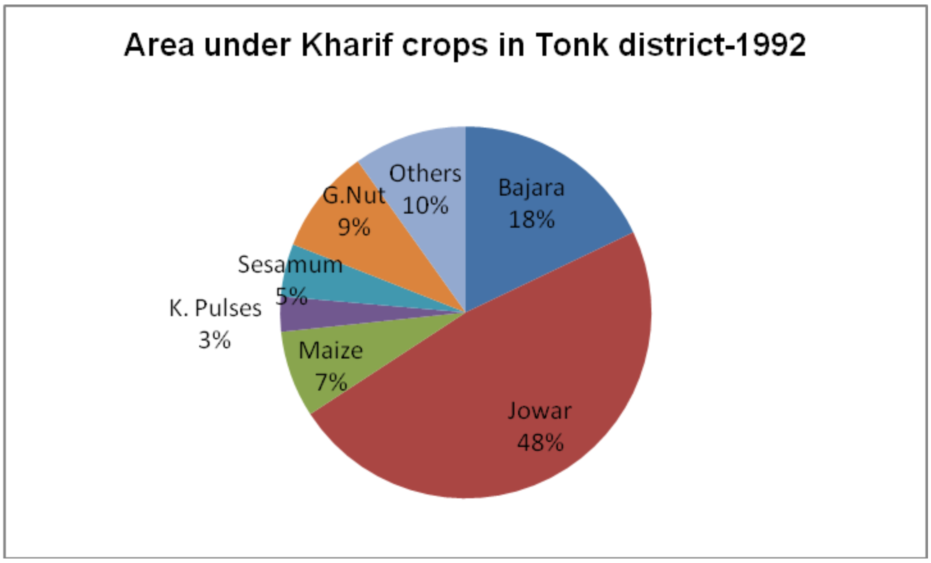
Wheat, Mustard and Barley are the three prominent Rabi crops grown in the Jaipur district and mostly under irrigated conditions. The area covered under these crops change based on availability of irrigation facilities. Barley is less water demanding crop than wheat.

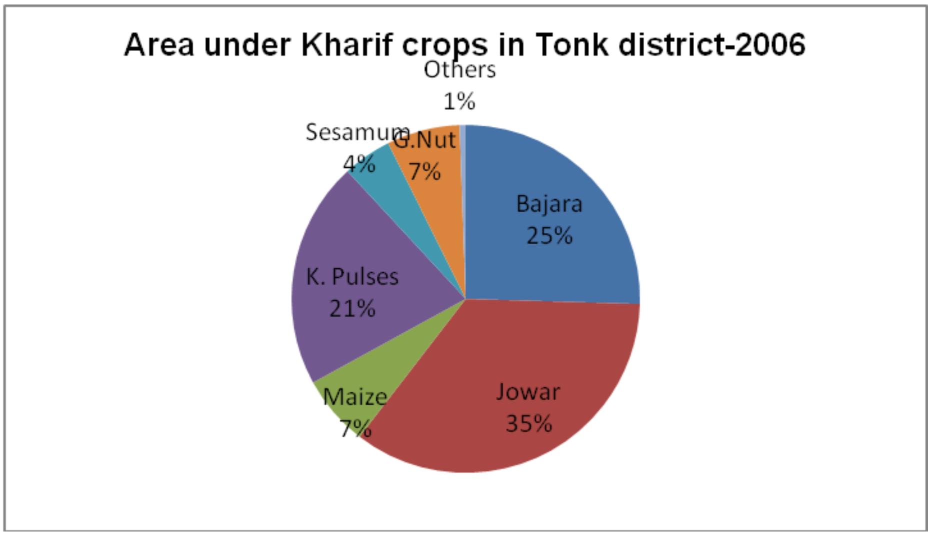


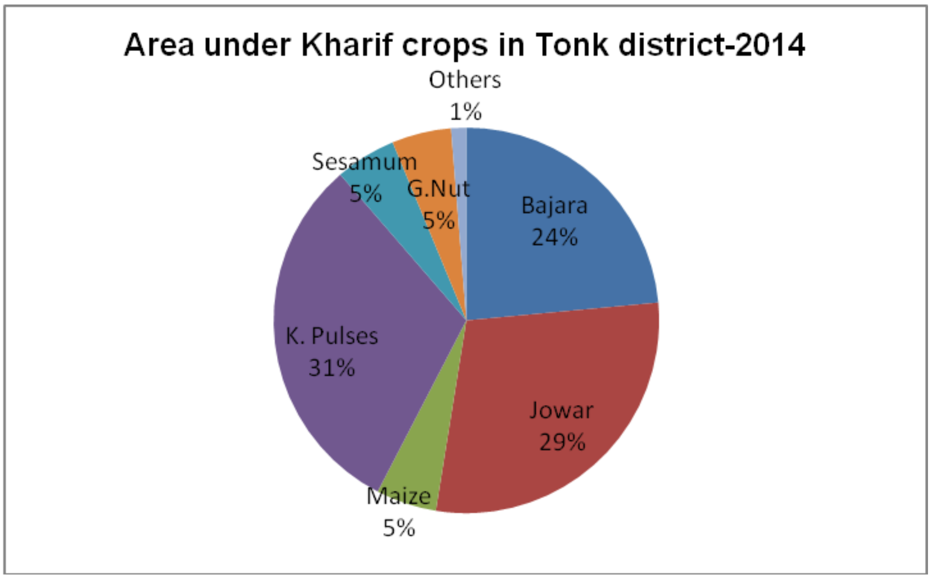




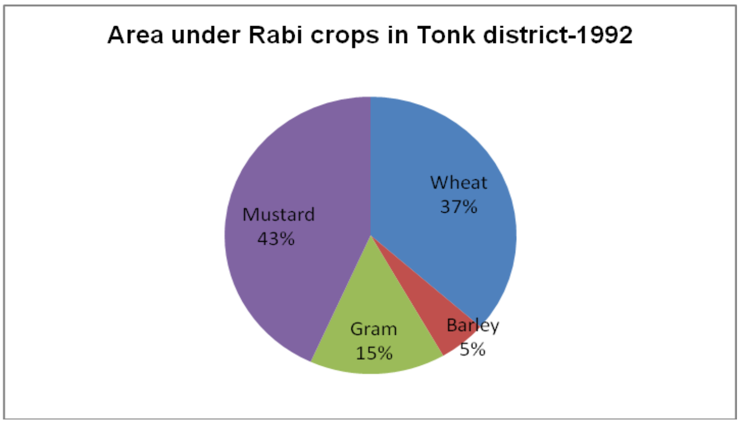
Tonk District: Bajra and jowar are the main cereal crops of Kharif season and area under these has changed over time. Kharif pulses are becoming more popular as the area increased from 3% in 1992 to 31% in 2014. Groundnut crop is loosing area as water scarcity is increasing in the district. Maize and Sesamum area did not change much, while area under other crops was 10% in 1992 has declined to only 1% in 2014.

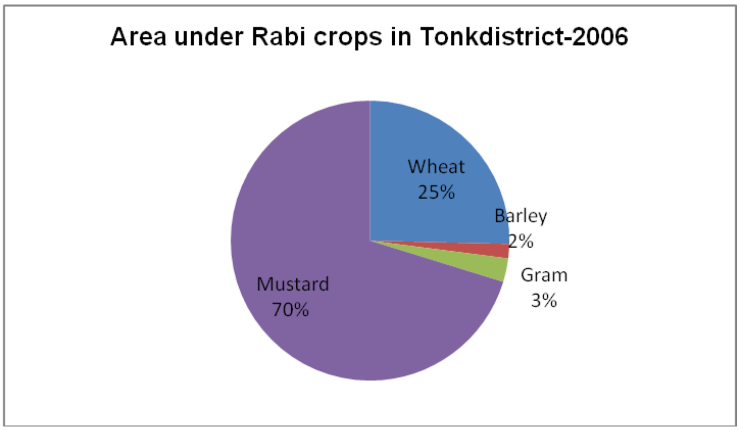


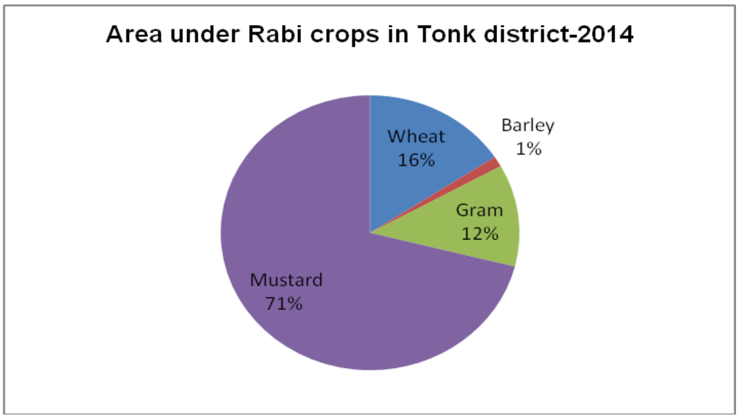




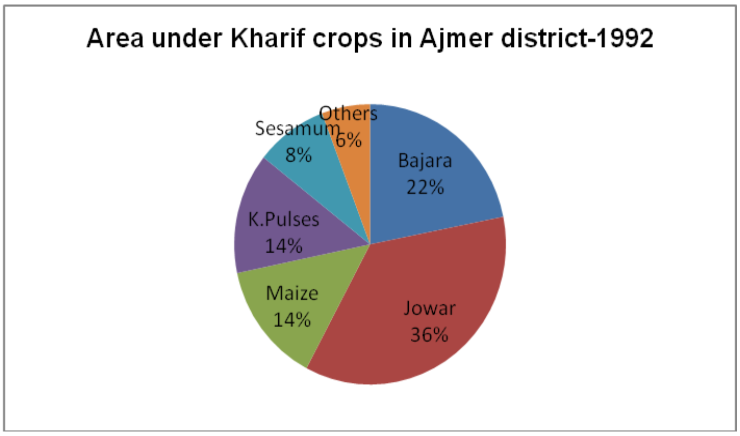
Wheat, Mustard and Gram are the main crops grown in the Rabi season. The area under wheat crop has declined from 37% in 1992 to 16% in 2014, mainly because of deplition of groundwater in the area. The area of Mustard crop increased from 43% in1992 to 70% in 2014. This significant change has been because it is low water demanding crop and has repleced the wheat which is relatively high water demanding. The other important factor respnsible for this major change is better farm gate price of mustard crop. Gram is mostly rainfed crop and if there is winter rains area under gram and mustard increases.

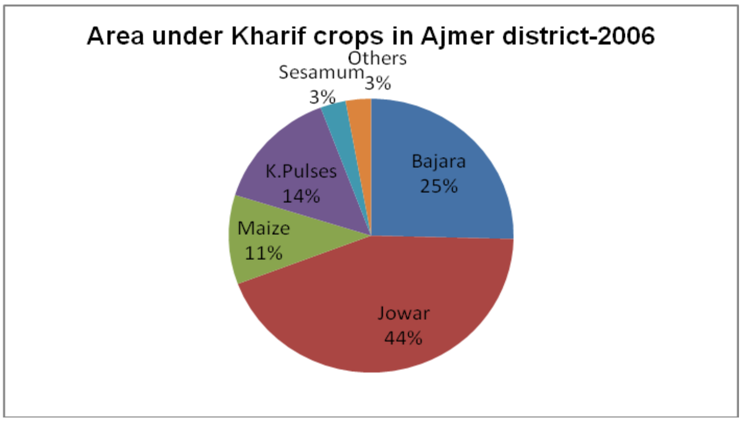


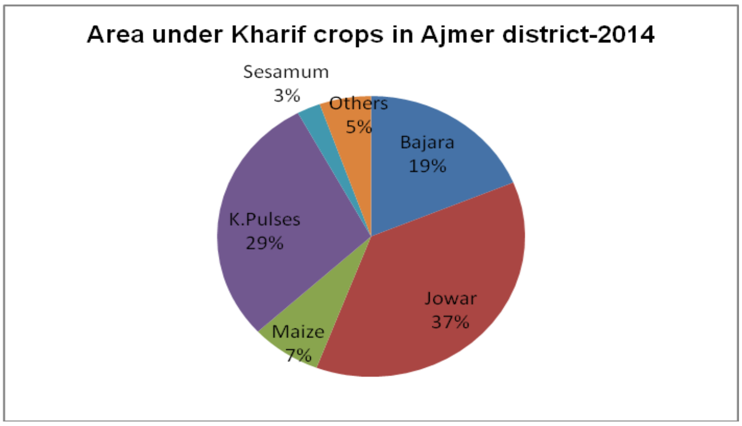




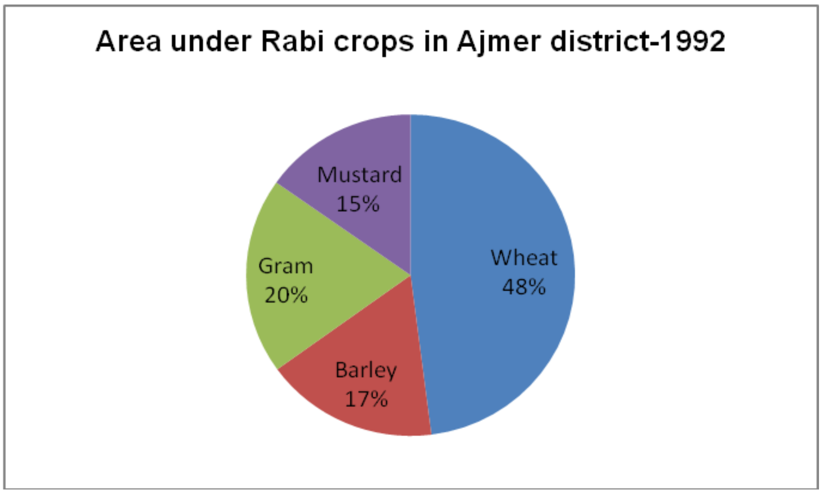
Ajmer District: The cropping pattern followed in the Ajmer district shows that Bajra, Jowar, Maize and Pulses are the main crops of Kharif season. The area under Maize crop declined from 14% in 1992 to 7% in 2014, while area of Pulses increased from 14% in 1992 to 29% in 2014. While the total area under Bajra and Jowar remained largely unchanged. Farmers have adopted short duration Green Gram in the district mainly because of reduction in rainy days and low rainfall.

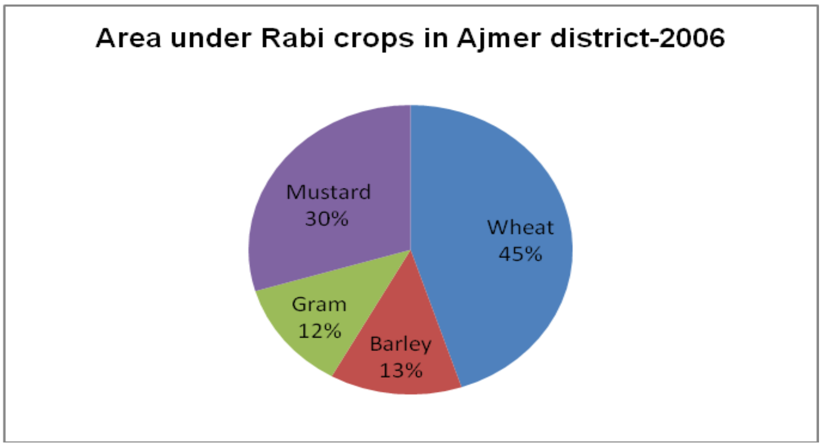


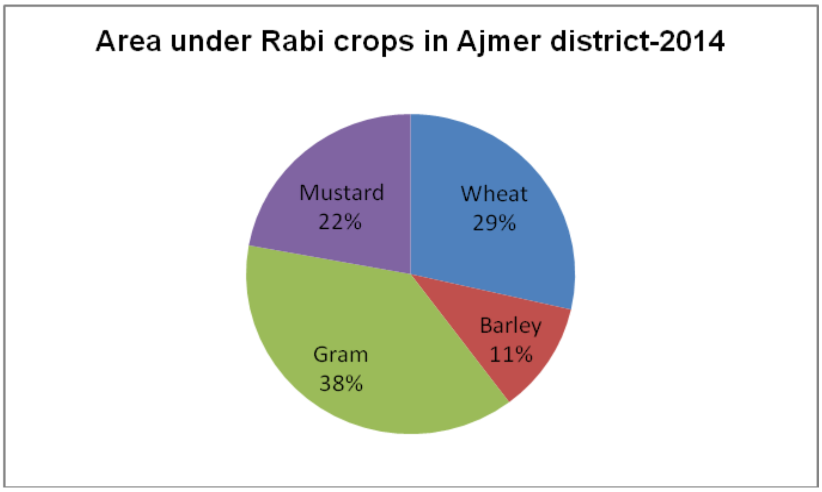




Wheat, Barley, Mustard and Gram are the prominent crops of Rabi season in the Ajmer District. The area under high water demanding crop wheat has declind and area under low water ctops mustard and Gram has significantly increased. It is mainly because of decline in irrigation water as the ground water has depleted and has reached in the ststus of dark zone.







The above description of cropping pattern in the three districts was based on the secondary data and this will provide input in the water balance study for the Mashi basin. To know the reasons for adoption of this cropping pattern primary survey in the sample villages in Mashi Basin was conducted and the results are discussed below.

The crops grown and cropping pattern followed by the farmers in the Mashi River Basin is given in the Tables 29 and 30. The Table 29 shows area under Kharif crops in the sample village. The Mashi Basin has two different set of areas, i.e. the catchment areas of Bandi and Mashi rivers and they are differently endowed with quantity and quality of water (both surface and groundwater) and therefore difference in cropping pattern. Jowar (fodder crop), Bajra and Pulses (particularly short duration green Gram) are the main prominent kharif crops. In the Bandi River catchment area where groundwater availability is higher and tubewell irrigation is practiced even the rainfed crop like Bajra is also irrigated, mostly as life saving irrigation. Irrigated Groundnut is also grown in the Bandi river sub-basin mainly because of the sandy soils and availability of groundwater. Jowar as fodder crop is more popular in the Mashi Basin as it is profitable because the fodder rates are high. Overall 77.8% of the crops are rainfed and only 22.3% crops are irrigated in the Kharif season.

Table 29: Village wise area under kharif crops in sample villages.

(Percentages)

Crops		Sample Villages										Overall
		Pachar	Begas	Jhag	Ajmeri	Mala	Mangal wara	Shankar pura	Shriram Ganj	Kagya	Sandera	
Bajra	IR	53.0	39.2	6.0	0.0	0.0	4.0	0.0	45.1	0.0	0.0	9.9
	UIR	0.0	12.7	27.7	14.4	19.8	13.6	5.7	5.6	25.8	6.9	13.6
Jowar	IRR	4.5	0.0	0.0	0.0	0.0	16.0	0.0	0.0	0.0	0.0	2.3
	UIR	0.0	0.0	33.7	29.7	46.5	25.6	66.0	0.0	33.3	40.6	32.7
K. Pulses	IRR	0.0	0.0	6.0	0.0	0.0	8.0	0.0	0.0	0.0	0.0	1.5
	UIR	0.0	0.0	20.5	25.3	30.7	23.2	22.0	7.5	27.5	36.9	21.6
Guwar	IRR	16.7	17.7	2.4	0.0	0.0	6.4	0.0	36.6	0.0	0.0	5.4
	UIR	0.0	11.4	3.6	25.3	3.0	3.2	6.3	5.2	13.3	11.1	8.8
G Nut	IRR	25.8	19.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.2
	UIR	0.0	0.0	0.0	5.2	0.0	0.0	0.0	0.0	0.0	4.6	1.1
Kharif	IIR	100.0	75.9	14.4	0.0	0.0	34.4	0.0	81.7	0.0	0.0	22.3
	UIR	0.0	24.1	85.5	99.9	100.0	65.6	100.0	18.3	99.9	100.1	77.8
Total		100	100	100	100	100	100	100	100	100	100	100

The Rabi season cropping pattern followed in the sample villages is reported in the Table 30. It shows that except Gram crop all other crops in the Rabi season are grown under irrigated condition. Wheat and mustered are the main Rabi crops. Barley the low water demanding crop almost went out of the area a decade ago because area was comfortable in availability of ground water and farmers were growing wheat. But overexploitation of groundwater lead to emergence of drak zone and people are now looking for less water demanding crops namely, Mustard, Gram and Barley. In Rabi season 94% area is under irrigation and only 6% is under rainfed crops (Gram and Mustard/Taramira)

Table 30: village wise area under Rabi crops in sample villages.

(Percentages)

Village		Pachar	Begas	Jhag	Ajmeri	Mala	Mangal wara	Shankar pura	Sriram Ganj	Kagya	Sandera	Overall
Wheat	IRR	60	65.8	20.5	34.7	25	45.5	0	46.8	33.3	49.3	43.6
Barley	IRR	8.3	0	0	0	20.8	6.4	0	0	33.3	0	5.7
Mustard	IRR	26.7	31.6	27.3	53.3	20.8	19.1	0	43.4	33.3	47	34.4
Gram	IRR	0	0	38.6	2	33.3	29.1	0	0	0	3.7	9.6
Gram	IRR	0	0	6.8	10.1	0	0	38.9	0	0	0	3.1
Onion	IRR	5	2.5	0	0	0	0	0	0	0	0	0.8
Rabi	IRR	100	100	86.4	89.9	100	100	0	90.2	100	100	94
	UIR	0	0	13.6	10.1	0	0	100	9.8	0	0	6
Total		100	100	100	100	100	100	100	100	100	100	100

Note: IR – Irrigated area, UIR – Un irrigated area

Household income and its sources can be a basis of judging livelihood strategies of rural population and that can also guide in analyzing the coping strategies. The cash income per household in the sample village is reported in Table 31. The table shows that sale of agriculture produce, both main and by products (fodder) is the major source of cash income in the sample villages in Mashi Basin. The other sources are from business and nonfarm activities. Income from livestock rearing is only 2.2 % as most of the milk and milk products are consumed by the household and not marketed. The overall per household annual cash income is Rs. 1,90,520.

Table 31: Cash Income per household in sample villages.

(Percentages)

Village	Milk Sold	Agri. produce sale	Agri. Labour	Non Agr. labour	Artisan	Business	Service	Other income	Total income
Pachar	1.4	49.6	0.6	12.7	0.0	24.6	7.4	3.7	100.0 (244254)*
Begas	3.0	54.2	1.9	5.6	0.0	35.4	0.0	0.0	100.0 (233998)
Jhag	2.9	60.0	16.0	11.0	0.0	10.1	0.0	0.0	100.0 (163244)
Shankarpura	2.4	60.5	4.0	15.2	0.0	18.0	0.0	0.0	100.0 (188964)
Ajmeri	1.9	73.8	3.3	6.6	0.0	14.4	0.0	0.0	100.0 (173886)
Mala	7.1	65.5	14.2	7.9	0.0	5.2	0.0	0.0	100.0 (126242)
Mangalwara	1.7	69.5	9.3	1.6	0.0	13.1	4.7	0.0	100.0 (213370)
Shankarpura	2.4	60.5	4.0	15.2	0.0	18.0	0.0	0.0	100.0 (188964)
Shriram Ganj	0.9	55.2	1.4	17.4	0.0	25.1	0.0	0.0	100.0 (132020)
Kagya	1.6	66.8	11.0	2.6	0.0	18.0	0.0	0.0	100.0 (189228)
Sandera	1.2	62.0	3.9	0.0	2.5	25.8	0.0	4.6	100.0 (239996)
Overall	**2.2**	**61.3**	**6.0**	**7.5**	**0.3**	**20.1**	**1.5**	**1.0**	**100.0 (190520)**

Note: * Figures in parenthesis are total cash income in rupees.

In this Chapter we have tried to list the physical and social factors that may act as opportunity or constraint in addressing the impact of climate variability and/or change. Infect the physical factors shape the livelihood strategies and through challenges for future interventions. The social dynamics also play significant role in adapting or coping with the climate change and also determines the viability of any intervention by state or NGOs. In the next chapter NGOs and Sate Government interventions will be reviewed keeping the above discussed physical and social condition prevailing in the Mashi Basin.

CHAPTER III

NGO & STATE INTERVENTIONS

Strategies for Mitigation/Adaptation to Climate Change

3.1 Introduction

Changes in environment, i.e., temperature and rainfall variability, ultimately affects the livelihoods of rural population and increases their vulnerability. Traditional wisdom/knowledge helped them so far to cope with the situation but presently besides change in natural environment there is change in social, political and economic environment and rural population find it difficult to self manage or cope with the increased vulnerability. NGOs and State Government have been working in the rural areas to provide support to the marginalized people to reduce their vulnerability in more than one way. NGOs are actively working in the three districts falling under Mashi Sub Basin, namely, Jaipur, Tonk and Ajmer since 80s and helping people in having sustainable livelihood by better management of their natural resources. In the subsequent section the interventions made by NGOs, though in good numbers but we have picked the three most prominent, having made significant impact in the area to provide sustainable livelihoods are discussed in the context of climate change, i.e. how far the support provided by the NGO improved the resilience of people to face the climate change events and outcomes.

3.2 NGO Interventions

The interventions can be grouped in five general categories based on Modified Sustainable Livelihood Model discussed in the Chapter I, namely, Natural, Physical, Social, Human Capital, Financial, and Political/legal Capital. NGOs have hardly done any work on Political /legal capital but has large number of activities covering all other categories. Interventions till 2013 are listed by these categories and are discussed below.

I. NGO Activities

(A) Activities in the area of Natural and Physical Capital

The following activities of NGOs are put under the category of Natural and Physical capital:

- Pasture Land development – Chauka System
- Soil Moisture conservation - Field Bunds
- Water Harnessing Structures/watershed works
- Developing Eco Parks
- Organic Farming
- Afforestation
- Agriculture and Livestock Development

The NGOs activity wise numbers reported in Table 3.1. There are two aspects of each activity; first, physical works, those were related to land, water, biomass and livestock with the objective to improve the productivity of these resources by undertaking various measures. Second aspect is the larger objective behind each activity of addressing the climate variability affecting the income and livelihood of people particularly the marginalized and most vulnerable section largely dependent on natural resources in the villages.

Table 3.1: NRM - Physical Construction Cumulative Total (up to 2014)

Activity	GVNML	Pryas Kendra	Gramodaya Samajik Sansthan
Chauka Building (Hectares)	1698	-	-
Farm pond(No.)		15	160
Field Bunds (Hectares)	4282.5	1800	10000
Nada, Nadi (Number)	361	-	-
Anicut	-	-	30
Kheli /Animal drinking water structure(No.)	10	-	-
Talab/ponds (No.)	81	54	105
Khulla Chidya Ghar (Eco Park) (Hectares)	62	-	-
Jungle Hall (No.)	2	-	-
Organic Fertilization (Hectares)	325	-	-
Plowing (Hectares)	350	-	-
Grass Seeding (Hectares)	1600	-	-
Vermin Composting (Kg.)	21200	-	-
Garbage Pits (No.)	2	-	-
Wastewater Soak Pits(No.)	15	-	-
Rain water Harvesting Structures (Kund Tanka) (No.)	21	250	63
Plantation (Numbers)	2025	50000	75 hectares
Drinking Water Security (No. of Family)	432	134	-
Kitchan Garden (Family)		350	-
Keir Protected in Five Villages in 2000 Hectares.		250000	-
Protection from Encroachment of Pasture (Hectares)		600	500
Soil & water conservation (Hectares)			400000

Source: Annual Reports and information given by the NGOs.

Though larger objective of all the activities was to address the increasing demand for natural resources and provide sustainable livelihood to the rural population, however, these activities were part of different donor funded programs and therefore, objective(s) may have been worded differently but the ultimate objective was the same.

As the major expectation of rural population is to get addressed the vulnerability caused by; first, over exploited natural resources (land, water, vegetation), and second, climatic risks directly affecting their livelihood. Under each activity efforts were made to restore the productivity of natural resources and to improve resilience and strengthen the age old well tested adaptations strategies of the people. Most innovative intervention created by NGO namely, Gramin Vikas Navyuvak Mandal Laporia (GVNML), for which they received many state and national level awards, is pasture land development through 'Chauka System'. This single activity could increase biomass supply, restore the village biodiversity, recharge the groundwater and provided fodder and food security to humans, all kinds of animals(domesticated and wild) and birds. Even in a low rainfall year grazing lands were very productive. This activity strongly supported the traditional adaptive strategy, i.e., adoption of mix farming system to address climatic risk, by ensuring fodder availability to livestock component in the system. Also livestock rearing became sustainable livelihood activity even in the drought years. There were evidences of decline in out migration of human and livestock population after introduction of Chauka system in numbers of villages. The outcomes of each activity can be highlighted at length but the purpose here is to establish that all these interventions in NRM sector brought significant outcome in terms of enhancing resilience of people to cope with climate variability/change as reported in many publications of the GVNML and few of them are discussed in the subsequent sections.

Natural Capital/Physical Capital

Technology development- **Pastureland -Chauka**

Construction of Chaukas in community lands

The other innovative intervention of NGOs in the area of agriculture sector is construction of field ponds and bunds on large scale through community participation in order to convert single season agricultural land into both seasons cropping land. The outcome of this intervention was that there were years when kharif season crop failed yet with the water available in field pond and soil moisture created by the bunds farmers' could get Rabi season crops. It has reduced the climatic risk and vulnerability and ensure food security.

Water Harvesting Structures

Talab

Personal Nada

Water Harvesting Structures in series

Water Harvesting Structures in series

Organic Farming

Wormy Compost

Organic Farming

Agricultural Crops

Sesamum Crop

Bajra Crop

Rajaka (Alpha alpha) in Summer

Wheat in Rabi

Similarly, all the activities listed above as shown in pictures had helped farmers to mitigate or adapt the impact of climate variability and change.

(B) Activities in the area of Social/Cultural Capital

The following activities of NGOS are put under the category of Social Capital;

- Formation of Village Development Committees/Gram Vikas Samiti
- Gwal Samiti
- Jan Chetna Padyatra
- Training to VDC, SHG, Gawal Samiti Members
- VDC and SHG members Exposure Visit
- Camp and Training in Village
- Cultural Program for awareness generation
- Contact with Govt. Departments

These activities are basically for seeking participation of all the sections of society in a village, for example, Jan Chetna Padyatra (Prakriti Pujan Yatra) is a unique feature of GVNML, which started in 1987 and is continued even now. Every year on a fixed lunar calendar date an inter-village foot march of men and women together is organised in a traditional fashion. In a procession with band and traditional musical instruments people move from one village to other and organise meeting at the bank of a water body and worship the traditional water body, trees, etc., a colorful ritual is performed. The auspicious date (Dev uthani Gayaras) was selected because it is generally believed that from this date changes in weather takes place, i.e., transitional phase from rainy season to winter season and also traditionally known day for worship of nature. People use to pay respect to natural resources and protect village ponds, trees, wildlife, etc. Through this activity a mass movement, in around 150 villages, was build to create awareness about protecting environment and to seek peoples' participation and commitment to do some environment conservation activities, i.e., planting trees in house premises, in common lands, schools, near the water bodies, etc. and also take responsibility to protect them. Few people even commit to construct ponds/talabs or new water bodies to harness rain water. This movement has resulted in mass awareness among all age groups of population and also influenced other NGOs. Other NGOs in the region have started the *yatra* (procession) as a tool to mobilize people and create social harmony. Such social mobilization activities, in different forms, are organised by NGOs in the Basin, which facilitates planning community strategy to avert climatic risks. It was observed that the social capital generated through these activities facilitated taking up grazing land development at large scale in many villages/ districts without much conflict. All other activities also helped in creating hormonal relationship in the intervention villages. Most of the village development or livelihood activities are taken up by Village Development Committee (VDC) or committees with different name as suited to different NGOs.

Social/Cultural Capital

Pad Yatra

Kalash Yatra

Talab Pujan

Talab Pujan

Under Social Capital building activities village level and project based institutions/ groups were formed including thrift groups of women. Members of these groups mostly lack skills and capacity to perform the assigned roles and responsibilities. Hence, capacity building programmes in the form of trainings, workshops, exposure visits, etc are planned and undertaken to build required capacity of the people. These activities helped people in improving their condition/position in the society and also in attaining sustainable livelihoods. In the climate variability/change context it helped in improving their resilience/ capacity to face the risks. Details about the activities are given in Table 3.2.

Table 3.2: Capacity building activities Cumulative Total. (up to 2013-14)

Particulars	GVNML (No.)	Pryas Kendra (No.)	Gramodaya Samajik Sansthan (Rs.)
Training to VDC, SHG, Gawal Samiti Members, Staff	46		170
VDC, SHG, Gawal Samiti Members Exposure Visit	30		30
Camp and Training in Village	9		
Cultural Program for awareness generation	8		6
Contact with Govt. Departments	14		25
Gawal Samiti Members	7		
SHG Members	94		200
Farmers Training	2		5
Exposure Visit	2	6	3
VDC Members	3		155
VDC members and Govt. officers	1		150
Padyatra (No of Villages)	26		89
Capacity building training of Village water and sanitation comity			249
Capacity building training of watershed development comity			45

Source: Annual Reports 2007-2014.

(C) Activities in the area of Human Capital Development.

The following activities undertaken by NGOs under different programs/projects are categorized under the heading Human Capital:

- Health and Sanitation
- Education
- Women Empowerment
- Food and Nutrition
- Child Development Program
- Trainings

Generally in any poor State there is lack of basic amenities in rural areas and Rajasthan is no exception. Most of NGOs in Rajasthan helped in providing basic amenities in areas which were less attended by the State Government sectoral departments, particularly tribal areas, scattered settled population in desert districts and also pockets in the semi-arid areas. NGOs in the Mashi Basin also provided some of the basic services or made people capable of availing the various government basic services in the areas of health and sanitation, education, food and nutrition, child development, etc. Those activities and achievements till 2014 are reported in Table 3.3.

Table 3.3: Maternal & Children's health Cumulative Total (Up to 2014)

Activity	**GVNML**	**Pryas Kendra**	**Gramodaya Samajik Sansthan**
Dai Training/ Village health worker (No.)	1988		19
Vaccination & Supplements Program (Population)			
Nutritional Food Distribution (Families)	23103		
Baby Weight Monitoring (No.)	19370		
Birth Registration Children (No.)	59301		
At-home Medical Checkups (No.)	23103		
Hand Pump Water Quality Check (Villages)	130		
Animal Treatment Camps	71		
Construction of Latrines	82		
Awareness Build Against ADIS / TB (No. of Village)		10	50
Training of children on discovery of dream			10
Capacity Building Exposer of Children on child right			20
Training of adolescent for boys & Girl on Life skill education			80
Teachers Training (TOT)			15
Capacity building training of School Development and Management comity			45
Science exhibition fair			6
Training of children's on child club			60
Capacity building of Bay care center staff			15
Capacity building training of govt. school teachers on child psychology			20
Capacity building training of police & media on protection and education issues			5
Advocacy training for children's			20

Source: Annual Reports 2007-2014.

The above listed human capital formation activities helped the poor and marginal section of the population in building their capacity to live better quality of life and build their resilience to face natural calamities. The details on each activity are reported in annual reports of the NGOs.

All the above listed interventions discussed under the four sustainable livelihood categories are documented in various annual reports published by the NGOs and in respective programme/ project reports. Therefore, activity wise details are avoided in this document. However, the outcome of these activities is discussed in the next section.

Human Capital

VDC

Women Empowerment

Child Development

Gwal (Grazer) Samiti

3.3 State Interventions

State has major role in providing basic amenities and livelihood support to people particularly to the targeted poor and marginalized section. These basic amenities in the field of health, education and employment sector are delivered through number of line departments, setting independent goals and targets, even without coordination. But ultimately they help building resilience capacity of individuals and households to even face the climatic risks. However, there are few programs/projects directly planned to address the rejuvenation of natural resources and addressing the natural hazards, such as droughts and floods. It is difficult to list and generate correct and comprehensive data on number of activities and expenditure by different line department by River basin as the data is available either block or district wise, yet effort was made to provide some broad idea about the state effort in addressing climate variability/change in the Mashi Sub basin. Table 3.4 gives activity wise number and expenditure incurred on such activities for the five Blocks covering the major area of Mashi Basin.

Table 3.4: State efforts in addressing climate change under MGNREGA

(Rs. In Lac)

Blocks under Mashi Basin	Flood control		Water harvesting & conservation		Renovation of traditional water Bodies		Drought Mitigation		Canal System		Irrigation Facilities		Land Development	
	No.	Rs.	No.	Rs.	No.	Rs.	No.	Rs.	No.	Rs.	No.	Rs.	No.	Rs.
Jhotwara														
2012-13	-	-	4	2.34	6	10.8	9	2.43	2	13.29	45	10.66	1	0.46
2013-14	-	-	-	-	-	-	8	0.64-	-	-	-	-	1	0.17
2014-15	-	-	-	-	5	1.46	23	19.08	2	2.07	-	-	-	-
Total	-	-	4	2.34	11	12.26	40	21.51	4	15.36	45	10.66	2	0.63
Dudu														
2012-13	-	-	60	97.12	430	601.01	76	90.34	24	138.9	139	23.37	6	14.83
2013-14	-	-	38	40.18	307	476.26	48	38.34	17	27.9	150	20.81	9	9.01
2014-15	-	-	33	62.9	240	456.52	71	21.51	17	29.9	234	35.96	8	9.47
Total	-	-	131	200.2	977	1533.79	195	150.2	58	196.7	523	80.14	23	33.31
Phagi														
2012-13	-	-	140	248.94	92	144.93	-	-	19	16.48	553	161.57	20	9.36
2013-14	4	1.43	313	387.75	106	23.06	9	6.69	13	1.68	489	71.39	11	4.38
2014-15	1	0.03	91	225.13	34	57.29	24	42.71	11	0.45	558	45.87	9	0.92
Total	5	1.46	544	851.82	232	225.28	33	49.4	43	1861	1600	278.83	40	14.66
Malpura														
2012-13	-	-	231	449.16	54	38.55	44	23.23	46	69.27	108	10.03	-	-
2013-14	-	-	197	89.8	37	5.67	31	5.24	41	7.41	73	2.96	-	-
2014-15	-	-	219	443.51	38	33.4	125	13.81	42	32.38	135	4.36	-	-
Total	-	-	647	982.47	129	77.62	200	42.28	129	109.06	316	17.35	-	-
Tonk														
2012-13	1	0.45	119	192.39	13	24.21	40	10.86	29	20.6	-	-	34	12.06
2013-14	-	-	70	105.92	9	9.49	23	6.92	17	8.25	-	-	32	1.58
2014-15	-	-	69	117.35	60	51.12	199	9.55	18	5.3	356	3.4	33	0.36
Total	1	0.45	258	415.66	82	84.82	262	27.73	64	34.15	356	3.4	99	14.54
Grand Total	6	1.91	1584	2462.5	1431	1933.8	930	290.7	298	373.9	2840	390.4	164	62.6

Source:http://www./netnrega/homestciti.aspx?state_code=27&state_name=RAJASTHAN year 2012-13, 2013-14, 2014-15.

3.4 Household Strategies for Mitigation/Adaptation to Climate Change

The challenges posed by translating global projections of climate change into courses of action that can be implemented at local levels particularly by farmers are complex. While climate models and the insights they provide have immense value, models, however, aren't sufficient because they cannot predict precisely where, when or with what intensity events will occur in specific regions. Developing effective systems to deal with such surprises and to reduce their impact continues to remain a challenge. People in rural areas mostly respond to climate variability based on their generational sharing of knowledge/experience about occurrence of events and success and failure of their responses. People have evolved some broad strategies to deal with climatic risk by adopting mix farming system in agriculture, diversification of occupation, managing their accumulated assets as per the intensity/severity of risk, use of social capital, etc. Primary survey in the sample villages in Mashi Basin was conducted to capture the household strategies to deal with climatic risk and is reported in Table 3.5.

The table shows that diversification of occupation and out migration are the main strategies adopted by the people in the Mashi Basin. A financial management particularly public or private borrowing to bear the impact of climatic risk is also an important part of the household strategies. Water resources availability play major role in shaping household coping strategies as people are forced to migrate during drought years. The strategies reported in the Table 3.5 will guide in planning and management of water resources in the Mashi Basin.

Table 3.5: Household strategies in response to climate variability

(Percentages)

Village	In drought year				
	Mix Crops	**Diversification of occupation**	**Out Migration**	**Sale of Assets**	**Borrowings**
Pachar	20	70.0	80.0	20	50.0
Begas	20	90.0	100.0	10	40.0
Jhag	0	100.0	100.0	0	40.0
Ajmeri	0	100.0	100.0	0	40.0
Mala	0	100.0	100.0	0	20.0
Mangalwara	0	90.0	90.0	0	20.0
Kagya	0	100.0	100.0	0	30.0
Shankarpura	0	100.0	100.0	0	30.0
Shriram Ganj	0	100.0	100.0	0	50.0
Sandera	0	100.0	100.0	0	0.0
Overall	**4.0**	**95.0**	**97.0**	**3**	**32.0**

CHAPTER IV

WATER RESOURCES MANAGEMENT: NEW APPROACH

4.1 Review of Water Resource management Approaches

Water resources management has been a major challenge of all the societies in the past. Countries have adopted different approaches of management based on their resource availability and usage pattern. However, globally Integrated Water Resource Management (IWRM) approach has been recommended as universal solution to water related problems. In this chapter few well known approaches to water resources management are discussed to look for a alternative new approach based on Rajasthan socio-economic and political environment. The Few approaches are as follows:

(a) **The Techno-economic Approach** to water resource management has been the conventional or mainstream approach throughout the latter half of the twentieth century. This approach has solved some of the short term crises of availability that plagued the countries of the Third World during the mid-twentieth century. Food production, availability of power, and access to water has increased for significant number of people. However, the long term adverse effects of such large scale interventions on the natural environment and on human communities raised doubts about such projects and this in turn led to a new way of looking at water management.

(b) **The Integrated River Basin Management (IRBM) approach** is a concept that aims to conserve and utilize the natural resources within a river basin sustainably, through integrating the needs and skills of various stakeholders like farmers, industries, government departments, academics, NGOs and people and their representatives. IRBM has been accepted formally by the national government in the National Water policy 2012 and gradually states' are also adapting it by enacting River Basin Management Acts. Despite agreeing to Integrated Water Resource Management (IWRM) approach it is not being practiced in true spirit. Water management continues to be a centralized top-down approach causes more problems than solutions.

It seems that the policy makers, planners and executers find difficult to internalize the concept of IWRM and working out practical implications of implementing the concept at different levels. The resultant outcome is that even the integration of identified line departments to be involved in water resource management at state level has become difficult proposition. To address the emerging issues a new approach namely

Negotiated Approach to IRBM is tried. The negotiated approach is a variant of conventional IRBM. It is aimed at creating space for negotiation, including with local stakeholders, on river basin management options. The negotiated approach calls for the reverse, allowing local actors to develop basin management plan and strategies specific to their local context, which are then incorporated in the larger basin management plan. This allows their knowledge to influence regional and national decisions and feel sense of ownership, responsibility and accountability towards the change in the management and implementation system. This ultimately results in a truly participatory bottom-up process of policy development and management.

(c) The IWRM Approach

Integrated Water Resource Management (IWRM) approach has emerged at Global level from the United Nations Water Conference in 1977, with most governments later committing in 2002, to application of IWRM by developing IWRM and water efficiency plans. By 2012, more than 80% of countries had made progress towards meeting the target.

IWRM is a process which can assist country and within country different States in their endeavor to deal with water issues in a cost effective and sustainable way. IWRM as an approach to manage water resources has been Globally accepted by most countries including India as it find place in National Water Policy 2012 and in Rajasthan State Water Policy 2010. The recent announcement and promulgation of The Rajasthan River Basin and Water Resources Planning Act 2015 on April 24, 2015 is a big step in this direction.

General principles, approaches and guidelines relevant to IWRM are numerous and each has their areas of appropriate application. The Dublin principles are particularly useful set of such principles and out of the four principles particularly the principle; “Water development and management should be based on a participatory approach, involving users, planners and policy makers at all levels”, is critical for sustainable management of water resources particularly at local level, i.e. basin or aquifer level. The requirements for IWRM is to have holistic approach to management, recognizing all the characteristics of the hydrological cycle and its interaction with other natural resources i.e. land, biomass and ecosystem. The effects of human activities lead to the need for recognition of linkages between upstream and downstream users of water. Upstream users must recognize the legitimate demands of downstream users to share the available water resources and sustain usability. This clearly implies that dialogue or conflict resolution mechanisms are needed in order to reconcile the needs of upstream and downstream users. Groundwater management also need understanding among users on regulating it to ensure sustainable present and future use.

The other important component of IWRM is participatory approach. Real participation only takes place when stakeholders are part of the decision making process. Participation occurs only when participants have the capacity to participate. It implies that, first, build the capacity of the stakeholders, particularly women and marginalized social groups. This may not only involve awareness building, confidence building and education, but also the provision of the economic resources needed to facilitate participation and the establishment of good and transparent source of information.

The main practical elements of IWRM can be listed as follows;

(i) A strong enabling environment – policies, laws and plans that put in place "rule of the game" for water management that use IWRM
(ii) A clear, robust and comprehensive institutional framework for managing water using the River Basin as the basic unit for management while decentralizing decision making.
(iii) Effective use of available management and technical instruments – use of assessments, data and instruments for water allocation and pollution control to help decision makers make better choices.
(iv) Sound investments in water infrastructure with adequate financing available – to deliver progress in meeting water demand and needs for flood management, drought resilience irrigation, energy security and eco-system services.

The ultimate objective of IWRM is to make changes in water management approach in the complex social and political context. Besides water management and governance issues there are other issues and the most pertaining is the food or agricultural issues, as water use in irrigation is the highest among all other usages.

4.2 Review of IWRM Approach in Rajasthan[4]: The approach for Gram Panchayat level planning of IWRM activities of Water Resource Department (WRD) of the Government of Rajasthan started in 2007 with the following components:

[4] For details see A J James, M S Rathore et al. (2015) Monitoring and Evaluation of EC-assisted State Partnership Programme (Rajasthan), Submitted to ICF INTERNATIONAL, UK, INSTITUTE OF DEVELOPMENT STUDIES, JAIPUR

Component 1: Water Sector Reforms

- Human Resource Development including institutional restructuring & review of mandate, tasks resources, and change management (to change attitudes, behaviour and working environments for departmental staff)
- Capacity Building based upon Training Needs Assessment (TNA) of staff
- Coordination of activities_of water related departments, WRD, GWD, PHED and PRRD and organizing Project Steering Committee meetings.
- Commissioning studies by private companies or NGO’s
- Legal reform for community-based water management (including modifying existing laws and proposing new laws)
- Financial planning through Medium-Term Expenditure Framework (MTEF)
- Infrastructural support for laboratories, office equipment, etc.
- Setting up a computerised water resources data centres to coordinate existing systems and put in place updated systems (including GIS)
- Monitoring progress of the entire EU-SPP implementation by the GoR, including periodic reviews by the Joint Review Mission (JRM) of EU and GoR.

Component 2: Sustainable Water Campaigns

- Awareness campaigns with posters, stickers and through the media
- Impact assessments of the campaigns
- Suggestions for improvement of these campaigns, based on reviews

Component 3: Institutional Development of water-related departments (WRD, GWD, PHED and PR&RD)

- Human Resource Development including institutional restructuring & review of mandate, tasks, resources, and change management (to change attitudes, behaviour and working environments for departmental staff)
- Capacity building of departmental staff based on Training Needs Assessment (TNA)
- Commissioning studies on specific information gaps
- Providing infrastructural facilities, including laboratories, libraries, computers, GIS & modelling systems
- Improving procedures for data collection, processing and dissemination

Component 4+5: Institutional Strengthening & Capacity Building in PRIs and User Groups

- Mobilization of NGOs for capacity building of WRCs, VWHSCs and PRIs
- Coordination with district-level officials of WRD, GWD, PHED, and PRRD for the IWRM programme
- Capacity building of village-level groups
- Awareness generation of PRIs, especially at district-level
- Selection of pilot districts for GP-IWRM programme (or "bottom-up" IWRM programme)

Component 6: Investment in PRIs/User Groups IWRM plans

- Financial facilitation of implementation of GP-IWRM plans in the 11 pilot Districts.
- Implementation of GP IWRM plans by VWHSCs and other PRIs facilitated by NGOs.
- Monitoring and evaluation of supporting NGOs and impact assessment of GP IWRM plans implementation activities.

The 2007 approach for Gram Panchayat level planning of IWRM activities was finalized only in October 2011. In late 2013, the State Water Resources Planning Department and the international Technical Assistance (TA) Team of the European Commission supported State Partnership Programme (SPP) with the Government of Rajasthan (GoR) developed a New Approach to multi-level Integrated Water Resource Management (IWRM). The approach was ensuring the emphasis of the GP plan by way of:

- sustainable management of water resources;
- regulating major users and uses;
- allocation of water to primary needs;
- equitable and secure access of the poor and marginalised to water services;
- to ensure that issues of inter-sectoral, inter-village and inter-block equity and sustainability are picked up.

The approach had the following key features:

- Planning Process: GPs had to create GP-IWRM Plans by collecting primary & secondary data, conducting situational analysis and water budgeting, identifying and listing all local IWRM requirements at GP-level, prioritizing them, identifying funding options from existing schemes and programmes of different government line Departments.
- Plan approval Process: The GP-IWRM plans were discussed and passed by the Gram Sabha.

- District-level approval: After Gram Sabha approval, the GP-IWRM Plan was submitted for approval to a District IWRM Team, comprising representatives from different departments, freshly-constituted for the sole purpose of implementing Component 6 of the EU-SPP
- Modifications in the GP-IWRM Plan, If necessary, the district IWRM Team suggested modifications to the plans, on the basis of technical feasibility. The final approved GP-IWRM Plans were returned to the GPs for implementation
- Updating the plans: Although not clearly specified in the approach, the understanding was that the GP IWRM Plan would be updated every year by the villagers. The GP Water Management Booklet finalized in early 2012, for instance, had tables with columns to be filled in for the next 5 years (for the Action Plan and for monitoring changes in water availability and water resources).

In the State level review meetings the following problems were reported in the GP-level planning process:

  - Lack of visibility of SWRPD at District level.
  - Need to strengthen the operations of the district IWRM Teams:
  - Need to revisit the district-level approval process
  - Need to ensure that GP-IWRM plan activities are reflected in annual departmental action plans:
  - Need to build on good relationship between GPs and RDPRD.
  - Low awareness of EU SPP programme.
  - Need for greater monitoring of NGOs: They observed that people's representatives at district level had insisted during district-level workshops that tighter monitoring of the implementing NGOs was required to ensure the quality of their work as well as the use of EU SPP funds, with regular feedback given to the Zila Parishad.

- NGO Feedback: Two key sets of issues raised by the NGOs, all of whom had been facilitating the preparation of GP-IWRM Plans in the project districts, were options for local water resource management and local water governance. These main points are summarized below;

  I. Local water resource management

  - *Need for hydrological unit-based holistic planning*: Need to keep the full hydrological area and boundaries in mind while doing holistic planning for ground water recharge (by both rain water and waste water) and other structures, keeping in mind the other activities within this boundary (including forestry and agriculture and industry); e.g., hand pump suggested now, but look for more sustainable sources (to maximize use of rainwater) – e.g., through *tanka*, open well and other structures.

- *Need for a technical check on plans*: The plans created hitherto have not considered impact of planned activities on ground water; and other gaps may also be there - so must relook at the plan from a technical point of view before implementation.
- *Need to include agriculture in GP-IWRM Plans in a better manner*: These are not emphasized in the current GP-level Plans. Also, NGOs now have a better understanding of the large proportion of water used by agriculture and so the Plans must emphasize water-efficient agricultural practices (e.g., drip and sprinkler).
- *Address demand management:* (1) Reduce withdrawal from bore wells, by either stopping them (difficult) or by levying charges so that the use reduces, and (2) change cropping pattern to less-water intensive crops - experiment with crops and do a demonstration, which remains the most effective to spread awareness among farmers, and also give some rewards to those who shift, so that others will also adopt (seeing additional benefits)
- *Plan for re-charge of drinking water bore wells*: There is an example of this being done in Pali district and it has also included in some plans now, but including such source protection measures, e.g., to recharge sources of existing drinking water bore wells must be part of all GP IWRM plans.
- *Give recognition for villagers working for water management*: e.g., Jal Mitra, Jal bandhu – and also incorporate women into this team – so that they can do good work at village level (since they know the problems).
- *Focus on missed out components to save water*: including sanitation and kitchen gardens: Waste water running waste currently, washing waste water and rain water runoff going waste can be reused and channeled. All these must be part of GP-IWRM Plans.
- *Promote new technologies to use less water*: Must persuade people using demonstrations, to adapt those that work best in India with farmers – and not through lectures or reading material.
- *Re-use water*: Revive the culture of water conservation in all its usages.
- *Find local solutions*: People in Santosh pura, Sikar district were using a bore well to get additional drinking water because there was no water from the piped system; so the NGO fixed taps on the open stand pipes, as a result of which the

pressure improved and water started flowing from the taps – and they no longer needed to use water from the bore well (thus saved water from 1 bore well)

- *Have a proper O&M of water supply system* – to control wastage and leakage
- *Promote rain water harvesting especially traditional systems*: used more and more for drinking – can approach PHED and ask them to use the neighbouring traditional harvesting structures as drinking water sources – by linking several of these to a distribution system, instead of drilling new bore wells.
- *Work with Agricultural Department staff*: Hold orientation camps for farmers by NGOs and Ag Dept staff to promote less-water using crops (e.g., *aloe vera* and *jojoba*) – but ensure market access, since farmers will sow only those seeds where they see a profit. There are examples of earlier failures (e.g., aloe vera and jojoba) which failed because market linkages were not promoted alongside production. Should also promote rainfed farming the same way the Agriculture Department promotes irrigated farming (e.g., Ag Dept has targets for extending sprinklers and drip with 90% subsidy on horticulture and 70% subsidy on sprinkler) otherwise, it will at best only be a 'side activity' – which will be a waste, with very few benefits after a lot of efforts
- *Support irrigation from ponds*: need IWRM training for local committee members; and a government policy made to clearly set down when they can release water from the pond and when they should not.
- *Promote Non-farming livelihoods*: Can promote a document showing best practices for alternative non-water using livelihoods – with examples of which villages to visit; can also promote this by spreading information and awareness and marketing; can link Societies with the Rural Non-farm Sector Development Agency (RUDA) which promotes livelihoods. Can similarly support migration.

II. Better local governance

- *Need to create greater awareness*: Need more awareness of the existence and provisions of GP-IWRM Plan activities, at all levels, so that everyone from GP level up to ZP-level is aware, and there is greater accountability for its implementation
- *Need community-generated water rules*: not made 'outside' and imposed on the community
- *Formulate and implement policies to limit water use*– to stop over use of water (e.g., with high water using crops) – which people will follow because they see advantage for themselves (and a potential disadvantage if not followed) and not just because it is a government regulation (like the helmet rule in cities – which

are followed not because people are concerned about safety but because of a fear of being fined!)

- *Improve coordination between SWRPD and RDPRD*: Need better coordination for local-level planning – otherwise there will be problems on the field. (Example: at a recent meeting in Barmer the RDPRD staff started by them saying 'we know all that you know about IWRM Planning') So need common training so that there is common understanding on IWRM and other issues. Need good Government Orders from the 'top' with clear roles and responsibilities
- *Make Gram Sabhas organized by RDPRD more effective*: not very effective at the moment (e.g., home signing of attendance registers!)
- *Hold Block-level meetings*: 'Saadharan Sabha' is a meeting that is already being held with all key stakeholders, including Sarpanch and MLA, so must have IWRM as an agenda point there.
- *Improve awareness of Panchayat Samiti and Zilla Parishad members*: Have training and then refresher and orientation regularly – so that they understand about IWRM and its importance and need in the district. Take 1-2 people from each Panchayt for training as well – so at least they are clear about the concepts and planning processes.

Three other issues were also important, especially in the context of the revision of the approach:

- ***GP-IWRM plans be revisited or revised before implementation****:* Participants strongly felt that, on the basis of additional inputs received at this workshop, there was a need for some correction of the GP-IWRM Plan – basically in the last part, specifying activities, schemes and cost estimates
- ***GP-IWRM plans to be included in departmental action plans****:* They also maintained that implementation should insist that all these GP-IWRM Plan activities must be included in the Annual Plan of Gram Panchayat, because 'if there is no budget, there will be no implementation'.
- ***Trainings provided by the TA Team and GoR have to be improved or changed*****:** Participants felt that VWSC training is a must and refreshers needed everywhere given high turnover of NGO staff and also where the NGO doing the training left in between (as a result of which, the effectiveness of training was very poor). But the new training material has to include agriculture and horticulture (e.g., what crops to include, etc.).

4.3 Learning from the Pilot IWRM in Rajasthan

The analysis of SWRPD experiment in the area of IWRM planning in the Rajasthan State was carried out and the gaps identified are as follows: Identified and approved (GP Plan activities are still in the supply-driven mode), small activities are considered such as construction of GLR, recharge of hand pumps, soak pits etc. Major aspects that affect the water basin or aquifer recharge etc are not considered in the GP plans. Successful implementation requires intensive facilitation, in which state department failed to support.

The GP-IWRM Planning process was being ineffective as a result of the bypassing of the regular structure of planning and monitoring of government activities that were operational at district and sub-district levels. Activities listed in the GP-IWRM Plan documents were not being included in the annual action plans of the concerned government departments. The main reason for this failure was that not only did the planning process unclear about how exactly villagers could address their key water problems (periodic water scarcities and groundwater overdraft), but it was also housed in a planning structure (the District IWRM Team) that was not well understood by district line department representatives and district administration officials as it bypassed the regular district-level processes that routinely created and implemented the annual departmental plans.

Lessons that emerges out of the review on international, national and Rajasthan State water resource management efforts are as follows;

The main learning from the pilot IWRM implementation in Rajasthan during last ten years and based on the review of the program and developments in the water sector in Rajasthan the lessons are as follows:

- **Hydrological assessments must be the basis for local IWRM:** In both basin and non-basin areas, water resources planning and management cannot be carried out effectively without detailed and accurate mapping of surface and groundwater resources and hydrological modelling and simulations of alternative scenarios (including of climate change induced weather variations).
- **Local people have to work alongside government departments to realize IWRM:** Effective co-management of water resources, especially local water resources, requires the joint efforts of government and local communities.
- **Joint implementation by government agencies is a must for effective local IWRM:** Integrated water resource management requires coordinated planning and implementation across various government departments so that schemes can be dovetailed and focused on supporting communities to re-engage in

community management of local water resources. This may require formation of River Basin Parliament represented by all the stakeholders and supported by a technical support group of experts and line department officials.

- **Existing government systems have to be used to support local IWRM:** Unlike in donor-supported projects and programmes in the past where new institutional structures and mechanisms government programme funding and oversight support for local water resources planning and implementation have to use existing processes. These include the departmental and village-level annual activity planning processes and their monitoring (e.g., through village, block-level and district-level meetings).
- **Considerable capacity building and awareness raising is necessary:** In order to tackle misconceptions and myths concerning water resources management, a concerted effort of awareness generation and capacity building is needed for all concerned stakeholders, from senior bureaucrats to implementing engineers and other government staff to Gram Panchayats and local communities.

These key components, however, will require considerable external technical support, at least in the initial period. Apart from raising awareness of water issues (including correcting misconceptions and myths) and building capacity to carry out hydrological assessments, such support will also cover the following:

- ***Technical guidance and support*** for the hydrological assessments (and the iteration with GP-level plans)
- ***Community mobilization and hand holding*** to help create technically feasible GP-level plans, with management rules under different scenarios (e.g., droughts, normal rains and floods) and
- ***Support to create community-level monitoring protocols*** to ensure that surface and groundwater use is as planned properly.
- Surface and groundwater has to be managed in an integrated way by adopting the negotiated approach of IWRM.
- Identification of Aquifers and generating information on different geological/geo-hydrological parameters and mapping of aquifers.
- Formation of Water Management Groups of stakeholders and their capacity building based on the information collected and the socio-economic and livelihood conditions of the stakeholders.

4.4 Our Approach

Based on the learning's from the above review of experiences in Rajasthan the CEDSJ will try to adopt a new approach of Participatory Community Management of River Basin. It is planned to have two associated partner NGOs namely Gramin Navyuvak Mandal Laporia (GVNML) and Gramodaya Samajika Sansthan (GSS) as field level implementation partners to facilitate, i.e., community mobilization, formation of River Basin organisations in the Mashi sub-Basin starting from Grampanchyat, micro watershed and sub-Basin level, Undertake capacity building activities jointly with CEDSJ in order to prepare IWRM plans. The information generated in this study with the input from Hydrologist or Hydro-geologist and Remote sensing expert etc. to map the land, water (water bodies and drainage system) and other natural resources in the Sub-Basin based on IWRM approach and document changes/obstructions caused in the sub-basin hydrological system by people, development agents and development activities by the State, will form the basis for capacity building training modules. Trainings will be imparted to the three group members, i.e., Stakeholder Group, Technical support Group and Public Representatives Group as shown in the organogram. The details about the groups are as follows:

Stakeholder Groups

The Stakeholder group comprise of three sub groups; (i) Farmer and Non farm sector members, (ii) Industrialist Group, and (iii) Unorganized sector members. The First sub group will be at the watershed level and as there are six watershed in the Mashi Basin in total there will be six groups of 5 members each adding to a total of 30 members. The Second Sub group will be of Industrialist and there are two major industrial area, namely SEZ- Mahindra City and RIICO area. This group will have 5 representatives. The third sub group is of unorganized sector members representing business groups on road side and will have two representatives.

Technical Support Group

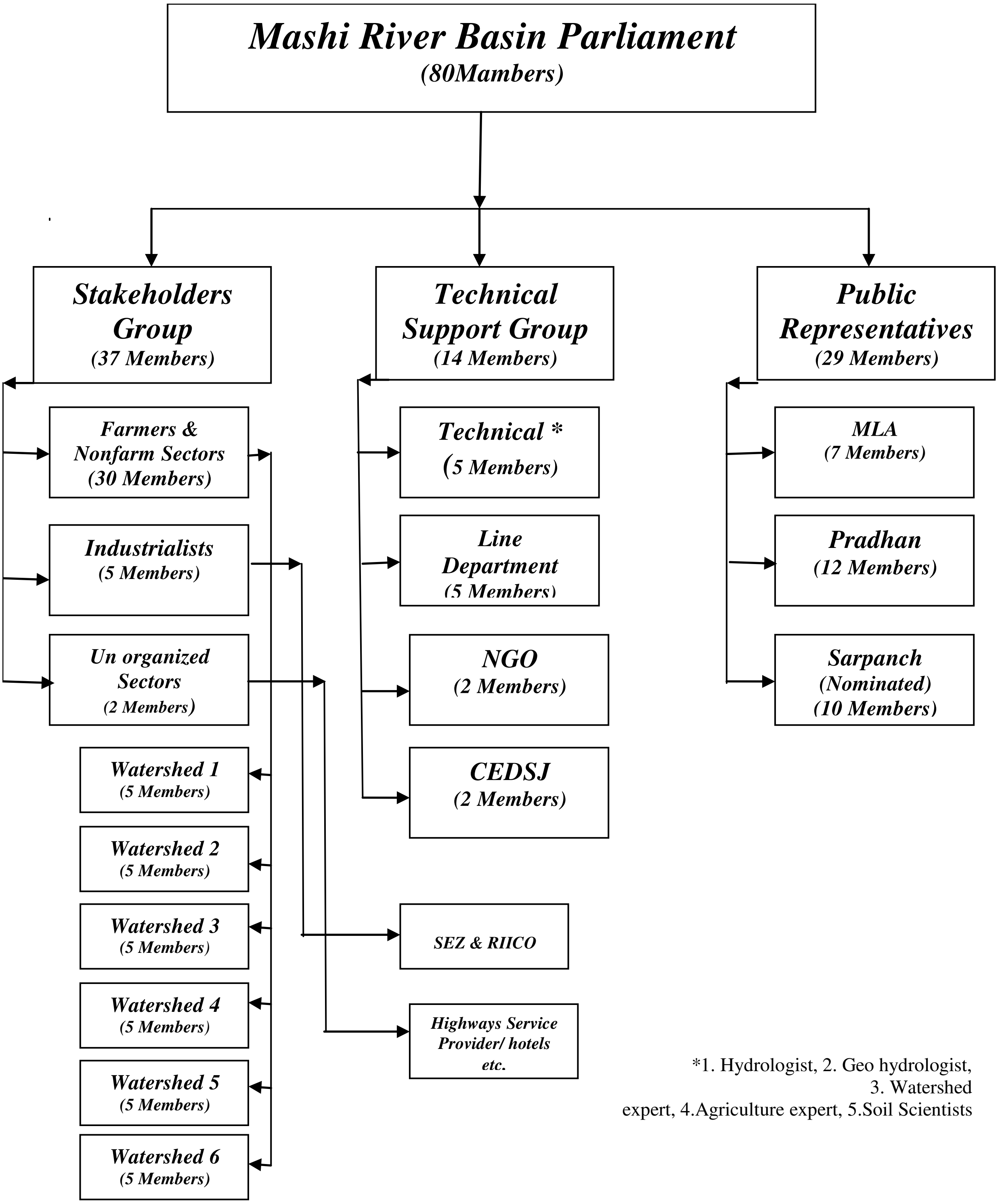
The group will comprise of representative of line departments at block level, subject matter specialist, such as Geologist, Geohydrologist, Agronomist, Watershed Specialist, Economist, Institutional expert, NGO representatives, CEDSJ representative, etc. In total this group will have 14 members. Technical support group will act like a advisory group to facilitate smooth working of parliament and help preparing IWRM plans and implementation of the plan.

Public Representatives

It has been observed that in most of the development groups formed by NGOs or State Government the public representative are either missing or are considered as passive members. Since each public representative has been allocated fund for development works in his/her constituency we thought of involving them in the River Basin activities and also take the issue at the state level. Their participation will ensure political support to the River Basin Parliament. Hence MLAs, Pradhans and Sarpanch's will be the member of this group and in total there will be 29 members.

Mashi River Basin Parliament

Mashi River basin Parliament will be constituted after discussion with the three group members. The process of formation will start from below with capacity building trainings of all the stakeholders. The constitution and working procedures of the Parliament will be formulated in the stakeholder meetings though the draft document will be prepared by CEDSJ based on the review of community based organisations working in different parts of India. The experience of Tarun Bharat sangh attempt to form Arvari River Parliament and its working of 20 years will also be considered. In total there will be 80 members in the parliament.



*1. Hydrologist, 2. Geo hydrologist, 3. Watershed expert, 4.Agriculture expert, 5.Soil Scientists

CHAPTER V

GEO HYDROLOGICAL ASSESSMENT OF THE MASHI RIVER BASIN

5.1 Introduction

The Physical features of the Mashi River basin are discussed in Chapter II. The specific issue came up while conducting field work was that why there is no groundwater in the Mashi River catchment area and wherever it is available is of bad quality, i.e. having high fluoride contents. Secondly, why no tubewells and only shallow dug wells with very little recharging despite large number of surface water harnessing structures. On the other hand in Bandi River sub basin there are tubewells with good quality groundwater and better recharge capacity. These issues were discussed with the Geohydrologist and Geologist and were decided to conduct geophysical assessment of both the rivers catchment areas. The answer to above listed issues will be needed for basin level water resource planning and developing stakeholder capacity building training modules. This chapter will also help understanding the climate resilient development interventions made by the NGOs and State Government.

Human societies have exploited and affected the ecosystems in many different ways. It also affected the health of billions of people, especially poor people and children, since water born diseases are the major cause of illness. The availability of freshwater fluctuates enormously due to geographical and seasonal conditions. To study how the variability and character of freshwater resources create different constraints and opportunity for economic development or livelihood of people in the rural areas a geophysical assessment survey was conducted. The survey was conducted in 20 villages along two profiles AA’ (Pachar – Phagi - Vimalpura) and BB’ (Pachewar - Phagi - Chittora) to delineate the permeable and impermeable layers, clay lenses, depth to rock and quality of ground water. Phagi Panchayat Samiti is the heart of study area as the most of the villages of this Panchayat samiti are facing acute problem of quantity and quality of ground water.

5.2 Hydrogeology

Ground water in the area generally occurs under water table in Quaternary sediments and weathered/ fissures, fractures of crystalline rocks. The alluvium is the main water bearing formation of the area. Topographic/physiographic features and lithology significantly control the occurrence and movement of ground water.

The ground water occurs in the pore spaces and interstitial openings of Quaternary alluvium while its occurrence and movement in quartzite, schist, granite, and gneisses is mainly controlled by fissures and fractures planes. Five hydrogeological formations viz; ***Younger***

Alluvium, Older Alluvium, Phyllite & Schist, Quartzite and BGC (Banded Gneissic Complex*)* are the main water bearing formation (aquifer) in this region. Quaternary sediments as older alluvium and Aeolian sand, gravel mixed with varying amount of clay and kankar covering north east part of basin area in Jaipur and Tonk. The Phyllite, Schist and Quartzite of Delhi Super Group occupy the parts of Jaipur and Tonk. Banded Gneissic Complex occupies western and southern part of the basin area. BGC is the main aquifer with Mashi River and Older Alluvium is the main aquifer with Bandi River area.

5.3 Artificial Recharge to Ground Water

The reasons for decline in water table in major parts of the area can be attributed to ever increasing exploitation of ground water to meet the growing demand for agriculture, drinking, domestic and industrial purposes. Increasing urbanization and industrialization have caused not only surface water pollution but have also caused ground water pollution in the area resulting in adverse effect on the health, environment and imbalance in the eco-system.

The artificial recharge to ground water aims at augmentation of ground water reservoir by modifying the natural movement of surface water, utilizing suitable civil construction techniques. Artificial recharge techniques normally address the following issues:

- Enhancement of the sustainable yield in areas where over-development has depleted the aquifer, conservation and storage of excess surface water for future requirements as these requirements often change within a season or a period.
- Improvement in the quality of existing ground water through dilution.
- Avoiding water impoundment and flooding on roads during storm showers.
- The basic purpose of artificial recharge of groundwater is to restore supplies from aquifers depleted due to excessive ground water development.
- It helps in reducing the soil erosion and flood hazard.
- It is a simple, economical and eco-friendly method of water resource augmentation.

5.4 Geophysical Techniques of Sub- Surface Studies

Geophysical methods are non- invasive and cost effective best approaches for indirect mapping of the sub surface geological formations and structures. Electrical Resistivity method is extensively used for ground water investigation. Electrical resistivity method is an artificial current source method in which low frequency (4HZ) current is used. Controlled amount of current is introduced into the ground through current electrodes and measurement has been carried out with the help of potential electrodes. All the four electrodes are placed on a straight line. The two current electrodes on outside and the two potential measuring electrodes on the inside along the array.

Geophysical methods can play an important role in subsurface studies as delineating different geo electric layers and their thickness, the permeable and impermeable layers, clay lenses, depth to rock formation, weathered/ fractured rock and ground water quality.

5.4.1 Objectives

- Delineation of ground water bearing formations (aquifers), their thickness and depth.
- Saturated and unsaturated zones.
- Depth to rock formation weathered/fractured rock.
- Variation in chemical quality of ground water with depth.

5.4.2 Investigation Methodology

The current and potential electrodes are placed in various configurations, but the most extensively used electrode configuration for subsurface investigation is the ***Schlumberger Configuration***. In this configuration the four electrodes are placed symmetrically along a straight line, the current electrodes are on the outside and the potential electrodes on the inside along the array. To change the depth range of the measurements, the current electrodes are displaced outward, when the ratio of the distance between the current electrodes to that between the potential electrodes becomes too large i.e. more than 5 times, the potential electrodes must also be displaced outward, otherwise the potential difference becomes too small to be measured with sufficient accuracy.

In the Schlumberger Configuration, the apparent resistivity (Pa) is calculated by the formula.

$$\rho_a = \frac{\pi}{2}\left(\frac{L^2 - l^2}{l}\right)\frac{\Delta V}{I}$$

$$= K\left(\frac{\Delta V}{I}\right)$$

Where ρ = Apparent resistivity

L = half of the distance between current electrodes

l = half of the distance between the potential electrode.

π = constant

ΔV = Potential difference

I = amount of current

K = constant, known as geometric factor and based on the type of electrodes configuration.

Geophysical measurement is based on the assumption that the subsurface consist of a sequence of distinct layers of finite thickness, each of these layers is assumed to be electrically homogenous and isotropic and the boundary planes between subsequent layers are assumed to be horizontal.

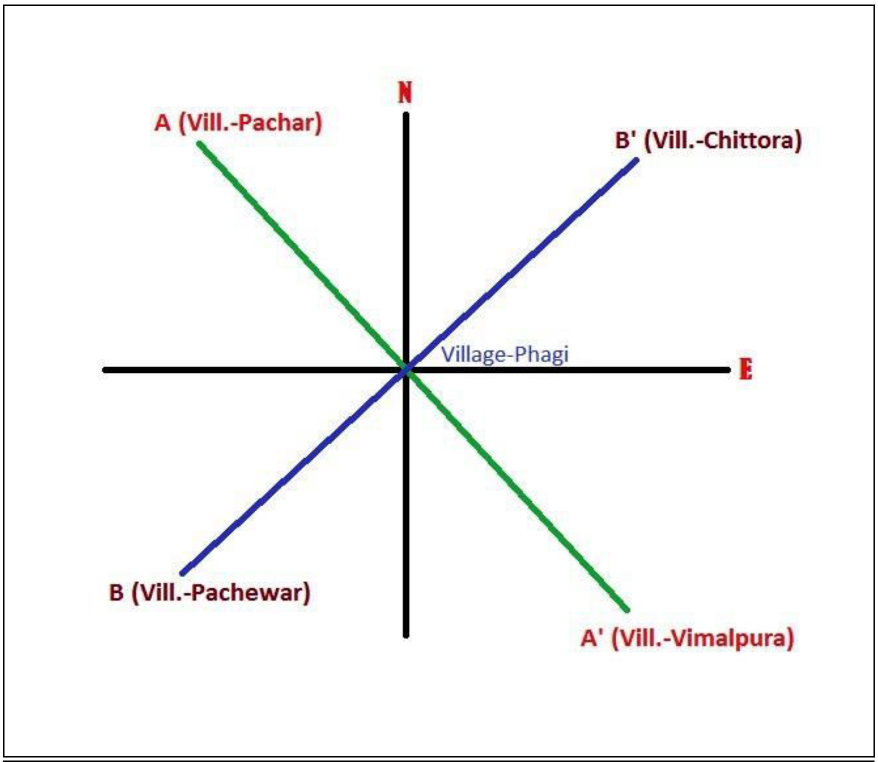
The resistivity data were interpreted with the help of computer using “Schlumberger Sounding Data Processing and Interpretation Programme.”

For ascertaining subsurface occurrence of ground water, the resistivity response depends primarily on the amount of impregnating water, the conductivity and quality of water and manner in which water is distributed. The first two factors have a nearly linear relation with the resistivity while the influence of the third factor is more complicated and depends on the nature of aquifer material.

Resistivity method of ground water is based on resistivity contrast rather than on absolute values. Summarizing, it can be stated dry formation, whether porous or non porous are practically poor conductors and hence the resistivity will vary with amount of pore water and quality of water.

5.4.3 Sub Surface Investigation & Interpreted Result

To delineate the subsurface geology, depth to rock formation and quality of ground water, Geophysical Survey has been conducted in the river basin area of Mashi and Bandi Rivers. Two profiles were selected for conducting geophysical investigation, profile AA’ and BB’ crosses each one at village Phagi. Vertical Electrical Soundings were conducted at villages Pachar, Gudha, Bobas, Begus, Bagru, Bhimpura, Harbanspura, Ladana, Phagi, Mandi, Kairiya, Kharunj and Vimalpura along profile AA’ and villages- Pachewar, Kundli, Kansiya, Lasariya, Phagi, Jharla Kantoli and Chitora along profile BB’.


N
A (Vill.-Pachar)
B' (Vill.-Chittora)
Village-Phagi
E
B (Vill.-Pachewar)
A' (Vill.-Vimalpura)

5.4.4 Interpreted Result

As per the interpretation of field data, the resistivity of different layers and corresponding thickness of layers of the formation are summarized as below:

Interpreted Result (Section AA')

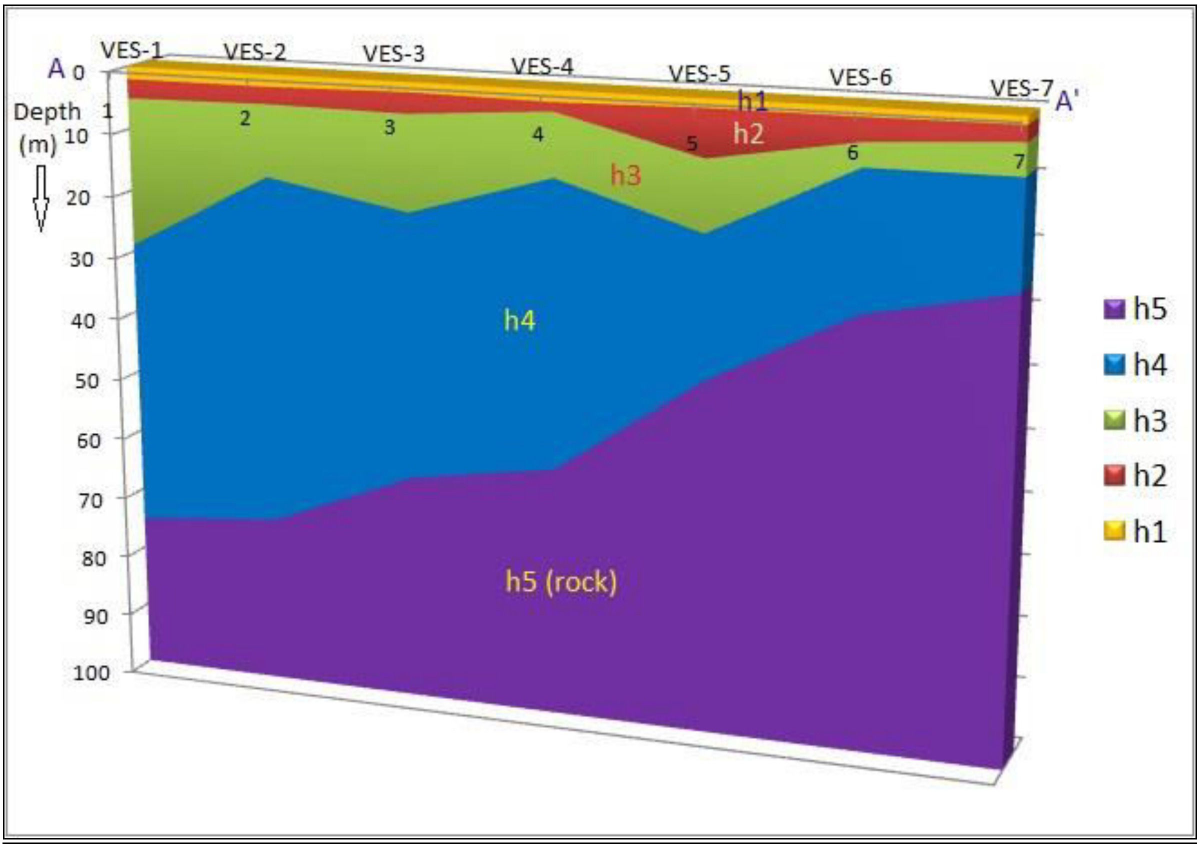
S. No.	VES No.	Village	Block	District	Location	Resistivity of different layers					Thickness of corresponding layers (Meters)				Depth to bedrock (Meters)
						ρ_1	ρ_2	ρ_3	ρ_4	ρ_5	h_1	h_2	h_3	h_4	H
1	1	Pachar	Jhotwara	Jaipur	South East Of Village	609	509	111	55.9	35.7	1.98	3.08	23.9	46.1	75.06
2	2	Gudha	Jhotwara	Jaipur	North West Of Village	189	142	244	55.9	35.4	1.98	2.74	11.6	56.5	72.28
3	3	Bobas	Jhotwara	Jaipur	Near Railway Crossing	117	77.4	171	80.4	49	1.58	3.36	15.5	42.9	63.34
4	4	Begus	Jhotwara	Jaipur	North West Of Village	56	67.6	90.8	46.3	71.7	1.85	1.42	10.2	46.1	59.57
5	5	Bagru	Sanganer	Jaipur	South East Of Village	137	61.4	108	24.8	99.2	1.43	7.61	11.4	22.9	43.34
6	6	Bhimpura	Sanganer	Jaipur	North West Of Village	71.7	47.1	39.7	35.1	276	1.43	3.71	3.77	22.1	31.01
7	7	Harbanspura	Phagi	Jaipur	In Front Of Shri Shrawan's House	73.9	16.9	32.7	11.8	142	1.29	2.49	5.08	17.1	25.96
8	8	Ladana	Phagi	Jaipur	South East Of Village	12	24.4	61.4	214		1.5	1.75	5.65		8.9
9	9	Phagi	Phagi	Jaipur	On Dudu Road	9.85	5.25	6.18	130		1.62	2.03	7.67		11.32
10	10	Mandi	Phagi	Jaipur	Near Atal Sewa Kendra	4.23	2.87	4.2	84.3		1.5	2.37	3.87		7.74
11	11	Kairiya	Phagi	Jaipur	South East Of Village	11.6	37.6	10.1	81.8		1.45	2.25	3.39		7.09
12	12	Kharunj	Phagi	Jaipur	North West Of Village	44.5	72	17.9	116		1.16	2.17	5.85		9.18
13	13	Vimalpura	Phagi	Jaipur	South East Of Village	110	48.7	45.4	48.8		1.18	4.66	13.17		19.01

Interpreted Result (Section BB')

S. No.	VES No.	Village	Block	District	Location	Resistivity of different layers					Thickness of corresponding layers (Meters)				Depth to bedrock (Meters)
						ρ_1	ρ_2	ρ_3	ρ_4	ρ_5	h_1	h_2	h_3	h_4	H
1	1	Pachewar	Malpura	Tonk	North East Of Village	12.3	6.95	8.9	93.3		1.86	1.6	7.35		10.81
2	2	Kundli	Phagi	Jaipur	South West Of Village	41.1	67.1	15.3	104		1.27	1.57	8.71		11.55
3	3	Kansiya	Phagi	Jaipur	North East Of Village	49	68.4	17.5	180		1.76	1.41	5.94		9.11
4	4	Lasariya	Phagi	Jaipur	North East Of Village	53.4	22.9	26	67		1.5	2.37	5.03		8.9
5	9	Phagi	Phagi	Jaipur	On Dudu Road	9.85	5.25	6.18	130		1.62	2.03	7.67		11.32
6	6	Jharla	Phagi	Jaipur	South West Of Village	46.48	61.41	10.97	87.67		1.98	1.37	5.14		8.49
7	7	Kantoli	Phagi	Jaipur	South West Of Village	49	72.2	14	171		1.98	1.34	4.6		7.92
8	8	Chitora	Phagi	Jaipur	South West Of Village	54	27.6	47.2	92.6		1.17	9.68	6.88		17.73

The following diagram shows the layers configuration along Profile AA'

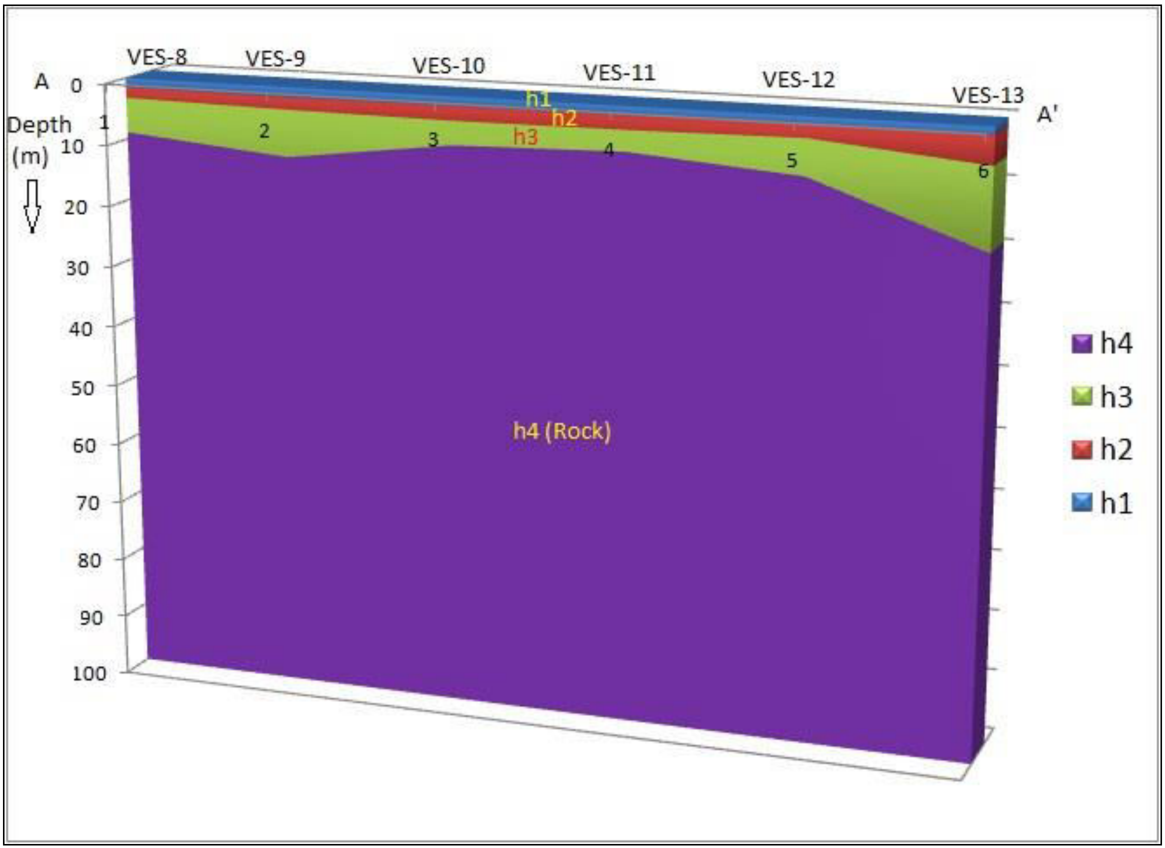
(From VES-1 to VES-7)



Ves-1,ves-2, ves-3, ves-4, ves-5, ves-6 and ves-7 are the vertical electrical soundings conducted along profile AA', at villages- Pachar, Gudha, Bobas, Begus, Bagru, Bhimpura and Harbanspura accordingly. h1 is top surface layer h2 is second layer below h1, h3 is third layer below h2, h4 is fourth layer below h3, h5 is deepest layer , known as bedrock.

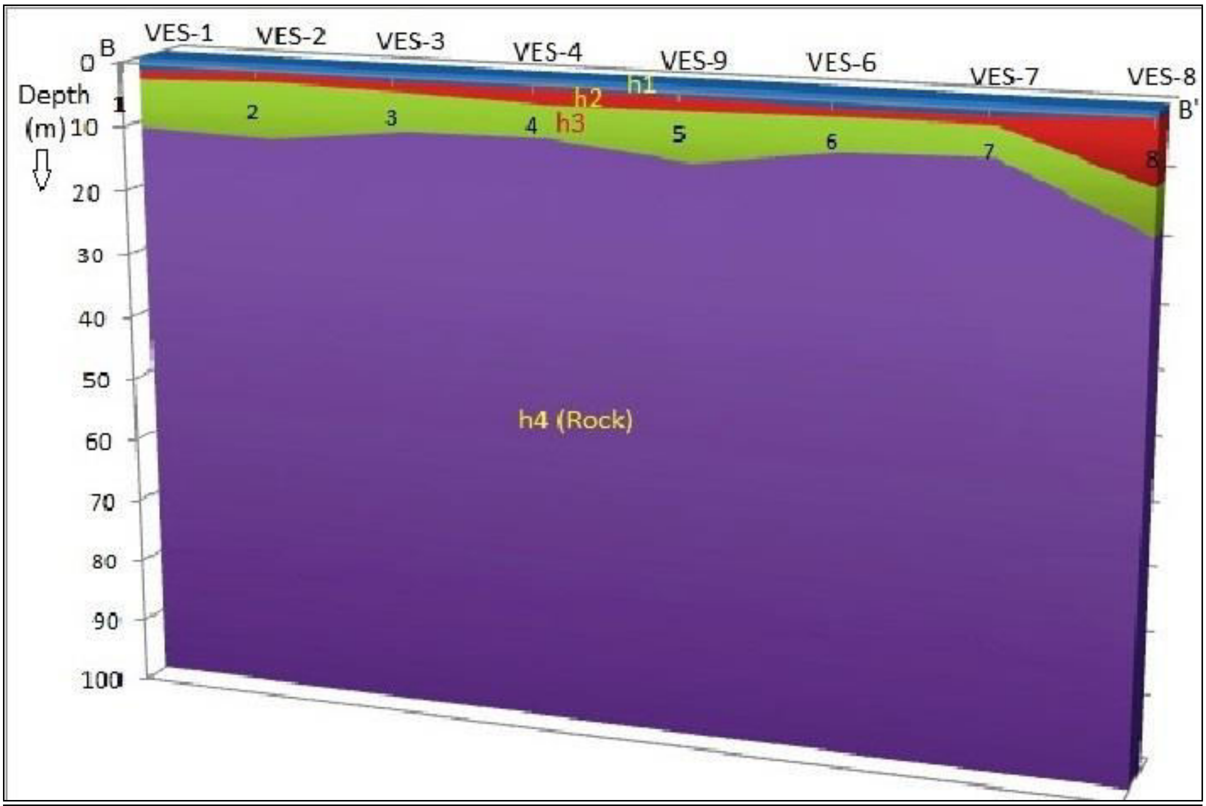
The following diagram shows the layers configuration along Profile AA'

(From VES-8 to VES-13)



Ves-8,ves-9, ves-10, ves-11, ves-12 and ves-13 are the vertical electrical soundings conducted along profile AA′, at villages- Ladana, Phagi, Mandi, Kairiya, Kharunj and Vimalpura accordingly. h1 is top surface layer h2 is second layer below h1, h3 is third layer below h2 and h4 is deepest layer , known as bedrock.

The following diagram shows the layers configuration along Profile BB′



Ves-1,ves-2, ves-3, ves-4, ves-9, ves-6, ves-7 and ves-8 are the vertical electrical soundings conducted along profile BB′, at villages- Pachewar, Kundli, Kansiya, Lasariya, Phagi, Jharla, Kantoli and Chittora accordingly. h1 is top surface layer h2 is second layer below h1, h3 is third layer below h2 and h4 is deepest layer , known as bedrock.

5.4.5 Village wise details of subsurface lithological formation along profile AA'

Pachar:

Layers	Lithological Formation
h_1	The formation consist of coarse to medium grained sand
h_2	The formation consist of coarse to medium grained sand and clay with minor kankar
h_3	The formation consist of medium to fine grained sand and clay
h_4	The formation consist of fine grained sand and clay
h_5	The formation encountered is rock which has few fissures & fractures containing little quantity of ground water.

Gudha:

Layers	Lithological Formation
h_1	The formation consist of sand with little clay
h_2	The formation consist of medium to fine grained sand and clay
h_3	The formation consist of clay, kankar and sand
h_4	The formation consist of fine grained sand and clay
h_5	The formation encountered is rock which has few fissures & fractures containing little quantity of ground water.

Bobas:

Layers	Lithological Formation
h_1	The formation consist of sand with little clay
h_2	The formation consist of fine to medium grained sand and clay
h_3	The formation consist of clay, kankar and fine to medium grained sand
h_4	The formation consist of fine to medium grained sand and clay with minor kankar
h_5	The formation encountered is rock which has few fissures & fractures containing little quantity of ground water.

Begus:

Layers	Lithological Formation
h_1	The formation consist of fine to medium grained sand and clay
h_2	The formation consist of clay, kankar and fine grained sand
h_3	The formation consist of clay, kankar and fine to medium grained sand
h_4	The formation consist of fine to medium grained sand and clay
h_5	The formation encountered is rock which has few fissures & fractures containing little quantity of ground water.

Bagru:

Layers	Lithological Formation
h_1	The formation consist of sand with little clay
h_2	The formation consist of fine to medium grained sand and clay
h_3	The formation consist of clay, kankar and fine to medium grained sand
h_4	The formation consist of clay and fine grained sand
h_5	The formation encountered is rock which has few fissures & fractures containing little quantity of ground water.

Bhimpura:

Layers	Lithological Formation
h_1	The formation consist of medium grained sand and clay
h_2	The formation consist of fine to medium grained sand, clay with little kankar
h_3	The formation consist of clay and fine grained sand with little kankar
h_4	The formation consist of clay and fine grained sand
h_5	The formation encountered is rock which has few fissures & fractures containing little quantity of ground water.

Harbanspura:

Layers	Lithological Formation
h_1	The formation consist of medium grained sand and clay
h_2	The formation consist of clay and fine grained sand
h_3	The formation consist of clay, kankar and fine grained sand
h_4	The formation consist of clay and fine grained sand
h_5	The formation encountered is rock which has few fissures & fractures containing little quantity of ground water.

Ladana:

Layers	Lithological Formation
h_1	The formation consist of fine grained sand and clay
h_2	The formation consist of clay, kankar and fine grained sand
h_3	The formation consist of clay, large Kankar and fine grained sand
h_4	The formation encountered is rock which has few fissures & fractures containing little quantity of ground water.

Phagi:

Layers	Lithological Formation
h_1	The formation consist of fine to medium grained sand and clay
h_2	The formation consist of clay and fine grained sand
h_3	The formation consist of clay, kankar and fine grained sand
h_4	The formation encountered is rock which has few fissures & fractures containing little quantity of ground water.

Mandi:

Layers	Lithological Formation
h_1	The formation consist of fine grained sand and clay
h_2	The formation consist of clay and fine grained sand
h_3	The formation consist of clay, kankar and fine grained sand
h_4	The formation encountered is rock which has few fissures & fractures containing little quantity of ground water.

Kairiya:

Layers	Lithological Formation
h_1	The formation consist of fine grained sand and clay
h_2	The formation consist of clay, kankar and fine grained sand
h_3	The formation consist of clay and fine grained sand
h_4	The formation encountered is rock which has few fissures & fractures containing little quantity of ground water.

Kharunj:

Layers	Lithological Formation
h_1	The formation consist of fine to medium grained sand and clay
h_2	The formation consist of clay, kankar and fine to medium grained sand
h_3	The formation consist of clay and fine grained sand
h_4	The formation encountered is rock which has few fissures & fractures containing little quantity of ground water.

Vimalpura:

Layers	Lithological Formation
h_1	The formation consist of sand and clay
h_2	The formation consist of fine to medium grained sand and clay
h_3	The formation consist of fine to medium grained sand, clay with little kankar
h_4	The formation encountered is rock which has few fissures & fractures containing little quantity of ground water.

5.4.6 Village wise details of subsurface lithological formation along profile BB'

Pachewar:

Layers	Lithological Formation
h_1	The formation consist of fine to medium grained sand and clay
h_2	The formation consist of clay and fine grained sand
h_3	The formation consist of clay, kankar and fine grained sand
h_4	The formation encountered is rock which has few fissures & fractures containing little quantity of ground water.

Kundli:

Layers	Lithological Formation
h_1	The formation consist of fine to medium grained sand and clay
h_2	The formation consist of clay, kankar and fine to medium grained sand
h_3	The formation consist of clay and fine grained sand
h_4	The formation encountered is rock which has few fissures & fractures containing little quantity of ground water.

Kansiya:

Layers	Lithological Formation
h_1	The formation consist of fine to medium grained sand and clay
h_2	The formation consist of clay, kankar and fine to medium grained sand
h_3	The formation consist of clay and fine grained sand
h_4	The formation encountered is rock which has few fissures & fractures containing little quantity of ground water.

Lasariya:

Layers	Lithological Formation
h_1	The formation consist of fine to medium grained sand and clay
h_2	The formation consist of clay and fine grained sand
h_3	The formation consist of clay, kankar and fine grained sand
h_4	The formation encountered is rock which has few fissures & fractures containing little quantity of ground water.

Phagi:

Layers	Lithological Formation
h_1	The formation consist of fine to medium grained sand and clay
h_2	The formation consist of clay and fine grained sand
h_3	The formation consist of clay, kankar and fine grained sand
h_4	The formation encountered is rock which has few fissures & fractures containing little quantity of ground water.

Jharla:

Layers	Lithological Formation
h_1	The formation consist of fine to medium grained sand and clay
h_2	The formation consist of clay, kankar and fine to medium grained sand
h_3	The formation consist of clay and fine grained sand
h_4	The formation encountered is rock which has few fissures & fractures containing little quantity of ground water.

Kantoli:

Layers	Lithological Formation
h_1	The formation consist of fine to medium grained sand and clay
h_2	The formation consist of clay, kankar and fine to medium grained sand
h_3	The formation consist of clay and fine grained sand
h_4	The formation encountered is rock which has few fissures & fractures containing little quantity of ground water.

Chittora:

Layers	Lithological Formation
h_1	The formation consist of fine to medium grained sand and clay
h_2	The formation consist of clay and fine grained sand
h_3	The formation consist of clay, kankar and fine to medium grained sand
h_4	The formation encountered is rock which has few fissures & fractures containing little quantity of ground water.

5.4.7 Depth to Water Level

Along Profile AA': The following table shows the variation in water level in Mashi river basin along profile AA'.

S No.	Village	Block	District	depth to water level(m)
1	Pachar	Jhotwara	Jaipur	80
2	Gudha	Jhotwara	Jaipur	72
3	Bobas	Jhotwara	Jaipur	67
4	Begus	Jhotwara	Jaipur	60
5	Bagru	Sanganer	Jaipur	45
6	Bhimpura	Sanganer	Jaipur	45
7	Harbanspura	Phagi	Jaipur	40
8	Ladana	Phagi	Jaipur	8
9	Phagi	Phagi	Jaipur	8
10	Mandi	Phagi	Jaipur	8
11	Kairiya	Phagi	Jaipur	10
12	Kharunj	Phagi	Jaipur	10
13	Vimalpura	Phagi	Jaipur	15

Along Profile BB': The following table shows the variation in water level in Mashi River basin along profile BB'.

S No.	Village	Block	District	depth to water level(m)
1	Pachewar	Malpura	Tonk	12
2	Kundli	Phagi	Jaipur	12
3	Kansiya	Phagi	Jaipur	10
4	Lasariya	Phagi	Jaipur	10
5	Phagi	Phagi	Jaipur	8
6	Jharla	Phagi	Jaipur	9
7	Kantoli	Phagi	Jaipur	22
8	Chittora	Phagi	Jaipur	19

5.5 Quality of Ground Water

The rain water after infiltration through soil adds water to ground water reservoir (aquifer) and hence affects the ground water quality, which is dependent on the type of soil, type of rock below the soil and the residence time in which the water infiltrates from the surface to the saturated zones. The ground water quality studied along the two profiles is discussed below:

5.5.1 Along Profile AA’

Geophysical survey were conducted in villages Pachar, Gudha, Bobas, Begus, Bagru, Bhimpura, Harbanshpura, Ladana, Phagi, Mandi, Kairiya, Kharunj and vimalpura along profile AA’. Quality of ground water is expected to be potable towards villages Pachar, Gudha, Bobas, Begus and Bagru varying up to the depth of 180 – 140m bgl. The quality of ground water towards villages Bhimpura, Harbanshpura, Ladana, Phagi, Mandi, Kairiya, Kharunj and Vimalpura is non potable for drinking purposes due to contamination of different chemical constituents as fluoride, nitrate, chloride compound of Na^{+} and K^{+} and bicarbonate of Ca^{2+} and Mg^{2+}. These chemical constituents harm the fertility of soil too, in these areas.

5.5.2 Along Profile BB’

Geophysical surveys were conducted in villages Pachewar, Kundli, Kansiya, Lasariya, Phagi, Jharla, Kantoli and Chittora along profile BB’. The quality of ground water in all villages along profile BB′ is non potable for drinking purposes due to contamination of different chemical constituents as fluoride, nitrate, chloride compound of Na^{+} and K^{+} and bicarbonate of Ca^{2+} and Mg^{2+}. These chemical constituents harm the fertility of soil too, in these areas.

5.6 Findings and suggestions

- Alluvial thickness is thick towards villages Pachar, Gudha, Bobas, Begus and simultaneously decreases towards villages Ladana, Phagi, Mandi, Kairiya, Kharunj and Vimalpura along section AA’ i.e. varying from 76m to 9m.
- Alluvial thickness along section BB’ is thin, varying from 10m in Pachewar to 18m in Chittora.
- A thin hard layer of clay, kankar with fine sand is present in lithological formation of most of the villages of studied area which hinder the percolation of rain water to ground water level.
- Yielding capacity of formation is better towards villages Pachar, Gudha and Bobas and poor in most of the villages of Phagi Panchayat Samiti.
- Quality of ground water is potable towards most of the villages in Jhotwara Panchayat samiti and non-potable in most of the villages of Phagi Pachayat Samiti.

Suggestions

1. Thick alluvial thickness in villages of Panchayat Samiti- Jhotwara become almost dry which is main aquifer in these area, artificial recharge and lowering of pumping rate may enhance the ground water augmentation.

2. Most of the villages of Phagi Panchayat Samiti have thin alluvial thickness, the main aquifer in these area are schist and gneisses. Artificial Recharge may be done in fissures and fractures of rock formation.
3. Dried open wells, hand pumps and tube wells may be useful for artificial recharge.
4. Recharge Shafts in ponds, Johor and Gabion check dams, woven wire dams across Nalah and big streams may be a good approach for artificial recharge.
5. Detail Geophysical Survey of the area may help to identify fissures/ fractures in rock formation and sand/ clay formation in alluvium, so that the artificial recharge structures may be constructed at suitable sites.
6. Artificial recharge to ground water may improve the quantity and quality of ground water.

Aquifer System	**Proposed Structure**	**Expected Yield**	**Conservation and Recharge of water**	**Benefits of conservation and Recharge of water**
B.G.C.	Open well	20000 – 40000 litres per day	Ponds and johor, suitable Recharge shaft may be constructed in Ponds and Johor to recharge in fissures and fractures in rocks	Improve the quality of drinking water and sustainability of ground water
Older Alluvium/	Tube well	4000 – 6000 litres per hour	Run off rain water may be channelized and conserved in a appropriate size storage tank after filtering through a filter pit. Over flow water may be recharge to ground water through a recharge shaft of suitable depth. Dried hand pumps, open wells and tube wells may be also used for recharge purpose.	Improve the quality of drinking water and sustainability of ground water
Phyllite & Schist	Open well/ tube well	For open well= 30000 – 50000 litres per day (for tube well= 3000 – 5000 litres per hour)	Ponds and johor, suitable Recharge shaft may be constructed in Ponds and Johor to recharge in fissures and fractures in rocks	Improve the quality of drinking water and sustainability of ground water
Quartzite	Tube well	4000 – 6000 litres per hour	Run off rain water may be channelized and conserved in a appropriate size storage tank	Improve the quality of drinking water

			after filtering through a filter pit. Over flow water may be recharge to ground water through a recharge shaft of suitable depth. Dried hand pumps, open wells and tube wells may be also used for recharge purpose.	and sustainability of ground water
Younger Alluvium	Tube well	5000 – 7000 litres per hour	Run off rain water may be channelized and conserved in a appropriate size storage tank after filtering through a filter pit. Over flow water may be recharge to ground water through a recharge shaft of suitable depth. Dried hand pumps, open wells and tube wells may be also used for recharge purpose.	Improve the quality of drinking water and sustainability of ground water

Besides the above suggested Aquifer System wise proposed physical measures suggested for rainwater harvesting and groundwater recharge are as follows:

Construction of new structures : The structures, such as Gabion structure, Nalah bunds, Check Dams, etc are sited to the area and these may be constructed across the nalah or streams to check the flow of surface water in streams in order to retain water for longer duration. The stream bed should be 5 to 10m wide and at least 1m deep. Excess runoff water be allowed to flow down the stream side. A series of such check dams can be constructed to have recharge on a regional scale particularly in the Bandi River catchment.

Rehabilitation or renovation of existing structure: The existing structures namely, ponds, Talabs, Bowadi, etc may be renovated to save the cost and to avoid problems of new site selection and related conflicts for runoff water conservation and recharge ground water.

CHAPTER VI
SUMMARY AND CONCLUSIONS

People based on their long experience have developed strategies to address the risk caused by climate variability, which vary by size of farm, social aspects and area. While the NGOs interventions/actions were mostly addressing the climate variability issues affecting the livelihood of rural population but the interventions were not directly designed from climate change perspective. This study is an ex post analysis of people, NGOs and government interventions to know that whether these interventions addressed the issues of adaptation or mitigation of the impact of climate change.

The main objective of the study was to list possible effects of Climate Change/Variability on agriculture sector or livelihood of the people in the Mashi sub Basin area. As climate change is manifested in variation in water availability and therefore the second objective was to explore possibility of adoption of IWRM approach in water resource management in a river basin by developing a new approach of participatory community management of river basin water resources to ensure water and food security in Mashi River Basin. This study will also act as pilot for River Basin management of water resources in Rajasthan.

Range of tools were used, such as, desk review, collection of primary data by organizing village surveys (by designing appropriate questionnaire), focused group discussion with key informants and other stakeholders, and direct observations. In order to know the impact of interventions on the livelihoods of beneficiaries few households were randomly selected from the sample villages for a detailed survey. Study was conducted by adopting participatory approach and had consultations also with PRI representatives.

The physical and social factors that may act as opportunity or constraint in addressing the impact of climate variability and/or change has been discussed at length. Infect the physical factors shape the livelihood strategies and through challenges for future interventions. The social dynamics also play significant role in adapting or coping with the climate change and also determines the viability of any intervention by state or NGOs.

NGOs and Sate Government interventions are reviewed in the given context of physical and social condition prevailing in the Mashi Basin. Changes in environment, i.e., temperature and rainfall variability, ultimately affects the livelihoods of rural population and increases their vulnerability. Traditional wisdom/knowledge helped them so far to cope with the situation but presently besides change in natural environment there is change in social, political and economic environment and rural population find it difficult to self manage or cope with the increased vulnerability. NGOs and State Government have been working in the rural areas to provide support to the marginalized people to reduce their vulnerability in more than one way. NGOs are actively working in the three districts falling under Mashi Sub Basin, namely, Jaipur, Tonk and Ajmer since 80s and helping people in having sustainable livelihood by better management of their natural resources. The interventions in the field of natural resources management (water, land, livestock, biodiversity, etc.) made by NGOs, though in good numbers but we selected the three most prominent once, having made significant impact in the area to provide sustainable livelihoods and their activities were analysed in the context of climate change. It was observed that the particular activity such as, rainwater harvesting system to provide irrigation in Rabi season and increase productivity of grazing lands have significantly contributed in addressing the impact of climatic risk particularly of small and marginal farmers. The village level institutions to adopt community management of common lands and water resources have given strength to face climatic risk particularly droughts.

The Government interventions are in terms of policy enactment and implementation programs through line departments. On both counts state government acted but there are gaps in achievements. There were programs addressing both mitigation and adaptation issues but difficult to isolate and quantify the outcomes in this study.

6.1 Household Strategies to address the impact of Climate Change

The challenges posed by translating global projections of climate change into courses of action that can be implemented at local levels particularly by farmers are complex. While climate models and the insights they provide have immense value, models, however, aren't sufficient because they cannot predict precisely where, when or with what intensity events will occur in specific regions. Developing effective systems to deal with such surprises and to reduce their impact continues to remain a challenge. People in rural areas mostly respond to climate variability based on their generational sharing of knowledge/experience about occurrence of events and success and failure of their responses. People have evolved some broad strategies to deal with climatic risk by adopting mix farming system in agriculture, diversification of occupation, managing their accumulated assets as per the intensity/severity of risk, use of social capital, etc. Primary survey in the sample villages in Mashi Basin was conducted to capture the household strategies to deal with climatic risk.

Diversifications of occupation, variation in cropping pattern and out migration are the main strategies adopted by the people in the Mashi Basin. Financial management particularly public or private borrowing to bear the impact of climatic risk is also an important part of the household strategies. The strategies guided by NGOs and State Government policies and programs were to some extent robust enough to address the climatic risks and because of that only climate resilient development in the Basin was possible. Water resources availability play major role in shaping household coping strategies as people are forced to migrate during drought years. Presently people are managing water resources either individually in their private capacity and/or as community resource at village level. The watershed or river basin level management do not figure out in their household strategy of community level management strategy. It is this gap we will be addressing in the next phase of our study.

6.2 Water Resource Management

The Physical features of the Mashi River basin are discussed in Chapter II. The specific issue came up while conducting field work was that why there is no groundwater in the Mashi River catchment area and wherever it is available is of bad quality, i.e. having high fluoride contents. Secondly, why no tubewells and only shallow dug wells with very little recharging despite large number of surface water harnessing structures. On the other hand in Bandi River sub basin there are tubewells with good quality groundwater and better recharge capacity. These issues were discussed with the Geohydrologist and Geologist and were decided to conduct geophysical assessment of both the rivers catchment areas, as the answer to above listed issues will be needed for basin level water resource planning.

Review of water resource management approaches adopted at international, national and state level was undertaken. Lessons that emerge out of the review will be used in developing a new approach called Participatory Community Management of River Basin to manage water in the Mashi River basin.

The main learning from the pilot IWRM implementation in Rajasthan during last ten years is:

- Hydrological assessments must be the basis for local IWRM
- Local people have to work alongside government departments to realize IWRM
- Joint implementation by government agencies is a must for effective local IWRM
- Existing government systems have to be used to support local IWRM
- Considerable capacity building and awareness raising is necessary

Including these key components of the new approach, however, will require considerable external support, at least in the initial period. Apart from raising awareness of water issues and building capacity to carry out hydrological assessments, such support will also cover the following:

- ***Technical guidance and support*** for the hydrological assessments, i.e. in Identification of Aquifers and generating information on different geological/geo-hydrological parameters and mapping of aquifers have to be undertaken.
- ***Community mobilization and hand holding*** to help create technically feasible GP-level plans, with management rules under different scenarios (e.g., droughts, normal rains and floods) and
- ***Support to create community-level monitoring protocols*** to ensure that surface and groundwater use is as planned properly.
- NGO support in formation of Water Management Groups of stakeholders and their capacity building based on the information collected and the socio-economic and livelihood conditions of the stakeholders.

6.3 The New Approach

The Integrated River Basin Management (IRBM) approach is a concept that aims to conserve and utilize the natural resources within a river basin sustainably, through integrating the needs and skills of various stakeholders like farmers, industries, government departments, academics, NGOs and people and their representatives. IRBM has been accepted formally by the national government in the National Water policy 2012 and gradually states' are also adapting it by enacting River Basin Management Acts. Despite agreeing to Integrated Water Resource Management (IWRM) approach it is not being practiced in true spirit. Water management continues to be a centralized top-down approach causes more problems than solutions.

It seems that the policy makers, planners and executers find difficult to internalize the concept of IWRM and working out practical implications of implementing the concept at different levels. The resultant outcome is that even the integration of identified line departments to be involved in water resource management at state level has become difficult proposition. To address the emerging issues a new approach namely Participatory Community Management of River Basin will be tried. The negotiated approach is a variant of conventional IRBM. It is aimed at creating space for negotiation, including with local stakeholders, on river basin management options. The negotiated approach calls for the reverse, allowing local actors to develop basin management plan and strategies specific to their local context, which are then incorporated in the larger basin management plan. This allows their knowledge to influence regional and national decisions and feel sense of ownership, responsibility and accountability towards the change in the management and implementation system. This will ultimately result in a truly participatory bottom-up process of policy development and management.

Based on the learning's from the above review of experiences in Rajasthan the CEDSJ will try to adopt a new approach of Participatory Community Management of River Basin. It is planned to have two associated partner NGOs namely Gramin Navyuvak Mandal Laporia (GVNML) and Gramodaya Samajika Sansthan (GSS) as field level implementation partners to facilitate, i.e., community mobilization, formation of River Basin Organisation in the Mashi sub-Basin starting from Grampanchayat, micro watershed and sub-Basin level, Undertake capacity building activities jointly with CEDSJ in order to prepare IWRM plans. The information generated in this study with the input from Hydrologist or Hydro-geologist and Remote sensing expert etc. to map the land, water (water bodies and drainage system) and other natural resources in the Sub-Basin based on IWRM approach and document changes/obstructions caused in the sub-basin hydrological system by people, development agents and development activities by the State, will form the basis for capacity building training modules. Trainings will be imparted to the three group members, i.e., Stakeholder Group, Technical support Group and Public Representatives Group as shown in the organogram.

6.4 Future Plan- Formation of Mashi River Basin Parliament

Mashi River basin Parliament will be constituted after discussion with the three group members. The process of formation will start from below with capacity building trainings of all the stakeholders. The constitution and working procedures of the Parliament will be formulated in the stakeholder meetings though the draft document and that will be prepared by CEDSJ based on the review of community based organisations working in different parts of India. The experience of Tarun Bharat sangh of Arvari River Parliament and its working of 20 years will also be considered.

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ANNEXURE 1

A BRIEF REVIEW OF SUSTAINABLE LIVELIHOOD FRAMEWORK

(A) Sustainable Livelihoods Framework

The Sustainable (Rural) Livelihoods Framework (SLF) was developed in the late 1990s and then widely promoted by the UK's Department for International Development (DFID). It quickly became widely used by all the major development organisations. Responding to earlier narrow visions of livelihoods (focused on economic or, even more narrowly, on financial aspects), the SLF defines a set of capabilities or assets, on the basis of which people construct their livelihoods (Figure 1). These assets and capabilities are commonly grouped under five headings:

- **Human**, e.g. education, formal and informal skills, health.
- **Natural**, e.g. natural resources such as farming and grazing land, forests and non-timber products, wildlife, and water.
- **Physical**, e.g. shelter, infrastructure such as roads and transport, buildings, irrigation systems, and productive assets such as seed, tools, livestock, fishing gear and other farm and processing equipment.
- **Financial**, e.g. cash income and remittances, credit, savings in kind and cash.
- **Social**, e.g. formal and informal institutions (including markets), associations (e.g. water users and savings and credit associations), extended families, and local mutual support mechanisms.

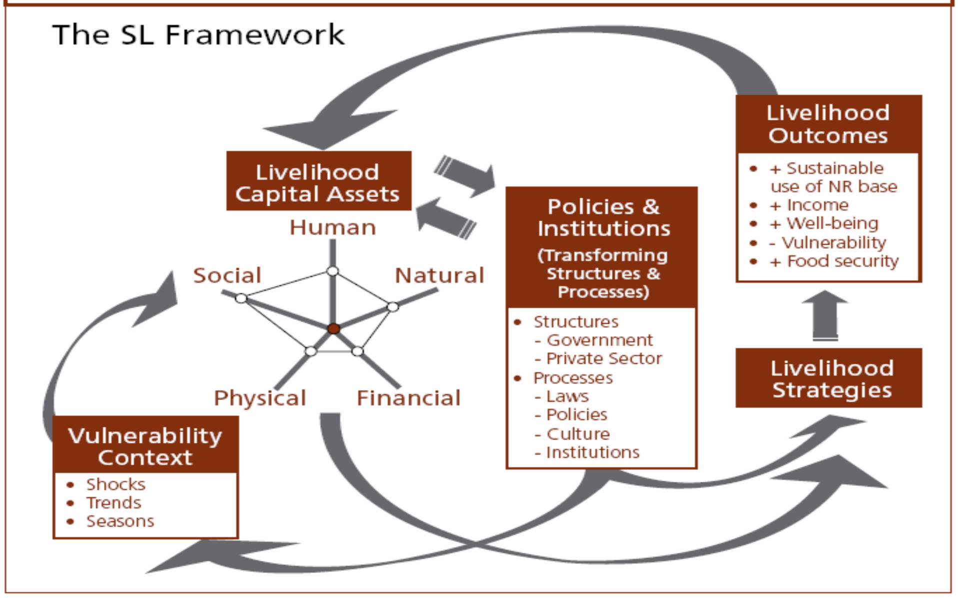
A livelihood can be considered sustainable when it 'can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base' (Chambers and Conway, 1992). The framework highlights the potential impact of policies, institutions, structures and processes on a household's assets and its vulnerability context, thus determining the livelihood strategy and outcomes achieved by a household (or other unit of analysis). Problems with the implementation of the SL framework have included:

- The five assets are intended to provide a multi-faceted view of livelihoods; however, many studies focus too much on collecting information for each asset at the expense of integrating the information (for which no agreed mechanism exists), resulting in a fragmented rather than a holistic understanding of impacts on livelihoods.
- Some users felt that certain aspects of livelihoods were not sufficiently captured by the five assets and added political, cultural, personal and/or organisational ones.

- The framework was originally designed for use at household level. It is now frequently also used at community level, which raises issues about how the 'assets' are defined at this level.
- Furthermore, how local-level processes are related to the national policy level is difficult to show using the framework.

In response to a view that the poor had actually been lost from view through too much focus on the asset pentagon, and a concern that the essential linkages between different elements of the framework were not represented effectively by DFID's diagram, the International Fund for Agricultural Development (IFAD) elaborated a new SL framework diagram (Hamilton-Peach and Townsley, 2004). Importantly, this also incorporated the aspirations of the poor and the opportunities they perceive for change, as well as indicating that 'the poor' are not a homogenous group, but differ by age, gender, class, etc.

Figure 1. DFID's Sustainable Livelihoods Framework diagram



Source: http://www.chronicpoverty.org/toolbox/Livelihoods.php

While DFID itself no longer explicitly promotes use of the SL framework, many other organisations have adapted it or developed their own definitions and approaches, which can easily be mapped onto the SL framework. All these cases include an explicit focus on 'political' systems, which was subsumed under 'social' assets in the original SL framework. Overall, application of the SL framework currently ranges from a very simplistic reference to the five assets to attempts to engage with the more complex reality displayed in the IFAD diagram.

(B) Causal models and 'theory of change'

A causal model is a form of conceptual framework with a focus on describing cause–effect relationships. Also known as a 'theory of change' model, this is a 'theory-based evaluation tool that maps out the logical sequence of means-ends linkages underlying a project and thereby makes explicit both the expected results of the project and the actions or strategies that will lead to the achievement of the results' (GEF, 2009). The advantage of a causal model is that it explains how an intervention can give rise to specific outcomes and impacts, thus tackling the issue of attribution. Richards (2008) notes that causal models are commonly used in the microfinance sector, which has the advantage of being able to draw on a large body of econometric research showing how social outcomes are correlated with poverty reduction. One reason for using causal models is that, by outlining the process by which impacts are expected to be achieved, they can help to assess impacts of interventions that are too recent for long-term impacts to be evident. They are therefore potentially useful for environmental projects, the impacts of which occur slowly and may be difficult to measure directly. This is the model used for many social assessments of conservation initiatives.

Global Environment Facility (GEF) projects, leading the GEF Evaluation Office to produce a draft practitioner's handbook (GEF, 2009) on what it terms 'Review of Outcomes to Impacts' (ROtI). The ROtI's theory of change approach allows for an 'assessment of the logical process linking outcomes to impact, which is realistic to achieve during short evaluation missions, and provides a potentially robust indirect measure of the ultimate impact' (GEF, 2009). While the causal models in the reviewed studies were all locally specific, there are more generic causal model frameworks. One of these is the 'Driving forces – Pressure – State – Impact – Response' (DPSIR) framework, an extension of the PSR (Pressure-State-Response) model, developed by Anthony Friend in the 1970s, and subsequently adopted by many European and international organisations for reporting on relationships between the environment and the economy (Yangang Xing *et al.*, undated). The DPSIR framework has been modified for use in the Millennium Ecosystem Assessment (MEA) and has also been proposed to the UN General Assembly for the global reporting and assessment of the state of the marine environment, including socio-economic aspects (UNEP and IOC-UNESCO, 2009). The DPSIR framework is used for organising information about the complex chain of cause-and-effect in the interactions between society and the environment and consists of several components.

In this framework *Driving forces* refer to economic, technological, social and even natural (e.g. temperature trends) factors that shape human activities exerting *pressures* on the environment. The *pressures* are the specific ways that human activities lead to changes in the *state* of the environment and *impacts* on valued parts of ecosystems or on society. Impacts may trigger *responses* from regulating authorities or the private sector (UNEP and IOC-UNESCO, 2009). A DPSIR framework could be developed at the level of a protected area system or an individual protected area. As discussed above for causal models, a DPSIR cause–effect framework can be useful in helping to identify priorities and find the most efficient response measures. The attraction of the DPSIR is that it draws attention to drivers and pressures at various scales, including within and outside a protected area and might, therefore, assist in visualising the relative importance of the protected area versus other drivers and pressures affecting livelihoods in a locality.

As with the SL framework, it is possible to identify a number of advantages and disadvantages of a causal model in relation to rapid assessment of social impacts of protected areas:

- Can help to overcome the attribution issue by describing expected links between the protected area and specific livelihood (and other) outcomes and impacts.
- Highlights the external drivers and pressures that may contribute (possibly more than the protected area itself) to the perceived social impacts.
- Provides an understanding of the process by which particular impacts are achieved (and often the key actors involved), making it easier to identify interventions to achieve desired change.
- Focuses on intended impacts and may, therefore, not uncover unexpected impacts.
- Methodologies, such as development of logical frameworks or problem trees, require skilled facilitation if process is to be truly participatory and understood by local communities.
- Difficult to use in retrospect.
- Fairly broad-brush approach – not easy to determine socially disaggregated impacts.
- If locally specific, then difficult to compare between sites or aggregate upwards.

(C) Millennium Ecosystem Assessment framework

Another conceptual framework of relevance for the current study is that developed by the Millennium Ecosystem Assessment (MEA). It splits ecosystem services into supporting, provisioning, regulating and cultural services and then indicates how these four attributes relate to different aspects of human well-being. Well-being is defined as having 'multiple constituents, including basic material for a good life, freedom of choice and action, health, good social relations, and security' and being 'at the opposite end of a continuum from poverty' (Millennium Ecosystem Assessment, 2005). While there is a clear overlap between protected areas and ecosystems in the services they provide, protected areas with their associated management and governance structures and arrangements and cultural institutions are more than 'just' ecosystems. The MEA framework is particularly useful, in combination with a livelihoods framework, as a means for taking a more detailed look at impacts on different aspects of natural assets. Based on the preceding discussion about conceptual frameworks, Figure 2 attempts to capture these issues in a slightly modified sustainable livelihoods framework. It includes the usual five assets of the original DFID version, with 'natural' assets being broken down (as in the Millennium Ecosystem Assessment) into provisioning, regulating and supporting services (cultural services – also included in the Millennium Ecosystem Assessment – are included under 'social' assets). Physical assets are broken down into built assets (e.g. housing) and non-built assets (e.g. the luxury goods). A sixth addition is the 'political/legal' asset, reflecting in part the focus on rights of both the rights-based approach as well as the latter's focus on empowerment. The different sets of assets and related opportunities together help determine livelihood strategies taken by individuals, households and even communities. As in the original sustainable livelihoods framework, decisions are also influenced by the vulnerability context and by other external drivers such as policies, institutions and markets. Note that the diagram does not represent any causal relationships and is simply a check-list of issues to be considered when developing a conceptual framework.

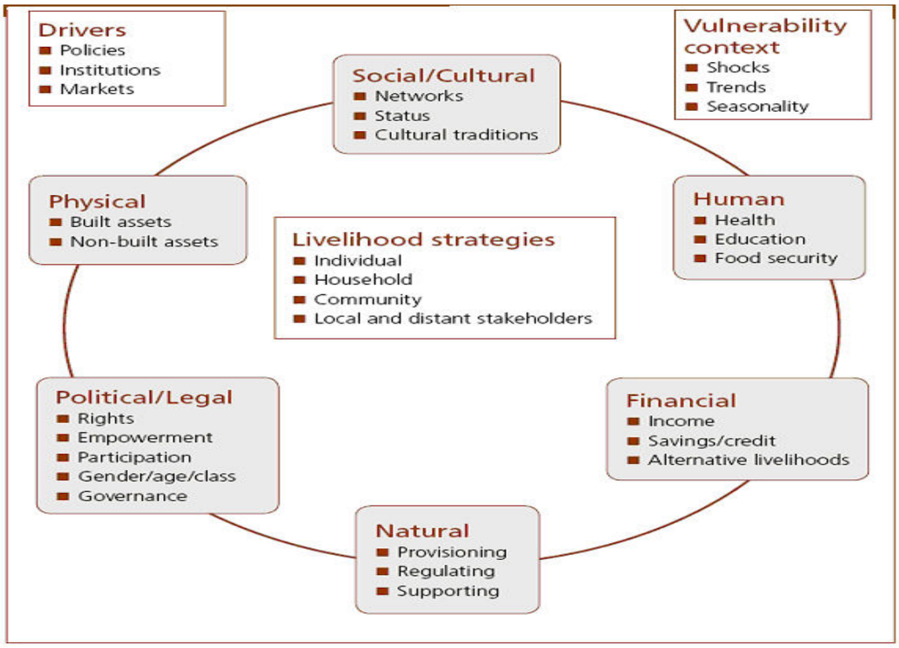


Figure 2: Modified Sustainable Livelihoods Framework

ANNEXURE II

BREIF FINDINGS OF IPCC REPORTS

The Third Assessment Report of Working Group II of the Intergovernmental Panel on Climate Change (IPCC) predicted that climate change would impose significant stress on resources throughout Asia. The IPCC's Fifth Assessment Report (AR5) considers new evidence of climate change based on many independent scientific analyses from observations of the climate system, paleoclimate archives, theoretical studies of climate processes and simulations using climate models and suggested for **South Asia**: Enhanced summer monsoon precipitation; increased rainfall extremes of landfall cyclones on the coasts of the Bay of Bengal and Arabian Sea. The summary of other observations is as follows:

Confidence in precipitation change averaged over global land areas since 1901 is low prior to 1951 and medium afterwards. Averaged over the mid-latitude land areas of the Northern Hemisphere, precipitation has increased since 1901 (medium confidence before and high confidence after 1951). For other latitudes area-averaged long-term positive or negative trends have low confidence.

Changes in many extreme weather and climate events have been observed since about 1950. It is very likely that the number of cold days and nights has decreased and the number of warm days and nights has increased on the global scale6. It is likely that the frequency of heat waves has increased in large parts of Europe, Asia and Australia. There are likely more land regions where the number of heavy precipitation events has increased than where it has decreased. The frequency or intensity of heavy precipitation events has likely increased in North America and Europe. In other continents, confidence in changes in heavy precipitation events is at most medium.

Human influence on the climate system is clear. This is evident from the increasing greenhouse gas concentrations in the atmosphere, positive radiative forcing, observed warming, and understanding of the climate system. Human influence has been detected in warming of the atmosphere and the ocean, in changes in the global water cycle, in reductions in snow and ice, in global mean sea level rise, and in changes in some climate extremes. This evidence for human influence has grown since AR4. It is *extremely likely* that human influence has been the dominant cause of the observed warming since the mid-20th century.

Continued emissions of greenhouse gases will cause further warming and changes in all components of the climate system. Limiting climate change will require substantial and sustained reductions of greenhouse gas emissions.

Global surface temperature change for the end of the 21st century is *likely* to exceed 1.5°C relative to

1850 to 1900 for all RCP scenarios except RCP2.6. It is *likely* to exceed 2°C for RCP6.0 and RCP8.5, and *more likely than not* to exceed 2°C for RCP4.5. Warming will continue beyond 2100 under all RCP scenarios except RCP2.6. Warming will continue to exhibit interannual-to-decadal variability and will not be regionally uniform.

It is virtually certain that there will be more frequent hot and fewer cold temperature extremes over most land areas on daily and seasonal timescales as global mean temperatures increase. It is very likely that heat waves will occur with a higher frequency and duration. Occasional cold winter extremes will continue to occur.

WATER: Changes in the global water cycle in response to the warming over the 21st century will not be uniform. The contrast in precipitation between wet and dry regions and between wet and dry seasons will increase, although there may be regional exceptions.

Globally, it is likely that the area encompassed by monsoon systems will increase over the 21st century. While monsoon winds are likely to weaken, monsoon precipitation is likely to intensify due to the increase in atmospheric moisture. Monsoon onset dates are likely to become earlier or not to change much. Monsoon retreat dates will likely be delayed, resulting in lengthening of the monsoon season in many regions.

The most recent and most comprehensive analyses of river runoff do not support the IPCC Fourth Assessment Report (AR4) conclusion that global runoff has increased during the 20th century. New results also indicate that the AR4 conclusions regarding global increasing trends in droughts since the 1970s are no longer supported.

Changes of average precipitation in a much warmer world will not be uniform, with some regions experiencing increases, and others with decreases or not much change at all. The high latitude land masses are *likely* to experience greater amounts of precipitation due to the additional water carrying capacity of the warmer troposphere. Many mid-latitude and subtropical arid and semi-arid regions will *likely* experience less precipitation. The largest precipitation changes over northern Eurasia and North America are projected to occur during the winter.

The comparison between the four previous reports highlights the evolution in our understanding of how the climate system responds to changes in both natural and anthropogenic forcing and provides an assessment of how the projections compare with observational estimates.

Since the AR4, there is some new limited direct evidence for an anthropogenic influence on extreme precipitation, including a formal detection and attribution study and indirect evidence that extreme precipitation would be expected to have increased given the evidence of anthropogenic influence on various aspects of the global hydrological cycle and high confidence that the intensity of extreme precipitation events will increase with warming, at a rate well exceeding that of the mean precipitation. In land regions where observational coverage is sufficient for assessment, there is medium confidence that anthropogenic forcing has contributed to a global-scale intensification of heavy precipitation over the second half of the 20th century.

South Asia : Enhanced summer monsoon precipitation; increased rainfall extremes of landfall cyclones on the coasts of the Bay of Bengal and Arabian Sea.

TS.5.8.3 El Niño-Southern Oscillation

There is high confidence that the El Niño-Southern Oscillation (ENSO) will remain the dominant mode of natural climate variability in the 21st century with global influences in the 21st century, and that regional rainfall variability it induces likely intensifies. Natural variations of the amplitude and spatial pattern of ENSO are so large that confidence in any projected change for the 21st century remains low. The projected change in El Niño amplitude is small for both RCP4.5 and RCP8.5 compared to the spread of the change among models

SPM 1.1 Observed changes in the climate system

Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, and sea level has risen. *{1.1}*

SPM 1.2 Causes of climate change

Anthropogenic greenhouse gas emissions have increased since the pre-industrial era, driven largely by economic and population growth, and are now higher than ever. This has led to atmospheric concentrations of carbon dioxide, methane and nitrous oxide that are unprecedented in at least the last 800,000 years. Their effects, together with those of other anthropogenic drivers, have been detected throughout the climate system and are *extremely likely* to have been the dominant cause of the observed warming since the mid-20th century. *{1.2, 1.3.1}*

SPM 2. Future Climate Changes, Risks and Impacts

Continued emission of greenhouse gases will cause further warming and long-lasting changes in all components of the climate system, increasing the likelihood of severe, pervasive and irreversible impacts for people and ecosystems. Limiting climate change would require substantial and sustained reductions in greenhouse gas emissions which, together with adaptation, can limit climate change risks. *{2}*

SPM 2.2 Projected changes in the climate system

Surface temperature is projected to rise over the 21st century under all assessed emission scenarios. It is *very likely* that heat waves will occur more often and last longer, and that extreme precipitation events will become more intense and frequent in many regions. The ocean will continue to warm and acidify, and global mean sea level to rise. *{2.2}*

SPM 2.3 Future risks and impacts caused by a changing climate

Climate change will amplify existing risks and create new risks for natural and human systems. Risks are unevenly distributed and are generally greater for disadvantaged people and communities in countries at all levels of development. *{2.3}*

SPM 3. Future Pathways for Adaptation, Mitigation and Sustainable Development

Adaptation and mitigation are complementary strategies for reducing and managing the risks of climate change. Substantial emissions reductions over the next few decades can reduce climate risks in the 21st century and beyond, increase prospects for effective adaptation, reduce the costs and challenges of mitigation in the longer term and contribute to climate-resilient pathways for sustainable development. *{3.2, 3.3, 3.4}*

SPM 3.1 Foundations of decision-making about climate change

Effective decision-making to limit climate change and its effects can be informed by a wide range of analytical approaches for evaluating expected risks and benefits, recognizing the importance of governance, ethical dimensions, equity, value judgments, economic assessments and diverse perceptions and responses to risk and uncertainty. *{3.1}*

SPM 3.2 Climate change risks reduced by mitigation and adaptation

Without additional mitigation efforts beyond those in place today, and even with adaptation, warming by the end of the 21st century will lead to high to very high risk of severe, widespread and irreversible impacts globally (*high confidence*). Mitigation involves some level of co-benefits and of risks due to adverse side effects, but these risks do not involve the same possibility of severe, widespread and irreversible impacts as risks from climate change, increasing the benefits from near-term mitigation efforts. *{3.2, 3.4}*

SPM 3.3 Characteristics of adaptation pathways

Adaptation can reduce the risks of climate change impacts, but there are limits to its effectiveness, especially with greater magnitudes and rates of climate change. Taking a longer term perspective, in the context of sustainable development, increases the likelihood that more immediate adaptation actions will also enhance future options and preparedness. *{3.3}*

SPM 4. Adaptation and Mitigation

Many adaptation and mitigation options can help address climate change, but no single option is sufficient by itself. Effective implementation depends on policies and cooperation at all scales and can be enhanced through integrated responses that link adaptation and mitigation with other societal objectives. *{4}*

SPM 4.1 Common enabling factors and constraints for adaptation and mitigation responses

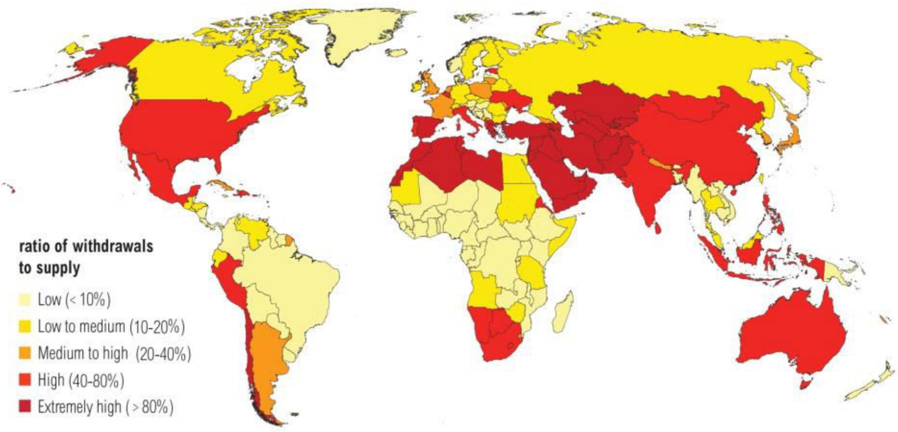
Adaptation and mitigation responses are underpinned by common enabling factors. These include effective institutions and governance, innovation and investments in environmentally sound technologies and infrastructure, sustainable livelihoods and behavioural and lifestyle choices. *{4.1}*

SPM 4.4 Policy approaches for adaptation and mitigation, technology and finance

Effective adaptation and mitigation responses will depend on policies and measures across multiple scales: international, regional, national and sub-national. Policies across all scales supporting technology development, diffusion and transfer, as well as finance for responses to climate change, can complement and enhance the effectiveness of policies that directly promote adaptation and mitigation.

The Asian region is home to more than 60% of the world's population; natural resources are already under stress, and the resilience of most sectors to climate change is poor. Many countries are socio-economically dependent on natural resources such as water, forest, grass-land and rangeland, and fisheries, and changes to these resources as a result of climate change will have far-reaching implications. For example, food and fiber, biodiversity, water resources, coastal ecosystems and human settlements in South Asia are thought to be highly vulnerable to climate change. The impacts of climate change are expected to vary significantly across the different sub-regions and countries of Asia and certain countries will be able to cope better than others. The Least Developed Countries (LDCs), which are already struggling to tackle issues of poverty, health and education, are expected to be among the most vulnerable to climate change and extreme events because of their lack of economic strength, low level of institutional capabilities and greater dependence on climate sensitive resources. It is vital that realistic measures for adapting to climate change are developed for these vulnerable countries and integrated into their wider development agenda. Recognizing that climate change phenomena will seriously affect and alter the distribution, type and quality of natural resources of the country and the associated livelihoods of the people attempt was made to look at micro level the impact of climate change and how people cope or adapt it in a small area of Rajasthan.

Water Stress by Country: 2040



NOTE: Projections are based on a business-as-usual scenario using SSP2 and RCP8.5.

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