An Institutional Analysis of Rainwater Harvesting Technologies in the 'Commons': A study of select areas in Rajasthan

Thesis submitted to the Jawaharlal Nehru University for the award of the degree of

DOCTOR OF PHILOSOPHY

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CERTIFICATE

This is to certify that the thesis entitled **"An Institutional Analysis of Rainwater Harvesting Technologies in the 'Commons': A study of select areas in Rajasthan"** submitted by Anushree Singh, Centre for Studies in Science Policy, School of Social Sciences, Jawaharlal Nehru University, New Delhi-110067, India in fulfilment of the requirements for the award of the degree of Doctor of Philosophy, is her original work and has not been previously submitted for any degree in this or any other university.

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I declare that the thesis entitled "**An Institutional Analysis of Rainwater Harvesting Technologies in the 'Commons': A study of select areas in Rajasthan**" submitted by me for the award of the degree of **Doctor of Philosophy** of Jawaharlal Nehru University is my original own work. The thesis has not been submitted for any other degree of this University or any other university.

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Dedicated to my daughter Sanghavi

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LIST OF ABBREVIATIONS

CGWB	**Central Ground Water Board**
CPR	**Common Property Resource**
IGNP	**Indira Gandhi Nahar Project**
LOCA	**Logic of Collective Action**
NGO	**Non Government Organisation**
NIE	**New Institutional Economics**
NTFP	**Non Timber Forest Production**
OPR	**Open Access Resource**
PD	**Prisoner's Dilemma**
PWD	**Public Works Department**
RWHS	**Rainwater Harvesting System**
TBS	**Tarun Bharat Sangh**
TOC	**Tragedy of the Commons**
UIT	**Urban Improvement Trust**
WOTR	**Watershed Organisation Trust**

Glossary

Aagaar- place where water gets collected

Aagaur- catchment area

Abadi-deh- residential site

Apara- drain outlets

Banjar- fallow land

Banjarkadim- common fallows

Barani- land irrigated by canal

Bhaichara- brotherhood

Bhoodan/gramdan- land gift

Darbar- court

Dewan- chief administrative officer of Mughal period

Ghair- Dakhilkars- tenant at will

Ijara- is an exchange transaction in which a known benefit arising from a specified asset is made available in return for a payment, but where ownership of the asset itself is not transferred

Jagir- was a type of feudal land grant bestowed by a monarch to a feudal superior in recognition of his administrative and military service

Jagirdar- a conditional jagir required in reciprocity from the beneficiary some form of public service such as levying and maintaining of troops for the State and is liable to land revenue to the State

Jal-bharao- place where water gets filled

Juhana- process of joining of stones in the talaab

Kamdars- Government servant

Kanungo- a person who measures the land and has detail records of land

Khalsa-State's property

Kharif- monsoon crops in India

Khatedar- tenants in the cultivator possession of their lands

Kheep- is a rangeland shrub in Western Rajasthan (Leptadenia pyrotechnica)

Khel- small tanks near wells for collection of water

Khudkasht- cultivator culivationg on his own land

Khudkasht- cultivator is the land owner

Khurra- barriers in talaab

Lambardar- title which applies to powerful families of zamindars in a village or town

Mahalwari- land was divided into mahal. Each mahal comprised of one or more villages.

Ownership rights were vested with peasants

Malikala- primary owner

Malikan-deh- body of shareholders of village lands

Maurusi- hereditary

Meum- mine

Milkiyat Sarkar

Muafi- revenue free land

Muafidar- a person holding land under the State granted to him

Muqarari Riaya- enjoyed the right of settling cultivators as tenants on his surplus lands known as muzariah

Muzarian- those who belonged to the same village but who did not have land and were dependent on khudkasht for their supply

Nahri- unirrigated land

Nail/gul- outlet

Nazrana- gift/present

Neshta- part of talaab which protects the paal

Paal- boundary of talaab

Pacca- made of bricks

Pahikasht- cultivator is not land owner

Patta- a title deed to a property

Rabi- crops sown in winter season in India

Rahat- Persian wheel for pulling water out of well

Rayatwari- ownership rights were vested with peasants. The British Government collected taxes from peasants

Riaya/raiyat-someone who has acquired a right to hold land for the purpose of cultivating it whether alone or by members of his family, hired servants or partners

Rozinadar- daily-wage workers

Sakin-deh- resident of village (new entrant)

Sailab-

Sasan- land carved out for religious institutions

Shamilat- common land

Shamilat-deh- body of shareholders of village (same as malikan-deh)

Shramdan- voluntary labour

Sirkars- government

Suba- province

Tahsil- an administrative area in different parts of India

Tahsildar- tax collector

Tazimi- a person who enjoyed respect in the Royal Court

Tum- yours

Zamindar- a landowner specially who leases land to tenant farmers

Chapter 1

Introduction

1.1. Background and Motivation

Water is considered an important natural resource which has diverse socio-religious uses. It has economic importance in India as agriculture in India is dependent on rainfall. India is diverse in ecology and climate.Water is an essential necessity of life and is used in many different ways for several purposes. There has been increasing freshwater scarcity in the arid as well as temperate climatic zones of the world. The primary reason for lack of water is annual fluctuations in precipitation due to monsoon rainfall. Other reasons for lack of rainfall are low water storage capacity, low infiltration and high evaporation demand (Sivanappan 2006). Therefore, to attain water security there has been shift from centralised management of water to decentralised community based practices of water harvesting which means revival of rainwater harvesting practices which got decayed in last few centuries.

India lies in tropical/sub-tropical zones of the world that receive seasonal rainfall. Rainfall in India is concentrated in four months of the year and does not occur daily; it is also not evenly spread over a period of 24 hours as opposed to temperate countries like the UK and North America where rainfall occurs throughout the year. Precipitation throughout India varies from 100 millimetres to 15,000 millimetres. Water has multiple uses, for irrigation, drinking water, bathing, washing, groundwater recharge etc. and it becomes essential to harvest rainwater especially at places where there occurs very less amount of rainfall. The reason for harvesting of water also varies with variation in rainfall. In very dry parts of India, where average annual rainfall is 100 mm, where agriculture is not the mainstay of economy, rainwater needed to be harvested mainly for domestic uses and drinking. In other parts, for instance in coastal areas, ensuring water availability throughout the year for agriculture is the major concern. Increasing evidences are emerging how varied patterns of design and governance of water harvesting systems in India took root to cater to such diverse requirement of water and diversity in topography of region.

RWH is, however, a ‘Dying Wisdom’ in India, reflecting the fact that knowledge of the management and technology of RWH has not been preserved (Agarwal & Narain 1997).

There have been recent attempts by Non-Government Organisations (NGOs) to revive the unpreserved knowledge of RWH in many parts of India like Tarun Bharat Sangh, Alwar and Gram Vikas Navyuvak Mandal Lapodia, Jaipur, Rajasthan. There are many NGOs who work on natural resources management sector such as WOTR Maharashtra, Sadguru Foundation Gujarat, Arghyam Karnataka. Many of these RWHS are considered as CPRs. However, failure continues to intrigue research scholars. One wonders why a body of knowledge, so successful for centuries, was left unused during and after the British regime?

Extensive work, primarily motivated by Elinor Ostrom now establishes the complexity of institutional arrangements required to preserve common pool resources. Ostrom (1990) argues that the key mechanism to sustain Common Property Resources (CPRs) is communication between individuals. This ensures collective efforts to overcome free riding, and helps avoidance of destruction of those CPRs. Participation of individuals in provisioning of CPR, in Ostrom's (1990) framework, is guided by a complex calculation of discount rates by the concerned *individuals*. Such a view, however, has drawn criticism from various scholars. Gudeman and Rivera (2001), for instance, note that such an 'individualistic' framework undermines the fact that commons is embedded in a community of shared and indivisible knowledge, experiences and interrelationships. Guha (1982: 18) also argues in the context of colonial India that "the notion of community continued to act as a live force in the "*Consciousness* of the peasantry", perhaps weakening the basis of such individualistic calculations of discount rates proposed in the framework developed by Ostrom. The literature motivated by Ostrom discusses five (access, withdrawal, management, exclusion and alienation) bundle rights to define rights on properties. Embree (1969), on the other hand, argues that layers of rights existed on property in India, making it often difficult to segregate different kinds of rights by different people. Indeed, such misunderstanding was, perhaps the reason behind the promulgation of The Permanent Settlement Act, where zamindars were wrongly assumed to be the ultimate owners of an estate. Finally, the framework developed by Ostrom (1990) points out that a blending of various kinds of knowledge is important for reducing the uncertainties for governance of CPR. However, the problems in blending such diverse knowledge systems are left unexplained in Ostrom's framework. In fact, the perceived superiority of the modern western knowledge by the British administration is often cited as the key reason for the decay of much of these local knowledge based technological

systems. Clearly, the blending between different kinds of knowledge never took place the way Ostrom would have liked.

If one considers the recent debates on plurality of knowledge (Berkes & Turner 2006), one can safely argue that the literature on CPR treated the whole issue of knowledge in a rather simplistic manner. It was based on the once dominant discourse on knowledge, which treated scientific knowledge to be rational, sequential and, therefore, superior to local knowledge, which was considered to be experiential and simultaneous. In the fields of ecological knowledge, at least, it is now well established that such hierarchies do not carry much meaning, and filed experience based local knowledge at times are more effective than laboratory based modern scientific knowledge (Dusek 2006).

The present research is an attempt to provide a more comprehensive, institutional perspective on the decay of these complex bodies of technological systems during the last two centuries.

It has been argued that technology[1] cannot be understood in isolation; rather, it must be seen in relation to the community and its practices (Layton 1974). Institutions play an important role in shaping the knowledge of the system (Lam 2000). Its production involves the application of physical and social technologies, which, in turn, requires the mediation of institutions (Eggertson 2009). This way, knowledge, technology, and institutions are interlinked. It is, therefore, important to understand the way various technological and institutional interventions have been taking place regarding water governance, and how prevailing power structures have shaped these processes. Our research will discuss the notion of commons in India and how knowledge was shared, stored and disseminated for maintenance of commons. For the present study we focus on Alwar and Bikaner districts, in Rajasthan, India.

1.2. Brief Overview of Rainwater Harvesting technological practices in India

Rainwater harvesting has been practiced in several parts of the world in different forms depending upon the climate of the region since ancient times. Previously, water harvesting was used for arid and semi-arid areas but recently the use has been extended to sub-humid

1 Knowledge and technology are used interchangeably.

and humid regions too. Rainwater harvesting means capturing the rain or direct collection of rainwater where it falls and store that water for direct use or recharging the groundwater (Julius et al 2013). It can be undertaken through a variety of ways, capturing run-off from roof tops, capturing run-off from catchments, capturing seasonal floodwater from local streams, conserving water through watershed management. Harvesting rainwater has several functions, providing water to people and livestock, raising food and cash crops, increasing groundwater recharge, reducing storm water discharges. Some variables which determine the patterns of usage for rainwater harvesting are, total rainfall quantity, rainfall pattern, collection surface area, daily consumption rate, number of users, user demands from men and women, socio-economic differences in demand, and cost of the system (John M Bugua http://www.samsamwater.com/library/TP40_7_Rain_water_harvesting.pdf) <DOA 1/09/2015>.

The locally developed RWHS were supported by a system of property rights and social norms in India. Croplands were private property while grasslands, tree lands, tanks and ponds were largely community property and common rules were set by the villagers to manage these systems (Agarwal & Narain, 1997). The desire of the British to exploit the natural resources of the country also affected the water management systems built by the rural communities. Their policies were based on Britain's natural resources policy where water harvesting was not required probably because of temperate rainfall pattern in The UK. With the introduction of private property in land in the British period, village headmen and the State appropriated for themselves the ownership of soil which led to sale of peasant's land for revenue and peasants had to surrender their traditional duties to bureaucracies which led to decline in knowledge of management of water harvesting systems (Agarwal & Narain 1997).

The Indian government policies after Independence were also based on Britain's natural resources policy. This led to gradual decay of knowledge in the communities of RWHS. There have been recent attempts by the government, Non-Government Organisations, and local communities to revive these systems whose knowledge has decayed in last century (Agarwal & Narain 1997). The Citizen's Report (Agarwal & Narain 1997: 25-28) gives a detailed description of the traditions of various types of harvesting of water in different parts of India. Depending on the sources available to people, they have developed a wide range of techniques to harvest all possible forms of water. For instance, in arid and semi-arid regions where water in streams was more seasonal and scarce round the year, the

diversion channels were directed into a storage structure, called *zing* in Ladakh, an *ahar* in south Bihar, or a *kere* in Karnataka, so that water could be used in dry periods for human and animal consumption and for agriculture. The people of Northeast have developed use of bamboo for developing systems for carrying water over a difficult terrain. All over the eastern Himalaya and north-eastern hill ranges people continue to build simple bamboo pipelines to carry water from natural springs to a convenient point where it can be used for drinking. The decision whether to store or recharge rainwater depends on the rainfall pattern and the potential to do so in a particular region. Delhi, Rajasthan and Gujarat are example of places where groundwater recharging is practiced. In places like Kerala, Tamil Nadu, Mizoram and Bangalore, rain water is stored (Agarwal & Narain 1997: 25-28).

1.3. Study area

Alwar falls in the semi-arid zone with an average rainfall measuring 620 mm. The temperatures vary from 0°C in winters to 49°C in summers. The region suffered one of the worst droughts in 1985-86. The water table receded below critical levels and rivers and wells dried up. Crop failure became common, the lack of vegetation led to soil degradation and monsoon run off caused soil erosion.

Alwar district is situated among the hill ranges in north eastern Rajasthan. The Aravali mountain range in western India runs approximately 482 km from northeast to southwest across the State of Rajasthan. Until the 1930s and 1940s, the Aravali range had vast forest cover. The water harvesting systems used to be practiced in Alwar till British period and few centuries later till around 1980s were *baandh*[2]*, baori*[3]*, kund*[4] *and kuan*[5] in rural Alwar as well as Alwar city. A number of water-harvesting systems ensured adequate water supply to the village community throughout the year despite low rainfall. These RWHS existed till late 1980s in Alwar. After the intervention of TBS in 1985, *johad baandh* and

2 A bank of earth, or wall of any kind, as of masonry or wood, built across a water course, to confine and keep back flowing water.

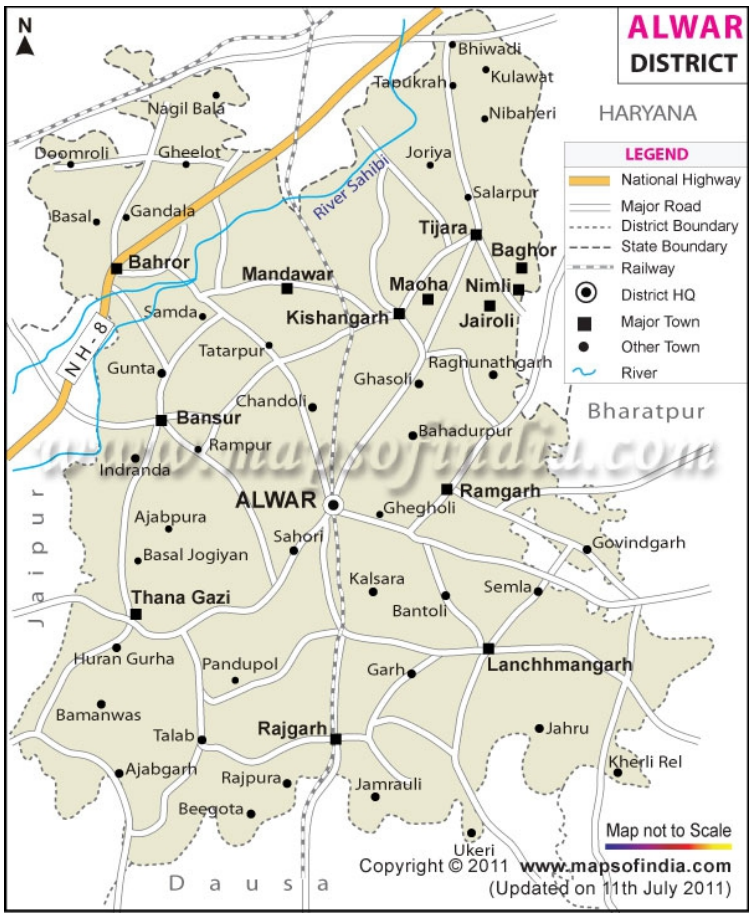
3 *Baoris* are ponds in which water is reached by descending a set of steps, in Bikaner the catchment area usually has *kund* whose outlet is connected to the *baori.*

4 *Kund* is a tank or reservoir in which rainwater is collected for drinking, water gets collected from the catchment area and is collected into the tank through a sieved inlet.

5 *Kuan* is a well with diameter of 4 to 100 *(haath)* hands.

anicut have been practiced in the rural parts of Alwar (Mathur 2009). Till date Siliserh, Vijay Sagar and Jaisamand *baandhs* provide water for domestic purposes through pipeline system of water supply.However, due to large-scale logging in later years, surface runoff increased, resulting in depletion of groundwater recharge. The field work was carried out in Alwar city and in Gopalpura, Hamirpur and Gadhbasai villages of Thanagazi tehsil of Alwar.

Figure 1.1: Tentative location of field study area in Alwar



S o u r c e : http://www.mapsofindia.com/maps/rajasthan/districts/alwar.htm <D O A : 15/05/2016>

Bikaner district is located in the north-western part of Rajasthan. The climate is arid with a high temperature and high evaporation losses. The mean annual rainfall (1971-2005) is

297.7 mm, and (1991-2010) is 277.55[6] mm whereas normal rainfall (1901-1971) is lower than the average rainfall and placed at 257.8 mm. Almost 90% of the total annual rainfall is received during the south-west monsoon, which enters the district in the first week of July and ends in September. The temperature varies from 48 degrees in summer to 1 degree in winter (Sehgal, 1972). A number of water-harvesting systems ensured adequate water supply to the village community throughout the year despite low rainfall. The RWHS practiced in Bikaner were *talaab*[7]*, baori*[8]*, kund*[9]*, kuin*[10]*, kuan*[11] till around 1980s. But with the intervention of Sutlej Valley project, 1921 the water supply to urban and rural Bikaner was gradually catered by this project which changed to Rajasthan Canal Project in the post independence period.

The total area of the district is 30247.90 square kilometres. The major part of the district is comprised of dry regions which form part of the Great India Desert of Thar. There are two natural divisions of the district name, North and Western desert and south and Eastern semi desert. At many places there shifting sand dunes. The district is devoid of any perennial stream. The construction of Gang Canal is in the western part of the district. The vegetation of Bikaner district falls under tropical forest and comprises of 812.62 square kilometres (Ministry of MSME, Government of India). The field work was carried out in Bikaner city and Gangapura, Dev Kund Sagar and Kodamdesar villages of Kolayat tehsil of Bikaner.

6 http://www.cgwb.gov.in/District_Profile/Rajasthan/Bikaner.pdf

7 *Talaab* is a rain fed *and* well designed reservoirs constructed to be deep and embanked on all four sides with high masonry walls holding enough water for the year-round. Many of these constructions are made up to five to ten metres deep and have banks for different purposes like bathing, washing, cattle, aesthetic purpose etc. The catchment area of *talaab* is usually a large area and used to have medicinal varieties of trees planted in it.

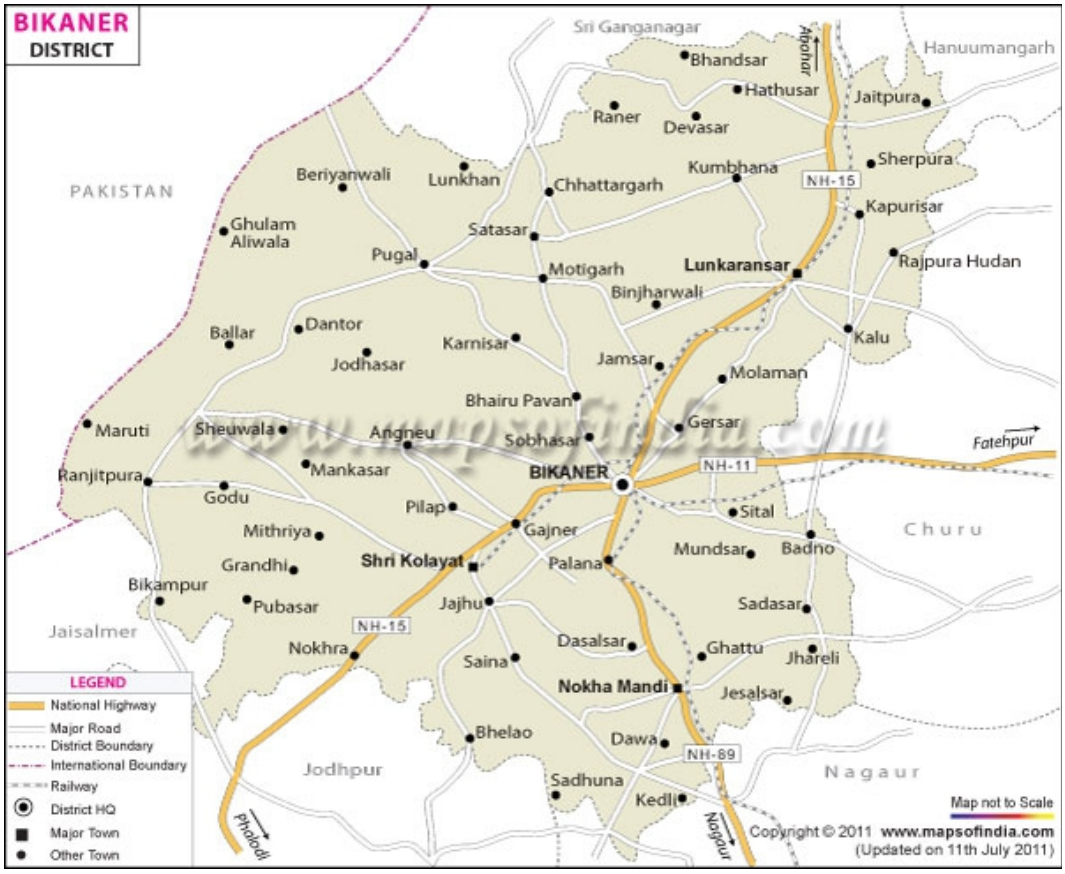
8 *Baoris* are ponds in which water is reached by descending a set of steps, in Bikaner the catchment area usually has *kund* whose outlet is connected to the *baori.*

9 *Kund* is a tank or reservoir in which rainwater is collected for drinking, water gets collected from the catchment area and is collected into the tank through a sieved inlet.

10 *Kuin* is well with a smaller diameter of 4 to 8 *(haath)* hands.

11 *Kuan* is a well with diameter of 4 to 100 *(haath)* hands.

Figure 1.2: Tentative location of field study area in Bikaner



S o u r c e : http://www.mapsofindia.com/maps/rajasthan/districts/alwar.htm <D O A : 15/05/2016>

Alwar lies in semi-arid zone of India where average rainfall occurs at 620 mm while Bikaner lies in arid zone of India where rainfall occurs at 258 mm. There have been existences of diverse RWHS in Alwar and Bikaner owing to low rainfall conditions since pre-British period. While the primary use of RWHS in Alwar had always been for irrigation, in Bikaner the RWHS is primarily used for catering daily requirements like drinking water, bathing, washing and very less amount had been in use for irrigation till the advent of Gang Canal. The understanding of knowledge of construction and maintenance of RWHS by the communities and institutions governing these RWHS in Alwar and Bikaner is the primary aim of study of the thesis.

A qualitative semi-structured interview schedule was used to collect information regarding water harvesting systems in Alwar and Bikaner districts of Rajasthan in 9 field visits. Fieldwork was carried out both in urban and rural parts of Alwar and Bikaner. Respondents were selected from diverse backgrounds, who were well experienced with the system. Key informants were academicians who had worked in the area, activists who had helped in saving the catchment areas of RWHS from encroachment and research officers and archive officers of Alwar and Bikaner State Archives. Apart from these visits, visits to Alwar State archive and Bikaner State archive helped in collecting records on water harvesting.

1.4. Research Objectives

1. To understand the dynamic nature of rainwater harvesting governance systems in Alwar and Bikaner since the onset of British rule.

2. To understand the institutional frameworks and knowledge system around RWHS and factors responsible for the decline of RWHS in Alwar and Bikaner.

3. To understand how uncertainties around knowledge, and institutional framework shaped the process of revival of RWHS.

An interview schedule was prepared to collect information from the urban and rural areas of Alwar and Bikaner related to governance of RWHS. Apart from field visits, documents related to governance of RWHS in the Bikaner State Archive and the Alwar State Archive were also consulted.

1.5. Outline of the chapters

The thesis has 7 chapters. In chapter 2 we discuss the literature on governance of natural resources with special emphasis on Elinor Ostrom's work on institutional approach for community based management of natural resources. The chapter opens with the discussion of CPR and then discusses the critique of various models (proposed by different scholars) by Ostrom for management of the Commons. This chapter also discusses the detailed aspects of community based governance of natural resources. It describes the characteristics of knowledge and an interlinkage of knowledge, technology and institutions. Chapter 3 discusses property rights in pre-independent, British and post-independent periods with special emphasis on common property resources. Chapter 4 describes how water harvesting practices decayed in India during the British period and discusses the complex ways the institutional and technological interventions shaped the practice of rainwater harvesting in pre-British, British and post independent periods in India. It also discusses the traditional rainwater harvesting practices in India which prevailed in the historic periods and prevailing practices. Chapter 5 discusses the sample, methodology and field work with special emphasis on the objectives of the study. Chapter 6 deals with the analysis of the study. Chapter 7 gives conclusion of the thesis.

Chapter 2

Governance of Commons: A Conceptual Framework

2.1. Background

A common pool resource is a natural or human made resource that is available to more than one person and subject to degradation as a result of overuse. Exclusion from a CPR[12] is costly and one person's use reduces what is available to others. CPRs face two kinds of problems. First is the problem of overuse. Second is the free-rider problem (Dietz et al 2002). There have been debates on the governance of common property resources by many scholars. The most influential article was "The Tragedy of the Commons" by Garret Hardin (1968), which stimulated debates in natural and social sciences. Subsequently, "Logic of Collective Action" by Olson (1971) and "Prisonner's Dilemma Game" followed by "Institutional Analysis for Governing the Commons" by Elinor Ostrom (1990) became the most popular works in CPR governance literature.

The Tragedy of Commons by Hardin generated debatable issues on the problem of Commons which was a fulcrum for recent work on CPRs. However scholars long before Hardin had expressed pessimism about management of these resources. Dietz (2002) notes Aristotle's work that 'what is common to the greatest number has the least care bestowed upon it. Everyone thinks chiefly of his own, hardly at all of common interest' (Dietz 2002: 8).

'The French Naturalist, Marcet (1819) wrote that open access to natural resources results in overexploitation and harvesting of the resources prior to their harvest time. Lloyd, whose work influenced Hardin, argued that a common-pool resource will be over used because present benefits of use provides more value than the possible future costs of unrestricted use. This value gets further intensified when each individual user bears only a fraction of those costs but gains the entirety of present benefits. He argues further that an individual's decisions regarding whether to withdraw another unit from CPR depends on the institutions that define the benefits and costs of such action' (Dietz 2002: 8).

12 Note that common pool resource and common property resource terms are interchangeably used.

Thematically, the literature on governance of commons can be put into two groups: one where people involved in provisioning and appropriation do not communicate with each other, and the other where communication between these people is possible for proper monitoring and provisioning activities. We have accordingly divided the literature on governance into independent action-interdependent situations and collective action-interdependent situations in this chapter. The chapter is divided in four sections. Section 2.2 describes the theories on independent action. Section 2.3 explains theories on collection action. Section 2.4 outlines the knowledge, institutions and uncertainty in CPR management

2.2. Theories of Independent action

As noted, several scholars have studied the 'governance of Commons' problem. Indeed the world of academia and politics have long debated on the issues of how to best govern natural resources used 'commonly' by many individuals. We begin our discussion with the TOC (1968) followed by PD and LOCA (1971) in this section.

The Tragedy of the Commons by Hardin (1968) states that with the increase in population, the demand for natural resources as a whole increases. Quantity of such resources naturally differs among all the resources. While none of the members put in efforts to enhance them, instead, there is tendency to free ride. Garett Hardin poses the problem of over-population by giving example of perspective of a rational herder. Each herder receives direct benefit from his animals so he is motivated to add more number of animals through time but bears only a small share of the costs of overgrazing. The general tendency to overuse common property resources is negatively pictured as to result in the Tragedy of Commons by Hardin (1968). The herders in Hardin's model of Tragedy of Commons act independently. Each one of them decide on the number of animals to put on a CPR meadow without concern for how that will affect the action of others.

In the Prisoner's Dilemma game, players can adopt either cooperate or defect. Cooperation results in benefit to the opposing player but incurs a cost to the co-operator while defection has no costs or benefits. Since the prisoners normally cannot communicate with each other in the PD game, as such and both the prisoners chose the dominant strategy[13]

13 'A strategy is dominant if regardless of what any other players do, the strategy earns a player a larger payoff than any other. A strategy is dominant if it is always better than any other strategy, for any profile of other players' actions. (www.gametheory.net/dictionary/Dominant Strategy.html, DOA 15/04/2015)

which is to non cooperate.W Then it will continue to remain the dominant strategy and there would be non-cooperation among the prisoners (Doebeli and Hauert, 2005). Every private owner will have his or her own particular stake in maintaining the balance between the resource in quantity, quality and proper use.

The Logic of Collective Action by Olson (1965) states that

"The idea that groups tend to act in support of their group interests is supposed to follow logically from widely accepted premise of rational, self-interested behaviour. In other words, if the members of some group have a common interest or object, and if they would be better off when that objective is achieved, then it has been thought to follow logically that the individuals in that group, if they were rational and self-interested, act to achieve that objective '(Ostrom 1990: 6).

Olson (1965), however, argues such a scenario is possible only when group size is small. "Unless the number of individuals is quite small, or unless there is coercion or some other special device to make individuals act in their common interest, rational, self-interested individuals will not act to achieve common or group interests" (Olson 1965). He accordingly suggests that for smaller group free rider problem is less serious. Olson (1971) argues that a group may have the motive to work together for a collective good without coercion or outside inducements. This motive depends upon the number of individuals in the group, since the larger the group, less likelihood the contribution would be.

He further quotes that 'the standard for determining whether a group will have the capacity to act, without coercion or outside inducements, in its group interest is the same for market and non-market groups: it depends on whether the individual actions of any one or more members in a group are noticeable to any other individuals in the group'[14] (Olson 1971,: 45).

14 'The noticeability of the actions of a single member of a group may be influenced by the arrangements the group itself sets up. A previously organized group might ensure that the contributions or lack of contributions of any member of the group, and the effect of each such member's course on the burden and benefit for others, would be advertised, thus ensuring that the group effort would not collapse from imperfect knowledge. He defines noticeability in terms of the degree of knowledge, and the institutional arrangements, that actually exist in any given group, instead of assuming a natural noticeability unaffected by any group advertising or other arrangements.' (Olson 1971, pp. 45-46)

He argues that the smallest type of group in which one or more members get a large fraction of total benefit, find worthwhile to see that collective good is provided even if they have to pay the entire cost and they may even get along without any group agreement. In any group larger than this no collective good can be obtained without some agreement or coordination or organization. In oligopoly sized group two or more members are supposed to act simultaneously before a collective good can be obtained and there must be some kind of tacit coordination or organization (Olson 1971). Ostrom (1990) puts that herders in a commons cannot remain so unconcerned for long about the deteriorating situation of their common resources. Their common sense will hit on sensing the coming of common tragedy for all. In Hardin's model, the herders act independently although the prevailing situation is also an interdependent one. Here each herder's action is independent of each other but the action of one has consequences on the benefit of other, hence there is interdependency on the consequences (Ostrom 1990: 29-55). In the LOCA, the problem of free-rider is less serious only for a small group . Ostrom (1990) discusses that solution of free rider problem is also possible for larger group, which is discussed in section 2.3 of the chapter.

Ostrom (1990: 1-2) has critiqued the prevailing models derived from TOC, PD and the LOCA for solving the problem of commons. She argues that all these models incorporate free-rider problem and all of these shows how individual rational users will behave in the ways not in the best interest of users collectively (Ostrom 1990, Wunderlich 1992: 240-242). Ostrom (1990) argues that whenever one person cannot be excluded from benefits that others provide, each person is motivated not to contribute to the joint efforts of others. If all participants chose to free-ride, collective benefit will not be produced. Alternatively, some may provide to joint efforts while others free-ride leading to less than optimal level of provision of collective benefit. She further argues that these models are useful for explaining how perfectly rational individuals can produce, under some circumstances, outcomes which are not rational (Ostrom 1990: 6). The constraints shown in these models are assumed to be unalterable unless external authorities change them. Ostrom (1990) addresses the question of enhancing the capabilities of the participants by changing the constraints of the game.

2.3. Theories of Collective (interdependent) action

Ostrom (1990: 2-3) states that as per Hardin's (1968) the State should control natural resources to prevent destruction and solve free-rider problem by these so-called rational

herders. Some other scholars recommend that only privatization will solve the problem. Every private owner will have his or her own particular stake in maintaining the balance between the resource in quantity, quality and proper use. Further, in the theory of the firm[15], an entrepreneur recognizes an opportunity for increasing the return which is achieved by individuals who are involved in an interdependent relationship. After that the entrepreneur negotiates a series of contracts with various participants which specify how to act in a coordinated rather than independent fashion. Each participant is free to choose to join or not to join the firm. The participants are agents of the entrepreneur. After paying each agent the entrepreneur retains residual profits or absorbs losses. In the theory of the State[16], a ruler recognizes the benefits which can be obtained by organizing some activities.

Both the theories talks about how a new institutional arrangement can come by involving an outsider, taking primary responsibility for supplying the needed changes in institutional rules for coordinating activities. Similarly how credible commitments can be made by the ruler or the entrepreneur by punishing anyone who does not follow the rules of the firm or the state. Since they gain something so it is in their interest to punish the non conformance to their rules and consequently their threats to punish are credible. It is also in the interest of the ruler or the entrepreneur to monitor the actions of the agents and the subjects to conform to their prior agreements. However both of these theories have been able to solve the problems involved in a collective-action situation in a particular way when communities are not involved in the governance of CPR (Ostrom 1990: 42). Her work suggests that the communities have traditionally relied on institutions resembling neither State nor market to govern resource systems for over long periods of time. Again, at many places problems cannot be solved by privatization or nationalization. Moreover, both these theories describe how collective action can be achieved in a particular way. As a third approach, Ostrom suggests that individuals should, over time, adopt coordinated or collective action in interdependent situations. Hence, there is a shift from independent action-

15 The theory of the firm is linked to privatization and nationalisation respectively.

16 The theory of the State is linked to nationalization.

interdependency to collective action-interdependency in Ostrom's work. This is what Ostrom, refers to 'changes in institution' which is different from nationalization and privatization but she also suggests that the State should work in co-operation with the local communities for managing the commons. The solution suggested by Ostrom is the communities who have traditionally relied on institutions for governance of CPR. The people can communicate among themselves which leads to self-organised groups where collective action situation prevails. But organising people into group and achieving collective action is not a simple task. Ostrom introduces the concept of polycentrism which suggests that local decision making groups must often be nested within State structures at a higher level. So that these higher structures can provide coercion and other resources which make local negotiation efficient. The State has four crucial roles to play in a poly-centric system:

1. To impose a solution if local parties cannot come to a negotiated agreement.
2. To provide a source of relatively neutral information to mitigate the problem of self-serving bias regarding the relevant facts.
3. To provide an arena for negotiation that facilitates low cost, enforceable agreements.
4. To help monitor compliance and sanction defection in the implementation phase.

Ostrom (1990) argues that the community can prevent destruction and solve free-rider problem by deriving institutional options. Ostrom (1990) and Dietz et al (2002) argue that if acted by the group members free rider problem can be taken care of by changing institutions for larger group as well. The process of institutional analysis includes identifying physical, cultural and institutional setting to sort out relevant participants and then determining costs and outcomes. Physical setting includes construction and maintenance of the resource while cultural setting includes the environment where the problem resides and persists. Ostrom (1999) argues that the appropriators experiment with rules trying to understand the biophysical structure of a CPR and how to affect each other's incentive so as to increase the probability of sustainable and efficient use over long term. She suggests that they have to explore and discover the biophysical structure of a particular resource which will differ on

specific parameters in different regions. The theory of institutional analysis for managing the commons by Ostrom is described in this section.

Araral (2013) notes that the second generation theories of collective action which is given by Ostrom and her colleagues challenged the first generation theories of collective action typified by Hardin's TOC, Olson's LOCA , Prisoner's Dilemma which assumed tragic outcomes in the commons. As these incorporate free-rider problem while the second generation theories do not incorporate free-rider problem. The second generation theories point to 'trust' and 'reciprocity' as core determinants of collective action in commons as well as social order.

According to Ostrom, at the most general level, the problem of CPR appropriators, is that of institutionalizing 'organization'. In other words, to change the situation from one in which appropriators act independently, to one in which they adopt coordinated action interdependently to obtain higher joint benefits and reduce joint harm. The core of organization involves sequential,[17] contingent[18] and frequency dependent decisions[19]. Almost the entire organization process is accomplished by specifying a sequence of activities which should be carried out in a particular order. Because of the repeated situations involved in organization process, individuals can use contingent strategies in which cooperation will have greater chance of evolving and surviving. Individuals frequently are willing to forego the immediate gains so that larger joint benefits can be obtained, when they observe many others following the same strategy. However switching from independent to coordinated or collective action can require high costs as the benefits produced after coordination are shared by all appropriators whether or not they share the cost.

17 Certain activities take place regularly.

18 Uncertain activities take place and follow in succession without gaps.

19 When a critical minimal set of individuals come together, organisations can draw frequency-dependent behaviour to obtain willing contributions by others.

The problems of supply of new institutions, credible commitment and mutual monitoring arise from features of CPR which is rivalry in consumption of resource units and difficulty in exclusion of resource system (Lejano 2013). In the problem of supply of new institutions, Ostrom further states that according to Bates (1988), supplying new rules of institutional arrangement is considered easier to accomplish than it is in Prisoner's Dilemma games; because people can communicate with each other, they can share their ideas. Under such a situation, supplying new rules would be easy and people can mutually derive beneficial outcomes. Supply of institutions develops credible commitment and mutual monitoring behaviours of the individuals. In this situation action of individuals are shaped by social, political and cultural factors. The shift from independent action-interdependency to collective action-interdependency in Ostrom's work is referred to as institutional change which involves analysis of nesting of rules. Lejano (2013) discusses that Ostrom offered a notion similar to theory of 'natural selection' to explain how institutional context creates different selection pressures. Actors who prosper and survive in a highly competitive setting with strong selection pressures are presumed to be selfish agents. If the same actor behaves similarly in a community, then selfish behavior is unlikely to survive in a long run. Lejano notes that for Ostrom it is the selection pressure induced by institutional context which influences motivation and behavior rather than assuming that motivation is intrinsic. Lejano (2013) further discusses that Ostrom used Agent-Based Modelling to understand how agents learn and adapt and also how institutions evolve in controlled laboratory settings. He further quotes, 'in agent-based modelling a system is modelled as a collection of autonomous decision making entities called agents. Each agent individually assesses its situation and makes decisions on the basis of set of rules. Agents may execute various behaviors appropriate for the system they represent. Repetitive competitive interactions between agents are a feature of agent-based modelling which relies on the power of computers to explore dynamics out of the reach of pure mathematical methods. Ostrom uses this modelling to study evolution of norms and formal institutions among agents in a strategic setting' (Lejano 2013: 5).

Most current analyses of CPR problems and related collective-action problems focus on single level of analysis of rules called operational level of analysis. At operational level, it is assumed that rules of game and technological constraints are given and will not change during the time frame of analysis. However both technology and rules do change over time

which adds complexity to the analysis. It is necessary to study the rule structure of the system. For understanding the rule structure of the system, difference between strategies, norms and rules should be well understood (Ostrom & Basurto 2010: 1-27). There exists fundamental distinction between strategies, norms and rules. Strategies are the plans made by individuals in a situation as to what actions people plan to undertake to achieve outcomes, given their information about basic structure of the system. Norms are prescriptions about actions or outcomes not focused on short term material payoffs to self. Rules are statements containing prescriptions similar to norms but rules contain some kind of monitoring and sanctioning activities. There are certain mechanisms for rule change according to Ostrom (2010), which can be roughly divided into self-conscious and unconscious processes of change. Among self-conscious processes of rule change, one of the processes is imitation. Imitation of rules used by others can lead to rule evolution over time in a system. Another process is external intervention when external aid support is conditioned to changes in local institutions based on views of fairness, productivity and democracy or development. Unconscious processes of change include forgetting, language loss[20], cognitive dissonance[21], technological change, or non-enforcement. These mechanisms can slowly erode rule systems over time, and new practices and norms of behaviour have to be adopted (Ostrom & Basurto 2010: 1-27).

Also, Ostrom (1999) discusses that the appropriators have to cope with uncertainty of climate, knowledge etc. and price fluctuations affecting costs of inputs and value of outcomes, in addition to physical changes that the appropriators can make in the resource; they use tools to change the structure of action situations they face. Four clusters of rules are the major tools used to affect appropriation situations in many CPRs which are boundary,

20 Language loss is a term which includes language shift (often investigated in several generations and refers to intergenerational and group process) and language attrition (refers to decreasing competence in the mother tongue of individual speakers). Language loss can be loss of dialect within dialect community, loss of native language within migrant workers, foreign language loss, language loss by aging migrants. See:<*humanidades.uprrp.edu/.../**LANGUAGE**%20**LOSS**%20OR%20**ATTRITION**.ppt - Puerto Rico> (DOA: 07/1/11)*

21 This is the feeling of uncomfortable tension which comes from holding two conflicting thoughts in the mind at the same time. See:<http://changingminds.org/explanations/theories/cognitive_dissonance.htm> (DOA: 07/1/11)

position, authority and payoff rules whereas information, scope and aggregation rules are used for complementing the changes induced by these four rules. These tools are discussed as follows:

1 . Boundary rules affect the characteristics of the participants. 'Boundary rules can be broadly classified in three general groups defining how individuals gain authority to enter and appropriate resource units from a common-pool resource. The first type of boundary rule relates to an individual's citizenship, residency, or membership in a particular organization. Many forestry and fishing user groups require members to have been born in a particular location. A second broad group of rules relates to individual ascribed or acquired personal characteristics. User groups may stipulate that appropriation depends on ethnicity, clan, or caste. A third group of boundary rules relates to the relationship of an individual with the resource itself. Using a particular technology or acquiring appropriation rights through an auction or a lottery are examples of this type of rule. About half of the rules relate to the characteristics of the users themselves. The other half involves diverse relationships with the resource' (Ostrom 1999, pp. 511). These rules govern difficulty level of monitoring activities and imposing sanctions.

"A change in a boundary rule to restrict the entry of appropriators reduces the number of individuals who are tempted to break authority rules, but it also reduces the number of individuals who monitor what is happening or contribute funds toward hiring a guard. Thus, the opportunities for rule breaking may increase. Further, the cost of a rule violation will be spread over a smaller group of appropriators, and thus the harm to any individual may be greater. Appropriators are more apt to use their intuitive understanding of the resource and each other to experiment with different rule changes until they find a combination that seems to work in their setting" (Ostrom 1999: 509)

2. Position rules differentially affect the capabilities and responsibilities of those in positions. This normally refers to appointment of a guard for monitoring rule conformance made by the appropriators in CPR. Creating position of a guard requires change in payoff rules so that the guard can be remunerated.

3. Authority rules affect the actions that participants in positions may, must, or must not do. These rules also affect how easy or difficult it is to monitor activities and impose sanctions on rule violations.

4. Scope rules affect the outcomes that are allowed, mandated, or forbidden. 'Scope rules are used to limit harvesting activities in some regions that are being treated as refugia. If no

appropriation from these locations is allowed, the regenerative capacity of a system can be enhanced (Ostrom, 1999: 518).

5.Aggregation rules affect how individual actions are transformed into final outcomes. 'Aggregation rules are used extensively in collective choice processes[22] and less extensively in operational settings[23]. One aggregation rule that is found in diverse systems is a requirement that harvesting activities can be done in teams. This increases the opportunity for mutual monitoring and reduces the need to hire special guards' (Ostrom, 1999: 518).

6 . Information rules affect the kind of information present or absent in a situation. 'Information rules are important when resource units are very valuable and size of group is larger, more and more requirements are added regarding the information that must be kept by the appropriators or their officials' (Ostrom, 1999: 518).

7 . Payoff rules affect assigned costs and benefits to actions and outcomes. These rules are used when appropriations need to be reduced or redirected from a CPR so that penalty can be given to the actions that are prohibited. Three broad types of payoff rules are the imposition of a fine, loss of appropriation rights, and incarceration. Changing payoff rules is the most direct way of coping with commons dilemmas.

"The boundary, authority, payoff and position rules are the major tools used to affect appropriation situations in many common-pool resources, whereas information, scope, and aggregation rules are utilized to complement changes induced by these four rules. Many smaller and informal systems rely entirely on a voluntary exchange of information and on mutual monitoring. Where resource units are valuable and the size of the group is larger, more and more requirements are added regarding the information that must be kept by appropriators or their officials. Scope rules are used to limit harvesting activities in some regions that are being treated as refugia. If no appropriation from these locations is allowed, the regenerative capacity of a system can be enhanced. Aggregation rules are used extensively in collective choice processes and less extensively in operational settings, but one aggregation rule that is found in diverse systems is a requirement that harvesting activities be

22Collective choice rules indirectly affect operational choices. These are the rules used by the appropriators, their officials, or external authorities in making policies as to how CPR should be managed. This includes the right to management, exclusion and alienation.

23 Operational rules directly affect day-to-day decisions made by appropriators which is concerned with, where, when, and how to withdraw resource units, "who" should monitor the actions of others and how, what information must be exchanged or withheld and "what" rewards or sanctions will be assigned to different combinations of actions and outcomes. Operational rules allow authorised users to transfer access and withdrawal rights.

done in teams. This increases the opportunity for mutual monitoring and reduces the need to hire special guards" (Ostrom 1999:509 & 518).

While addressing the question of institutional change it is essential to recognize the following-

1. Changes in rules which are used to order action at one level occur within fixed set of rules at deeper level.
2. Changes in deeper-level rules are more difficult and costly to accomplish therefore, increasing the stability of mutual expectations among individuals interacting according to set of rules.

In a nutshell, there are three kinds of rules. (i) Operational rules, (ii) Collective-choice rules and (iii) Constitutional choice rules. (Ostrom 1990: 52) All these kinds of rules are devised with respect to property right holders. Ostrom (2000: 8-9) discusses bundle rights to define rights on properties.

The rights are as follows:-

1. Access- the right to enter a defined physical area and enjoy non subtractive benefits.

2. Withdrawal- the right to obtain resource units or products of a resource system.

3. Management- the right to regulate internal use patterns and transform the resource by making improvements.

4. Exclusion- the right to determine who will have access rights and withdrawal rights and how those rights may be transferred.

5. Alienation- the right to sell or lease management and exclusion rights.

Accordingly, there can be five types of beneficiaries. They are as follows:-

- **Authorised entrants**- include most recreational users of national parks who purchase operational right to enter and enjoy natural beauty but don't have right to harvest products.

- **Authorised users**- those who have both entry and withdrawal use-right units.
- **Claimants**- possess the operational rights of access and withdrawal plus a collective choice right of managing a resource which includes decisions concerning the construction and maintenance of facilities and authority to devise limits on withdrawal rights.
- **Proprietors**- hold same rights as claimants with addition of right to determine who may access and harvest resources out of it.
- **Owners**- possess the right of alienation, the right to transfer a good in any way the owner wishes which doesn't harm the physical attributes or uses of other owners in addition to the bundle of rights held by a proprietor. (Ostrom, 2000: 9) If in addition to collective-choice rights of management and exclusion, individuals who also hold the right of alienation, that is they can sell or lease their collective-choice rights, are defined as owners.

In CPR an individual or the community often have rights of access, withdrawal, management, exclusion for management of resources. They can exclude other individuals/communities from using the resource but they do not have the alienation rights on the CPR.

Operational rules directly affect day-to-day decisions made by appropriators which is concerned with, where, when, and how to withdraw resource units, "who" should monitor the actions of others and how, what information must be exchanged or withheld and "what" rewards or sanctions will be assigned to different combinations of actions and outcomes. Operational rules allow authorized users to transfer access and withdrawal rights. Collective choice rules indirectly affect operational choices. These are the rules used by the appropriators, their officials, or external authorities in making policies as to how CPR should be managed. This includes the right to management, exclusion and alienation. Constitutional choice rules affect operational activities and results through their effects in determining who is eligible and determining the specific rules to be used in crafting the set of collective choice rules that in turn affect the set of operational rules. Ostrom argues that changing the rules at any level of analysis increases the uncertainty that individuals will face. Operational rules are easier to change than collective choice rules, and further, collective choice rules are easier to

change than the constitutional choice rules. The process of appropriation, provision, monitoring and enforcement occurs at operational level. The process of policy making, management and adjudication of policy decisions occur at the collective choice level. Formulation, governance, adjudication and modification of constitutional decisions occur at constitutional level.

External coercion is often accepted as a theoretical solution to the problem of commitment leading to designing of an appropriate institution. The presumption made is that if individuals will commit themselves to a contract where a stiff sanction coould be imposed by an external enforcer to ensure compliance during all future time periods then each individual can make credible commitment and obtain benefits that would not be otherwise attainable. However, the theorists do not address what motivates the external enforcer to monitor the individual's behavior and impose sanctions whatsoever (Lejano 2013). The issue here is that a self-organised group must solve the commitment problem without an external enforcer. They have to motivate themselves or their agents to monitor activities and willing to impose sanctions to keep the behavioral conformance at a higher level. The appropriators should commit themselves to follow the decided rules in future spirit. An appropriate monitoring mechanism is necessary to achieve credible commitment. The problem of mutual monitoring, as noted by Ostrom, deals with monitoring of actions without which there can be no credible commitment, and without credible commitment there is no reason to propose new rules. The process unravels from both ends because the problem of supply of rules is presumed to be unsolvable in the first place. Nevertheless some individuals who have created institutions mutually committed themselves to follow rules and monitored their own conformance to their agreements as well as their conformance to the rules in a CPR situation (Ostrom 1990: 42-46). The problem of credible commitment is related to the provision problems of the CPR while the problem of mutual monitoring is related to the provisioning activities as well as appropriation problems of the CPR. Ostrom and Gardner (1993: 93-112) clustered the problems facing CPR appropriators into two classes that are provision problems and appropriation problems.

2.3.1. Appropriation problems

Table 2.1: Differences between provision and appropriation problems

Provision problems	Appropriation problems
Concerned with the stock of the resource	Concerned with the allocation of flow of the resource
Concerned with the effects of various ways of assigning responsibility for building, restoring, or maintaining the resource system over time as well as well-being of appropriators	Concerned with appropriating from a resource
Time-dependent[24]	Time-independent[25]

Source: Compiled from Ostrom 1990 literature

The solution to both provision and appropriation problems are interrelated. The structure of an appropriation problem or a provision problem will depend on particular configuration of variables related to physical world, rules in use and attributes of individuals involved in a specific setting.

Ostrom & Gardner (1993: 93-112) have identified the key problem of appropriation in a CPR which is how to allocate a fixed, time-independent quantity of resource units to avoid rent dissipation and reduce uncertainty and conflict over assignment of rights.[26] In fact, rent dissipation occurs when too many individuals are allowed to appropriate from the particular resource or when appropriators are allowed to withdraw more than economically optimal quantity of resource units, or when appropriators over-invest in appropriation equipment. In 'open access CPR', in which no limit is placed for appropriation, the process

24 Time dependent- construction of a resource should take place within particular time frame, the time taken should not be unlimited.

25 Time independent- appropriators harvest resources at all points of time. There is no fixed time frame within which a resource should be harvested.

26 Rent is dissipated when marginal returns from appropriation process are smaller than marginal costs of appropriation.

can be characterised as PD game because the appropriators do not communicate with each other. In this situation, institutional changes might not occur with the consent of all appropriators. Thus rent dissipation is endemic in open access CPR. In contrast, in case of 'limited access CPR' rent is not dissipated because appropriators can communicate with each other.[27]

2.3.2. Provision problems

Ostrom & Gardner (1993: 93-112) argue that provision problems may occur on supply side, or on demand side or both sides. Demand side provision problems are related to the regulation of resource withdrawal rates by the individuals in the group. The supply-side problem faced in CPR environment is related to the construction of resource itself and its maintenance. When this difficult long-term problem is combined with free-riding incentives of multiple appropriators, organising to maintain a system becomes a challenging task. In a CPR situation unless the appropriation problems are resolved, the provision problems may not be solved.

According to Ostrom, therefore, solving CPR problems involves two distinct elements-

1. Restricting access
2. Creating incentives (by assigning individual rights to or share of resource for users to invest in resource instead of overexploiting it)[28]

The credible commitment and mutual monitoring are important to solve the problems of appropriation and provisioning. But both credible commitment and mutual monitoring depend on a host of factors. The problems of credible commitment and mutual monitoring

27 Another kind of appropriation problem relates to assignment of spatial or temporal access to the resource and it occurs because spatial and temporal distributions of resource units are heterogeneous and uncertain.

28 The rights assigned to the individuals or collectivities are discussed in the section 2 of the chapter where the aspect and characteristics of CPRs have been discussed.

depend on the expected benefits and costs, internal norms[29] and discount rates[30] of the society. Credible commitment will be high when discount rate is low and mutual monitoring will also not be required. Credible commitment of the resource users would be high if shared norms of the society are rigid. When shared norms of the society are rigid, mutual monitoring would not be required as people would be committed to work. When the appropriators are physically and economically secured at present, then it is likely that the discount rate would be high. As such, if the present generation maintains the resource system by quantity and quality, their discount rate falls to low level; because they are assured that their progeny will be deriving gains from the well-maintained system. Discount rates are also affected by the shared norms of the community. When an individual has strongly internalised a norm, the individual feels ashamed when committed personal promise is broken hence his/her discount rate falls to a low level. If a norm is shared with others, individual is subject to social censure if the individual has done something wrong. Norm of the society is also a factor in measuring commitment of the people; the shared norms of behaviour compel people to work for the CPR. Since CPR settings extend over time and individuals adopt internal norms, it is possible for individuals to utilise contingent strategies[31] in relation to one another. The benefit which people gain from working for the CPR is that they get, apart from the economic gains, a good practical knowledge of the system which is helpful for long term maintenance of the CPR reducing their discount rates to low level hence raising their commitment for maintenance of CPR. The commitment problem is linked with the mutual monitoring aspects; people will be committed to work when mutual monitoring takes place for the CPR but it may not be always true. People can also be committed to work when shared norms of the society are rigid but in every group there are individuals who ignore social norms and act opportunistically which can be dealt by sanctioning mechanisms (Ostrom 1990).

29 Norms of behaviour reflect valuations that individuals place on their actions.

30 Discount rates are affected by the range of opportunities an individual has or may have outside any situation. Individuals by nature attribute less value to benefits which they expect to receive in distant future and more value to those expected in immediate future. It means that individuals more often tend to discount future benefits and are attracted more to immediate or present gains. Moreover, discount rates applied to future yields derived from a particular CPR differs across various types of appropriators. This is because discount rates are affected by the levels of physical and economic security faced by the appropriators.

31 Contingent strategies meaning whole class of planned actions that are dependent on given conditions.

Lejano (2013) discusses that 'reciprocity' and punishment of norm violators occupied important place in Ostrom's argument that actors are conditional cooperators rather than selfish agents, as implied in non-cooperative game theory. 'Reciprocity', 'trust' and 'reputation' are three core variables which Ostrom (2009) argues to be determinants of cooperation. Reciprocity is a function of shared norms and the actor's discount rate, both of which requires evolutionary approach of analysis.[32] On the same line, Araral (2013) and Ostrom (2009) quote that the extent of cooperation in the commons is a function of two core variables: 'trust' and 'reciprocity'. Trust in turn is a function of reputation as well as information about the past actions of the actor, which in turn is a function of face-to-face communication, which in turn depends on small group size. Face to face communication affects the cost of arriving at agreements as well as the development of shared norms, which determines the extent of reciprocity. Besides norms, reciprocity is a function of the discount rate of the appropriator of the resource, which is a function of the degree of certainty or uncertainty about the resource and the behavior of resource users. Uncertainty is positively correlated with discount rates (i.e. higher uncertainty, higher discount rates). For example, when there is high uncertainty about the availability of the resource, resource users are unable to make credible commitments. It is likely that there will also be a high discount rate among resource users thereby increasing the likelihood of resource degradation' (Araral 2013: 14).

Giest (2013) argues that 'in order to create trust and reciprocity within a community there needs to be a leader who operates within the system and complements it through directed management activities aimed at its membership. Such a leader enables communication among heterogeneous actors for building social capital and exchanging knowledge. A manager of this kind can also mobilize new and valuable participants as well as attract funding opportunities. Overall, this type of leadership can be governmental or community-based, but in either case builds trust and long-term cooperative structures in a way which is not self-forming or auto-poetic' (Giest 2013: 2). Such leadership can create trust and reciprocity among the members of the group who can monitor the actions of the group members, impose sanctions when norms are violated, ensure the outcome of their efforts hence reducing discount rates of the group members.

32 Norms evolve over time depending on costs of arriving at agreements and possibility for actors to have face to face communication and develop norms of behavior.

Therefore, in a nutshell we can say that there are three basic problems required to solve the collective action problem where communities are involved in the governance of CPR. The problems are supply of new institutions, problems of credible commitment and mutual monitoring. Supply of new institutions provides rules and rules in turn try to solve problems of credible commitment and mutual monitoring. The problems related to supply of new rules are addressed by studying institutional changes which occur at the level of nesting of operational, collective-choice and constitutional rules. At the operational level, the process of appropriation, provision, monitoring and enforcement occur and access and withdrawal rights are operated. As mentioned earlier, the boundary, authority, payoff and position rules are the major tools used to affect appropriation situations in many common-pool resources and affect the operational rules of the system. Collective choice rules are used by the appropriators, their officials, or external authorities in making policies as to how CPR should be managed. This includes the right to management, exclusion and alienation. Information and scope rules affect the collective choice rules of the system. Aggregation and payoff rules affect the constitutional choice rules of the system. While the problems of credible commitment and mutual monitoring shape the provisioning and appropriation behaviours of CPR which are governed by the collective choice rules.

There have been empirical studies which have identified necessary conditions for management of commons and some experimental studies which have identified variables influencing cooperation in common dilemmas. Ostrom (1990) considers four conditions for management of commons which are well defined boundaries of resource system characteristics, group characteristics (clearly defined boundaries of the group), institutional arrangements and external environment (technology and role of State). Institutional arrangements include locally devised access and management rules, ease in enforcement of rules, graduated sanctions, availability of low cost adjudication and accountability of monitors and other officials to users. External environment includes technology, role of State and central government in not undermining local authority and nested levels of appropriation, provision, enforcement and governance (c.f. Agrawal 2002).

Wade (1994) identified fourteen conditions to be important in facilitating successful management of commons. These are categorized into four categories which are resource

system characteristics, group characteristics, institutional arrangements and external environment. She discusses that small size of resource system and well-defined boundaries of resource system, small size and clearly defined boundaries of the group, social capital of the group and interdependence of group members and also high level of dependence of group members on resource system are facilitating conditions for management of common property resources. The institutional arrangements suggested by Wade are locally devised access and management rules, ease in enforcement of rules and graduated sanctions. External environment includes introduction of low-cost technologies, involvement of state and central governments and also that the central government should not undermine local authority (c.f. Agrawal 2002).

Baland and Platteau (1996) do not consider resource system characteristics as important factor in successful management of commons. They argue that small size of group, shared norms of the group, social capital of group and appropriate leadership in the group with changing external environment connected to a local traditional elite, interdependence among group members and heterogeneity of endowments and homogeneity of identities and interests are important factors in management of commons. Overlapping of residential and resource location and fairness in allocation of benefits from common resources are also other factors in management of commons. They further discuss that locally devised access and management rules, ease in enforcement of rules and accountability of monitors are other important factors in successful management of commons. They do not consider technology as an important factor in successful management of commons. They argue that the state should provide supportive external sanctioning institutions and appropriate levels of external aid to compensate local users for conservation activities. Baland and Plateau (1996) arrive at conclusions which overlap Ostrom's and Wade's views. Small size of a user group, a location close to the resource, homogeneity among group members, effective enforcement mechanisms and pat experiences of cooperation are some of the themes Baland and Plateau emphasize as significant to achieve cooperation. In addition they highlight importance of external aid and strong leadership (c.f. Agrawal 2002). The LOCA discusses that group size is an important characteristic in management of the commons and that a small group can successfully manage the commons which overlaps with Baland & Plateau's and Wade's views. But Ostrom (1990) discusses that CPRs can be successfully managed in large group

too by deriving institutional options. Baland & Plateau do not give much emphasis to technology while Ostrom says that technology and State have important roles managing the commons.

A study by Bardhan and Johanson (2002) review large scale surveys of locally managed irrigation systems as an empirical illustration of the relationship between heterogeneity (economic, cultural and social dimensions) and success in managing the commons. The peasant water users in conditions of low income rural sectors are the empirical context of the discussion and the unit of analysis is the resource using group of which heterogeneity is the characteristic. They discuss that heterogeneity either cultural or economic has a negative impact on cooperation on the commons in these irrigation cases. Heterogeneity weakens the effect of social norms and sanctions to enforce cooperative behavior and collective agreements. Inequality affects the degree to which irrigators follow rules and also affects the types of rules chosen. Wade, Baland & Plateau and Bardhan & Johanson discuss that heterogeneity among group members weakens cooperation among the commons.

Kopelman et al (2002) identified nine classes of independent variables which influence cooperation in common dilemmas which are social motives, gender, payoff structure, uncertainty, power and status, group size, communication, causes and frames. Their study is based on review of experimental psychology literature. Ostrom also gives emphasis on factors like social motives, payoff structure, uncertainty, group size and communication. She discusses that these factors are important for successful management of the commons but does not consider gender and power as important factors for the management of commons. In our study, however we analyse that power and gender play important role in knowledge generation activities which is helpful in successful management of the commons.

2.4. Knowledge, institutions and uncertainty in CPR Management

Ostrom (1990) discusses that organizing appropriators for collective action regarding CPR is an uncertain and complex job. In case of natural resources, uncertainty can arise from quantity and timing of rainfall, temperature, amount of sunlight, market prices of inputs and products etc. which are external to the CPR. A major source of uncertainty, internal to the

system, is the lack of knowledge. "Uncertainties[33] stemming from the lack of knowledge may be reduced over time as a result of skilful pooling and blending of scientific knowledge and local time-and-place knowledge" (Ostrom 1990: 34). Ostrom presumes that the folk knowledge is preserved and thus is passed along from one generation to another (Ostrom 1990: 33). However, the literature inspired by her work has not discussed the exact process and challenges in blending these two contradicting paradigms of knowledge and complexities of these knowledge. This framework also does not discuss how knowledge could be re-claimed, when not preserved for a long period. This issue is important because much of local knowledge is held orally, and demonstrated through practice. Their non-practice, therefore, makes it vulnerable to disappearance from public memory.

We have argued in the previous section that Ostrom mentions about uncertainty of knowledge, which arises in two conditions. First, when knowledge is not preserved over generations and second, when blending of local and scientific knowledge has to be done. Ostrom does not deal with the problem of uncertainty in great length, while discussing the institutional approach for solving the problem of commons. In contrast, the present study would deal with a case where knowledge has not been preserved. This issue of uncertainty in the revival of knowledge will be analyzed in the study which will describe the revival of rainwater harvesting system called *Johad* in Alwar district, Rajasthan. We also discuss a case of water harvesting systems in Bikaner where the knowledge has declined completely and scientific knowledge has been replaced by local knowledge. Uncertainty in knowledge scales up the problem of credible commitment and makes supply of new rules to manage the system more difficult. Also blending of local (tacit) with explicit (scientific) knowledge is itself an uncertain and time consuming process. When water harvesting in the present study is analyzed with respect to Ostrom's work then the issues of revival of knowledge and complexities of knowledge which has component of uncertainty in knowledge[34] come in. We discuss the complexities of knowledge in sub-section 2.4.1.

33 Uncertainty applies to situations where effects and consequences of provisioning activities are unknown.

34 Since the knowledge was not preserved over generations which led to decline of the RWHS.

2.4.1. Characteristics of knowledge

That there exists plurality of knowledge is now well established (Gibbons 1994). Besides deductive reasoning, empiricism is now recognized as an important component of modern knowledge. Every society, it is believed, thrives to produce knowledge. Nonaka (2003) conceptualized knowledge creation as a dialectic process where new boundaries are created through dynamic interaction between agents as well as between agents and structure (i.e. institutional structure, community). In this view, knowledge is created through interactions between human agency and social structures. Such knowledge is often based on a path-dependent framework where history and distinctive characteristics of the concerned society play an important role. Recent literature on ecological studies is replete with evidences of use and generation of local knowledge and community practices in the areas of biodiversity management and conservation practices (See, Berkes and Turner 2006, Wade 1995 for reviews). It is presumed that such locally developed knowledge is concerned with the immediate and concrete necessities of people's daily livelihoods. It may be noted in this context that in the modern era, knowledge is often understood to attempt to construct general explanations of empirical realities, denying such localness. Methodologically, modern knowledge is argued to be open, systematic, objective, and analytical which rely generally on rigorously built conceptual frameworks. The modern/scientific knowledge, therefore, has a universal appeal that is divorced from any particular epistemology. Conventionally, local knowledge, on the other hand, was seen as closed, non-systematic, holistic rather than analytical, without an overall conceptual framework, and advances on the basis of new experiences, not on the basis of a deductive logic. In a nutshell, therefore, such knowledge is local-specific, anchored to a particular social group in a particular setting at a particular time. Historically, such forms of knowledge have also been in the form of tacit knowledge, sometimes in the absence of codification technologies, sometimes because of their very nature. Indigenous knowledge refers to knowledge of local people acquired through the accumulation of experiences, informal experiments and intimate understanding of the environment in a given culture (Rajasekaran & Whiteford 1992, Warren 1991). Grenier (1998) describe indigenous knowledge as a local knowledge existing within, and developed around, the specific conditions of women and men indigenous to a particular geographical area. Indigenous knowledge is cumulative, representing generations of experience, careful observations and trial-and-error experiments. Indigenous knowledge can also be dynamic,

new knowledge is continuously being added. Such knowledge innovate from within, internalise, use and adapt external knowledge to suit the local situation. It is stored in peoples' memories and activities and expressed in stories, songs, folklore, proverbs, dances, myths, cultural values, beliefs, rituals, community laws, local language, agricultural practices etc. it is shared and communicated orally through culture (Grenier 1998). Further, it is the sum total of the knowledge and skills which people belonging to a particular geographical area possess, and which enable them to get the most out of their natural environment. Warren (1991) describes indigenous knowledge as a knowledge which has a long term information base. It is useful as a basis for self- sufficiency and determination because people are familiar with indigenous practices and technologies. "Indigenous knowledge is a complete knowledge system with its own epistemology, philosophy, and scientific and logical validity which can only be understood by means of pedagogy traditionally employed by the people themselves. Indigenous knowledge refers to knowledge and technologies around communities indigenous to particular space and context" (Battiste & Henderson 2000: 4). Local knowledge in non-literate societies contains considerable knowledge of medicinal and other values of local plants, agricultural techniques, survival skills in harsh climates, and navigational skills. 'Contemporary ethno-botanists investigate indigenous cures and the chemistry of plants used by local healers. Western Arctic explorers borrowed the design of their clothing and many survival techniques from the indigenous people and other inhabitants of the Arctic, usually without crediting them. Apparently local religious based seasonal cycles of planting, such as those in Bali, have sometimes proven more agriculturally effective than the recommendations of Western "experts"'(Dusek, 2006: 20-21).

Scientific knowledge is generally considered to be universal in at least three senses. First, scientific *laws* are logically, spatially, and temporally universal. Second, scientific knowledge can be *applied* anywhere in the universe. Third, Western science-based technology has a *geographic universality* of applicability. Any society can use it in any environment. In contrast, indigenous technology depends on locally handed down skills and on a particular, local, environmental situation. Although the debate over whether science itself is local knowledge may seem theoretical, local knowledge has importance for the fixing of the status of science in relation to indigenous knowledge. During the past few centuries, scientific knowledge has been seen superior to indigenous knowledge. The colonial

administrators saw themselves as bringing in genuine knowledge of technology to replace superstition and "primitive" knowledge. Colonial powers and Western scientific advisors have often ignored the traditional knowledge of local peoples they were ruling or advising (Dusek 2006: 157).

'Most discussion of technology is usually concerned with science-based contemporary technology. The Western science has its root historically from the scientific revolution in Europe in the seventeenth century. Non-Western technology, either from before the scientific revolution in ancient and medieval cultures, or more recent technology, but not based on Western science, has raised a number of significant issues. One of the claims is that Western science is considered to be universal, applicable to all times and places. The mainstream Western view is that non-Western science is a rough and vague formulation of narrowly applicable rules and general laws of Western science, or superstition. 'Scholars of non-Western science and members of the science and technology studied community who take an anthropological approach to science have challenged this view. They claim that Western science, itself, is a kind of "local knowledge," appropriate for the laboratory, just as non-Western science and technology is appropriate for its own environment and community' (Dusek, 2006: 156). 'Another issue is that of the superiority or even the appropriateness of Western technology in developing nations. In the nineteenth and twentieth centuries, the most prevailing view was that developing nations should imitate the technology and organization of developed nations and import Western technology to replace their own. More recently, examples of failures of implanting advanced Western technology in the environments of developing nations have suggested that less complex and difficult-to-service technology is needed. This technology is called "appropriate technology" or "intermediate technology." It is "appropriate" to less developed nations, or is "intermediate" between indigenous technology and advanced Western technology. Another claim defended by many students of contemporary non-Western and indigenous technology is that local, indigenous technologies of non-literate cultures often have great usefulness and applicability to their environment. These critics further claim that in the past Western colonial powers often dismissed indigenous technology and logical knowledge, only to replace it with techniques less efficient and effective in the tropical, arctic, or other environments. Furthermore, the contemporary Western aid projects are mistaken to dismiss the local, traditional technology and replace it

with Western technology inappropriate to the environment' (Dusek 2006). However, Dusek (2006) argues that both Western science and local knowledge need to be evaluated on their own merits, especially with respect to applicability to local conditions. Particularly in the cases of medicine and agriculture, both of which involve biological and environmental complexity and where the strengths of local knowledge are evident. It is often observed that the local farmers have detailed knowledge of the environment and its soils, weeds, and pests that scientific agricultural experts from the city or from other countries lack (Dusek 2006).

Knowledge can also be distinguished as propositional and prescriptive knowledge. Propositional knowledge describes and catalogs natural phenomena and relations between them. It is sets of beliefs. It is the knowledge of scientists and scholars. Prescriptive knowledge is sets of instructions about how to produce goods and services using propositional knowledge. It is the practical knowledge of artisans and craftsmen. Propositional knowledge sets are potential preconditions for the development of useful knowledge (Mokyr 2002). He further argues that useful knowledge is combination of propositional and prescriptive knowledge by designing an institutional context that will stimulate a strong interaction between two processes of knowledge creation.

Nonaka (2003) argued that knowledge creation starts with 'Socialization', which is the process of converting new tacit knowledge through shared experiences in day-to-day social interaction. Since tacit knowledge is difficult to formalize and often time and space-specific, tacit knowledge can be acquired only through shared direct experience, such as spending time together or living in the same environment, typically in a traditional apprenticeship where apprentices learn the tacit knowledge needed in their craft through hands-on experiences. One can share the tacit knowledge of customers, suppliers, and even competitors by empathizing with them through shared experience. "Giddens (c. f. Nonaka & Toyama 2003) argued that we enact our actions with two main levels of consciousness: practical consciousness and discursive consciousness in our daily lives. While the discursive consciousness gives us our rationalizations for actions and refers to more conscious and therefore is more about explicitly theoretical knowing, practical consciousness refers to the level of our lives that we do not really think about or theorize. In that sense, we can say that tacit knowledge is produced by our practical consciousness and explicit knowledge is

produced by our discursive consciousness." (Nonaka & Toyama 2003) However, these two types of knowledge are not strict watertight compartments. Rather we enlarge our knowledge through our actions and interactions with the environment that help facilitate the conversion process of tacit and explicit knowledge. Nevertheless, such conversion processes depend heavily on availability of technologies (Witt *et al.* 2007), and methodological similarities between how these two bodies of knowledge are created. Nonaka (2003) described this process as 'externalisation', where various kinds of experiential knowledge are articulated, and synthesized if found to be in conflict with each other. However, the process of synthesis of conflicting knowledge depends crucially on power relations between the agents. As Foucault (1977) argued that power produces knowledge and that power and knowledge have implications on each other, there is no power relation without a correlative constitution of a field of knowledge and that there is no knowledge which does not pre-suppose power relations. Power-knowledge relations should be analysed on basis of modalities of knowledge, implications of power-knowledge relation and its historical transformation. The processes and struggles which determine the forms and domains of knowledge is the relation of power and knowledge. Power structure influences which kind of knowledge would be applied for problem solving (Bhaduri & Singh 2015).

2.4.2. Knowledge, technology and institutions: the interlinkages

After discussing the complexities of knowledge, we study the interrelatedness of knowledge, technology and institutions in this section.

According to Ostrom (1990: 51), "institutions can be defined as the sets of working rules that are used to determine who is eligible to make decisions in some arena, what actions are allowed or constrained, what aggregation rules will be used, what procedures must be followed, what information must or must not be provided and what payoffs will be assigned to individuals dependent for their actions." (Vatn 2005: 60) has defined "institutions as conventions, norms and formally sanctioned rules of a society. They provide expectations, stability, trust and meaning essential to human collective or community existence and coordination. Institutions regularize life, support values and produce and protect interests." Institutions are needed to prevent free riding.[35]

35 Note that both the scholars emphasize on self-governance as opposed to privatization and nationalization.

Institutions ensemble knowledge apart from property rights, costs and benefits. Knowledge changes when institutional changes take place. Institutions are means of knowledge exchange (Cheng et al. 2004: 2) and social conventions lie at the heart of institutons. Norms, rules and legitimization processes can be considered as social conventions which constrain action of individual (Cheng et al. 2004: 2). Eggertsson (2009: 2) says that knowledge is a scarce resource and depends on complex economic, political and cultural conditions which are not well understood. Knowledge according to Eggertsson is divided into two branches known as science and technology. Technology is further divided into physical and social technology. Social technology refers to application of social science for practical purposes and physical technology refers to application of physical science for practical purposes. Hence it can be said that production of knowledge involves joint application of physical and social technologies. Social technologies are difficult to implement than physical technologies. The New Institutional Economists theorize that social institutions emerge to mediate knowledge problems (Eggertsson 2005: 6).

Institutions depend on tacit and social skills and institutional changes are often accompanied by rapid changes in technology (Pinch, 2008). It has been argued that technology cannot be understood in isolation; rather, it must be seen in relation to the community and its practices (Layton 1974). Institutions play an important role in shaping the knowledge of the system (Lam 2000).

The assemblance of knowledge and institution together gives rise to the systemic approach to technology. The knowledge constitutes local and scientific knowledge while the community involved in maintenance of CPR constitutes institution whose actions are constrained by social conventions of the society. We give a brief outline of the systems approach to knowledge and technology. ‘The economist John Kenneth Galbraith (1908–2004) defined technology as “the systematic application of scientific or other knowledge to practical tasks” and describes this as incorporating social organizations and value systems. Others have extended this definition to mention the organizational aspect of technology, characterizing technology as “any systematized practical knowledge, based on experimentation and/or scientific theory, which enhances the capacity of society to produce goods and services, and which is embodied in productive skills, organization and machinery”, or “the application of scientific or other knowledge to practical tasks by ordered systems that

involve people and organizations, living things, and machines". We can combine these definitions into "the application of scientific or other knowledge to practical tasks by ordered systems that involve people and organizations, productive skills, living things, and machines." This definition is sometimes characterized as the "technological systems" approach to technology. The technological system is the complex of hardware (possibly plants and animals), knowledge, inventors, operators, repair people, consumers, marketers, advertisers, government administrators, and others involved in a technology' (Dusek 2006: 35-36). Rainwater Harvesting System (RWHS) can be conceptualized as a technology.

"Technological knowledge is the result of cumulative recombination of dispersed, complementary, internal and external, tacit and codified pieces of knowledge" (Patrucco 2005: 38). Technology systems emerge as complex result of systemic interdependences of technological and institutional features governing the production of localized technological knowledge (Patrucco 2005).

The systems approach is a way of perceiving and thinking through a problem by identifying and focusing on the critical elements (Chen, 1975). Technology is seen as craftsmen, mechanics, inventors, engineers, designers and scientists using tools, machines and knowledge to create a human-built world consisting of artifacts and systems. Historic cities were shaped by both nature and technology. "Today, cities often use technology to overwhelm nature rather than interact with it and adapt to it. Cities were formerly built in concert with nature are now becoming simply human built. Water for drinking, plants, trees, cleaning, waste removal and aesthetic enjoyment is considered to be urban essential. It transformed a rubble-strewn, flooding-prone downtown river into a greenway of parks, hiking areas, and bicycle paths" (Hughes 2004: 158-159).

RWHS is defined within systems approach framework as it involves application of scientific and local knowledge which involves scientists as well as villagers, physical and practical aspects, property rights etc. Our cases on governance of rainwater harvesting technologies in the commons in Alwar and Bikaner addresses the problem of uncertainty of knowledge by looking at the changes in the property rights of the study areas. We have already discussed that Ostrom's work does address uncertainty due to rule change, albeit incompletely. This body of literature argues that changing rules at the operational level are relatively easier. Uncertainty increases when changes are made at the levels of collective

choice (i.e. management, and exclusion rights) and constitutional levels (i.e. alienation rights). Arguably, uncertainty due to rule change arises because of the change in stability of expectation by the agents. However, with change in rule, it brings about changes the authority of decision making in many cases (particularly when management rights are changed), the knowledge that is used to manage CPR may also change, as different decision making authorities may be guided by different knowledge of how to manage a CPR. In other words, a change in management rights may actually change the dynamics of governance of a CPR. We discuss the property rights arrangement in next chapter.

Chapter 3

An overview of property rights: theoretical framework and the 'Indian' perspective

3.1 Background

Property rights are defined as 'the human-defined rules that permit or forbid actions with respect to a particular resource' (Coleman & Liebertz 2014: 652). Property rights toward Common Property Resources (CPRs) are different than property rights toward private goods because of the non excludability problem of the CPRs. The property rights come in conflict when users compete over the exhaustible resource because users cannot easily exclude others, and also property rights in CPRs are often incompletely defined. In CPR settings, rules about the application and enforcement of property rights are never unambiguous. Successful rule enforcement is not always easy to attain and is often undermined by relatively common conditions such as disparities in interests, resources, and social capital (Coleman and Liebertz 2014).

Dietz et al (2002) argue that the diversity of property rights regimes that can be used to regulate the use of CPRs is very large including broad categories of government ownership, private ownership, and ownership by communities.[36] He further notes that when no property rights define, who can use a CPR and how its uses are regulated, a CPR is considered an open-access regime. In this chapter, we discuss the understanding of CPRs and property rights in pre-independent, British and post independent periods in India.

The chapter is divided into five sections. Section 3.2 of the chapter discusses the debates on evolution of CPRs. Section 3.3 deals with the research on the commons in India. Section 3.4 describes the land distribution patterns in pre-British (Mughal period), British and post-independence periods in India and Section 3.5 gives a detailed account of land tenure of

36 'Given the wide diversity of rules in practice, each of these categories includes very diverse institutions. One needs to know that the rules being used for controlling access and making other choices about the resource.'

Alwar and Bikaner districts of Rajasthan during the pre-independent and post-independent periods.

3.2 Common Property Resources and debates on evolution of CPRs

'CPR refers to natural or manmade resource system that is sufficiently large as to make it costly to exclude potential beneficiaries from obtaining benefits from use. Difficulty of exclusion stems from factors like cost of fencing the resource, and cost of designing and enforcing property rights to exclude access to resource' (Ostrom & Gardner 1993: 2). Ostrom (1990) says that when appropriators act 'independently' for a CPR generating scarce resource units, the total net benefits they obtain will be less than could have been achieved if they had coordinated their strategies in an interdependent way. The benefits accrued to individuals would be more when such interdependence is accounted for, while undertaking individual actions. In other words, the returns to their provision efforts will be more when decisions are not made independently.

Ostrom (2000: 2) describes that the legal debate on private versus common property is a contested issue in modern legal scholarship. "Further, the superiority of individual property holdings was so well accepted in the legal literature of the early nineteenth century that the possibility of other forms of property existing on the European continent threatened juridical views about the origins of social order" (Ostrom 2000: 2). This was studied by Henry Sumner Maine which was discussed by Ostrom (ibid). Maine drew not only on his own extensive research in India but also on the work of Georg Ludwig von Maurer (1854, 1856) on the primitive Germanic village communities, the Mark, and of the pioneering work of William Blackstone (1766). Maine concluded that: "it is more than likely that joint-ownership, and not separate ownership, is the really archaic institution, and that the forms of property that will afford us instruction will be those that are associated with the rights of families and of groups of kindred" (ibid: 2). Economists view common property institutions as having a longer history than private-property institutions and try to explain the growth of modern, Western societies partly as the result of change from common property to private property. Common property regimes are presumed by many economists to be inefficient (Ostrom 2000). There at least are three sources of inefficiency: one is rent dissipation, because no one owns the products of a resource until they are captured, and everyone engages in an unproductive race

to capture these products before others do. The second is the high transaction and enforcement costs expected if communal owners were to try to devise rules to reduce the externalities of their mutual overuse. The third source of inefficiency is low productivity given that no one has an incentive to work hard in order to increase their private returns out of the CPR i.e. no one invests maximum possible. Ostrom (2000) further discusses that common property regimes are presumably retained by rulers who do not understand the enhancement in economic welfare gained from private property. Various resources are indeed used and managed in different ways in different parts of the world. These practices also keep changing with time. Similarly, the types of ownership and control of resources also vary with their type in both space and time. Two principal systems or frameworks are important in this regard; one is the territorial political state and governance, and the second one is the social structure. The territorial state and its various spatial structures hold the ultimate powers of control on resources occurring in their territories.[37] Under social structure, three kinds of resource ownership and control patterns are very frequently met within the world. These three are open-access resources, common-property resources and private-property resources. Open-access resources reflect the pre-ownership regime in the world; every environmental resource was sort of an open-access resource. It was later that territorial claim of control were exerted on particular resource or the entire set of resources in a controlled territory. In general, in wild hunting-gathering-fishing stage of pre-historic times, resources were of an open-access type. Anyone could take off a resource or resources, and that too in unlimited turns and quantities. There is no regulatory body or organised group to allocate the resources to the particular individuals or groups, whatsoever, under any controlling mechanism. Common property resource is a general evolutionary phenomenon over time, open-access resource patterns might evolve into common-property resource systems. It occurs particularly when certain group becomes a territorial group, occupying a particular territory and manages to exert its control on the territorial resources. This territoriality does not necessarily mean to be a physically bounded or delimited resource area. It may only be controlled by particular social group checks, not necessarily by physical bonds. Finally private-property resources are privately owned controlled and used land or other resources. They may be held under possession of individuals, families or other organisations. The owners normally enjoy

37 Although some recent supranational frameworks at the global or international level also are structured to regulate the responsibilities of individual states in some areas of ways of resource use and patterns.

proprietary legal, exclusive rights to use, manage and lease or transfer their entire or part of property to any one on agreed terms (Ciriacy-Wantrup & Bishop 1975, 713-727). There is another category of goods called public goods which are non-excludable and non-rival. Ostrom (2000) says that in open access resource, no one has the legal right to exclude anyone from using a resource. In contrast, in common property system, the members of a clearly demarcated group have a legal right to exclude non members of that group from using the resource. If exclusion is not accomplished by design of appropriate institutional arrangement then free riding is naturally expected. The appropriate institutional arrangement, according to Ostrom & Gardner (1993: 93-112) is community based institutional arrangement as discussed in chapter 2.

Chakravarty (1996) discusses that the Property Rights School[38] has stimulated the management of CPRs problem in academics but legal historians, lawyers and rural sociologists have been reflecting on this issue for long.[39] 'The Property Rights School claim that there exists cost-benefit analysis which gives answers to questions of how to choose from among alternative property rights. It argues that market reduces externalities to 'lowest economical level.' The Property Rights School maintains that assignment of property rights is a necessary condition for more efficient allocation of resources. Ronald Coase stressed the efficiency of voluntary and freely negotiated agreements between two parties without the necessity of governmental intervention beyond defining rights and enforcing contracts' (Chakravarty 1996: 6-8). Coase, however admits the possible need for government to regulate rights and enforce contracts. "The major idea of Property Rights School is the role of institutions governing property rights. The Property Rights School agrees that 'the wasteful use of a resource should be attributed to the absence of property rights assignments in that

38 'The Property Rights School maintain that assigning property rights is a powerful and possibly necessary condition for more efficient allocation of resources.' (Chakravarty 1996: 8)

39 In the 19th century, Georg Ludwig Maurer, August von Haxthausen in Germany, Henry Sumner Maine in England, Emile de Laveleye in Belgium, and Fustel de Coulanges in France led a debate on alternatives to private property. In the United States, Wiiliam Hamond Hall and Elwood Mead in the 19th century and Ciriacy Wantrup and Vincent Ostrom in the mid twentieth century have examined collective control over natural resources. It was the work of Public Choice School in the United States and those more concerned with institutional analysis that brought theoretical and empirical research to understanding of institutions of common property. Pigou's analysis in 1928 suggested role of government wherever externalities were involved in the use of resources. Pigou recommended that a suitable tax should be imposed on the externality generating source.

good rather than the individual's greed or lack of social responsibility.' Thus the absence of property rights assignment will lead to overuse and under-investment in the resource. This is partly because of free-rider problem, 'this form of ownership fails to concentrate the cost associated with any person's exercise of his communal right on that person. If a person seeks to maximise the value of his communal rights, he will tend to over-hunt and overwork the land because some of the costs of his doing so will be borne by others. It follows that private property assignments would result in a more efficient use and allocation of resources since the benefits will be reaped and the costs borne by the owners of the resource, who accordingly have incentive to keep the cost low. The cost of negotiation and policing in any one transaction would be less, since the number of those who would have to come to an agreement would be less. Whenever the costs of internalizing the externalities caused by an individual's action are less than the benefits to be reaped, the advantages of private property exceed those of communal property. While explaining property rights systems, the Property Rights School laid weight upon the concept of transaction costs"[40](Chakravarty 1996: 7-9). Though transaction costs arise when there is uncertainty, lack of information or need for policing contracts. Institutions which are able to deal with such transaction costs are considered to be efficient. The Property Rights School has been criticized for its assumption that the market will always be superior to non-market institutions.

Chakravarty (1996) discusses that Carl Dahlman (1980) contradicted the doctrine that communal ownership is associated with inefficient or over-utilization of scarce resources and to show that open field system in medieval England was an efficient adaptation to a particular set of economic problems. 'Asserting that collective property rights and decision-making can be quite consistent with private wealth maximisation, Dahlman's study sought to show that the open field system was a superior solution to the alternative of private ownership and decision-making from the standpoint of both joint and individual wealth maximisation. It was an adjustment of land-use to two different activities, livestock and crops' (Chakravarty 1996: 10). Each farmer tilled strips scattered over open fields and the cattle grazed on open lands. If the grazing land would have been divided for cattle of particular farmers, movement of cattle

40 Coase cites: In order to carry out market transactions it is necessary to discover who it is that one wishes to deal with, to inform people that one wishes to deal and on what terms, to conduct negotiations leading up to a bargain, to draw up the contract, to undertake the inspection needed to make sure that the terms of contract are being observed and so on.

over the fields would have to be policed to prevent overgrazing of other people's land and this would lead to high transaction costs. Thus a combination of privately owned strips all over the field but used in common after the harvest together with system of communally held pastoral land was superior to a system of only private ownership in Dahlman's view. Chakravarty (1996) discusses that according to Stephen Sandford (1983) "the alleged greater efficiency of private over communal land-ownership was initially based on evidence in fertile northern Europe not in arid tropical rangelands, and in Europe also the social consequences were often dire. He points out that neither in USA nor in Australia it is true that systems of property rights akin to private ownership of land led to a control and stabilisation of livestock numbers at a level whose range scientists believe to be rights. In other words, private ownership of land, particularly grazing land, is no guarantee that there will not be overuse and under-investment. He gives an example of Angola, where environmental degradation was worse on private commercial ranches than under the traditional communal system" (Chakravarty 1996:10). Chakravarty (1996) further discusses Amartya Sen's (1981) work on Sahel region in Africa. She argues, overgrazing in that region may be attributed to a series of influences such as: 'first, the commercialization of agriculture, with sowing of cash crops disturbing the seasonal rhythm of the 'relationship between nomadic livestock and crops.' Second, taking over of traditional grazing land for commercial farming. Finally third, with pastures held communally and animals owned privately, there is conflict of economic rationale in the package, which becomes relevant when pasture land gets short in supply. Having additional animals for grazing adds to families' incomes which might lead to loss of grass cover and erosion, and thus to reduced productivity for the pastoralists as a group, the loss to the individual family from the latter may be a good deal less than its gain from the additional animals. Thus the conflict of the type of the so-called 'prisoner's dilemma' is inherent in the situation because the herders are not communicating with each other and keep on adding animals to their flocks which leads to reduced productivity. As uncertainty grows, the desire to hold more animals for insurance also grows, leading to soil erosion and its attendant problems.' He suggests institutional arrangements for controlling the herd size (Chakravarty 1996:10-11) and communal ownership of grazing land which can be converted to arable land during periods of food shortages.

3.3 Research on the Commons in India

There has been extensive research on the commons and common property resources in India by a number of scholars like Rita Brara, N.S. Jodha, Madhav Gadgil, Kanchan Chopra, Ranajit Guha. These studies mainly analyze the decline of commons and common property resources with the exception of Chakravarty (1996) who has studied the historical institutional analysis of common lands in Punjab.

Chakravarty (1996) gives a description of scholarly works by Brara, Jodha, Gadgil, Guha. She notes that Rita Brara has highlighted that desertification, encroachment on the commons, and social tensions arising from allotment of grazing lands by the government has played role in shrinking of grazing resources in Rajasthan. Jodha has given a description of 'CPRs as those (non-exclusive) resources in which a group of people have equal use rights.' (Jodha 2001: 120) Jodha's work has focused on regions of *ryotwari* settlement or individual landlord tenures. He says that large-scale privatization of CPRs took place in North West Provinces and Punjab (survey conducted after the Land Reforms legislation of the 1950s). He has also mentioned that if the decline of CPRs is halted, poor of the villages can be potential gainers. Madhav Gadgil has referred to the colonial exploitation of forests and destruction of indigenous institutions of tribal and forest dwellers. Ranajit Guha's work gives an 'analyses of the impact of exogenously induced changes engendered by colonialism and usurpation of natural resources by the State which reshaped the society into whose habitat they intruded' (Chakravarty 1996: 14). In Nepal, Michael Bruce Wallace, has 'attributed soil erosion and disappearance of forests between 1964 to 1975 to the breakdown of communal system of forest management and its replacement by State ownership in 1957. Since there were no land records, villagers had incentive to destroy forests and convert them into croplands. Benefits were obtained by anyone who could clear and cultivate while the costs were imposed on forest dwellers' (Chakravarty 1996: 14).

Jodha (2001) defines CPRs as those (non-exclusive) resources in which a group of people have co-equal use rights. To quote Jodha, 'CPRs in Indian villages include community pastures, community forests, wastelands, common dumping and threshing grounds, water-shed drainages, village ponds, rivers and rivulets with their banks and beds. Community pastures, community forests and wastelands, being large in area are major contributors to rural people's sustenance. Even where their legal ownership rests with some other agency,

de facto CPRs belong to the village community' because these are contributors to rural people's sustenance (Jodha 2001: 120). His study is based on field works conducted in Rajasthan, Madhya Pradesh, Gujarat, Maharashtra, Karnataka, Andhra Pradesh, Tamil Nadu during 1982-1986. According to Jodha (2001), the key factor adversely affecting status of CPRs in dry regions is the overall pattern of rural transformation. The process of rural transformation is manifested by several factors; such as increased extent of technological and institutional interventions by the State, physical and market integration of dry areas, increased population pressure and significant changes in people's attitude towards common resources and visible changes in farming systems and resource use practices induced by new technological and market circumstances as well as State support. The State's assault on CPRs, accentuated by population growth, collapse of traditional forms of rural cooperation and reorientation of farming systems de-emphasizing role of biomass are the key factors which have led to marginalization of CPRs role and decline of their area and productivity in dry area. Jodha (2001) discusses that in smaller and isolated villages, where traditional social sanctions are respected, decline of CPR is less. Transaction costs of enforcing social discipline regarding CPRs are lower in such cases. It is easier to organize 'user groups' and group action for CPRs in such a situation as shown by experience of different NGOs. In villages, with greater distances from market centres, the protection of CPR area is better. In smaller and isolated villages ecological compulsions to retain and protect CPRs are stronger. In villages where communities have fuller knowledge and an active concern about their common resources, decline of CPRs is less. Informal social guarding of CPRs is easier in such areas. To summarise, the decline in CPR areas is lower in villages with following characteristics:

a. Lower extent of occupational changes implying lesser increase in demand for conversion of CPR lands into private crop lands.

b. Lower degree of commercialization implying lesser erosion of social sanctions and informal arrangements protecting CPRs

c. Lower extent of factionalism[41] in the village implying greater degree of social cohesion conducive to protection of CPRs

d. Lower socio-economic differentiation ensuring equity of access and benefits from CPRs

e. Lesser dependence on state patronage for resource transfers to village implying lesser opportunity for interference in village affairs including privatisation of CPRs (Jodha, 2001: 150-151).

Chopra (1990) discusses CPRs as resources that are non-exclusive, to which rights of use are distributed among a number of co-owners, often identified by their membership of a community or a village. The *de facto* access may be limited to some groups and legitimized by law, convention, customary rights or traditional practices. The property rights of common resources lie between CPRs and open access resources. CPRs are resources with varying degrees of access on which multiple and often overlapping property rights and regulatory regimes exist. Such rights of access include those defined on different categories of government forests. Common property resources, on the other hand, are defined in the literature as 'private property for a group.' In conclusion she says that 'the results for Karnataka in particular, and, Bihar and Maharashtra indicate that non-poor households collect NTFP (Non Timber Forest Production) for sale as well, provided access and property rights conditions are favourable. This is significant and provides pointers towards the development of NTFP (Non Timber Forest Production) related economic activity as an income diversification route for relatively affluent rural households. The study indicates that in certain pockets of the country, CPRs are providing the basis of income generation for households with multiple options, quite distinct from their role as providers of subsistence incomes.

Gadgil (1986, 1989) discusses the case of Uttara Kannada which is well known, historically, for its forests and wildlife. 'In the 17th century, both British and Dutch had established trade stations on its coast. These forests were extensively rich in wild pepper and cardamom, sandal and teak wood and poon (Calophyllumelatum) for ship masts. Accounts of

41 Factionalism is a concept in political anthropology that is used to describe groups of people formed around a leader who reject the status quo and actively work against established authority within a society, such as state institutions, political parties, or economic interests.

Europeans who worked at these stations mention the rich wildlife with an abundance of tiger, panther, elephant, bison and several species of deer. The district came into British hands in 1799. ‘The British were greatly exploitative rulers and appropriated the rich forest resources of the district as cheaply as possible which required restrained use of community based systems and conservation. This was accomplished by refusal of recognizing the customary and community ownership rights. The British recognized only two forms of ownership, State ownership of all non-cultivated lands and private ownership of all cultivated lands. The bulk of State-owned lands were converted into reserve-forest lands. A fraction, about 25% was set aside as minor or leaf-manure forest lands for meeting the subsistence biomass needs of local people. These are substantial since agriculture in this hilly district with its laterized nutrient deficient soils depends heavily on organic manure inputs. But the minor/leaf manure forest lands came to be treated as open-access resources and have consequently been subject to increasing degradation. The reserve forests were dedicated to supply cheap raw material, primarily, teak to serve colonial interests of shipbuilding, railways and other constructions. As a result, they were almost totally depleted of natural teak between the years 1800-1850; followed by depletion of other hardwoods, especially Terminalia and Lagerstroemia species, and conversion to single species plantations of teak. The evergreen tree species were of little commercial value until the 1940s, and up to that time forest working focused on their re-placement by the more valued timber species. Although a succession of management plans initiated in early 1900s professed sustainable harvests as their aim but in fact there was only further depletion. All management plans were set aside during the two world wars, permitting totally un-regulated harvesting from reserve forests (Gadgil 1989: 1-10).Before independence, ‘the aim of British forest management regime in Uttara Kannada was only dedicated to the export of teak and other timber as cheaply as possible. World War II brought about an important change, however, when the British decided to encourage plywood manufacture in India. With its rich evergreen forests providing abundant raw material, one of India's first plywood factories was set up in the Uttara Kannada district. This was followed by a paper factory and a poly-fibre industry, both of which were established soon after independence. The policy of dedicating State owned forest lands to furnish a cheap supply of industrial raw materials was carried to further extremes after independence. Thus, in 1958, bamboo, earlier prescribed to be eradicated as it constituted a weed in teak plantations, in spite of its manifold rural uses, was sold to the paper industry. The price was as low as Rs.

1.50 (USD 0.30 at the then prevalent exchange rates) per tonne, i.e. over a thousand times less than the market value. Giant wild mango trees that regularly yielded much valued fruit worth more than Rs. 100 per year, were also made over to plywood industry for as little as Rs. 150 for a whole tree. The result has been rapid destruction of a whole range of species in the more humid tracts, especially on the steeper western hill slopes. Other natural-resources have also been made available at highly subsidized rates to the urban, industrial, intensive agriculture complex. For example, there have been a series of State sponsored hydroelectric projects within the district. The electricity so generated has been supplied to industrial consumers and urban households as well as used in water lifting for irrigated agriculture at greatly subsidized rates. At the same time the cultivators whose lands were sub-merged under the reservoirs have been poorly compensated and often forced to encroach on forest land to eke out a living. This whole system of subsidized resource use has ensured that neither resource managers nor resource users are concerned with resource-use efficiency. While the commercial pressures have mounted, so have the subsistence demands of the rural population that has grown rapidly as a result of the eradication of malaria after World War II. These subsistence demands continue to be met from open-access public lands, with further erosion of traditional practices of disciplined harvests from common lands. Consequently, highly inefficient and wasteful patterns of natural resource use have prevailed' (Gadgil 1989: 1-6). Hence it can be argued that the British and post-independent policies continued to replace the species of trees and plants with teak and bamboo in the forests which generated revenue for the State. All these practices eroded the traditional management system of maintaining the forests which led to decline of community level management of the commons.

Chakravarty (1996) considers three reasons to study common lands in Punjab in the 19th and 20th centuries. First, in the past, the waste in India both within boundaries of villages and outside was treated as surplus land available for cultivation and there has been no historical study examining the allocation in use of waste or the institutions which managed it. She discusses that Greater Punjab had largest proportion of unused cultivable land in British India. Chakravarty puts George Blyn's (1891) argument that a large part of this unused cultivable land was dry land which could be brought under cultivation only by construction of irrigation canals. Hence before 1891 and early 1920s there was doubling in irrigated area and most of this expansion was into cultivable waste and into forested areas. Secondly, the role of the Government before and after independence has been complicated and significant. The

Colonial Government in the Punjab played a fundamental role in establishing and altering the property rights. 'British land settlements all over the Punjab, both in the hills and on the plains, extended one institution into Punjab- the joint land-lord village communities. These circumstances created a property rights framework within which joint overlordship over the entire land of a revenue estate or village was assumed within which it supported individual property in the arable and joint property in the cultivable waste' (Chakravarty, 1996: 22).

Between 1858 and 1912, the differential impact of a uniform property institution introduced by the settlement process caused change in the manner in which waste was maintained both inside and outside the village. British investments in canals and railways altered land occupation and land-use by shifts in labour and capital too. These trends were altered again after Independence when the State made greater changes to property rights by legislating land reforms. Thirdly, institutions of communal control over the waste in Punjab were complex and varied. At the onset of British period, large areas were called primeval waste by the British, by the end of British period much of this had been appropriated by communities and later privatized by partition. This process of partitioning common lands or cultivable waste within villages eroded the adhesive element in communities of cultivating owners. In the post-independence period, the situation changed, partition of common lands after the Land Reforms Act, 1954, in Delhi and Punjab was no longer possible as the entire village community of residents gained control as against the group of landowners or *malikan-deh* (Chakravarty 1996: 22-23).

Common property (*shamilat)*[42] in Punjab became subject of legal battle between *malikan-deh* which had organized and governed them and those who strove to free ride. 'The *shamilat* (common lands) cases were admitted in appeal both the Chief Court and the Financial Commissioner' (Chakravarty 1996). Issues of property rights to the *shamilat* were resolved by the Chief Court while disputes involving partitioning of common lands were decided by Financial Commissioner.

'The common lands had shrunk by the shortening of the cultivable banjarkadim (common fallows) and were fought over where population growth and density were high as in the sub-montane tracts like Hoshiarpur, and then when canal irrigation extended cultivation and intensified land use as in Hissar, Ferozepur and

42 Common land.

Jhang; and also when enclosure of public grazing and partition of village commons as in the montane and sub-montane districts of Kangra and Hoshiarpur reduced grazing fallows and gave incentive to free riding. The battle for the commons came into court because there was a process of attenuation in the institutions exercising communal control over them. Such situations arose where the market forces led to infiltration of 'outsiders' into village communities arousing animosities and dissension in matters affecting communal control as in Lahore and Karnal and where legislations like the Punjab Tenacy Act of 1868 supported the rights of a particular category of cultivators-the occupancy tenants, as in Hissar, Hoshiarpur and Lahore and where urban pressure mounted on rural common lands as in Delhi, Lahore, Ferozepur and Sialkot' (Chakravarty 1996: 221).

The village residential was the battleground as it was the access point for acquiring withdrawal rights from common property resources of a village. Every new entrant was a *sakin-deh* (resident of village) by virtue of which he obtained right to use village commons. According to customs, *malikan-deh* prevented free-riding by delimiting the residential site (*abadi-deh)*. The lawsuits indicated that, the *malikan-deh* screened new entrants which prevented newcomers, ensured that no new entrant transferred resource like house-site or building material to anyone other than *malikan-deh* as a group, which precluded transfers to any individual member of the proprietary body. No resident either new or old, could carry, sell, gift or transfer the building material or house site. A distinctive feature of Punjab was that the Colonial Government played major role in reallocation of resources like wastelands thereby altering property rights in them. The British Government tried to incorporate the indigenous system of customary law into legal system of Province as discussed above thereby recognizing traditional institutions of control in land ownership and management. It had set up modern law courts and therefore hastened the process of individualization in ownership of arable land. The role of the State in altering property rights was extensive. Chakravarty (1996) tried to highlight changes in two major activities in rural Punjab, the pastoral activity and as a unit of property over which the control of the village was communal. There was a decline in the uncultivated land and shrinkage in common lands from 1861 onwards. The reduced areas of the open waste outside the villages were reserved by the government after enactment of Indian Forest Act of 1878. Also, there was a tendency on part of *malikan-deh* or *shamilat-deh* to reserve village common lands for themselves leaving less common lands for other residents. There was a reduction in length of fallows as there was greater intensity of land use both for arable and pastoral purposes. Wherever common lands continued to exist,

such problems increased specially in Cis-Sutlej zones.[43] There was a shift from pastoral to arable land which coincided with increase in population and after 1868 there was shrinkage in area available per head of cattle. As population pressure and cattle numbers grew, policing of common lands became difficult. Partition and privatization of common lands hastened in last quarter of 19thcentury; consequently there was a trend towards erosion of the communal system of management of all CPRs. The decline in communal control over common lands was brought by weakening of cohesion within *malikan-deh* and attrition in authority of leaders i.e. the powerful families of *zamindars* of village or town (*lambardars)* over various categories of CPR which included co-sharers, tenants, and service groups and cattle grazers'. The governance of commons required managerial skill on part of headmen of the community as they bargained on behalf of the general body of co-sharers with external agents like government on one hand and service groups on other hand. Such kinds of authority depended on customary rules of villages. The bargaining and policing of user rights among *sakin-deh* was maintained by *lambardars*. The authority of *lambardars* and collective action among the *malikan-deh* declined in different degrees in areas where value of land had risen and alienation of land made individualization of rights in land possible. The control of *malikan-deh* over common lands was weakening because of juridical and legislative action of the government. Land in Punjab was divided into arable and pasture land by the British and the British understood pasture land as common land. *Malikan-deh* and *shamilat-deh* were reserved by the British Government leaving less for common use. The decline in communal control over common lands was brought by weakening of cohesion among *malikan-deh.* Also the authority of leaders were taken away by the British Government who were involved in management of *malikan-deh*. Free-rider problem increased in the common lands. Common lands were getting increasingly privatised and partitioned, hence access to people on common land was reducing. This shows that the modern law-courts were replacing the indigenous system of dispute settlement on one hand and on the other, legislation gave protection to certain groups like occupancy tenants besides the recording rights ensured the protection of user rights other than those of *malikan-deh*. Free-riding via encroachment on common lands also existed before 1947 but it increased after independence.

43 Group of states in Punjab region, lying between Sutlej river on the north, Himalayas on the east, Yamuna river and Delhi district on the south and Sirsa district on the west.

Encroachments in water channels were not allowed by anyone but moment irrigation canals were made, encroachment on water harvesting systems (*johads)* or ponds also started as these became redundant, perhaps because people started getting easy supply of water from canals so these *johads* became redundant therefore encroachment started in the catchment area as no one took care of these systems. Encroachment also began post 1954 period when common lands have been redistributed by the government among certain groups of poor who do not belong to the proprietary body (Chakravarty 1996).

The growing population in Hyderabad has encroached the lakes of the city. The three reasons attributed for decline of lakes in Hyderabad city are rapid urbanisation without environmental planning, increased land prices due to urban expansion and common water bodies are easy targets for land acquisition and role of politicians and bureaucrats in changing land use and transferring them to builders (Prakash). Lakes in Bangalore, initially created by local communities to support agricultural and domestic uses have witnessed encroachment and pollution in recent years and these spaces are used for recreation by joggers and walkers (Nagendra & Ostrom, 2014). Study by Vij & Narain (2015) discusses how urbanisation process and urban expansion intersect with power relations to reduce the access of periurban communities to the CPRs in Gurgaon. They further discuss that there are certain groups which are deprived of access to village CPRs and process of urban expansion further reduces their access to CPRs (Vij & Narain 2015).

The studies discussed above describe the reasons attributed for decline of CPRs in different parts of India. The reasons for decline of CPRs in the North West Provinces and Punjab were technological interventions by the State like introduction of canal system for water supply which changed the pattern of property rights of land, as land was required by the State for construction of canals, which led to shrinking of the common lands. Increased population pressure led to increased number of animals which created pressure on the common (grazing) lands as the demand of land both for arable and pastoral use had increased. Also, there was shift from pastoral to arable land with increase in population. The State's role in altering property rights was extensive from 1961 onwards in Punjab. Partitioning and privatisation of common lands was attributed a major factor for decline of CPRs all over India. In Karnataka, Bihar and Maharashtra, the CPRs provide income for non-poor households and decline of these CPRs can have effects on these households. The replacement

of plant species inhabitants of respective forest types were gradually getting replaced by revenue generating tress like teak and bamboo from the British period which eroded the system of traditional management of forests by their communities. The literature on urban commons in India discusses that urbanisation, land acquisition and real estate development have played significant role in depletion of common lands (Singh 2016).

3.4 Land distribution pattern in India: A snapshot since the Mughal era

In this section we describe the understanding of land and common property in pre-British, British and post-independence periods.

3.4.1. Understanding of land in pre-British period (Mughal period)

Land in pre-British India was ruled by a king, in the body of brotherhood or in person by a *zamindar*. There were not many ways to earn money in India and the person who acquired political power also acquired control of land which was the main source of income or wealth for him (c.f. Embree 1969). *Zamindars* in the Mughal period were classified in three categories: a. the autonomous chieftains b. the intermediary *zamindars* c. the primary *zamindars*. These categories were not exclusive. Within the territory of autonomous chieftains, intermediary and primary *zamindars* can also have their rights. The intermediary *zamindars* exercised jurisdiction over groups of primary *zamindars*, most of the intermediary *zamindars* were also primary *zamindars*. A *zamindar* could hold territory in both *jagir*[44] and *khalsa*[45] lands. All arable and cultivable lands were divided into *jagir* and *khalsa* lands (Grover 1964).

The Chieftains: were hereditary autonomous rulers of their territories and enjoyed sovereign powers. In any cases of their extension or deduction of their territories, their nature of rights on territories remained the same. During Mughal period, the position of chieftain became dependent on the goodwill of the emperor rather than his inherent rights. The hereditary dominions of autonomous chiefs were treated as *watan jagir*. Theoretically, the

44 If the revenue from a particular area were assigned to an officer in lieu of salary, it could be considered as a *jagir* land.

45 If the revenue from particular area were deposited in imperial treasury, it would be considered as *khalsa* land.

chiefs were supposed to have status of *jagirdars*, they were subject to the imperial revenue regulations but exercised *jagirdari* rights in hereditary succession over their territories which were non transferrable rights.

The Intermediary *Zamindars*: most of them possessed hereditary rights although in few cases they held position on short-term contracts. 'Although the rights were hereditary, the state reserved the authority to interfere with succession or to partition among relations or brothers. In some cases the Mughal emperors conferred *zamindari* rights on persons appointed to maintain law and order and collect land revenue.

The Primary *Zamindars*: holders of proprietary rights over agricultural and habitational lands. The rights held by primary *zamindars* were hereditary and alienable. The Mughal state protected the rights of *zamindars* and encouraged the registration of transfer deeds at the court of *kazi*. The *zamindars* gave their lands in hereditary lease to their tenants who enjoyed security of tenure on condition that they paid land revenue regularly. 'This class may not include peasant-proprietors who carried on cultivation themselves or with help of hired labor but also the proprietors of villages' (c.f. Embree 1969).

"The European visitors held the view that all land was owned by the State because they ignored the working of the *jagir* system. Though the State was proprietor of all jungles and unreclaimed land for agrarian purpose, it did not possess proprietary right in absolute sense on cultivable lands which was already in hereditary possession of various classes of *Riaya*" (Grover 1964). Any transfer of jungle or *banjar* land to *riaya* or *zamindar* took place on condition that land will be cultivated. Tenants were classified into two kinds:

1. Riaya/Raiyat- stands for all kinds of agriculturists owning land and pay revenue to the State as tax on the cultivated lands under possession. The *khalsa* lands dealt with *riaya* of various types.

2. Muzarian- tenants holding lands on terms stipulated in the *patta*. Had right to give their spare lands to the tenants called *muzarian* who also had hereditary title to the land. Ownership of land was split between r*iaya* which acted as landlord owning full responsibility of payment of land revenue to the State and the *muzarian* who tilled the land with full rights of hereditary possession so long as he paid rent to the landlord and wished to retain the land.

Riaya was further classified into

a. *Khudkashta*[46]- Peasant proprietor with holding and resident house in same village. Holding was hereditary and had full rights in land for transfer, mortgage and sale.

b. *Pahikashta*[47]- Peasant proprietor with holding in different village from his residence. Holding was hereditary and had full rights in land for transfer, mortgage and sale.

c. *Muqarari Riaya*[48]- Full rights of transfer, mortgage and sale of land. (Grover 1964)

The tenure holding of *khudkashta* and *pahikashta* riaya are similar, the difference is that the *khudkasht riaya* holds resident house and land for cultivation in same village while *pahikasht* riaya holds resident house in a different village. *Muqarari riaya* has hereditary ownership of land vested by the State. He had the direct responsibility of payment of land revenue to the State but had the right to keep a part of holding for his personal cultivation and give spare land on contract to the revenue farmer or give it on a temporary base to the revenue farmer (Grover 1964).

Layers of rights existed on common lands which protected interests of people of the community. As a result, there emerged a variety of land rights, where rights of various kinds were superimposed on each other (c.f. Embree 1969). These layers of rights gave rise to layers of duties for the management of land in the Indian as well as Mughal periods. D'Souza (2004) argues that the Mughals absorbed the existing infrastructure of the previous regime giving a sense of continuity of the legal framework on land rights through the Mughal period. Perhaps, this shows that the governance regime existing in pre-British India strongly bound the community among themselves even though the property had been sold to another *zamindar* or ruler. Gudeman and Rivera (2001) argue that commons is embedded in a

46 *Khudkashta* cultivate their own lands.

47 *Pahikashta* rent out their land.

48 *Muqarari Riaya* had hereditary ownership vested by the state.

community of shared and indivisible knowledge, experiences and interrelationships. They wrote "taking away the commons destroys community, and destroying a complex of relationships demolishes a commons. Likewise, denying others access to the commons denies community with them, which is exactly what the assertion of private property right does" (Gudeman & Rivera 2001: 360).

3.4.2 Understanding of land in British and post-independence periods

In the European tradition, there are three distinct meanings of land: land as an area to be farmed or owned, land as the sum total of natural resources and land as the area over which a political sovereign wields power. Land to the early Romans made up family or clan under the authority of the pater families (c. f. Embree 1969: 41). Historically, the Western European way of thinking about property comes from practices and legal codes of the Roman Empire. The British understanding of property was a mixture of Roman and the Norman influence. 'While Roman ideas of property were part of intellectual inheritance of educated men in the eighteenth and nineteenth centuries, and they played a part in India. The characteristic Roman idea about property that became rooted in the European mind was the concept of unqualified possession. The Norman or the Anglo-Saxon concept of property was the transfer of land from old owners to the followers of the Conqueror was made possible by a legal theory that land belonged to the king and people were king's tenants.' (c.f. Embree 1969: 37) The relationship between political control and land ownership was a dominant feature of British social and political history. "The eighteenth century British thought about property was rooted in the writings of John Locke. Locke interpreted nature of private property ownership as "law of nature. While the earth was given in common to all men every man has property in his own person. Locke insisted on right of individual rather than state" (c. f. Embree 1969: 39). Locke (2003) held the view that ownership on land is vested in mixing it with labour. Also, Locke was in favour of ownership of land to reduce social conflict. Baden Powell argues from the fact that the word 'possession' lies in Western jurisprudence and not articulated in Indian thought "What emerges is an understanding of property admirably suited to a society dependent upon trade and commerce, where land was scarce, and political stability had been achieved. Ownership meant that neither sovereign nor intermediary landlord could prevent the sale or transfer of property, nor was the use of property hindered by any services to be rendered to them." (c. f. Embree 1969: 41) "The idea

of the king granting land to the tenants who became both territorial powers and eventually, the supporters of royal power, is surely one of the organizing concepts that the British used for understanding Indian political and social life" (c. f. Embree 1969: 38).

The British understood waste land and pasture land as common land. Pasture land was common for the entire year but access was limited; while in waste land, all members of village community had free access. Common land in England was referred as open land while private land as enclosed land because generally common lands were unfenced and scattered in small parcels in open fields whereas private land was fenced. Private land was arable and meadow land. Clark divided up land based on its property rights characteristics. Private land was under the exclusive private use of one owner or a small number of owners and was r fenced. Regulated common refers to land subject to communal control, where access to the land was regulated. Land described as "common," and "open field land" was put in this category. Physically enclosed common land such as *lammas* land, *michaelmas* land, "half-year" land, and stinted communal pastures were also included. Such regulated common was often only common property for part of the year and private property for the rest. A stinted pasture was a common pasture where each owner of a common right was allowed to graze a specified number of animals. In a few cases stinted pastures were measured in such units as "cow gates," and "sheep gates". Unregulated common or "waste" refers to common land on which there was unrestricted access. This is generally referred to as "waste." In most cases the existence of access to common waste associated with a plot only becomes known because there was a later enclosure under which the charity plot received an allotment of waste. Finally enclosed common and enclosed waste refers to private land which was formerly respectively regulated common or waste. The following five descriptions of land from the tenth report of the Charity Commission illustrates the kind of information available with which to classify land as common, waste, private, and enclosed waste, common waste (Clark 1998: 84).

The ideal position for an Indian who is interested in power was to be a leader of dominant caste in the village. It would have been difficult for the British to differentiate between a person who has a position and the owner in the village. The historic relationships between wealth and political power were part of Indian's perception of land. For the Englishmen, the word estate expressed the primary idea about rural social and economic

organization. The estate manager[49] would sacrifice a particular measure of gross output to increase net profit. The associations of estate were productivity, profit, efficiency; an estate was land viewed as an element in economic activity (c.f. Embree, 1969).

Almost every British institution introduced in India in the 19th century had some effect on landholding. There are three closely related institutions characterized by Embree, the latter two were necessary concomitants of new ideas of property

1. Institution of property as understood in Britain in early and late 19th centuries. The institution of property required a state and the state needed property that was owned by someone.

2. Second institution is that of efficient government as understood in 19th century. The evaluation of property in India was on the basis of ability of a society to provide political order in which commerce might flourish and property be protected. The correspondence from the British agents in Burma to Calcutta in early 1850s stated that a government which could not protect property and trade had forfeited its right to rule.

3. Third institution is the legal system, the establishment of which was connected with question of ownership of property and the extent to which the East India Company should interfere in actual process of government (c.f. Embree 1969: 35).

According to the British, no Government could be assured of its revenue unless it was prepared to guarantee the rights of proprietorship. Without private property there can be no public revenue. Different British administrators came to very different conclusions about land revenue systems of Mughal India period. All cultivable land in North West Provinces and Punjab in British India fell under three systems. The first regular settlement in the Ajmer and Merwar was made on system of village settlements prevalent in those provinces.[50]

49 Estate manager is a British creation who was supposed to create a balance between social and economic organization to increase the profit.

50 The settlement done by the British was for cultivable lands in the *jagir/zamindar* areas. The responsibility of maintenance of common lands like the pasture land, water bodies, forests belonged to the *zamindars* or the *jagirdars* in the *zamindar* or *jagir* villages. In the *khalsa* areas, the common lands were managed by the State.

- *Zamindari*- a landlord-based system. Single person/family made up the village. In the Mughal period *zamindars* were not the absolute owners, the British misunderstood that they were the owners and hence gave full rights including selling rights to the *zamindars*. This shows that private property system was introduced completely in British period while in Mughal period private property was recognized as in the tenants could sell their rights but had no ownership of land.

- *Rayatwari*- individual cultivator based system. Revenue Settlement was done directly with the cultivator.

- *Mahalwari*- village based system. Village bodies jointly own the village responsible for land revenue (Banerjee & Iyer 2005).

In this chapter we have discussed that different decision making authorities may be guided by different knowledge of maintaining CPRs. In the next chapter, we describe how change in the management rights gradually led to decay in knowledge of RWHS in India, initiated during the British period. The chapter also discusses the complex ways the institutional and technological interventions shaped the practice of rainwater harvesting in pre-British, British and post-independent periods in India.

Chapter 4

Water Harvesting Technology in India: An Overview

4.1 Background

India is credited with having a long history of human intervention in the management of water because of its distinctive climatic conditions, such as intense monsoons in some parts alongside prolonged droughts in others. Furthermore, rainfall is confined to a few months in the year, while its uncertain, erratic and uneven nature make Indian agriculture dependent on different sources of irrigation. This dependence has led people and successive ruling regimes, from pre-colonial to colonial and post-colonial times, to make choices across space and time from a wide range of technologies for water control and distribution' (Naz 2014: 29).

Rainwater Harvesting System (RWHS) is practiced in common lands and can be a part of 'Commons' of any village or a group of village or a group of people hence it can be considered as Common Property Resource (CPR). In terms of bundle rights also RWHS qualifies to be a CPR where the people collectively have the rights to access, withdraw[51], manage and exclude outsiders from the resource.

4.1.1. Rainwater harvesting: basic concepts and characterizations

Technically, rainwater harvesting, means catching, collecting and storing rainfall water before they rush off and disappear beyond reach of a particular society's area of habitation and surroundings. Oweis et al (1999) define water harvesting as the process of concentrating rainfall as surface runoff from a larger catchment area for use in a smaller target area for various purposes. The objective of rainwater harvesting is mainly to serve two purposes of a society:

1. Storing rainwater for ready use in containers, and/or cisterns or water tanks erected above or just below the ground floor. At present many people place it on the top roof of houses or below the ground, with covers to evade evaporation.

2. Manage the runoff flow as to facilitate its infiltration into the ground to recharge and replenish the groundwater resources (Oweis, Hachum & Kijne 1999: 2).

51 Access and withdrawal rights will be similar in case of RWHS.

Both the methods serve the human society to supply water for drinking, cooking and other domestic purposes including serving the domestic animal stocks, and also for irrigation to raise crops. There are basic differences between the highly decentralised, small-scale indigenous rainwater harvesting systems on one hand, and the formal centralised, large-scale, bureaucratic, more technical functions of the irrigation department on the other. The former is distinguished from the latter by three key features:

a. the water catchment area is contiguous with the benefiting target area in RWHS

b. the application of water to the target area is regulated and controlled by the communal norms and traditions in time and space according to needs, and

c. water harvesting can be used to concentrate rainfall for domestic supply as well along with agricultural purposes and crop production (Oweis, Hachum & Kijne 1999: 3).In contrast, irrigation is meant only for agriculture.

The chapter is divided into seven sections. Section 4.1. gives an introduction of RWHS and its basic concepts and characterization. Section 4.2. discusses rainwater harvesting governance systems in pre-British, British and post-independence periods in India in details. Section 4.3. describes various kinds of rainwater harvesting practices in different parts of India. Section 4.4. gives an account of knowledge of rainwater harvesting. Section 4.5. gives a description of rainwater harvesting in general in Alwar and Bikaner districts of Rajasthan. Section 4.6. puts research questions.

4.2 Rainwater harvesting in ancient period: A brief overview

Often viewed as ‘pre-technical’, the origin of rainwater harvesting takes back to 8000 BC. Domestication of plants and animals necessitated such a step. Neolithic (New Stone age) period gave rise to man’s attempt to produce his own food, uplifting himself from the phase of gatherers and hunters. Agriculture, necessarily led towards settling of human groups at various sites which furthered the formation and evolution of hamlets and villages at discrete

places.[52] Anil Agarwal and Sunita Narain have outlined some details of rainwater harvesting in the Citizen's Report (1997), which are about 6000 years old. When human settlements started, there was two-fold struggle for water; people had to protect themselves from the double pronged menace of floods, and to ensure safe water supply for domestic use and irrigation to save their crops from lack of moisture in soil, and droughts (Agarwal & Narain 1997: 13). In order to satisfy these essential needs, they developed techniques to catch rain and surface runoff. In fact, in settled life (in contrast to nomadic life depending on water resources at random) the techniques of fetching water to settled communities, were very early developed, but still older were man's personal/familial water supply efforts (Smith 1976: 69). Proceeding onto these steps, mankind succeeded in raising better hydro-technical installations, a technological achievement. Since then, human groups have produced many hydro experts, even though not much existed in the form of organised and documented scientific hydro theories.

Storage of water in cisterns became known when the first cities like Jericho in Palestine or Harappa and Mohenjo-Daro in the Indus Valley were built-up. The remnants of oldest cisterns were discovered from Palestine and Greece. These cisterns were used to collect rainwater from roofs, paved squares and also from water-bearing subsoil strata. Rock was the first material used by them to make cisterns in this initial stage. Masonry cisterns came into existence in a later period. From 2000 BC, mortar was used for sealing these cisterns from possible leakage. By middle of first century AD, covered cisterns with storage volume up to 75,000 cubic metres were built and fundamental elements of dam construction became known for the purpose of impounding water behind the flowing water course. The earliest dams impound and retain water in large quantities were constructed in Jawa (Jordan) in 3000 BC and in Wadi Garawi (Egypt) in 2600 BC. Many civilizations and states in ancient world built dams and contributed to human experience and knowledge in this field. All these dams were built more by using empirical experience and rules, technical skills and close acquaintance with hydraulic forces. The Indus Valley and Mesopotamian civilizations had excellent water supply and sewage disposal systems. The early Hindu texts, written in 800-600 BC, reveal knowledge of hydrological relationship. The Vedic hymns, particularly the

52 http://www.hort.purdue.edu/newcrop/history/lecture01/lec01.html <DOA: 05/7/11>

Rig Veda, have many notes on irrigated agriculture, river courses, dykes, water reservoirs, wells and water lifting structures (Agarwal & Narain 1997: 13).

4.2.1 Governance of rainwater harvesting in India

India gets its maximum rainfall in seasonally operating South West summer monsoonal and North East winter monsoonal periods and some through western cyclonic disturbances in winter in North West and Northern parts of the country. These provide widely spatially fluctuating and uneven rainfall, both in amount as well as in time and space. Therefore, it becomes incumbent on the people of India living in different agro-climatic zones and habitats to develop widely varying mechanisms for different uses of rainwater.

4.2.1.i. Governance of rainwater harvesting system during pre-British India

According to Citizen's Report (1997), rainwater harvesting has been practiced from very ancient periods in India. Evidence of rainwater harvesting tradition can be found in ancient texts, inscriptions, local traditions, folklores and archaeological remains all over. There are some evidences of advanced water harvesting systems from pre-historic times also. Vedic texts, the Puranas, the epics like the Mahabharata, the Ramayana and various Buddhist and Jainist texts contain many references to conduits, canals, tanks, embankments, wells and springs. There are several terms used in the original text such as in Kautilya's Arthashastra, related to rainwater harvesting systems. For instance, the term *setu* is used for embankment or dam for storing water, *parivaha* for channel, *tataka* for tank, *nadyayatana* for water from river, and *khata* for well. There are several interesting points which emerge from Kautilya's Arthashastra, as noted and described in the 'Dying Wisdom', related to common property. The land on which the tank was built was state property (*raja svamyamgachechhet*) but was used by the common people. Settlers or villagers on their own initiative could also pool their resources to build a tank for common use (*sambhuya-setubandhat*). A set of very strict rules were observed in the repair, maintenance and use of these common resources. Person who did not contribute in the building of irrigation work was given punishment. Fines were imposed when the embankments got damaged or when lower tank got flooded because of construction of tank at higher level. This shows that collective action was readily promulgated on such

misdeeds and wrong usage of water. Such punishments were commonly preached elsewhere also (Agarwal & Narain 1997: 14).

Evidence of water management in pre British India can be found in ancient texts, inscriptions, local traditions and archaeological remains. The Arthashastra gives a clear account of water management in the Mauryan Empire. It states that local communities were aware about their rainfall regimes, soil varieties and irrigation techniques. The Arthashastra also mentions that the state rendered help and support to promote water harvesting structures (Naz, 2014). Traditional Indian water structures were generally large and built at the behest of kings seeking agricultural prosperity and to increase state revenue, along with religious sentiments attached to such constructions (Naz, 2014). Indian kings also encouraged nobles, ordinary people and temples to construct water harvesting structures by giving grants in the form of revenue-free lands, provided local communities were willing to invest in the construction and maintenance of the structures. Whereas finance and organization were provided by kings in the larger delta systems of south India, day-to-day management was entrusted to local cultivators. Small community-managed schemes were also developed in other parts of India such as *ahar-pynes*. Vedic literature describes about open-lined and unlined wells which were used for domestic water needs and for complementing irrigation needs. The *Satwahanas* of ancient India introduced ring wells-dug wells for irrigation use, whereas privately owned open wells operated manually or were powered by animals in the high water table areas of the Upper Gangetic Basin. From third century BC to Mughal rule through sixteenth to eighteenth centuries and even later during colonial years, land irrigated by wells was assessed at higher rates than rainfed lands. Wells were mostly owned and constructed by individual peasant families of dominant castes. Their control over water enhanced their local power over lower castes and untouchables (Naz, 2014).

Vani (2005: 173-176) gives a description of water management systems in the Pre-British period. She says the control and management of water systems was significantly decentralised. The political and legal arrangements in use of water resources enabled decentralised water and land management which had integral connection with culture as well as religion. The integration of functions of defining, allocating and regulating rights with local management allowed the definition, allocation and regulation of duties in terms of protection and conservation of resources by the members of local communities.

In the semi-arid and arid (Marusthali) parts of Rajasthan, for instance, people developed covered wells for drinking water purposes (saving from evaporation and dusts and sands in these windy areas), while there had to be deep and wide open *talaabs* for bathing, washing and animal stock watering purposes. The large raised embankments of these *talaabs* were shaded by growing huge leafy shady trees in rows to reduce evaporation. Agriculture in dry parts of India, like Rajasthan was mostly rain fed and seasonal, which consisted of consumable cereals for humans, and fodder for animals. The villages were divided units based on castes and so water system had its own hierarchical governance. Still, social norms ensured that everyone had access to water. Groundwater resources were hard to get, and was not exploited on any sizeable scale. Only deep wells, sourcing ground water, could exploit the aquifers, while ordinary wells were unlined and had ordinary surface wells few feet down the ground floor. Most of these structures were built by local people under the guidance of local water experts, available locally. Traditionally, these experts did not charge any fees for their consultancy. Common people, mostly landless and some poor peasants of the community, provided labour, while the money and some grains and jaggery, which were the village produce required for the workers, were provided by the wealthy villagers as well as by the officials of the local rulers. Since the entire community participated and got involved; every member of the community for generations was obliged to help in repairs and maintenance of these structures over time.

Invariably, at least in some areas, as in Rajasthan, evidences exist that local ruler, laid down norms and rules, which governed the repair, maintenance and use of water. There used to be a communal accountability and responsibility through the village leadership. The rulers never involved themselves directly into this task. Very often, many rulers used to grant or gift some land, to the community and the revenue accruing from the gifted land was spent on the maintenance of the tanks. In fact, there are examples of religious shrines being built up and maintained along with the tanks. Bundelkhand and Rajasthan are profuse with such arrangements. Evidences show that these structures carried legal bindings promulgated by the rulers/builders to be provided regularly the details of water sharing and propose use and conservation. Communities also respected these bindings as there were also social penalties on abusers and wrong doers. The entire village was considered as a revenue unit. The headman or mukhia of the village collected levies and deposited with the ruler. This kind of

regulated collective responsibility and accountability existed for both land and other natural resources ownership as well (Jacob 2008: 2-3; Agarwal & Narain 1997: 269-313).

Kumar (2007) discusses that in Rajasthan, the water table varied and was brackish in western part of the state. The water table sinks rapidly as one moves away from the Aravallis across the desert. The depth of the water varies from 50 metres to 115 metres from the west to the north-west therefore it was necessary for the people of Rajasthan to manage water for drinking as well as irrigation purposes. 'The irrigation pattern map in Bhadani's writing gives a confirmation that the pattern of settlement depended largely on the character of water supply. Settlements tended to be denser where the water table was high in the eastern and south-eastern portions of Marwar and remaining parts it was much lower.' (Bhadani 1999: 9) Kumar further discusses Bhadani's view that brackish nature of water made non-feasible for drinking as well irrigation purposes. Kumar (2007) further argues that 'as a response to the given level of technology and such environmental conditions we witness the greater emphasis on the water storage mechanisms rather than on water procurement systems in pre-colonial Rajasthan.' Most of the indigenous methods for water conservation in pre-colonial period were practised at individual level some of which required larger community participation or support from political power. The most important method for water appropriation was wells wherever feasible. The structures and functioning of the wells also changed with variation in depth of water table.

Deployment of water lifting devices (which differed according to topography and water-table and also nature of requirement) resulted in decline of water table. 'Apart from wells, which were the most common method of water harvesting, several other methods of rainwater harvesting were practiced. One such method of water harvesting was known as *kuin* or *par* or *teen*. In appearance it was similar to a well but with a different mechanism which evolved to adapt to the particular environmental niche. It was difficult to construct a *talab* or tank in sandy soil of Churu, Bikaner, Jaisalmer and Barmer districts of modern Rajasthan. Sandy soils of the region made it difficult to construct a *talab* or tank as water could permeate deep and traditional wells could not be constructed. However, these districts had an underground layer of chalk or limestone, which restricted percolated rainwater from mingling with brackish groundwater. The presence of underground layer of limestone ensured that rainwater would remain potable and could be appropriated. Moreover, sand does

not bind up like soil, hence restricting the possibilities of evaporation of trapped percolated water. Rainwater so retained by sand gradually seeps into the open space available at bed of *kuin.* It was usually not more than three to four earthen pots in a day. Therefore, *kuin* was not meant for round the clock water availability and was used for drinking purposes only. The presence of wells speaks for the better appropriation of given environmental conditions and better management of limited natural resources' (Kumar 2007: 78-79). *Bera* or *beri,* another method of water harvesting and variation of well was constructed near a water body or on the dry bed of water body.

Another important method of water conservation was *kund* or *kundi*. It was used for direct accumulation of rainwater used primarily for drinking purposes. This method was extensively used at places where water was brackish or available at greater depths or both. *Kundis* were constructed for both domestic and public purposes. The roof of the houses were used as catchment area for collection of rainwater, before onset of rain, the roof was cleaned with first rainfall and then subsequent rains were directed to the underground water tank. The underground tanks were used as reservoirs of water. Lime mortar was used for construction of *kundi* or *tanka* as it was able to restrict seepage. Since the cost of construction of *kundi* was high enough, therefore it was beyond reach of common man and it was only possible for those who could construct *pucca* houses and lower sections of the society depended on *kuin.* There are a number of *kundis* in open fields meant for public use. The roof of the *kundi* is used as catchment area of the system. The State also promoted construction of *kundis* at times. The bigger form of *kundi* is known as *tanka*. Tanks were constructed in regions which had clayey soil and hard ground surface which allowed limited percolation and construction was easy and feasible. Its construction required knowledge of thorough geography of the area. Slope direction, gradient and topography of the catchment area were important considerations for its construction. *Ranas*or the rulers of Mewar constructed a number of water storage systems for drinking purposes.

Kumar (2007) discusses that there are a number of evidences to safely argue that the state extended financial and material support looking at peculiar environmental conditions for the construction and maintenance of water appropriation mechanisms. Most of these investments were made to ensure beneficial agricultural production. 'The ruling elite extended support for the construction of wells to encourage the habitation in the region to

enlarge the revenue base of the states. Kings actively promoted the construction of mechanisms for water management. Construction of wells was promoted in the regions with relatively high water-table. The state extended loans to the peasantry to excavate new wells. Regions with deep water tables opted for tanks which were also state financed. Rulers also offered financial support for the repair of wells. The peasants who dug up new wells were offered concessions in land revenue. In *pargana* Pahari the failure of *rabi* crops was attributed to the lack of well irrigation in most of the villages in 1727. Similarly, the state was urged to provide loans to peasants in order to enable them to buy *lao-charas* (rope and leather) so that they could operate wells to irrigate crops' (Kumar: 2007, 82-83).

"The declaration by the State that rivers and water bodies 'are the property and subject to the control of the state' does not, however make the State the absolute owner of water. The nature of the proprietary interest of the State was made clear by some significant judgments around the same time. Court judgments before independence also establish that the rights exercised by the States over waters are in fact not proprietary in nature but sovereign in character" Upadhyay (2005: 138).

4.2.1.ii. Governance of rainwater harvesting system during British rule

Evidently, India, as a whole, had established and maintained highly decentralized but well-organized and regulated rainwater harvesting systems for serving domestic and agriculture needs under local communal ownership/management systems. The British, however, were greatly exploitative colonial rulers in each and every sense. They viewed India as a large revenue-providing country and changed the traditional system of land ownership and natural resources use patterns. Different sorts of taxes in villages were imposed on these resources and on city-dwellers, and on houses and other establishments. The British policy was so made as to maximize revenue from all resources, including common use lands (*banjar* land, waste lands, village forests and woodlands, grasslands and animal stock resting places and ponds and other water impoundments). Several natural resources such as forests and woodlands could be exploited by the state as much as possible (Jacob 2008: 3-5). They required timber to feed industrial revolution at home as well to build navy, railway system and thousands of administrative buildings all over India. Water resources also became sources of revenue as government started controlling tanks and ponds, and levied charges on farmers. 'British colonization brought three influences- a transformation from resource-gathering and food-production economy into a commodity-oriented economy; a change in

long-standing social relations and customs as local social relations became less important and social cohesion declined; and the development of the market and the importance given to wealth.' In order to gain quick economic returns from water development, the colonial government attempted to initiate large-scale irrigation projects in the Deccan region which was not successful. This failure provoked the British to look towards the reintroduction of the traditional irrigation tanks system. But their attempts could not succeed due to lack of understanding of complex socio-ecological system involved in its management. In order to bring all the bigger tanks under direct control of (Public Works Department) PWD of the colonial regime for repair and maintenance, centralized administration for irrigation was evolved. All this led to decline of the systems as PWD did not have the budget or staff to take care of such independent systems and people were under the impression that the state would look after structure of tanks with formation of PWD (Naz 2014: 35-37).

Jacob (2008: 3-9) gives an account of the governance of RWHS by the British government. Several drastic changes were made at the level of rules and organizational structures of governance. A separate department of irrigation was formed by the State, creating a centralized government-driven system for maintaining varied water structures in India: tanks, *tankas, kunds, baolis*, wells, canals and large dams. This department had fixed procedures for maintaining the structures which did not always match the conventional, diverse, procedure for maintenance and use of the system by villagers. The irrigation department engineers were often corrupt and the work done by the Department was found to be usually sub-standard; it could not hold for more than a very limited period. The result was that the structures started falling apart very soon. Also, people in villages and towns gradually gave up their responsibilities for maintenance and repair of these water storage facilities. People started feeling as to have lost any stake of theirs in these structures. It took very long for break down to come to light and when it became noticeable, it had become irreversible in many places. The government did not look into the root cause of the problem; rather it chose large projects as solution, which had no participation of the people either. Jacob (2008: 5) says that under the British State policy, water became de-linked from its cultural and religious roots and became a purely economic asset. In the British rule, custom had no existence outside the law. "A shift in rights and control over natural resources in favour of the state was combined with 'de-authorization' of custom as a source of law, and a centralization of law-making and implementation or enforcement of law- a change that terminated the

potential for local 'self-governance', and thereby the scope for the engagement of citizens in resource management through their local institutions" (Vani 2005: 175-176).

All water resources, like land and forest, became subject to the exclusivity of State sovereign rights. State Control was affected over water sources that is, rivers, streams, lakes. Water systems included government-constructed canals and other works, as well as 'privately' constructed water systems such as canals, tanks, wells and the various water technologies that predated colonial rule, or were constructed later as well. Water rights were recorded and regulated by State law. As with land and forest rights, water rights were also recognized legally on an individual basis, and mostly in association with land rights. Interestingly, it is also argued that the British did not have knowledge of water harvesting because of temperate rainfall pattern in Britain so it was lacking in their natural resources policy.

We have discussed in the previous chapter that rainfall patterns are different in Britain and India. While India receives monsoonal rainfall, Britain has a temperate rainfall pattern where water "...was treated as *given*, to be used at *will" (*Jacob 2008: 5). As a result, it has been argued that British continued to treat water as given, which can be used to raise revenue at will. Incidentally, traditional water harvesting structures which had multiple uses[53] were de-legitimized and categorized as "minor irrigation systems. The most adverse feature to the concept of RWH was the separation of land, forest and water resources under different legal and administrative systems. The preamble to the Limitation Acts (1859-71), the Northern India Canal and Drainage Act 1873, the Bengal Irrigation Act, 1876 and the Specific Relief Act, I of 1877 reflected that the Provincial Government is entitled to use and control for public purposes the water of all rivers and streams flowing in natural channels and other natural collections of still water. These Acts do not talk about varied patterns of ownership and asserted the right of the State to use and control water (Upadhyay 2005: 135). Vani succinctly puts it as "The colonial period of history abruptly suspended the practice of rainwater harvesting and the modes of governance that enabled it. They were supplanted by an alien 'scientific' perspective, environmental philosophy, political economy and

53 Such as drinking and domestic use; irrigation; fisheries; flora; animal husbandry, including duck rearing; as groundwater recharge mechanisms; for silt; for seasonal cultivation on beds of water bodies; as flood controlling mechanisms; for social and religious purposes.

governance systems" (Vani 2005: 169). 'Through these Acts, the Government of India intended to lay down a proposition (that the property in the lakes, rivers and streams of British India was vested in the state, subject in certain cases to rights acquired by usage or grant) which was indicated in 'not only existing custom of India, but of a fundamental rule universally recognized in Western Europe which resembled India in their dependence on artificial irrigation' Vani (2005: 178). The declaration of the rights of the state over all water resources met a lot of opposition from the national and regional levels both within government and outside it. For instance 'the Government of North-Western Provinces and Oudh, in a letter to the Government of India, Department of Revenue and Agriculture objected to the Preamble of the Act saying that the statement that was set forth that all lakes, rivers, channels and other collections of water are properties of government was not correct as regards the North-West Provinces. The running water in the rivers and streams was the 'property' of the government, and as long as due provision was made in the Act for compensation to individuals for rights that were affected by government action, there was no objection to the declaration. However, natural drainage channels and lakes were sometimes private property. Sometimes these were partly private and partly public as some of them in Bundelkhand' Vani (2005:179-180).

'The Northern India Canal and Drainage Act 1873 set the precedent for water statutes that followed. The rights of the state over water resources were reiterated in the Punjab Minor Canals Act 1905, the Preamble of which set out clearly the need for 'interfering' with private rights which was prevalent practice across the country before the British colonial establishment took up the business of supplying water for irrigation' Vani (2005: 181-182). Vani discusses that agriculture in the hilly tracts was not considered as profitable enterprise by the British and agriculture in hills could be very costly in mountainous terrain. Earning revenue from water existed through the medium of water mills, small-scale technologies which used power of running water to turn mills for grinding corn and wheat. The owner of the mill was supposed to pay tax to prevent disputes.

'The control and management of water resources by the British in India was exercised ubiquitously, within territories that had been brought under direct British administration, within '*zamindari*' areas as well as within 'native States'. 'Control was affected over water

resources that are rivers, streams, lakes and other collections of water and water systems. Water systems included government constructed canals and other works as well as 'privately' constructed water systems such as canals, tanks, wells and various water technologies that pre-dated colonial rule, or were constructed later as well. The latter type of systems, which constituted the main indigenous technology for the harnessing and use of rainwater for all purposes, was relegated in British policy to 'minor irrigation' status, where they remain cemented to this day. Thus, in totality, all water systems and technologies in all territories in the country came under British control in varying degrees. At the same time, irrigation and land laws provided for the maintenance of the records of private and community use rights to water. As protecting private use rights to water supported the colonial revenue policy of maximising revenues from agriculture. The colonial water law brought about a fundamental and radical change in the relationship between state and citizen in the matter of ownership, use and management of water resources. The same respective positions have been meticulously maintained till date is evidenced by the post-independence water law Vani (2005: 183-184).

Sengupta's (1980) work informs that the British changed the then existing community organisational structure in South Bihar. There existed interdependency of land and water during pre-British period which was disrupted in the British period after the introduction of land rights in the country. The *ahar-pyne* system of irrigation practiced in south Bihar decayed primarily because of shift from produce rent system to fixed rent system after the introduction of Tenancy Act (1885), which came into force in Bihar in 1904. Before the British rule, the irrigation system was maintained by the local people and patronised by the *zamindars*. Sengupta (1980: 73) points out that "once the rents were fixed, and the *zamindars* had nothing to lose by decline in irrigation, they stopped taking care of those works. In addition, in order to increase their income, they sought another course of action by using irrigation works as the level of control." As a result, the *zamindars* became less interested in maintenance of these structures which led to the decline of *ahar-pyne* system. Rosin (1993) argued that the local people of western Rajasthan perceived harvesting of rainwater through groundwater recharge and established a direct relationship between their surface water storage facilities and quality and supply of soil and groundwater. Furthermore, Rosin discussed that removing accumulated silts in turn improved the permeability of the bed to increase infiltration rates for soaking and recharge according to local understanding. But the

British hydrologic engineers' viewed high groundwater levels as threat to kinds of irrigation systems they built. They were not in favour of removing silt from the bed of the dam either because soakage through dam bed or through walls of canal may contribute to water logging and high loss of surface water diverted from irrigation. Rosin thus underlines the connection of locally embedded knowledge to sustenance of traditional practices.

Vani (2005) argues that prevailing constitutional and legal provisions on natural resources in India was borrowed from colonial law and it constituted the primary obstacle to the involvement of local communities and groups in governance of water resources. The principal law among the obstacles is the doctrine of eminent domain which is 'premised on the proposition that the state always, by definition, acts in the public interest and that it can therefore claim eminent domain over all other social entities.' Vani (2005) discusses that Article 31A of the Indian Constitution, says that private and community rights to and in land resources are not absolute but are subject to the state's rights as the supreme landlord with private property rights exercised subject to the payment of revenue or taxes. 'The colonial Land Acquisition Act 1984, still in force in India says that the rights of citizens and local communities over land either customary or legal are not absolute but is subject to state power to control them in 'public interest.'

4.2.1.iii. Changes in Governance of RWHS during the post-Independence period

Unfortunately, however, the same policies continued to practice after the independence. The forest department proceeded to generate revenue by cutting trees, the irrigation department 'pretended' to control water resources, and huge revenues of irrigation were misused and accounted for never-performed canals. Further, the government continued to alienate the villagers from forests and water reserves. More importantly, the tanks and wells which maintain groundwater level started getting attention with the Community Development and Block Development works. New tanks were not built by the government because they did not want the arable land to get occupied.

Water resources have recently caught attention with the noise made out all over on lack of fresh water for drinking purposes and drought-prone agriculture areas. Environmentally sustainable development as a fundamental aspect of and special approach to political governance was not envisaged in India at the time of creation of the Constitution of India, although the Community Development Works was started in 1952 on a pilot basis. The Community Development Programme lies in close relationship with the Five-Year Plans of the government. After the publication of Balwantrai Mehta Report, it was realized and recognized that the rural areas and people will need assistance and resources continuously. Community development could not always be put under Five-Year Plan for bringing development over a long period of time. The development blocks were given responsibilities to do work primarily in agricultural field and to promote the growth of panchayats and co-operatives (Mukerji 1961: 17-27). Rainwater harvesting was not recognized by the government till 1980s. "Post-Constitution, the class of elites that took up the reins of power retained this same colonial apparatus for ushering in a new political economy of 'Independent' India. Consequently, the monsoon as defining factor of ecology and economy of the country has been ignored in water and land management policy and law. By 1980, the government was compelled to acknowledge the extensive land degradation that had taken place across the country because of the unsustainable management of land and water resources. According to estimates made by the Ministry of Agriculture in March 1980, as many as 175 million hectares (mha) out of a total of 305 mha for which record exists were subject to environmental problems" (Vani 2005: 169). India has varied climatic, topographical, geological and ecological features in its different regions. Such a varied ecological profile shows that there should be suitably varied approaches to RWH which indicates a highly decentralised approach. In fact, RWH is based on the approach that since rain is decentralised therefore its harvesting should also be decentralised. But this factor was never taken into account either by the colonial engineers or by the Indian engineers who continued to commit same mistakes and build projects inappropriate to the native environment. Apart from the highly diversified ecological conditions, the prevailing cultural dimensions of Indian society also demanded an inclusive approach for resource management (Vani 2005: 171-172).

Nevertheless, despite such acknowledgement of flaws in earlier policies, the same trend continued. The National Water Policy, 2002, arguably reflected the same colonial

perspectives of India's natural resources profile and their administration. The NWP states that "precipitation is confined to only about three or four months in a year and varies from 100 mm in the western parts of Rajasthan to over 10000 mm at Cherrapunji in Meghalaya". It does not acknowledge the narrower interval of time for measurement of rainwater, which can acknowledge the existence of diverse rainwater harvesting practices too. Although a section has been added on participatory mechanism (The section on Participatory Approach to Water Resources Management), it does not visualise people's participation in the governance of rain water harvesting systems. RWH is mentioned as one of the traditional methods, along with other non-conventional methods of water conservation. However, "Water resource is considered as State subject under the constitution. Water policies at the State level reflect the same sectoral, project oriented approach to water resources management, which constitutes a barrier to RWH".

The enactment of the Kumaon and Uttarakhand Zamindari Abolition Act 1950 in Uttarakhand confirmed that ownership of private well like pond, *naula* or *nauli* lied in owner of land on which it was located. Rules framed under the acts established that this gives the right to transfer of the pond to owner of the land. The rules also said that 'tanks, ponds ferries, water channels belonging to the State shall be managed by the Gram Sabha or any local authority. The Kumaon and Garhwal Water (Collection, Retention and Distribution) Act 1975 was passed to regulate and control water resources in the mountain tracts of the Kumaon and Garhwal divisions and for this purpose it empowered the State government to regulate and control by rules under the Act, the collection, retention and distribution of water and water resources. The Act also declared that all the existing rights of use of water whether customary or whether vested in any individual or in village communities shall stand abolished. The next section of the Act says that State Government should regulate and control water and water resources and adds that while exercising its powers, the State Government will 'give preference to the persons or village communities whose rights in respect of water have been abolished' under the previous section (Upadhyay ,2005: 140-141).

National Project for Repair, Renovation and Restoration of Water Bodies Directly linked to Agriculture, 2005, was prepared to take up pilot projects in States for implementation by State Governments for which funds would be released by the Centre. A clear focus of the project is the revival of traditional water bodies. But Upadhyay (2005)

argues that if the State is really serious about reviving traditional water bodies, can it continue to work under a legal regime which fails to recognise the customary water rights that were prevalent. The policies related to water management in India is more people-oriented and demand driven through a series of State-induced initiatives but non of these discuss the issue of ownership of water. Under the Provisions of Panchayats Act, 1996 (PESA) wherein Gram Sabhas and Panchayats have been given special powers in respect of minor water bodies. Upadhyay (2005) argues further that PESA only talks about planning and management of Minor Water Bodies by the Panchayats and not their ownership while in principle most agree that village people should have sense of ownership in the local water bodies if realistic efforts are to be made to revive and maintain them. Upadhyay (2005) further discusses that in "India Participatory Irrigation Management programme, scant attention is given to water rights and also the 'sense of ownership' should not be an illusion but should be grounded on people's right to water and their ownership over local water harvesting structures" Upadhyay (2005:145-147).

The Rajasthan Water Policy project is a slightly better perspective than other states. It contains a section on "Maximizing Water Availability" and lists several strategies to achieve this. One of them is "traditional water harvesting practices shall be preserved and encouraged" and the other: "Projects for artificial recharge of ground water shall be prepared". However, many scholars feel that there is a need to expand the concept of RWH beyond "traditional water harvesting" and mainstream it in all aspects of developmental planning (see, for instance, Vani 2005). Jacob (2008) also points out that the section on "Water Conservation and Efficiency of Utilization", which discussed the topic in different sectoral contexts domestic sector, agriculture, industry, watershed development, *does not once mention RWH*." (Jacob 2008: 6, emphases in original)

Vani (2005) discusses that the post-constitutional water and land laws emphasized the rights of the state over water resources in order to enable State-centric water policy. Customary individual and community water rights of ownership and use were mostly associated with 'minor irrigation systems'. And customary rights were neglected adversely affecting the strength and clarity of 'use' rights.

4.3 Diverse rainwater harvesting practices in India

There are two subsections of this section; the first section outlines the rainwater harvesting practices on streams and rivers and the second section discusses the rainwater harvesting practices in different ecological regions.

4.3.1. Rainwater harvesting practices developed on streams and rivers

The discussion is based on The Citizen's Report (Agarwal & Narain 1997: 25-28) which gives a detailed description of the traditions of various types of harvesting of water in different parts of India which started growing when people started realising that human society cannot grow without saving monsoon water for dry months. Depending on the sources available to them, Indians have developed a wide range of techniques to harvest all possible forms of water. Examples of such systems developed on streams and rivers are given below.

Wherever there were streams in hilly regions, people developed techniques to divert its water with help of simple structures. When streams became bigger and turned into rivers, engineering also became sophisticated and diversion systems bigger; an example of such system is *The Grand Anicut* on the river Cauvery. Sometimes in arid and semi-arid regions where water in streams was more seasonal and scarce round the year, the diversion channels were directed into a storage structure, called *zing* in Ladakh, an *ahar* in south Bihar, or a *kere* in Karnataka, so that water could be used in dry periods for human and animal consumption and for agriculture. Many of these structures collected water running off a catchment area to be stored for later use. Stream-fed storage system was more reliable because it collected water over a much large catchment. In the dry areas of Rajasthan, people built structures like step-wells; wells below tanks and other types of water storage structures. This way they could harvest clean groundwater to meet their drinking needs when the water of tanks dried up in parched season.

In the flood plains, people developed techniques to use the floodwater to irrigate their fields and also to fertilize their fields and control diseases like malaria by making use of fish in floodwaters to eat mosquito larvae. Pre-British India had developed mechanisms for harvesting floodwaters in the flood plains of Bengal which was not present in post-

independence India. In the coastal areas, where coastal tides periodically turned river water saline and made it unsuitable for agriculture, people developed techniques which resulted flow of high saline river waters and control the productivity of rice agro-ecosystems and long-term soil fertility in *khazana* lands of Goa. In areas having good groundwater aquifer, Indians harvested rainwater with help of *dugwells* and developed various techniques by using local materials to lift that water to irrigate the fields. Wells were important source of irrigation in groundwater rich region of the Indo-Gangetic Plains.

In the hills and mountainous regions of Eastern Ghats, people learnt Middle Eastern technology o *qanat* to build subterranean structures or rather horizontal wells called *surangam* to tap the water seeping down from hillsides to use as drinking water. People started relying on rainwater when there were no options. For irrigation purposes, they built rain-fed tanks to provide irrigation water. In the *haveli* system of Madhya Pradesh, the soils and traditional crops were such that farmers found it useful to store rainwater in agricultural fields. In several places, people constructed embankments to catch monsoon runoff from catchment area to collect water in the bed of storage structure itself. This allowed the collected water to seep down in the soil and give it enough moisture.

The people of Northeast have developed use of bamboo for developing systems for carrying water over a difficult terrain. All over the eastern Himalaya and north-eastern hill ranges people continue to build simple bamboo pipelines to carry water from natural springs to a convenient point where it can be used for drinking. The decision whether to store or recharge rainwater depends on the rainfall pattern and the potential to do so in a particular region. Delhi, Rajasthan and Gujarat are example of places where groundwater recharging is practiced. In places like Kerala, Tamil Nadu, Mizoram and Bangalore, rain water is stored in their own ways.

4.3.2. Typology of Indian Traditional Rainwater Harvesting Systems

The discussion is based on 'Dying Wisdom' (Agarwal & Narain 1997: 27).India is divided into four ecological regions and there are varied traditional rainwater harvesting systems for agriculture and drinking water based on the ecological conditions.

1. Hill and mountain regions: there are two systems of agriculture; the first is diversion channels leading directly to agricultural fields (eg. *Guhls* and *kuhls* of western Himalaya) and the second is also diversion channel leading to a water storage structure which can be used in dry periods (eg. *Zings* of Ladakh). The systems for drinking water are natural springs, rainwater harvesting from rooftops and spring water carried through long bamboo pipes.

2. Arid and semi-arid regions: the systems for agricultural purposes are described as follows. Tanks are structures which are rain fed and provide water for a downstream command area, stream or river-fed storage structures sometimes built in a series with overflow from one becoming runoff for the subsequent one (eg. system tanks of Tamil Nadu, *bandhara* of Maharashtra, *keres* of Karnataka), rain fed storage structures, which allow runoff to stand over and moisten the fertile soil-bed of the storage structure itself, which is later used for growing crops (eg. *khadin* of the Jaisalmer district and *johad* of the Alwar district in Rajasthan). The systems for drinking water purpose are discussed next. Groundwater harvesting structures like wells and step wells were built to tap groundwater aquifers (eg. *Bavdi* of Rajasthan). Groundwater harvesting structures like wells and step wells were invariably built especially below storage structures like tanks to collect clean seepage for use as drinking water (eg. several such structures can be found in the forts of Chittor and Ranthambore). Rainwater harvesting from rooftops were done (eg. *tanka* of Pali). In very dry areas, the primary need of people was drinking water and various techniques were developed to collect rainwater to use as drinking water. In Rajasthan, there has been tradition of using the rooftop as a catchment area to collect water. In some areas, people developed structures known as

kundi to obtain drinking water. *Kundi* are artificial wells which store runoff from artificially prepared catchment, surrounding the well so that any rainwater that falls on the catchment rapidly runs into the well and gets stored. *Kundis* are common in the Thar Desert of Rajasthan. The nomadic *Maldhari* of Kutch region of Gujarat have developed system of procuring potable sweet water in an area where rainwater is scarce and groundwater saline. They know that the density of sweet water is less than that of saline water and it is possible to keep the harvested sweet rainwater stored in a way that the sweet water will continue to float on the denser saline water and provide people with an opportunity to live and survive; this particular system is called *varida.* Horizontal wells similar to the *qanat* of the middle East to harvest seepage downhill slopes (eg. *surangam* of Kerala)

3. Plains and flood plains: the systems for agricultural purposes are described as follows: In the flood plains of major rivers, people built inundation channels which allowed floodwaters to be diverted to agricultural lands (eg. flood irrigation system of West Bengal). In specific types of soil and cropping regions, people also store rainwater in the agricultural fields by bunding them (eg. *haveli* system of Madhya Pradesh). The system for drinking water purpose is dug wells.

4. Coastal areas: the systems for agricultural purposes are regulatory systems to control ingress of saline river waters, especially during coastal tides, and thus maintain crop productivity in the coastal plains (eg. *khazana* lands of Goa). The system of dug wells is used for drinking water purposes.

Thus, in a nutshell, we can say that water was governed diversely in different ways in different parts of India, which would have led to formation of a variety of locally managed institutional structures. Some of these institutional structures might be prevailing as such while some might have evolved over time along with scientific practices. One of these

institutional structures for governance of rainwater harvesting in Alwar, Rajasthan will be taken for the present study in next chapter.

4.4 Knowledge of rainwater harvesting: A general overview

'The term water harvesting describes a range of techniques for collecting and concentrating runoff. These systems harvest water directly from rain, or dew, or indirectly from runoff or ephemeral streams for agricultural, livestock, or domestic use. Rainwater harvesting is often seen on the fringes of cultivated regions in arid and semi-arid zones, and near deserts providing food, fibre, and drinking water for local communities. Water harvesting structures can improve the standard of living of local farmers and livestock managers. In many areas, without water harvesting, domestic crop production would not be feasible. In other semi-arid regions, crop yields are more stable with the use of these systems. Water harvesting can only be successful if farmers or resource managers design the systems to fit the local physical, economic, and social environment. Technical manuals highlighting the physical elements of various water harvesting techniques are frequently lacking sufficient information for practitioners to build successful systems' Frasier (1984).

Physical and technical design characteristics of micro catchment RWHS:

In any water harvesting system, the runoff collected during rains must fulfil the needs of the crop during the growing period of dry, sunny weather. The catchment area must have a smooth soil surface with sufficient slope to generate runoff during precipitation events. The soils of the infiltration basin must have a sufficient depth with a texture and structure suitable for infiltrating, retaining, and storing the runoff water. If the physical system is poorly designed and managed, problems of soil erosion, flooding and insufficient water to meet the needs of the crops will occur. Frasier (1984) commented that there is no universal water harvesting technique because each location has unique conditions that influence the design of the optimum system. Some important physical and technical design characteristics for consideration are as follows: precipitation, soils, slope, runoff and catchment area ratios, runoff efficiency, agronomic features and plant species.

4.4.1 Physical design considerations

4.4.1.i. Precipitation characteristics

Water harvesting is of significant interest in arid and semi-arid regions. Research suggests that the frequency of rain and probability of certain intensities and amount is important than annual quantity. It is easy to design the necessary size of water harvesting structures with information on rainfall during growing season rather than annual quantity. At places where there is high fluctuation in rainfall, the two years of greatest and least amount of rainfall is discarded for taking out an average.

4.4.1.ii. Soil characteristics

For water harvesting systems, soil texture must have good water holding and infiltration capacities. The soil of a micro catchment should allow rain to infiltrate with sufficient size soil pores for proper aeration. With sandy soils, the water holding capacity in the infiltration basin may be insufficient to sustain crop growth. With very fine textured soils, water may not infiltrate and be lost due to evaporation. High clay soils with low infiltration are suitable if infiltration is increased in the infiltration area by addition of some organic material. The soil texture must also be able to generate runoff in the catchment area. With sandy soils, the runoff from the catchment area may be low making area unsuitable for water harvesting. Highly erodible and self-mulching soils do not make durable crusts so are not suitable for water harvesting.

4.4.1.iii. Slope

The most efficient slope for holding water is 3 to 5%.

4.4.2 Technical design considerations

4.4.2.i. Runoff area ratios

The ratio of the runoff area to the infiltration basin area is an important technical design consideration. In smaller catchments on a steep slope a higher percentage of rainfall is collected because less water is lost by soil depressions.

4.4.2.ii. Runoff efficiency

Runoff efficiency is defined as the percentage of total rainfall which is harvested as runoff. The efficiency of the system, the amount of runoff collected in relation to precipitation, depends on storm duration and intensity and antecedent soil water. Typical runoff efficiencies range from 30 to 50% of average monthly precipitation (Renner & Frasier 1995).

4.4.3. Socio-economic considerations

Water harvesting systems are usually labor intensive to construct and maintain. Depending on the type of water harvesting systems, amount of capital cost and labor requirements vary greatly. Some water harvesting systems have high material construction costs with low labor needs. In some instances, the amount of labor required to maintain water harvesting systems can be higher than the construction labor. The maintenance labor can be high since these systems may need to be inspected and repaired as necessary and especially after major rainfall events. (Renner & Frasier 1995: 79)

4.4.4. Social design characteristics

The social aspects of a community must be understood in order to enlist local participation. In some villages, it may be difficult to get community members to give their input during planning and development phases. If good local participation exists, the design of water harvesting systems can be changed and improved to better meet the needs of the local population. Participation throughout the phases of a water harvesting project depends on many socio-economic factors. It is also affected by the scale of the water harvesting project. If the water harvesting system is very large, a communal organization may need to be formed to organize and run the project. As a result, individual participation may be minimal. Greater local participation may occur after the communal organization becomes decentralized. Water harvesting systems can have higher individual participation because of the small scale and need for minimal communal organization. The most successful water harvesting systems are those where communities work in small collective groups. One benefit of these small

collective systems is that local people can be trained during work sessions by community extension service. (Renner & Frasier 1995: 81)

4.4.5. Knowledge of construction of water bodies in the 15th century

Qaisar (1988) discusses about the knowledge of rainwater harvesting in the pre British period. A variant of *Akbari* source shows that Mir Bahr was concerned with the development of agriculture, gardening and digging of canals and streams in *khalsa* area[54] (Qaisar, 1988:" 7). Besides site overseers or supervisors, overseeing workers and artisans are seen in the paintings. Their outstretched hands show controlling and commanding operations. These examples prove the extent of power exercised by site overseers. In the 14th century, Sultan Feroze Shah appointed an alert superintendent over each category of worker connected with construction. This practice must have continued during Mughal era too (ibid:11). There was another group of building staff category which consisted of workers and artisans of diverse sorts collected at construction site, both local and brought from different regions of the country. No child labour is noticed (ibid:12). Qaisar (1988) discusses that according to Abul Fazl, some artisans and workers worked as *ijara* for definite tasks of specified dimensions and measurements while others were daily-wagers (*rozinadar*). *Ijara* workers probably got slightly higher wages. Wages were of three grades in the same craft, the amount with little variation. European sources distinguish between ordinary and superior labourers. Differential wages in the same craft must have been related to artisan's skill but its exact determination is unknown. Sometimes wages dependent on specialization of a particular artisan (ibid: 13).

The foundation trenches were dug after an auspicious day was fixed by an astrologer. Digging was done by *beldar*. Bricks or stone were used. There was absence of formal institutions for transmission of theoretical knowledge, a feature shared in common by every society in earlier times. There were technical supervisors or engineers called *muhandis* who had knowledge of geometry and mathematics. This specialization was a trend and was not institutionalized. No Mughal architect was a high court official. These architects rose from

54 For instance, Aurangzeb once issued orders that the builders at Aurangabad should remove mud from the tank and fill it with clean water where he also specified that expenses should be paid out of *buyutat* accounts. (ibid: 9)

ranks of non-literate manual artisans which proved a major handicap for their social mobility (Qaisar 1988).

This discussion is made on basis of Vishwa Vallabh Ullas by Chakrapani Mishra (2004) who was a *pandit* in court of Maharana Pratap. He describes that if there is ample land in between two hills, *talaab* can be constructed. If the land has slope, boundary can be constructed at that place and water can stay for longer periods. From the bottom of the land till the top of the boundary (*paal*), circular stairs should be constructed. *Paal* should be painted with lime for stability. If water is filled from all sides then it forms *talaab* itself. Wells should have circular stairs. The wells should also have passage for outlet of water which should be in shape of an arch and should have a flag on top of it. To prevent mixing of sand with water in the well, teak wood is placed at the bottom of well. Villagers are dependent for water on wells only in villages. *Kund*s should be very deep, can be of measurement of 8 hands (*haath*) to 100 hands (*haath*) and its boundary should be made with lime and stones. *Baori* should be made of stones, which should be made wet be water soaked with roots of medicinal plants and for breaking stones, hammer should be used. In wells, if water filtrate of catechu leaves (*khair)* is put, salty water gets sweet. At places where water is dirty, *bhasm* of bastard teak (*palash)* makes water clean. The diameter of well should be 4 to 1 2 *haath*. Talaab has three kinds of measurements, length 4000* breadth 2000 *haath*, 2000*1000 *haath*, 1000*500 haath. The reservoirs whose catchment area is small and tank capacity is more are considered best for storage.

4.5. Rainwater harvesting systems in Alwar and Bikaner districts of Rajasthan

4.5.1. Rainwater harvesting system in Bikaner, Rajasthan

Bikaner receives mean annual rainfall of 297.8 mm. Water harvesting is a necessary requirement specially for drinking purpose. The major soil type of Bikaner is loam, clay loam, pebbly and stony and sandy loam. Renner and Frasier (1995) have discussed that highly clayey soil is good for infiltration in water harvesting systems. The CGWB report states that the soils have good porosity and good to very good permeability which is quite good for construction of water harvesting structures. Although it is difficult to construct water harvesting structures in sandy soils; the soils of Bikaner are light textured, weak structured

but well drained. Soils are generally of desert type with poor fertility status and very low water retention capacity.

Before the onset of construction of Indira Gandhi Nahar Project in 1958, the traditional water harvesting systems, *talaab, kund, baori* etc. were in use for all kinds of uses of water. IGNP canal provided pipeline supply of water to the most parts in Bikaner and gradually after 1980s when the IGNP canal had provided water to almost all parts of Bikaner. IGNP was initiated as Gang Canal in 1921. See details for Gang Canal in appendix 4.1.

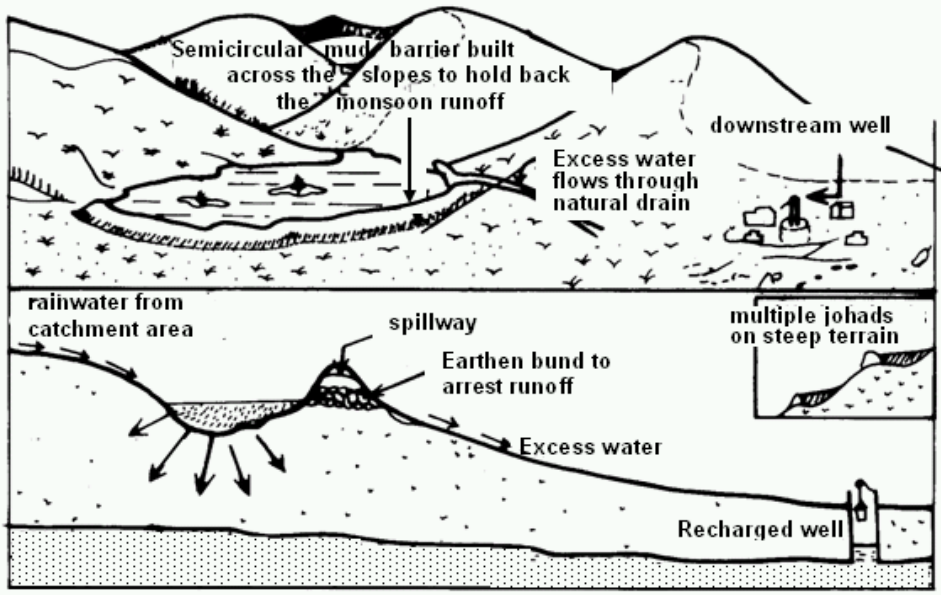
4.5.2. Rainwater harvesting system in Alwar, Rajasthan

The discussion is primarily based on the UN Report (Samantaray 1998: 1-21). Rajasthan, located in the north-western region of India, once consisted of a number of princely states. It is divided broadly into two climatic and geographic regions by the Aravali range. To its northwest lies the ill-watered sandy tract of the Thar Desert and to its east lies Malwa Plateau. Rajasthan is the second largest state in the country covering an area of 34.271 million hectares which is more than 10% of total geographical area of the country. Around 5% of the total population of the country resides in the state and it has more than 15.7 million hectares of land suitable for agriculture. The state of Rajasthan is one of the driest region in the country and the total surface water resources in the state is about 1 % of the total surface water resources of the country. All the rivers of the state are rain-fed and identified by 14 major basins divided into 59 sub-basins. The surface water resources in the state are confined to south and south-eastern parts. There is a large area in the western part of the state which does not have any defined drainage basin. Thus the water resources in the state are scarce and highly uneven in distribution, both in time and space. Groundwater also plays an important role especially in agriculture and drinking water supply. Groundwater exploitation is also not satisfactory as in areas where surface irrigation is provided there is a tendency of not using groundwater for agriculture which creates problem of water table rise and even water logging. On the contrary, in large areas of the state, ground water is being over exploited and the water table in some areas is going down at rate of 1 metre per year. Such a situation existed in four blocks of Alwar district until 1985-86. A highly low seasonal distribution of rainfall, coupled with ever-increasing deforestation had resulted in significant lowering of the water table in the district. Existing wells and government installed hand pumps remain dry for most part of the year. Climatically, the district falls under semi-arid region receiving 620

mm of average annual rainfall. Ninety percent of the rainfall occurs during the months of July and September, and most of it gets lost as flash floods. Alwar district is located in the north eastern part of Rajasthan. It is divided into eleven blocks (smaller administrative units of the district). The district has two distinct features: the Aravali mountain range which covers a large part of the district and the forest type which covers roughly 10-15 percent of the total land mass in the district.

The report states that Alwar has undergone a major transformation in past few years. Although the average rainfall in the area is 620 mm in a year, several wells have been recharged. With the help of Tarun Bharat Sangh and inspired by tradition, people of Alwar have been able to construct tanks called '*Johad*' . *Johad* is an earthen bund which has been used to store rainwater runoff (*Johad*, watershed in Alwar district, Rajasthan). *Johads* are smaller variants of *talaab* or tanks. *Johad* is a well-known traditional system of water storage for lean periods. *Johads* are simple mud and rubble barriers built across the contour of a slope to hold back rainwater. Sometimes a series of *Johad* are constructed depending on type of slope and terrain. These structures have high embankments on three sides while the fourth side is left open for rainwater. The *Johads* constructed on the private land have two objectives; (i) it helps in storing rain water and recharging down-stream wells and (ii) it reduces soil erosion. The following figure gives details of rainwater harvesting through *Johad*-

Figure 4.1: Rainwater harvesting using *Johad*



Source- (Sharma undated[55]: 2)

Johad fulfils three initiatives; the individual family gets water for irrigation and drinking purpose, second livestock gets water to drink and third it gives ecological stability by increasing groundwater. *Johad* construction requires a local resource that is soil/mud, pebble, labour etc. since mud and stones are extracted from common land it is not accounted and is not included in cost distribution norms for each family. See details for *johad* technology in appendix 4.2.

Alwar receives average annual rainfall of 636.8 mm. There are three major soil type of the area. Red grey valley soil is found in Aravalli hills of south western part of the district. These soils are shallow with gravels found very near the surface, light textured, fairly drained, reddish brown to grayish brown in color. Older alluvial soils are found in western parts of the district. These are non-calcareous semi-consolidated to unconsolidated brown soils, loamy sand to sandy loam in texture. They are well drained and occupy gently sloping terrains. Red sandy soils are developed in alluvium and found in eastern part of the district these soils are deep, well drained, sandy loam to loam in texture and non-calcareous. These

55 http://gwadi.org/sites/gwadi.org/files/CaseAlwar2.pdf <DOA:05/6/11>

findings of Central Ground Water Board (CGWB) report can be analyzed for construction of RWHS and it can be interpreted that the eastern part of the district is good for construction of RWHS as the soil is well drained. These parameters were analyzed by TBS and along with help of local community Tarun Bharat Sangh (TBS) was able to revive RWHS which had completely declined.

4.6. Research questions

1. How knowledge about water harvesting was distributed across social groups and castes for provisioning and appropriation of CPR in various institutional regimes?

1.a. How did knowledge of RWHS and its distribution across social groups change with institutional changes?

1.b. What are the various ways the State interacted with the communities regarding provisioning and appropriation of RWHS in various time periods? What were the diverse forms of cooperation of State and the community in different time periods?

1.c. What was the motivation of different social groups in provisioning of RWHS?

2. What were the changes in property rights in different regimes?

3. How did the provisioning and appropriation of water harvesting technology respond to the changes in property rights since the onset of the British rule?

4. How power relations in different time periods shaped the governance and knowledge distribution of RWHS?

5. What are the reasons for decline of the RWHS? To what extent the reasons for decline of RWHS overlap with reasons of decline in other CPRs discussed in the literature on commons in India?

Chapter 5

Sample, methodology and field work

5.1. Background

Collection of data is an important aspect of methodology. For our research we have made use of both primary and secondary data. Though the primary data involved collection of relevant documents fromm the various archives, for the secondary data a field work was carried out. Since our study aims at understanding the institutional framework and knowledge of governance of RWHS and factors responsible for the decline of RWHS we employ a more interactive method of data collection. This chapter discusses the eight rounds of field visits in our area of investigation, Alwar and Bikaner. Third field visit in Alwar, was mainly archival visit to the Alwar archive, In case of Bikaner first, second and fourth visits were mainly done for researching archival records. The documents mainly comprised of gazetteers, administrative reports, and irrigation department reports. The remaining field visit focused on collecting primary data in both Alwar and Bikaner district with the aid of semi structured interviews (see appendix 5.1 of the thesis).

We adopted qualitative research design which provides multiple techniques and gives flexibility in data collection from various sources. In this study along with Qualitative research design we employ case study method (Gerring, 2004). A qualitative research design helps understanding the perspective of the respondents and captures social reality through fieldwork (Gerring, 2004). The case study method is qualitative, research is participant-observation or in the field and the research investigates single case. Case studies are useful for making descriptive inferences and for demonstrating a causal argument about how general social forces shape and produce results in particular settings. Case studies provide evidence that depict complex, multiple factor situations and processes which occur over time and space (Neuman, 2014). The detailed observations entailed in case study method enables to study different aspects, examine them in relation to each other and this method is open to use of theory that guide in analysis of data (Meyer, 2001). The case study method is highly informative when one is examining correlative relationships. It is easier to conduct descriptive work rather than drawing causal propositions in a case study method (Gerring,

2004). This method also relies on multiple sources of evidences (Yin, 2003). For our study we take the case studies of RWHS in two districts of Rajasthan, Alwar and Bikaner.

In line with the objectives of our research the field work was conducted in Alwar and Bikaner districts of Rajasthan. The field work in Alwar was conducted in three villages, Hamirpur, Gadhbasai including the main sample village of Gopalpura, in Thanagazi tehsil and urban areas of Alwar, Rajasthan. The field work in Alwar was undertaken to make a reconnaissance survey of the area in general through particular visits to two other village communities around the sample village of the Gopalpura. The field work in Bikaner was conducted in Kodamdesar, Gangapura and Devkund Sagar villages of Kolayat tehsil and urban areas of Bikaner, Rajasthan. However, there were two core objectives of the field work concerned with particular context of the research. The first objective was to have a close grasp and understanding of the presently existing rain water harvesting management in Gopalpura village of Alwar and Kodamdesar, Gangapura and Devkund Sagar villages of Bikaner in particular and the neighboring rural locations as well in the semiarid zone. Second objective focused particularly on how the knowledge and techniques pertaining to traditional rainwater harvesting systems, almost forgotten during the modern period of about one and half centuries of neglect and disuse, were being revived by the help of villagers and through the newly induced guidance and demonstration framework of Tarun Bharat Sangh. It is to be noted that Gopalpura was selected by for detailed sample study as the village happened to be the first site of the construction of a *Johad* (water impoundment) in the area under this institutional set up in 1985. The chapter is devided into three main sections. The first section offers a comparative profile of Bikaner and Alwar district. The second and third section discusses our field visits of these two districts in detail.

The chapter is divided into 4 sections. Section 5.2 gives comparative profiles of Alwar and Bikaner districts. Section 5.3 gives description of field visits in Alwar and section 5.4 gives a description of field visits in Bikaner.

5.2. Comparative profiles of Bikaner and Alwar districts

5.2.1 Ecology and climate

The soils of Bikaner district are light textured, weak structured but well drained. The climate is arid with high temperature and high evaporation losses. Soil is generally of sandy type with poor fertility status and very low water retention capacity. Mean annual rainfall (1971-2005) of Bikaner is 297.7 mm whereas normal rainfall (1901-1971) is lower than average rainfall and placed at 257.8mm. Almost 90% of the total annual rainfall is received during the southwest monsoon, which enters the district in the first week of July and ends in September. The temperature varies from 48 degree in summer to 1 degree in winter. Atmosphere is usually dry except in monsoon period.

Alwar lies in the flood prone eastern plain region of the half of Rajasthan comprising the districts of Alwar, Bharatpur and Dhaulpur and the northern part of Sawai Madhopur (Mahuwa, Todabhim, Hindon, Nadauti, Bamanwas, Gangapur, Karauli, Sapotra and Bonli tehsils). Except for few low hills which exist in Alwar and SawaiMadhopur districts, the entire region forms the flood plain of the Banganga and the river Ghambhiri. As such the region is endowed with rich alluvial soils and its fertility is replenished every year by the seasonal flood waters of the rivers. In periods of heavy rainfall, the rivers outflow their banks and inundate the surrounding villages, causing great damage to life and property.[56]Climatologically the region is semi-arid with an average monsoonal rainfall of around 610 mm. Rainfall is relatively higher in the eastern part of the region. Table 1 shows the wide ranging yearly fluctuations in the annual rainfall incidence, typifying the erratic behaviour of the monsoonal rainfall. During the eight year period of rainfall regime (2000-2007), the highest rainfall amounts to 898 mm in 2003, while the minimum goes down to 118 mm in 2002. The trend shows that the agricultural economy of the region is based on such fluctuations in rainfall and may not be sustainable unless supplementary arrangements are available or the agriculturists go for some rainfall-fed crops and/or dry farming. However, the region is fed by a network of distributaries from the upper Yamuna Canal and the Panchana Dam canal System. The ground water in the area in general varies from 5 to 15 meters from

56http://waterresources.rajasthan.gov.in/1climate.htm

the surface and the wells are meant to draw upon ground water sources for irrigation in different parts. However, these sources do not provide sustainable water supply, and the region shows use of rainwater harvesting for retaining soil moisture and assure water for every village to serve the domestic purposes. Natural vegetation can be traced only along some of the hill slopes, wetlands and protected zones while most part of the regions are almost completely devegetated.[57]

Table 5.1: Annual Rainfall trend at Thanagazi

Year	Rainfall in mm
2000	565
2001	578
2002	118
2003	898
2004	556
2005	846
2006	625
2007	685

Source: http://alwar.nic.in/Agriculture.html <DOA: 17/03/2014>

5.2.2. Economy

The village economy of Bikaner largely depends on agriculture. Agriculture is confined to traditional *Kharif* cultivation as it heavily relies on monsoonal rainfall. *Rabi* cultivation is restricted to localized areas where irrigation facilities are available. The main crops grown are *bajra* and wheat, *kharif dals*, mustard and groundnut, cotton and sugarcane.

The village economy of Alwar depends basically on agriculture, which produce a variety of crops by utilizing canal and well water for irrigation. Here the important crops are sorghum, *bajra*, maize, sugarcane, sesame and wheat, barley, gram and mustard in the *rabi* season.

57http://waterresources.rajasthan.gov.in/1climate.htm

5.2.3. Gram Sabha and Gram Panchayat

Bikaner district is located in the north-western part of Rajasthan and encompassed between north latitudes 27° 11' to 29° 03' and east longitudes 71° 52' to 74° 15' covering geographical area of 30247.90 square kilometer It is bounded on the north by Ganganagar district, on the east by Churu and Nagaur districts, on south by Jodhpur and Jaisalmer districts and on the west by International border with Pakistan. It is administratively divided into five blocks namely, Bikaner, Nokha, Lunkaransar, Dungargarh and Kolayat. The district has one municipal council, 219 Gram Panchayats and 889 villages. As per 2001 Census, the total population of the district is 19.02 lakh out of which 10.03 lakh male population and 8.99 lakh female population.

The Gram Sabha created in all the villages, associated with Tarun Bharat Sangh (TBS)in Alwar,are different from the Gram Sabha defined under the Panchayati Raj Act. The Gram Sabha, under the Panchayati Raj Act of Rajasthan, is the lowest of the three tiers structures of Panchayat and the most fundamental to any developmental initiative undertaken by Panchayat. It exists in each village, representing few selected members of the village. On the contrary, each Gram Sabha associated with TBS, consists of one representative from each household of the village, and for all practical purposes coordinate with the existing Panchayat. As per Rajasthan Panchayati Raj Act, it is the duty of Panchayat to manage water resources of the region concerned. In principle, Gram Sabha being an informal institution does not have legal entity and does not have any legal control over the water stored in the *Johad*. In practice, however, Gram Sabha controls the available water in *Johads* (Samantaray 1998: 3). Gopalpura shares a Gram Panchayat with seven other villages closely.[58] The Panchayat Sarpanch (Head) is elected from among the eight panches (headmen), one each of the eight villages. The Gram Panchayat Sabha sits in Kaira village, on schedule, for resolving various problems of the villagers and looks after the general law and order situation.

5.2.4. Drinking water facilities

Drinking water in villages of Bikaner is provided by the panchayat by tankers, *talaab* is another source of drinking water for people. Since the water is salty there is absence of tubewells and handpumps. The soil type is another factor which makes it difficult to dig

58Govindpura, Bheekampura, Sutgarh, Kaira, Nimwal Ka Gwada, Dholpura and Bakada

handpumps in the village In Alwar people use wells for drinking water in villages. Here too digging handpumps is difficult because of the soil type.

5.2.5. Types of water harvesting structures in Bikaner

There are basically five kinds of water harvesting structures practiced in the region. *Talaab, kund, kuan, kuin, baori.*

Talaab: *Talaab* is a rain fed and well designed reservoirs constructed to be deep and embanked on all four sides with high masonry walls holding enough water for the year-round. Many of these constructions are made up to five to ten metres deep and have banks for different purposes like bathing, washing, cattle, aesthetic purpose etc. The catchment area of *talaab* is usually a large area and used to have medicinal varieties of trees planted in it.

Kund: *Kund* is a tank or reservoir in which rainwater is collected for drinking, water gets collected from the catchment area and is collected into the tank through a sieved inlet.

Kuan: *Kuan* is a well with diameter of 4 to 100 *(haath)* hands.

Baoris: Baoris are ponds in which water is reached by descending a set of steps, in Bikaner the catchment area usually has *kund* whose outlet is connected to the *baori.*

Kuin: *Kuin* is well with a smaller diameter of 4 to 8 *(haath)* hands.

Figure 5.1: Harsholaav *talaab*

Figure 5.2: Gangapura *talaab*

Figure 5.3: Rangaji *kund*

Figure 5.4*:* Kalyan Sagar *talaab* with *kuin* (Dev Kund Sagar village)

Figure 5.5: *Kuan*

Figure 5.6*: Rangaji kund* connected to a *baori*

Source: Field Work

5.2.6. Types of rainwater harvesting systems in Alwar

There are basically three kinds of rainwater harvesting systems practiced in Alwar; *Johad*, *Baandh*, and *Anicut*, which are used for irrigation, drinking water for cattle and groundwater recharge.

***Johad*:** *Johad* is a traditional system of water storage for lean periods. *Johads* are water holding ditches, embarked by simple mud and rubble barriers built across the contour of a slope to hold back rainwater. Sometimes a series of *Johad* is constructed depending on type of slope and terrain. These structures have high embankments on three sides while the fourth side is left open for incoming rainwater flow. *Johad* is concave shaped. The height of *Johad* varies depending on the site, water flow, pressure etc. The cover area of *Johad* may vary from 2 hectare to 100 hectares in Alwar. The point at which water pressure is higher, width at the base of the barrier is increased by 2-3 times that of the normal. In some cases, a masonry structure is made for outlet of excess water. The inner side of *Johad* is constructed vertically up to a height of about 5-7 feet from the base. The construction of *Johad* is a labour intensive

exercise. The water collected in the *Johad* during monsoon is used for irrigation, drinking and other domestic purposes. For irrigation purpose, water is either pumped or taken to the field through unlined simple, deep channels. The advantage of *Johad* is in improving moisture level at sub-soil level in the field especially in down-stream areas which also recharges groundwater and wells. *Johad* needs annual repair. Most of the *Johads* in Alwar have been constructed on common land and few on private land. Private *Johads* are generally smaller in size and, major part of the capital cost is contributed by 5-6 families who receive benefit directly by the impounded water while *Johads* on common village are built and repaired by the village community for the common village use, those on private lands are exclusively private initiatives.

Figure 5.7: *Johad*

***Baandh*:** is a system for rainwater harvesting. *Baandh* is usually simple mud and rubble barrier built across the contour of a slope to hold back rainwater. The top breadth of *Baandh* should be atleast half of the bottom breadth. *Baandh* cannot be made in private lands as it generally requires larger area. As such it is generally constructed on common lands and benefits are stream areas which recharge groundwater and wells as well.

Figure 5.8: *Baandh*

***Anicut*:** the purpose served by *Baandh* and *Anicut* are almost same. The difference is that *anicut* is usually made of cement and bricks rather than mud. It can also be constructed on private as well as common lands; on common lands, it is generally larger in size than on private lands.

Figure 5.9: *Anicut*

Irrigation facilities

In Alwar, all the three systems as well as wells are used for irrigation. There are several *anicuts* built in the fields. People who own the fields have taken their own initiatives by contributing their labour (*shramdan*) as part of their contribution and TBS contributes in the construction. These *Anicuts* stop water coming from the hilly slopes (Fig. 5) which help in recharge of nearby wells as well. Water is withdrawn from the wells with thehelp of generator and then water is diverted to the fields by help of pipes as shown in the figures (Fig. 5 and 6).

Figure 5.10: A picture showing *Anicut* stopping water coming from sloped area

Figure 5.11: A picture of a well showing pumping water out of the well

Figure 5.12: A picture showing course of water from the well to the field

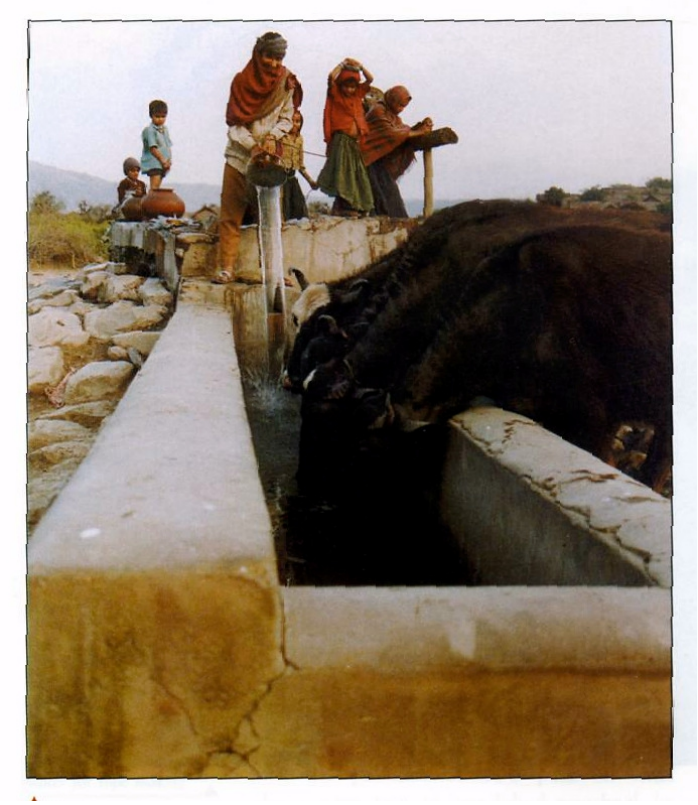
Caste-wise, people in the Gopalpura village can be categorized in three groups- Meena (Schedules Tribe), Balai (Scheduled Caste) and Brahmin (Upper Caste). Most of the farmers have small land holdings, with plots of each located in different distance zones from the village. Even family, however, owns some land and there is no landlessness. Farmers are not very big agriculturists. Most of them try to grow sufficient food crops for the family sustenance, even though they are also keen to produce some extra for market sales. While some may use their own seeds for sowing, most of them purchase seeds from the seed selling vendors in nearby *Kishori*village. Farmers have also turned to use tractors for activation and sowing purposes as four tractor owning farmers in the village rent out their tractors to others for use. The village agriculture is mostly mixed type as in most of India's agricultural pattern, where every family owns some animal stock as well (particularly cow, buffalo and some goats).

5.2.7. Animal rearing

In Alwar, animals are taken to the woodlands and straw wastelands for grazing grasses in new greeneries in rainy season, but over the remaining dry period, they are fed

with fodder for a limited period in combination with straws of crops, and husks of barley, gram and wheat crops. Animals are well taken care of for fresh milk and their value as source of manures. They are also valued for cash-like property to be sold in times of crisis. While grazing, animals can water themselves in various holed-out trenches and pit -like water sources outside in Jungles, in the rest of the year they are regularly watered through *Kheds* (small-size elongated water tanks), which are water filled by farmers from wells. When *Johads* get constructed, they naturally serve for the purpose of watering the animals.

Figure 5.13: Feeding water to livestock in *Khed*



Source: Samantaray (1998: 6)

Most of the families irrespective of the caste or sub-caste, are found to be staying with their parents and growing children of various age and gender. Few families are joint type with grandparents and very few with one or both great grandparents, living together and sharing one and the same kitchen. The general marriage age varies between 16-19 years for both genders but there is some caste wise variation. According to the respondents, the advantage of the small-size family is that the entire family may be engaged in earning their livelihoods from their farming business, working on their land more intensively. If the family is large, it

allows one or two members to migrate to urban areas like Alwar or Jaipur for earning their livelihoods or remit some money.

5.2.8. Tarun Bharat Sangh and its foundation work in Gopalpura village

TBS is a non government organisation founded by some professors and students of Jaipur University in 1975, to help people of the slums who got affected by a fire which broke out in the slum area near Jaipur University. Rajendra Singh, inspired by the Gandhian model of rural-development started working with his four friends with TBS in mid 1980s. Rajendra Singh[59] was drawn towards the J.P. Movement in 1975 and then joined the youth organisation, *Sangharsh Vahini*. Later in 1980, he joined the Rajasthan government's education department as a project officer. During this period, he got associated with TBS. In 1984, he resigned from his government job, and along with four other friends and colleagues, set out to one of the most poverty ridden regions of Rajasthan. Since December 1985, he along with his four friends used to travel in nearby villages and made contacts with people. They all started their work with educating children of Govindpura village. All five of them roamed in different villages to impart education, they also brought funds to schools. In 1986, the region was struck with drought. In Gopalpura village, Rajendra Singh observed that, Mahangu Patel, who owned 200 *bighas* of land was not dependent on agriculture for his income and that three of his sons used to pull rickshaw in Ahmedabad city. Rajendra Singh was trained with class struggle oriented politics, who had deliberately chosen one of the poorest rural pockets as his *karmabhumi* (field of action) in search of the *antimjan* (the last person in the economic hierarchy), was now witnessing the *sahajjudav* (spontaneous and easy social connections) between various castes and classes in the village society. He was stunned to see the warm social interaction between Mahangu *Patel* (one of the "bigger" landowners) and Nathi Balayan (a scheduled caste woman). Insights gained through numerous such incidents and interactions apparently convinced Rajendra Singh develop an inclusive model for the upliftment of people. In his opinion, villagers need to strengthen their mutual bonds which traditionally knit various caste groups into mutually interdependent and cohesive

59TBS volunteer gave the details about the initial work of TBS and how and Rajendra Singh came to Gopalpura village and started working in water sector. A book published by TBS also helped the researcher extracting information about Rajendra Singh's work motivation for people.

village communities. This way, *Nathi Balayan* and *Mahangu Patel* became motivation for Rajendra Singh's team for the construction of RWHS (Madhu Kishwar, Manushi).

5.3. Description of field visits in Alwar

Field work in Alwar was completed in four visits. The first visit was carried to have a general idea of the field and to gain some knowledge about the indigenous rainwater harvesting systems. The first visit also enabled us to make some acquaintance with key people who could assist us, particularly the TBS workers working in the field. The first visit was made during a short period of 4 days (27 September to 30 September) in 2010. We visited three villages, as suggested by TBS volunteers who had first hand working knowledge about RWHS. These villages were Gopalpura, Hamirpur and Gadhbasai, distanced around the tehsil headquarters of Thanagazi, under which tehsil they all administratively fall. While Gopalpura is located about 20 km. south of Thanagazi, Hamirpur is on the South-West from the centre of about 40 km. Gadhbasai is locationally distanced about 10 km westward from the centre. Clearly so well distanced, these three villages represent different kinds of small rural localities, little different from each other in details of resources and geographical-economic patterns.

We combined the direct face to face interview with chosen and willing respondents and observation methods for collection of primary data from the villages. The interviews were conducted through semi-structured interview schedules which are attached to appendix 5.1. Two groups of people were interviewed during both visits, although some of these respondents were different with a much varied responses and experiences of the prevailing system. Such selections immensely paid for the attempt. The two kinds of respondents selected for interviews were the villagers, and TBS volunteers. The respondents were mostly chosen randomly, however, some selection of respondents were done by TBS.

Interviews during the first field visit:

Respondents during the first visit (27-30 Sept., 2010) were selected on the basis of recommendation of TBS volunteers, who had been well acquainted with the system. We could gain valuable information from the respondents pertaining to the water problem, the new attempts being made for organizing, and reviving indigenous rain water harvesting

systems under the guidance and help from TBS. Some details of this first visit are briefly outlined below:

Day 1: Some TBS volunteers operating in the area were interviewed. We were appraised by them about their general interest in the tasks undertaken, their to experience about the vital relations between the nature of agricultural economy, cropping system, types of crops grown in this water problem area. We could then learn about the level of farmer's willingness and enthusiasm about undertaking the task of rainwater harvesting for their benefit. Some technical and organizational details were also obtained regarding the establishment of *Johad*, *Baandh* and *Anicuts* in the area. We could also gather concept of volunteer labour (*shramdan*) among village residents for these activities and their response level among them. They also highlighted the significance of *Padyatra* (on foot yatra or travelling about the villages) to explain the villagers the significance of water and ways to solve the water problem on their own benefit.

Day 2: Visit to Gopalpura-On the second day, we carried out interviews in Gopalpura with some experienced older people both male and two females of different sub-castes and age. Females indicated some problems as to how poor women managed to procure water even for drinking and domestic purposes in critical summer dry periods in some years.

Day 3: Visit to Gadhbasai- Interview with some selected village residents of different social status, subcaste, and experience level were carried out. Some respondents spoke about callous attitude, neglect and general indifference of Panchayat leaders and government officials about village problems, and even differential treatment of families and sub-castes in pick- and-choose- manner.

Day 4: Visit to Hamirpur Village - This visit was particularly important as the village was the venue of Gram Sabha meeting which was supposed to be held by, Shri Rajendra Singh, the General Secretary, TBS. He was on an important mission at this venue on that particular day to launch the start of Ganga Padyatra. We found an opportunity a have a lively group interview and discussion with more than half a dozen people about many problems faced by the rural communities, particularly the agricultural problem in relation to critical situation of water supply. Some of the old people indicated about the decay and even loss of community feeling during last few decades, increasing individualistic self-interest and general neglect of

community work, particularly in providing labour for community work. In fact, some of them did think that it is indeed their collective muscle power that could be harnessed for improving the physical and social conditions[60] of the village community

Second field visit

Second field visit (Jan 26-Feb. 03, 2011) was more confinedand proved to be very fruitful. We had noted in the first visit that some of the respondents were not much willing to respond, or even were rather reluctant to respond to the queries about their personal or family affairs in relation to education, girls education, income, profession, division of labour, and related things like sub-caste and relations with other people in the community at large. Most of the respondents we interviewed in first visit were involved in farming and stock-raising as occupation. In the second visit, with the help of the first visit acquaintances we could find out people of varied age- and-gender group in general readily willing to give their responses. This survey focused only on Gopalpura village.

Day 1: One important fact emerged that the farming activity still mostly aimed primarily at achieving self-sufficiency in food, and only secondarily at marketable surpluses. This is why even the rainwater harvesting systems like *Johad* and even ground water sourced wells could not be used for irrigation for growing those crops giving highest yields, like wheat. The farmer in general did note that irrigation affected crop productivity of different crops, and was certainly important. As such, there was general enthusiasm and awareness about the need for augmenting rainwater harvesting and impounding techniques for their economy. Then it was possible to include one member from each family as representative in Gram Sabha, and it was found to be easier to find agreement on various issues such as awarding some kind of punishment for abuse of certain common village resources, such as cutting trees, or missing water.

Day 2: We conducted ourinterview in depth with older people, including two women, who were said to have some knowledge about technical details of rainwater harvesting and impounding systems including the construction of suitable barrage. They could probably look into the possible water flow, choice of sites and drainage outlets, and other relevant points.

60 Construction like *Johads* road connections, repair of village school could be such targets.

They helped the researcher to draw up a resource map of Gopalpura village particularly in locating the *Baandhs* and *Johads* including smaller ones in the close by woodland area. They also helped in correctly identifying the rainwater harvesting structure raised in 'on village commons', as well as those 'on private lands'. We could thereby identify that some of the families did not participate on water holding formations even if they use water form these sources. They also stated that some of the people who did participate did not habitually work harder. On private land structures, the same work of identical measure was finished well in comparatively fewer work hours.

Day 3: On the third day the workers of TBS were interviewed who detailed their job experience in the field, as to how they could slowly and steadfastly raise awareness and willingness of village people in general, about some people's harder attitude. They stressed the crucial fact that diffusion of an innovative idea, concept or technique among the people was a complex job and it required persuasion. They argued that some but few people lead the way, others slowly followed, and other laggards come late. According to them, once the people are made aware of the advantage, they do cooperate.

Day 4: On the fouth day we paid visit to some private land holders, who had their own rainwater harvesting systems. Women watering their crops were easily cooperative in detailing their experienced advantages from the system.

Day 5: On the fifth day we visited village common lands and some upcoming harvesting systems. Photographs were taken.

Day 6 and 7: The cook of the TBS workers was very knowledgeable about the work operations. A priest of the Gopalpura village, looking after a temple at the village Bheekampura gave some idea how the villagers entertained some of the rituals of the traditional agricultural calender, about crop sowing and harvesting times. Half a dozen people received us in their houses and shared their views properly and freely about various aspects related to their works.

Third field visit

This was carried out between 8th April to 11th April 2013. This was mainly archival visit to the Alwar archive, a branch of Bikaner state archives. In this visit, the researcher was

focused on collection of English documents regarding perception of British on water harvesting. The documents mainly comprised of gazetteers, administrative reports, and irrigation department reports.

Fourth field visit

This was carried out between 5th January to 8th January 2016. During this visit, people from diverse backgrounds who have worked on areas of water and people from land record section of Alwar were interviewed.

Day 1:,An activist and a lawyer in Alwar who has worked in area of water was interviewed. He gave a detailed description of water conservation practices by the rulers existing in Alwar since 17th century.

Day 2: A retired tahsildar of Alwar was interviewed. He gave a detailed understanding of the land rights in Alwar in the pre-independence and post-independence periods in Alwar.

Day 3 and 4: Nearby sites of water conservation was visited and some photographs were taken.

5.3.1 Gender and Age Profile of the respondents

Gender and age profiling was done for analyzing gender and wise responses of the people, the reason being difference in responses according to gender and age of the community.

Table 5.2: Gender profiling

Males	Females
24	17

Source: Field work

Table 5.3: Age profiling

Age in years	Number of people
10-20	8
21-30	11
31-40	9
41-50	7
51-65	6

Source: Field work

5.4. Description of field visits to Bikaner

Four field visits have been carried out to Bikaner. The first visit was carried to have a general idea of the field and have some knowledge about the indigenous rainwater harvesting systems, as well as making some acquaintance with some people, some key people who could guide me, particularly the academicians who have worked in this area. The first visit was made for 5 days (from 23 November to 27 November) in 2012. The second visit was made from 5 days (3 February to 7 February) in 2013. The third visit was made for 2 days (19 April and 20 April) aagain in 2013 to get a glance of water harvesting technologies in Bikaner city and people associated with it. And finally the fourth visit was made for 5 days (from 21 October to 25 October) in 2013. First, second and fourth visits were mainly done for researching archival records. Apart from archival visits, interaction with researchers was also done.

The researcher combined the direct face to face interview with chosen and willing respondents and observation methods for collection of primary data from chosen locations of rainwater harvesting technologies which were located in common places. The interviews were conducted through semi-structured interview schedule which is attached to appendix 5.1 of the thesis.

Interviews during the first field visit:

Respondents during the first visit (23-27 Nov., 2012) were selected on the basis of people working in this area, who had been well acquainted and experienced with the system. We could received precise information from the respondents (except from a few) about the issues pertaining to the water problem and the new attempts being made for organizing and reviving indigenous rain water harvesting systems. Some details of this first visit are briefly outlined below:

Day 1: A professor of history, Dungar College, assisted us on archival documents and other books and publications related to rainwater harvesting technologies. Some technical and organizational details were also obtained regarding the establishment of *kuin, baori, kund and talaabs* in the area and concept of volunteer labour (*shramdan*) among residents for these activities and their response level among them. We were told that Bikaner is divided in three areas: *Nali, Thali* and *Magra*. As the name indicates, *Nali* (which is now known as *Tibi*) is the region where *Ghaggar* Canal passes through and therefore this region never faced scarcity of water. *Nali* region used to have maximum crops grown because of abundancy of water. Mostly, wells exist here, which are used for irrigation purposes. *Thali* region is not very dry region not abundant in water. *Magra* is the driest region of Bikaner. This region has maximum number of water harvesting structures such as *kuin, kunds, baori* etc.

Day 2: Visit to Bikaner State Archive: We were briefed by the professor to study *Kamthana* and *Kagad bahis* which had some information on rainwater harvesting technologies. The researcher also learned the calculations in Marwari which were done by the state for construction or maintenance of rainwater harvesting systems. The *Kamthana bahis* pertain to the period from 17th to the late half of the 19th century. These *bahis* provide information about various types of artisans and skilled labourers, who were deployed on various construction and repair works. These *bahis* also contain information about the wage structure of the artisans class and details on the artisans who came from place such as Jaipur, Marwar and Deccan. Since there were regular provision for buildings, and maintenance of royal places and other State buildings, the artisans were retained on daily wages basis and on permanent basis. Some permanent artisans were granted *Jagirs* in lieu of their services. At time of bigger construction works the State raised funds from local *Sahukars* (moneylenders) and the loans were repaired with interest. But, interestingly enough, the State used to realize a nominal tax

from the artisans as well. These *bahis* throw light on the source of various building materials e.g. *Murad,* Lime, *Bajari*, bricks, stones, water colours and their prevalent market rates. These *bahis* also contain information about the mode of transportation of building material from the points of origin or supply upto the construction site.

Day 3, day 4 and day 5: these three days were spent by the researcher in the archives mainly focusing on *Kamthana bahis.*

Second field visit

Second field visit (Feb 3-Feb 7, 2013) proved to be very fruitful. This field work was also focused mainly on archival visit. Apart from archival visit, we met another assistant professor fromDungar College, Bikaner who had written a book titled *Jal aurSamaj* which was perhaps a pioneer work in field of technology and techniques related to rainwater harvesting technology of Bikaner region. Dr. Joshi guided us more on *Nali,Thali* and *Magra* regions. After interaction with these professors we came to know that the *kunds* and *talaabs* in Bikaner city belong to a particular caste, although people are allowed for provisioning and appropriation activities regardless of their caste. We also came to know that each *kund* and *talaab* of the city has a temple of its own along with its *pujari.* In this visit, we dealt mainly with *Kamthanabahis* the description of which is given above.

Third field visit

On April 19, 2013 we conductedtheinterview with people, which included wife of a *swami* caste who is the *pujari* of the temple located in *Raj Rangaji ka kund*. The lady named *Gadhoi* stated that the *kund* has 8 trustees. The *pujari* of the temple belongs to *swami* caste. They have been provided with house to stay in the *kund* premise. They have the duties of cleaning, washing of catchment area of the *kund* and performing religious rituals of the temple every day. After this *Sansolaav talaab* of Bikaner was visited. Some photographs of catchment area and *talaab* were taken. We visited a research officer in Bikaner State Archive. He informed us that since medieval times, the cities were under *khalsa* land and the villages were under *jagir* land. Related to rainwater harvesting systems, land was not transferrable to anyone without the permission of *jagirdars*. In *khalsa* areas, people could buy lands from the state while in *jagir* areas; people could buy lands from the *jagirdars.*According to him the decline of water harvesting systems was maily due to introduction of pipeline system of water

supply (first introduced by Maharaja Ganga Singh of Bikaner). Such a change has madepeople lazy and also the population has exploded. This has resulted into people encroaching thecatchment areas of *talaabs, kunds* and there is no one to monitor such encroachments as people are getting water easily. We met another who tried to save and protect the catchment area of *Sansolavtalaab* from encroachment. He stated that the decline of the *talaab* started taking place since 1970s. According to him, post independent period was the period of decline of *talaabs* of Bikaner. Construction of *talaab* culture started in V.S. 1572 when *Sansoji Mohta* first took initiative for the construction of *talaab*. According to him, there was no British interference in Bikaner regarding the water harvesting systems.

On April 20, 2013, we visited*Shivbaditalaab* and met its *mahant.*We could find that the decline of *Shivbaditalaab* started from 1990s. According to him, the main reason for decline of the *talaab* was encroachment in the catchment area of the *talaab.*

We met another professor, who guided us to read books related to construction during Mughal India. We could also learn from him about the castes like *chejara, chunigar, mali, swami, od* who helped in construction of rainwater harvesting systems.

Fourth field visit

This visit was carried out for 5 days (from October 21 to October 25) in 2013 and was focused exclusively on archival records. The researcher mainly dealt with the *Kagadbahis* and the English records (*Mahkamkhas*) during this visit. The researcher did not get precise information regarding water harvesting system in the *Kagadbahis*. The information provided was mainly related to water disputes not particularly emphasizing on *johad/kuin/talaab*.[61]

Mahakamakhas is a list of English records and covers the period from 1898 to 1914 A. D. this series gives information about the modernization of the state both political as well as in the socio-economic fields.

Fifth field visit

This visit was carried out from March 12 to March 15, 2014 and comprised on visit to villages of Bikaner. We have noted thatnoted in the visit that the respondents were more keen

61Note those johad/kuin/baori/talaab are terms used for common land. The term common land had not evolved then.

to answer ther questions when accompanied by theassistant Professor from Dungar College, Bikaner and also a native of Bikaner who is well aware of water related issues and water harvesting systems in Bikaner. The respondents were reluctant to respond to the queries about their personal or family affairs in relation to education, girls education, income, profession, and related things like relations with other people in the community at large. The main occupations of most of respondents were related to farming and stock-raising. This survey was concentrated to Gangapura, Dev KundSagar and Kodamdesar villages. The village used to have a number of wells but now none of them are in use. The entire structure on which well was made is called *jagat,*a person called *khilia* used to tie bull or camel to the rope of the well and the bull/camel used to walk till water was pulled off from the well. This entire area covered by the camel/bull was called *rahat.* The water was then filled to the *haud* or *kotha* (a tank kind of structure) which had a number of diversions for castes and animals and these structures were also like small tanks and called *khelia*.

Day 1: Visit to Dev Kund Sagar village was made. Interview in Dev KundSagar with some experienced older people both male and two females of different castes and agewere done. Females indicated some problems as to how poor women manage to procure water even for drinking and domestic purposes in critical summer dry periods in some years.A 60 years old female named *Pushpa* narrated the stories of how in older times the head of the family and if females and children of the family got time used to get water from Devi KundSagar*talaab* to their homes for drinking purposes. Magan Lal Purohit Sagar, 65 year old man gave details of crops grown during *rabi* and *kharif* seasons which were as follows, *rabi: wheat, chana, jau, sarso and kharif: moth, bajra, taramera, gwar, til*. The village has around 650-700 households. The village comprised of *brahmin, jaat, nayak, meghwal, kumhar* and *saisi* castes. A visit to one of these caste households was also made. The *nayak, megwal* and *saisi* castes comprised of schedule caste groups. They do not have agricultural land and have very less animal rearing. They mostly worked as labourers in other's field. Agriculture is dependent only on rainfall in this village. The village has two *talaabs* Devi Kund Sagar and Kalyan Sagar. Kalyan Sagar *talaab* has two *kuin* in the centre and its circumference absorbs water and water was stored inside and used exclusively for drinking purpose only. Kalyan Sagar *talaab* has *chatri* of *sati maharani's* all around. Devi Kund Sagar *talaab* has structures built on one side for bathing for *maharani* of Bikaner. Devi Kund Sagar has a temple in

between where the *pandit* of the *talaab* used to sail on boat and visit the temple for performing religious rituals. Some photographs of the area were taken.

Day 2: Visit to Gangapura village was made. Gangapura village has 245 households. The village comprises of *kumhar, vishnoi, jaat, meghwal and brahmins*. A person *Deburam Kumavat* gave details of the wells and *talaabs* of the village. The basic structures are same in entire Bikaner region. The *rabi* and *kharif* crops were also the same as mentioned above. He stated that the water harvesting structures are now not maintained by the people as their needs are fulfilled by pipeline supply of water. Hardly 2-5% very interior villages of Bikaner do not have pipeline supply of water.

Day 3: Visit to Kodamdesar village. This visit was mainly done to see Kodamdesar*talaab*. This was built for Maharaja of Bikaner to visit and stay in summers.

5.4.1. Gender and Age Profile of the respondents

Gender and age profiling was done for analyzing gender and wise responses of the people, the reason being difference in responses according to gender and age of the community.

Table 5.4: Gender profiling

Males	Females
17	9

Source: Field work

Table 5.5: Age profiling

Age in years	Number of people
10-20	2
21-30	4
31-40	3
41-50	7
51-65	8

Source: Field work

Through our various visit to Alwar and Bikaner, we could gather several crucial details about the factors affecting the decline of the RWHS. We discuss the analysis of the study in next chapter.

Chapter 6

Knowledge, technology and institutions of rainwater harvesting systems in the commons in Alwar and Bikaner: An Analysis

6.1. Introduction

As the main chapter of this thesis, the present chapter examines the rainwater harvesting (RWHS) governance in Alwar and Bikaner districts of Rajasthan. It will provide the reader with an analysis of the study based on the literature on governance of commons as discussed in chapter 2, literature on property rights in chapter 3 and literature on institutions governing RWH in different regimes in chapter 4. The chapter analyses the research questions given in section 4.7., chapter 4 of the thesis.

The chapter is divided into 8 sections. Section 6.2. analyses the factors guiding participation of people for provisioning activities of RWHS in Alwar and Bikaner. Section 6.3. analyses importance of local knowledge for management of CPRs and the way it was distributed across social groups. We also discuss the hierarchies of knowledge and power relations of knowledge. Section 6.4. analyses the uncertainties of knowledge. Section 6.5. analyses the changes in property rights in different regimes. We also analyse the diverse forms of cooperation of community with the State in this section. Section 6.6. analyses the changes in institutions. Section 6.7. analyses the reasons for decline of RWHS in Alwar and Bikaner which overlap with the reasons for decline of other CPRs in India. Section 6.8. gives a compilation of the chapter.

6.2. Motivation behind provisioning of RWHS: An Analysis

In chapter 1 we discussed in Ostrom's (1990) framework, participation by individuals is guided by calculation of discount rates and her framework presumes that knowledge is divisible in nature. According to Ostrom (1990), discount rate refers to long term benefits individuals accrue for their provisioning activities. While, Gudeman and Rivera (2001) argue that commons is embedded in a community of shared and indivisible knowledge, experiences and interrelationships. Taking cases of RWHS in Alwar and Bikaner, we argue that

participation by individuals for managing a CPR is governed by social returns, social norms, duties and obligations as well as economic incentives.

We will discuss the participation of individuals governed by social returns, social norms, duties and obligations in this paragraph. The knowledge of construction and management of RWHS in Bikaner and Alwar belonged to a particular social group. Due to absence of codification technologies this knowledge was in the form of tacit knowledge. These communities possessed specific local knowledge for different kinds of work involved in RWHS. *Jalsungha* were a group of people who could smell the land and tell the underground water table level with the help of Mango or Blackberry wood in Bikaner. *Bulai* were a group of people who selected sites for construction of RWHS and supervised people in construction of these systems. In Alwar, there were involvements of *Gajdhars* who were equivalent to the *Bulai* community of Bikaner, they also used to select sites for construction of RWHS and supervise local people in construction of the system. These people knew about the type of soil, land ownership of villagers, earlier sites of *talaab, baori*etc and places where these RWHS can be constructed. Our fieldwork revealed that *Bulai* and *Sungha* did not demand anything for their work. They were paid in kind or cash by the people of the village and the *Chaudharys* and *Zamindars*. They considered it as their duty and were bound by social norms[62] of the community. It ensured their credible and high commitment for provisioning of RWHS. The knowledge of RWHS was distributed among the community and the participation of *Sunghas*, *Bulai* and *Gajdhars* were based on duties, obligations and social norms rather than economic incentives. Our field work revealed that there were other groups of people whose participation was based on economic incentives. Mishra (2010) gives a description of the communities skilled in different activities required for construction and maintenance of RWHS. Their skills were confined in their clan but their participation for provisioning activities was based on economic incentives. They were paid for their work but during drought these communities worked for *shramdan* activities too. In Bikaner these communities were *Chunkar, Koli, Agaria, Mali, Parihar*etc whose identities were based on their skills. The details of their work identities are discussed in section 6.3 of this chapter.

62 Water was a very scarce unit in Bikaner which bound the *sunghas* and the *bulai* to work for provisioning activities.

In around mid 1980s TBS started reviving the RWHS in the rural areas of Alwar. They searched for people possessing knowledge of water harvesting, in rural areas of Thanagazi tehsil called *Gajdhars.* With the help of *Gajdhars* they could revive the RWHS. *Gajdhars'* role remained same as discussed above but their participation was governed by economic incentives in the new era. Hence we see that there is a change in participation incentive of *Gajdhars* from duties and obligations in the pre-British and British period to economic incentives in the post independent period. The nature of interaction of knowledge, technology and institutions has undergone a change. The interaction of individuals and commons has also changed. In this changed set up social motivation was replaced by economic individualistic motivation.

6.3. Local knowledge and its distribution across social groups: An Analysis

In this section we will discuss the local knowledge of RWHS and the way it was distributed across social groups. Local people have developed their ways to solve the problems of fulfilling their water requirements of drinking, irrigation, domestic use in different ways. They have constructed RWHS for catering to their water needs. These practices were specific of region which embodied local knowledge of people. We have already discussed in section 2.4.1, chapter 2 local knowledge is an uncodified knowledge which is difficult to manifest. We argue knowledge of local people has been manifested in forms of different kinds of RWHS. We discuss the types of RWHS as following.

6.3.1. Local knowledge of RWHS in Alwar

The discussion in this sub-section is based on report by Mathur (2009), *A Study of Management of Water Resources in Alwar State During 18th-19th Century*.Mathur (2009) discusses the knowledge of RWHS in Alwar persisted from pre-British period till late 1980s. The dams, wells, *kund*, *baori* in Alwar were built as per the directions discussed in section 4.4.5., chapter 4 of the thesis. We discuss this aspect here. A dam is a hydraulic structure constructed across a river or lake to store water on its upstream side. According to applications, dams in Alwar were classified as storage dams and diversion dams and according to materials used in construction; dams in Alwar were classified into gravity and earthen dams. The gravity dams were constructed of concrete material. Gravity dams are relatively stronger than earthen dams. Gravity dams can be used as overflow spillway while

earthen dams cannot be used as overflow dams. Gravity dams can be constructed on sound rock foundation and require skilled labour while earthen dams can be constructed with local materials available on low cost. The earthen dams are constructed of earth or rock fill. Siliserh dam built in 1845 A.D. is a mix of gravity and earthen dam (shown in Figures 6.1, 6.2 and 6.3). Vijay Sagar built in 1918 A.D., Mangalsar built in 1896 A.D. and Jai Samand (Figures 6.4, 6.5 and 6.6) built in 1910 A.D. are gravity dams. Talav, Baleta and Ramgarh are earthen and storage dams built before 17th century. Gravity and earthen dams are also storage dams.

Figure 6.1: Siliserh lake

Figure 6.2: Canals passing through Siliserh dam

Figure 6.3: Canals passing through agricultural lands (channels are used for irrigation)

Figure 6.4: Jaisamand dam

Figure 6.5: Jaisamand dam

Figure 6.6: Canal passing through Jaisamand dam

Storage dams stores water for all purposes for lean periods. These dams are the most common types of dams. It is constructed to impound water to its upstream side during rainy season and used in period of deficient supply. Behind such a dam, a reservoir or lake is formed. These were constructed for purpose of irrigation and water supply. Diversion dams are of smaller height and no reservoir is formed to store water. Diversion dams can be masonry or earthen but mostly earthen. Diversion dams are meant mainly for distribution all over the year, these have small storage structures from which channels are made for distribution. Weirs and barrages are examples of diversion dams. These dams had canals and introduced in 18th century. During floods, water used to pass over or through these dams while during the period of normal flow, the river water partly or wholly is diverted to irrigation channels. An example of diversion dam is Bara weir built at the end of 18th century.

The construction of water bodies in Alwar is discussed as per the directions given by Mishra (2004) in section 4.4.5., chapter 4. Mathur (2009) discusses that reservoirs were required for storage dams. For reservoir planning at the dam site, the area is surveyed and a contour plan is prepared. The reservoir capacity corresponding to a given water level in the reservoir is calculated. Geological investigations like minimum percolation losses and maximum run-off is obtained, the site should be such that quantity of leakage is at minimum. The dam should be founded on water tight rock base. The reservoir basin should have narrow opening in the valley so that length of the dam is less. The topography of the site should be such that it has adequate capacity without submerging excessive land. The site should be such that a deep reservoir is formed. The soil and rock mass at the site must not contain soluble minerals and salts. The foundation of the dams was laid with the mixture of hard rock's stones and limestone. The walls of the dams were painted with lime paste as after mixing with water, lime does not allow water to seep through the walls.

Well irrigation was also very popular in Alwar. *Kachha*[63] and *KachhaPucca*[64] wells are common in Alwar, Thana Gazi, Behror and Tijara tehsils. *Santhara*[65] and *Papra*[66] wells are common in Rajgarh and Thana Gazi and in hilly portions of Alwar. Maximum number of wells were found at the foothills of Aravali range. During 17-18th century water table was very high and available at 15-20 feet depth. Most of the wells were situated at the foot hills of the fort in the villages. These provided irrigation facility to the villages. Evidences of irrigation through wells by Persian Wheel (*rahat)* are found at places in Alwar. For instance, evidence of irrigation by *rahat* from well can be found on the way of Machka to Gangodi where water was drawn by *rahat* and accumulated into a large tank and subsequently to smaller three tanks in three different directions. At the old road from Andheri pole to the fort, a square well is constructed to maintain water supply to the Jai Vilas Palace, built by Maharaja Jai Singh (1892-1937). For lifting water, to the *kund* of palace a machine with suction pipe was used r and water was also released in *khel* (a rectangular reservoir) for animals.

A well *baori* is found at foothills of BalaQuilla which has a round stair case around it which goes uptothe lowest point of the well. The *baori* is 20 feet deep and even today the water level is 10 feet deep. The water is drawn through canal and collected in a semi-circular tank which is 35 feet deep and has concrete layer around. A *khel*nearby indicates that animals used to come here for drinking water. Irrigation facility was provided to the villages by digging wells. *Kishan kund*, located at the foothills of Aravali is an example of filtered water supply to the fort in Alwar. The water collected in *kund* flows into a small tank with its front wall having large and small holes from top to bottom. As the silt settles down at the base and the filtered water flows down to *sagar* through the canal. The flowing water collects impurities again and to purify this water an indigenous technique was used in which the water was filtered by passing through three tanks called *Bhudar ki kundi*. It was a six storied structure approximately 35-40 feet high. The last storey was underground from where the

63 Kachha wells do not have masonry lining or stone lining and can be sunk only when subsoil is firm and stable.

64 KachhaPucca wells have 10 to 20 feet of masonry at the top which adds to stability of the well.

65 The well is first dug out often through loose stone and a rough lining of undressed stone, uncemented or cemented only with mud from below.

66 Papra, where a stratum of stone or solid rock ban has to be cut till water is reached after which the sides are smoothed and upper portion is lined for greater stability.

filtered water was supplied to *sagar* and inside the palace for domestic use. Channel gates were installed to drain the overflow which supplied water to people for daily needs in parts of Alwar (Mathur 2009). *Baori* and *kund* were used mostly for drinking water for the palace.

Here we discuss, the knowledge of *johad* technology which was revived by TBS in Alwar in around 1986.A *johad* is an indigenously built rainwater impoundment in Rajasthan, built to supply water for domestic water-needs as well for irrigation, production of crops and rearing of animal stocks. The techniques used by the local hydro-experts appear to be quite 'simple' in the era of complex science. An in-depth discussion of knowledge and technology of these systems, however, reveals that these systems embody a complex array of experiential knowledge, which is partially documented by TBS in Alwar. Village experts are known differently in different local languages or dialects. In Alwar they are known as *gajdhars* and mostly belonged to *meena* caste.

The site selection was done by the villagers in the Gram Sabha meetings. Actual water-fill port in a *johad* is termed *jal-bharao* (water-fill) area or simply *bharao* area. It is laterally embanked or dyked to hold the rain or runoff water into the *bharao* and disallow or check any outflow of water from the area on its own. Such dyke is termed *paal*. It is generally non-masonry, made of mud-cake or excavated materials from the ditch. If masonry is used, bricks, lime, mortar, cement or stone/rock pieces and bentonite clays are assembled from outside and constructed by experienced masons. By their own estimation and capabilities, the villagers used to make estimation of the barrage whose top breadth used to be half of bottom breadth of the barrage. Although earlier, people used no specific tools for such measurements, and the estimations were made by *gajdhar's* own experience and cognition, in recent times they use simple measurement tapes.

Usually, *gajdhars* selected the proper sites for such constructions, preparing first the outline of the possible rainwater runoff flow slopes or directions into the dugouts for holding water. The sites were selected on the basis of their estimation by observing the area of incoming water from sloped area. The slope of the area was checked by a hollow iron rod containing water in it which gave the approximate slope of the area. In the present era of modern science, the site for *johad* construction is selected using *toposheets* of different scales made by the scientists of the Geological Survey of India. The interaction of scientists with the *gajdhar*of the village conducted during TBS's training programmes helped people in

developing the knowledge of using *toposheets.* This requires a training of almost 15-20 days. During this training, one is acquainted with the basics of geography and geology. Interestingly, only local *gajdhar* are selected for these trainings, which presumably reveal that some amount of experiential knowledge is required for understanding the modern scientific instruments.[67]

Quite naturally these ditches were accordingly sized and shaped. Likewise, the shape, elongation, height and width dimensions were chalked out to raise barriers or dykes laterally opposite to the water flow-in ditches. The excavated materials were used for raising the barrier, and also as per need, externally procured materials were added. The experts also looked for suitable sites for constructing drainage outlets to take off overflows or flood waters so that least damage, if any, is done to the barrage. Diversion outlets were also there at suitable sites in the barrage to take up the water for irrigation purposes on the side off the barrage. Such outlets are known as *nali* or *gul* and are few inches deep to flush the water into cultivated plots. The embankments have to be raised higher up to hold large amount of water in the deep and with reservoir. In most cases, embankments are made only on one side, but if necessary on very even surfaces, on three sides.

In case, if the reservoir is filled-up to the brim, there is every danger of damage or breakage of the *paal*[68]. In this case, the usual arrangements of drain outlets are given to take-off the extra water. Such drain outlets are termed *apara*. *Apara* are deeper and little wider channels than the usual and are also well maintained. Then an equally essential system is that of *gul or kuhal*(outlet), one or more "irrigation outlets" made through well-water outlet for irrigation purposes lying beyond the *paal*. These are narrow channels, few inches deep and wide to take up the water to the cropped areas. If the *paal* is high enough to hold a high water level in the reservoir, *gul* can carry water through the outlet made in the p*aal* by itself; if the water level is low then some techniques to lift up the water become necessary. Technically, whenever a farmer or farm worker fills and lifts the bucket of water to pour down on the crop or plant roots, he is known as an irrigator. Humans anciently devised several different kinds of simple mechanical means to lift up the water. Often as in construction of water reservoirs, human muscle power was used for several thousands of years before animal power was used

67 See appendix 4.2. for details of the technical aspects of toposheets.

68 Definition of *paal.*

for the purpose. We may think in hindsight from the current view that the whole purpose was technically not very sophisticated and only meant to capture water, concentrate it into reservoir ditches or deeps, barred through raised walls, channelizing it onto the cultivated plots for irrigation and taking care of the surplus or excess water.

Our field work[69] revealed that there were clans of people who were skilled workers and were involved in generation of knowledge of RWHS till the RWHS were taken under the PWD during the British rule.We argue there was involvement of local people in provisioning activities of RWHS but perhaps they were not involved in generation of knowledge. We did not find any documentary evidence for this claim. As discussed in section 2.4.1., chapter 2, Colonial powers and western scientific advisors have often ignored the local knowledge of people they were ruling. Perhaps, the British would not have taken local people's knowledge into consideration for provisioning of RWHS,because formation of PWD in Alwar employed trained engineers who considered scientific knowledge superior to local knowledge.Here, Foucault's (1977) notion of power determining knowledge becomes evidentas discussed in section 2.4.1., chapter 2. In section 6.4. we discuss TBS' works on revival of *johad* in rural parts of Alwar. For reviving these practices, which had lost over centuries, local knowledge of RWH was required. Reviving such kind of knowledge would entail issues of uncertainty.

6.3.2. Local knowledge of RWHS in Bikaner

This section gives a description of knowledge of RWHS in Bikaner. The knowledge of RWHS in Bikaner persisted from pre-British period till late 1980s. The RWHS practiced in Bikaner are *talaab, kuan, kundi, tanka, baori*. We discuss the knowledge of construction of these RWHS. *Talaab* has several parts, catchment area is called *aagaur* and the place where water gets collected is called *aagaar*, both together are called *talaab*. The part which protects the *paal* of *talaab* is called *neshta*, it helps in extra water flow from the *paal* without breakage of the *paal*. In the first year of making of *talaab, neshta* is made small in size and the height of *neshta* is much lower than the *paal* because the newly constructed *talaab* is not capable of holding large amount of water and also the *paal* from beneath and after one year, the height of *neshta* is raised and at that time the *talaab* can also hold large amount of water. The *paal* is usually made of mud and is *kachha* but the *neshta* is made of lime and stone since

69 Discussions with Dr.AnuradhaMathur and Mr. Harishankar Goyal.

neshta bears overflow of water. For prevention of entry of mud and sand from *aagaur* of the *talaab* to the *aagaar*, small pathways of water are made till the *aagaar* and just before entry of water into the *aagaar*, barriers are made called *khurra*. In sandy areas, *khurra* is made *pucca* with help of stone and lime. Small boundaries of stone and lime are made in between those *khurra* so that only water can enter the *aagaar*. Wherever possible, in between *paal* and water, stony slabs are inserted in the *aagaar*. The process of joining of stones is called *juhana*. Small stones are joined together by a mixture of mud mortar, sand, lime, wood apple leaves, jaggery, raisins and fenugreek. Large stones were joined with nails by hammering the stones (Mishra 2010 & Joshi 2006).

Kuan is 100-150 feet deep and the water is often salty, in these structures. Therefore there was a trend of digging *kuin* rather than *kuan* in these areas. The diameter of *kuin* is equivalent to 20 *haath*. On top of *kuin, kheep* grass is kept and a strong rope out of *kheep* is made which is wound round the diameter of *kuin*. Strong wooden rods are put along the diameter of the *kuin* with help of *kheep* rope. The mouth of *kuin* is kept small, reason being sand particles absorb water very slowly so *kuin* can capture small amount of water. The bottom of *kuin* is kept small because if the diameter is large, water will spread and it would become difficult to extract water from *kuin*. The mouth of *kuin* is always kept covered by a wooden cap. *Kuin* can be constructed only at places where stony particles occur beneath desert (Joshi 2006).

Kundi, kund, tankas[70] are variants of same type of water harvesting structures. For these structures very large area is not required. A small catchment area is selected which is sloped and is painted by mud mortar and lime. This area is called *aagour.* The slope can be one sided or if the catchment is too big, slope is pointed towards the centre*Aagour* is kept very clean during the entire monsoon. People are not allowed to wear footwear before and during rainfall in the *aagour*. The mouth of the *kund* is usually round in shape. Most of the *kunds* are 30-40 hands deep. The rim of the *kund* is constructed by stony particles as discussed in chapter 4 by Mishra (2004). The bottom of the *kund* is sieved so that sand particles settle down and cleaning of the bottom is required only once in 10-20 years. *Kunds* are made in common lands as well as private lands. Usually *kund*, constructed in common lands are located in panchayat lands or boundary of two villages. Larger *kund* have doors and

70These structures are not located in the common lands and are mostly privately owned.

often have two open tanks called *hauj*, one is large, while the other one is small in size; these are made for cattle etc. Some of the *kund* still exist which is taken care by *pujari* and his family of the temple located in the premise of the *kund*. Earlier the *kund* were taken care by individual families and *kund* located in common lands were taken care by the person deputed by Raja who had donated the land for construction of *kund*(Mishra 2010). The processes of construction described above for different RWHS are similar to the process of construction as described in section 4.4.5., chapter 4.

6.3.3. Distribution of knowledge across social groups

As discussed in chapter 2, section 2.4.1, knowledge can be classified into modern/scientific knowledge and local/experiential/tacit knowledge. The other categorisation of knowledge is propositional and prescriptive knowledge. Propositional knowledge describes natural phenomena and relations between various natural phenomena. While prescriptive knowledge is practical knowledge of artisans and craftsmen. Propositional knowledge can be considered equivalent to scientific knowledge and prescriptive knowledge can be considered as local knowledge and uses propositional knowledge to produce goods and services (Mokyr 2002).

Gajdhars in Alwar and *Sunghas* and *Bulai* in Bikaner possessed propositional knowledge. *Chunkar, Bheel, Agaria, Mali, Parihar* etc. who possessed prescriptive knowledge are discussed in section 6.3 of this chapter and their knowledge can be traced back to the *rozinadar* workers of the Sultanate period. The knowledge of *gajdhars, sunghas* and *bulai* can be traced back to *ijara* workers of the Sultanate period. The difference which lies in *ijara* and *gajdhars, sunghas and bulai* was that *ijaras* were paid by the State while *gajdhars, sunghas* and *bulai* were offered gifts by people. Hence we can argue that for construction works, there always existed two kinds of workers. One who possessed higher forms of abstract knowledge and other who were skilled workers.

We have discussed earlier in this section that local knowledge of people was distributed across social groups. We discuss this aspect in this paragraph. Mishra (2010) gives a description of work of communities in Bikaner. *Chunkar* used to do work of bricks and lime. In spare time, they used to make salt. *Koli* and *Agaria* were involved in *talaab* construction. They were experts in using tools like *beti, fawda, bel, metak, tasle*, or *tagadi*

used for *talaab* digging. *Mali* and *Parihar* people were involved in *talaab* construction and gardening in the catchment areas of the *talaab*. Mishra (2010) says that *Bheel, Bhilale, Saharia,* and *Kol* have lost their identity in present era and have been included in the Schedule Tribe category (Mishra 2010). *Odhi* community used to keep donkey as pets. Sometimes they used to carry mud on donkey and help in construction of *paal* of *talaab* while at other times; they used to dig mud of *talaab*. They were experts in knowing pressure and level of mud. *Chelvanji* or C*hejara* were involved in digging of *kuin*. The depth of the *kuin* is almost 30-35 feet. The digging of *kuin* is done by *basauli* (a small sized spade made of wooden stick). The deeper part of the *kuin* is very hot, to prevent heat stroke people who stand on the floor keep on throwing sand with very high speed and *chelvanjis* wear a metalled cap on their head so that they do not get hurt. *Chelvanji* are also called *Chejaras.* They are experts in digging *kuin* whose diameter is very small on the top and very big at the bottom. The *kuin* is dug till depth of mud and as soon as the *chejara* start getting stones, they stop digging further (Mishra 2010). *Sunghas* possessed knowledge of searching water in the area for digging wells or *talaabs*. The distribution of local knowledge across various social groups and its use for provisioning of RWHS was prevalent in Bikaner till the canal started supplying water to all parts of Bikaner.

6.4. Knowledge uncertainties and provision of RWHS: An analysis

We have discussed in section 4.2.1.iii, chapter 4 the post-independent policies were based on British policies for governance of natural resources in which the concept of rainwater harvesting was absent and the traditional rainwater harvesting structures were categorised as minor irrigation systems. Rainwater harvesting was not recognized by the government till 1980s. By 1980, the government was compelled to acknowledge the extensive land degradation that had taken place across the country because of the unsustainable management of land and water resources. Apart from government, some NGOs also started reviving the RWHS in India. Ostrom (1990) has discussed that uncertainties stemming from lack of knowledge can be reduced over time by skilful blending and local knowledge. We have discussed in section 2.4.1, chapter 2, local knowledge is unpreserved knowledge since it is uncodified in nature; acquired through the accumulation of experiences, informal experiments and intimate understanding of the environment in a given culture.

Scientific knowledge can be preserved and passed on even if not in practice as it is codifiable. (Dusek 2006) However, the problems in blending such diverse knowledge systems are left unexplained in Ostrom's framework.

We argue that revival of RWHS involves reviving of knowledge of local people which entails issues of uncertainty in outcome. The people are uncertain of outcome about their provisioning activities as their knowledge is not preserved and is lost because of non use. We discuss how TBS dealt for reducing the uncertainties of outcome of people's provisioning efforts by blending local and scientific knowledge. We discuss this aspect in section 6.4.1. Uncertainty might also arise when scientific knowledge replaces local knowledge leading to knowledge incompatibilities. For analysing this aspect, we take case of Gang Canal which was introduced in Bikaner in 1921. We discuss it in section 6.4.2.

6.4.1. Revival of *johad* technology by TBS: A case of Alwar

Revival of RWHS by TBS was initiated in Alwar in 1985. The most challenging task for TBS was to search people who possessed knowledge of RWHS. Several discussions of TBS with the villagers in the Gram Sabha meetings were held which led TBS to identify local hydro experts and conduct training programmes for the people to train them to use modern instruments. The training programmes were organised by TBS and conducted by engineers who are also social workers and the villagers also contributed their knowledge of RWHS related to provisioning activities.TBS called these people as *gajdhars*.[71] So we focus on revival of knowledge in rural areas of Alwar only. Rajendra Singh along with his colleagues interacted with local people to revive the knowledge of RWHS when drought had struck the region in mid 1980s.

As discussed in chapter 2, knowledge creation starts with socialisation process where the community interacts with each other for sharing tacit knowledge. The *gajdhars* in Alwar possessed tacit knowledge of searching water in the area for making *baandhs.* We did not find the transfer of knowledge by *gajdhars* to any other community. This kind of knowledge is difficult to transmit since it is uncodified in nature. Nonaka has discussed that the actions of people are enacted through interactions of tacit and explicit knowledge, TBS, in Alwar interacted with local people and organised training programmes which helped in blending of

71Our field work revealed that the revival of RWHS was not possible in Alwar city as the catchment areas have been encroached by the land *mafias* or builders have constructed buildings in the catchment areas.

local and scientific knowledge systems. The *gajdhars* were trained in the training programmes by the engineers. We have discussed in the section 2.4.1., chapter 2 that the conversion process depends on technologies. We argue that the *gajdhar's* experiential and local knowledge of selecting sites and deciding slopes of the selected sites have been mixed with scientific knowledge of using instruments for deciding the slope and toposheets have been used for selecting site of the area. This process is called combination by Nonaka. Perhaps, this way blending of knowledge would have occurred.

We have argued that uncertainty in knowledge can be reduced when people started getting benefits of their provisioning activities for RWHS. We discussed the case of revival of RWHS in Alwar by TBS which took place in the post independence period in around 1985. We have discussed in section 6.3. of this chapter that by 1980s, the RWHS had declined and therefore the knowledge of local people holding specific local knowledge for construction of RWHS and the role of *gajdhars* had become redundant, because the knowledge generation for management of RWHS is now being done by trained engineers rather than the local people. The local labour working under the supervision of scientifically trained engineers had been in practice since the British rule, which gradually led to the loss of harmony of local labour and local knowledge. Apart from devising mechanisms for blending of knowledge, institutional mechanisms were also developed by TBS to solve the uncertainty problem. We discuss the institutional mechanism in section 6.6.

6.4.2. Uncertainties stemming from knowledge incompatibilities: A case of Bikaner

The RWHS maintained by the people was continued in Bikaner, till 1980s. The introduction of Gang Canal in 1921 was brought in mainly for irrigation purpose which further continued in post independence period in the form of IGNP. There were issues of uncertainty with the introduction of Gang Canal which was a scientific knowledge system. We discuss this aspect here. The British introduced the idea of bringing Bikaner under irrigation by canal system of water without understanding the fact that irrigation might lead to intensive agriculture which can be unsustainable on arid lands (Ramanathan & Rathore 1994). Arid lands are suited for extensive agriculture, a combination of pasture based animal husbandry. Report on Famine Relief Operations, 1939-1940, Bikaner states that, in command area of Gang Canal, the pace of settlement was slow, a number of settlers never took

possession and there were a large number of absentee landholders. The reasons for these were not all of the area allotted to the settlers was irrigable, even the irrigable land could be partially irrigated because of difficult terrain, undulating lands, faulty construction of water courses and large sand dunes which required high investments in land levelling and desilting of watercourses. Major problems identified for unsettling were uncertainties about the unavailability of water for domestic uses and unavailability of drinking water. The Assessment Report of Gang Canal, 1946 states that because of the silting of the parent channels and distributaries and minors, the supply of the water has risen which has resulted in good irrigation of high level land. But silt clearance of the channels is essential to feed the tail villages lying at low level land. The *zamindars* of the upper villages were not willing to clear the silts as it was to their advantage that if the silt does not get cleared, the upper villages will get more supply of water, while the *zamindars* at the tail villages were at disadvantage if the silt is not cleared regularly.

The IGNP is accelerating water-logging, seepage of water from irrigation channels and watercourses. One of the seriously waterlogged areas was adjacent to Ghaggar Depressions. Initially the water was diverted and released in these depressions situated along the banks of Ghaggar river to save the banks from flood. These lands were owned by politically well-connected and rich people whereas the villages adjacent to the Ghaggar Depressions were populated by resource poor farmers. The situation had become worse because the surplus water stored in the Ghaggar Depression was stored in pools for development of fisheries owned by rich farmers of the area. Accumulation of water in these pools leads to water logging of the low-lying lands. A large number of farmers have been accustomed to a water regime which enables them to obtain a good irrigation density of 130%, they have to be content at 80-100% irrigation density which will depend on demand management techniques, organisations of different sections of people in these areas, to induce farmers to move to water-saving cropping pattern, capability of the State to enforce equitable distribution of water. The technical challenges include, finding solutions to drain excess water, adopting cropping patterns which use less water, fixing water allowance for different areas to maintain soil characteristics and groundwater availability, building sound structures and systems of water conveyance (Ramanathan & Rathore 1994).

Hence, we can safely argue that scientific knowledge is not necessarily universally applicable. Such knowledge might bring in problems in the system which can entail severe issues of uncertainty. We have discussed in chapter 2.4.1, chapter 2 power-knowledge relations should be analysed on basis of modalities of knowledge, implications of power-knowledge relation and its historical transformation. The processes and struggles which determine the forms and domains of knowledge is the relation of power and knowledge. We see that the British thought of bringing genuine knowledge with them, being in power they imposed scientific knowledge of canal system to a place which was probably not suited for irrigation. We also see power relations operating in distribution of land when Gang Canal was in operation. The land near banks of Gang Canal belonged to the rich farmers and the land near Ghaggar depressions which faced problem of water logging belonged to the poor farmers. We can argue that the land distribution perhaps would have been in such a way that the rich farmers who were politically well connected to the *zamindars* and the State purchased lands near banks of Gang Canal. The cleaning off of water from the depression was not being done which also pre-supposes power relation. The rich farmers maintained pool for fishery in these depressions which stopped them to clear the pool as it was generating revenue.

6.5. Nature and Scope of Common Property Rights across time: An Analysis

We have discussed in section 2.3., chapter 2 that Ostrom discusses about five (access, withdrawal, management, exclusion and alienation) bundle rights to define rights on properties for the management of CPRs. We highlight that a change in rights to manage the system (management rights), can lead to a change in knowledge of the system which used to govern the CPRs might lead to decline in the knowledge of the system.

6.5.1. Property rights in Alwar

During Mughal times, Alwar came under Mewat region and the area was covered by *Sirkars* of Alwar, Tijara and Narnaul of the Agra *Suba* or province. It also included a small portion of Rewari *Sirkar* which fell under Delhi province. The cultivator in Alwar had long been recognised as the master of the land although the ruler was owner or the over lord

entitled to receive rent. The State asserted its own sovereign right as superior owner but always conceded subordinate property or *biswedari* rights to the village community. Each member of the community was entitled to occupy land in its possession as long as it cultivated and paid the state demand. *Tahsildar* used to allot villages or group of villages from which the realisation for payment of a particular bill would be made. The revenue collected did not go to the State treasury rather much of it went to the pockets of the *Dewans* and other revenue officers (Mayaram 1968). The tenures of land prevailing in the Mughal period were, *batti hui* or divided and *gol* or undivided. *Batti hui* is applied to villages, the lands of which have been divided according to hereditary rights. The proprietor in this category used to get irrigated as well as unirrigated land. The *gol* is of two kinds. In the first, occupation has grown into virtual ownership although the land held by each member of the community may not correspond with the hereditary right. In the other *gol* tenure, the village land is held in common and given to the cultivators. Rent is paid to the brotherhood by the cultivators whether the cultivators are owner or not. This is the property of the community and is divided according to hereditary shares. It is also called *zamindari* tenure. If a cultivator had paid as owners for same kind of land without a lease (*patta*) from before first settlement in 1871, he would always hold same land and will have occupancy right. If he held the land by lease (*patta*), or his rent had been raised at pleasure of proprietors or if he had paid more or if the owners have changed their holding at pleasure, it was held that he will have no occupancy rights. If however he had been an owner or ex *jagirdar* or *muafidar*, occupancy rights were given. Every cultivator, not an occupancy tenant, who held land in the village for two generations or from a period before first Settlement of Captain Impey, was held to be entitled to sufficient land to maintain himself (Powlett 1878).

The British in Alwar adopted a summary settlement for three years from 1859-1862. A new summary settlement was made in 1872 for 10 years. The method adopted in arriving at an assessment was to collect the revenue from the tenants at *tahsil* headquarters, select about five of them from different castes and villages. They were consulted while rents for each village were considered openly in the presence of all assembled. Villagers would themselves offer a fair sum for their assessment but ultimately the *Tehsildars* and *Kanungos*[72] would fix rents and assessments. The State Council sanctioned the settlement and noted with

72 Land record clerk of a tehsil or sub-division.

satisfaction that this would save peasantry from oppression of *Tahsildars* and their men give confidence to them resulting in proper pursuits of agricultural operations and better prosperity. The State Council was always in favour of saving rights of the peasants very clearly. Alwar had the *jagirdari* system and the system of giving villages in *muafi*[73]. The non-*khalsa* area was generally not thought to be the concern of the revenue authorities till 1954 (Mayaram, 1968).

The early recognition of agriculturists' right to land has been described by O'Dwyer as- "The agricultural population has been settled on the land from time immemorial long before the Alwar State was founded. Their rights in the soil are not the creation of a formal grant by any ruler but the growth of long centuries of uninterrupted occupation sanctioned by prescription and immemorial usage." This status of *zamindars* was always recognised in Alwar where the State though asserting its own sovereign right as superior owner always admitted *biswedari* right (a subordinate proprietary) in the village community and its members where each member was entitled to occupy and be protected in the occupation of land in his possession as long as he cultivated it and pay the State demand. This right passed on to his children by ordinary customs of succession and could be alienated by sale, gift or mortgage within certain limits and subject to the sanction of the State. The exception to this general rule in Alwar was the case of *jagirs*. Major Powlett remarks that- "*Jagirdars* have a tendency .... to become virtual proprietors, especially where their original settlement was in part due to their own sword or where they have by their own exertions protected their estates from danger. Indeed as the chief often claims in Native States to be the sole proprietor of fiscal villages, he cannot consistently deny the *Jagirdar's*proprietary title in his village, in the *Darbar's* right which have been transferred to him" (Powlett 1878).

The following four kinds of villages were found in Alwar:

a. *Milkiyat Sarkar*: these villages were such wherein proprietary rights over the land and its natural produce vested in the government. In such villages, the land was directly managed by the State.

b. *Muafi*: According the Alwar State *muafi* rules, seven kinds of *muafis* were prescribed:

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1. *Bhog-kharachMuafi*: when it was granted for the maintenance of a temple
2. *Puuya-UdakMuafi*: charitable endowment
3. *Kabila-kharachMuafi*: granted for the maintenance of a family
4. *Inam-Muafi*: granted as reward for meritorious services rendered to the Government
5. *Sewa-Muafi*: granted on the condition of the grantee rendering service specified in the *Sanad* of *Muafi*
6. *BaghatMuafi*: granted for the upkeep of a garden
7. *Jaida Muafi*: granted for the maintenance of the grantee

c. *Jagir*: The principal types of *Jagirs* were:

1. Qabila-kharach: this type was usually meant for members of the Royal family for their maintenance.

2. Inam: usually granted to persons by rulers for meritorious service.

3. Sewachakri: usually meant for persons who had to do some form of service to the granter.

d. *Biswedari*: most of the villages in the State fell in this category. *Biswedari*was a subordinate proprietary right which belongs to the *zamindars*who are responsible to pay the land revenue to the State. It had always been recognised in Alwar that the State has sovereign rights on land as superior owner. The proprietary rights over the land enjoyed by the *biswedar* did not amount to full ownership as the State was *malikala* (primary owner) but its main features were:

1. The *biswedar* was entitled to the use and occupation of the land during his life time.

2. On his death this title passed to his heirs subject to the rule of inheritance prevalent in the particular village.

3. The *biswedar* was entitled to let the land to the tenants on such terms as he thought fit subject to existing government rules in this regard.

4. The *biswedar* could alienate the rights sale, mortgage and gifts subject to the customary restrictions of the same family or the village community.

The *biswedari* tenure was further sub-divided in the following village tenures:

1. Zamindari Khalis: the chief characteristic of this type of *biswedari* was that land revenue was pain and property held by one individual owner who was responsible for profits and losses.

2. Zamindari Bilij mal: In this class the whole village was held by several persons according to hereditary or customary shares and was managed in common. The owners were jointly responsible for the *jamas*, profits and losses according to the shares shown in the settlement papers.

3. Pura Pattadari tenure (*Pattadari Mukammil*): In this all the lands, except roads, village sites and cremation grounds, were divided and held in severalty by the different proprietors according to certain known shares, each person managing his own lands and paying his fixed shares of revenue while all were jointly responsible to the extent of any co-sharer being liable to fulfil his obligation to the Government.

4. Mixed Pattadari tenure (*Pattadari Ghairmukammil*): was that in which part of the land was held in common and part in severality. In this tenure defined shares were recognised and the property of the lands held in common was usually first appropriated to the payment of the revenue and surplus divided or deficiency made up rateable distribution over the several holdings.

5. Pure *Bhaiyachara* tenure: were those in which the shares which determined distribution of revenue liability became extinct and each man's holding had become sole measure of his rights and liabilites. Each proprietor had a certain

defined share both cultivated and uncultivated which he managed and for which he paid land revenue according village customs.

6. Mixed *Bhaiyachara* tenure: differed from perfect *Bhaiyachara* estate in exactly same way as a pure *pattadari* tenure differed from mixed *pattadari* tenure.

Holding tenures: the following kinds of holding tenures were found in Alwar:

1. Khudkasht: in which a share holder in the above mentioned village tenures cultivated personally i.e. by his own labour or by the labour of any member of his family or through servants on wages.

2. Malik Kabza: owners were sometimes found in village communities who did not belong to the brotherhood and were not sharers in the joint rights, profits and responsibilities of its members. Their proprietary title did not include any share in village wastes.

3. Occupancy tenants: if a tenant had continuously occupied land for 12 years and paid a fixed rent therefore or rent at owners' rate without entering into any written agreements, he should be presumed to be entitled to occupancy rights.

4. Non-occupancy tenant: in such tenures, tenants cultivated under some lease, written or verbal with the owner and paid rent in cash or kind as agreed between the land lord and the cultivator.

5. Shikmi: in this a sub-tenant cultivated under a tenant according to the terms agreed to between them.

The land tenures described above existed both for *khalsa* (held by *biswedars*) and *jagir* (held by *jagirdars*) lands.

In Alwar, the RWHS which included mostly *bunds* and wells were built on State lands. At times, it was built on *jagir* lands as well. Most of the RWHS were funded by the rulers, they granted funds for construction of water bodies[74] and most of these investments

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were made to ensure beneficial agricultural production. Indeed in Alwar, in the settlement of 1872, *muafi* land (revenue-free land) was granted by the State for construction of water bodies.[75]In 1872, by the regular settlement, Rs. 80,000 was advanced to the *zamindars* by which 300 new wells were dug and more than 100 were repaired. During the British period, these systems were under the control of PWD. The PWD always promoted the maintenance of these systems. There are evidences to support this claim. The *Nazim* of Kishengarh requested for financial help from the revenue minister of Alwar for sinking of well in Chokuti village as it had no well, the *Nazim* had to give details of beneficiary villages apart from Chokuti by sinking of well and demanded for an account of how do people fulfil their requirements of water.[76]At most of the places chief engineer and superintendent engineer made up the committee for repair and construction works. The Collector of Rajgarh, Alwar gave orders to the PWD to repair the Thonsri *Bund* in 1936 which had considerable irrigation capacity but since the canals have not been repaired therefore the *bund* cannot be utilised for irrigation.[77] The Prime Minister of Alwar requested for restoration of the Qaziwala *bund* in Tijara *Nizamat* in 1938 which would improve irrigation in the area. An estimate for the restoration of Qaziwala *bund* in Tijara *Nizamat* shows that apart from materials required for the construction six supervisors, twelve (labourers) *mistries,* six mates and twelve people of *beldar* community (people who carry material) were employed.[78] A committee was formed for improvement of Siliserh Canal irrigation system for economical distribution of water to different gardens, dairy farm, agricultural farm and the *zamindars* who have been using it for long. For prevention of illegal use of water locks were recommended at important points. Construction of wells, repairing of water-courses for prevention of leakage and conversion of *kuchha* water courses to *pucca* water courses were also recommended. The owners of the private gardens were requested to construct *pucca* channels and if these *pucca* channels are made, the evaporation, percolation and absorption losses will be minimum and irrigation income of the State would double. To avoid wastage of water, a police guard was appointed

75Chapter 3, pg. 24 (UGC Project Report, Mathur, A.)

76File No. 4233-R/43, Revenue Branch, Subject: Demand for sinking of a new well in Chokuti village of Nizamat Kishengarh

77File No. 328-R/36, 1936, Revenue Branch, Subject: Repairs to Thonsri *Bund*

78File No. 354-P/38, 1938, Prime Minister's Branch, Subject: Restoration of the Qaziwala *Bund* in Nizamat Tijara

to help detecting the theft of water.[79] A letter dated 31/07/1939 to the Revenue Minister by the State Engineer states that the *zamindars* had damaged the *bunds* while ploughing their fields alongside of bunds. The State Engineer had issued orders to the *Nazims* to warn the *zamindars* in this connection saying that the security of the bunds is in interest of *zamindars* and they should exercise a certain amount of control and safeguard by avoiding ploughing up the fields.[80]

The document from the Collector Rajgarh to the Revenue Minister shows that after inspection of the Northern, Southern, Central Canal and *pacca* Canal, at some places *kachha* water courses were constructed by the *zamindars* to avoid breaches in the *pacca* canal. The revenue minister gave orders to *Nazim*, to get the *kachha* portion of the canal repaired by the *zamindars* so that they can irrigate their lands. Document of restoration and assessment of village in *jagir* of Captain Vikram Singh shows that in villages Saharanpuri and Jharoli new wells have been sunk respectively which irrigate lands for which protective leases are granted for those who own the wells.[81]A letter dated 18/11/43 from the Revenue Minister to the *Nazims* shows that the revenue minister asked for appropriate places for construction of model wells where water is scarce. The transfer of Irrigation Department from the control of the Revenue Department to the PWD resulted in better yields in agriculture. The revenue realised from irrigation increased from Rs 5,722 in 1911-12 to 17,216 in 1912-13 as the PWD spent for repair of bunds in different tehsils in Alwar.[82] Every effort was made to put in order and repair as many as breached *bunds* as possible so that revenue from irrigation can be increased. The total income realised from area irrigated during *rabi* and *kharif* crops was Rs 10,375 in 1918-19 to Rs 44,870 in 1919-20.[83]One might conclude from above documents that there was involvement of local people at higher levels like *Nazims* and the Collector in decision making. The documents also reveal that the State supported the *jagirdars* in continuing the practices of RWH.

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79 File No. 91-R/12, Revenue Branch, Subject: Formation of a Committee for Improvement of Siliserh Canal Irrigation System

80 File No. 674-R/39, Revenue Branch, Subject: Damage caused by the *Zamindars* to the Irrigation Bunds

81 File No. 1226-R/38, Revenue Branch, Subject: Restoration and Assessment of villages in Jagir of Captain Vikram Singh.

82 PWD Register No. 11, 1911-12

83 PWD Register No. 19, 1919-20

With respect to RWHS an individual or community often has rights of access, withdrawal, management, and exclusion for the management of such resources. They can exclude other individuals/communities from using the resource, but they do not have alienation rights on it. In the literature on bundle rights, it is generally assumed that owners have the authority to sell or lease a CPR. This would reflect ownership of the land as such. Also, being 'owners' automatically meant being in possession of all four 'common' kinds of rights (access, withdrawal, management, exclusion) as well as the right of alienation. The rights to access, withdraw were held by the communities but usually they did not exclude anyone from these rights because water was considered sacred. The provisioning of RWHS in Alwar was funded by the State as discussed above. It may be conjectured that the management rights of the people which existed in the pre-British period perhaps were not the same in British period in the *khalsa* areas. In *jagir* areas, the RWHS were supposed to be maintained by the *jagirdar*. Though the *jagirdar* were exploitative and did not contribute cash for provisioning of RWHS; but local people contributed for the maintenance of RWHS. Hence we can conjecture that the access, withdrawal, management, exclusion rights of the community were strong in the *jagir* villages. The RWHS in *khalsa* areas were built by the State during the British rule, perhaps people from all over Alwar would have contributed for the provisioning of RWHS. So the access, withdrawal, management, exclusion rights would not have been so strong as in *jagir* villages. The *biswedar* (who was a subordinate of the State in *khalsa* areas) was relatively more responsible than the *jagirdar* for maintaining the RWHS. Probably, only the *khudkasht* and occupancy tenants of *khalsa* and *jagir* areas held access, withdrawal and management and exclusion rights of RWHS. The *khudkasht* tenants had their land holding and residence in same village and occupancy tenants were not cultivating land under any lease so perhaps they had stronger rights of access, withdrawal and management than other tenure holders. The right to alienate people from appropriation of water was held by the *jagirdar* in *jagir* villages. The State perhaps had the right to alienate people from appropriation because the *biswedar* villages were held under the *khalsa* area. The occupancy tenants in Alwar State holding land under the *jagirdars* and *muafidars* and *biswedars* in *khalsa* villages have got inheritable and alienable rights.[84] The *khalsa* lands were given to the *biswedars* and *biswedari* rights were saleable rights (right to exclude and alienate) except in

84 Chamber of Princess, subject: Sale of right of alienation to occupancy tenants on prescribed charges, bag no. 189, s.no. 19, 1945

the common lands (*shamilat*) of *khalsa* villages. When the *biswedari* rights from one *biswedar* were transferred by the authorities to another *biswedar*, the local people's right of access, withdrawal and management remained same and they were not alienated from the common land.

The post independence reforms on land tenure are discussed here.The Rajasthan Tenancy Act which came into force on October 15, 1955 categorizes three kinds of tenants namely, *khatedar*, non-*khatedar* and *khudkasht*. Every person, who was a tenant of the land or a tenant of *khudkasht* became a *khatedar* tenant at the time of commencement of the Act. The Matsya union merged with Rajasthan on May 15th, 1949. Before independence, large areas of land were held by *jagirdars*. These *jagirs* were grants of land made by the State to them or to their forefathers either in recognition of services or means of conciliation. The *jagirdars* were free to realise rents from the cultivators of their estates and paid to the government by way of tribute, only a sum specified at the time of grant. There always existed a big difference between what the *jagirdar* realised from his tenants and what he paid to the government. Another class of intermediary between the State and the tiller was the *biswedar*, who paid revenue to the government but there was no check on his powers of fixing rates for his tenants, except in case of those recorded as occupancy tenants. The tenants-at-will had no stable rights in land.

Upon formation of Rajasthan, the *jagirdars* and *biswedars* apprehended that the legislation would start ejecting them and confer statutory rights on tenants.With a view for settling all disputes regarding the share recoverable by land-holders as produce rent and in order to prescribe maximum extent of such share and regulate its recovery, the Rajasthan Produce Rent Regulating Act, 1951 was passed. This fixed the maximum share at one-fourth (reduced to one sixth by a subsequent amendment) of the produce. Estate holders in the *zamindari* and b*iswedari* areas used to collect high amounts of rents from their tenants which were put to an end through the Rajasthan Agricultural Rent Control Act, 1952. The Act fixed the maximum rent for a holding at not more than twice the land revenue assesses on the holding.

The Rajasthan Land Reforms and Resumption of *Jagirs* Act, 1952 was brought into force from February 18th, 1952. The landed *jagirs*, cash *jagirs* or grants of money by way of *jagirs* were abolished with effect from April 1st, 1958 under the Rajasthan Cash

Jagirs Abolition Act, 1958. A provision for payment of compensation for these grants was also made. In Alwar district, a total number of 4,337 *jagirs* other than grants attached to temples or other religious places had been resumed by August, 1964. The Rajasthan *Zamindari* and *Biswedari* Abolition Act, 1959, was brought into force from November 1, 1959 and the *zamindari* and *biswedari* estates have been resumed and the area comprising them has vested in the government. The tenants of *biswedars* and *zamindars* whose estates have been abolished have become *khatedar* tenants.

In order to facilitate the *Bhoodan Yajna* and to provide for the constitution of *Bhoodan Yajna* Board, the Rajasthan *Bhoodan Yajna* Act, 1954 came into force, according to which, the donation of land to this board and distribution of land received in donation to landless cultivators or for community purposes was made mandatory. A development of *Bhoodan* movement is *Gramdan* which means gifting of the entire villages. This necessitated legislation for the establishment of *Gramdan* villages and the constitution of *Gramsabhas* to manage the lands and perform other functions. The Rajasthan *Gramdan* Act came into force from June 8th, 1960 which permits land holders and *khatedar* tenants to donate their rights, title and interest which stand transferred to and vest in the *gramsabha* of the village. All government owned lands in the *abadi* area, in possession of the Revenue Department have been vested in the village panchayats. The panchayats were given the authority to sell or lease out the lands and utilise the income for public utility works. Demarcated pasture lands have also been transferred to the village panchayats. Small tanks, with capacity to irrigate 50 acres have been placed under the control of village panchayats (Mayaram 1968).

From above discussion we observe that the *khudkasht* tenants of *jagirdars* and the *biswedars* became the *khatedars* in the post-independent period. The *jagirdars* and the *biswedars* who cultivated their own land became *khatedars* and the *jagirdars* and *biswedars* who had given their lands on lease for cultivation had to surrender their lands. The *khudkasht* tenants cultivating *jagirdar's* or *biswedar's* land since past 12 years had become *khatedars*. The common lands where RWHS existed were taken by the panchayat. The *khatedars* were necessarily allotted lands near or in the villages they maintained the RWHS. The *khatedars* who had been allotted lands by the government not necessarily belonged to same villages. So their accountability for provisioning of RWHS might have been low or nill. These reforms alienated people from the common lands. Hence, we can argue that the post independent

period took the rights of access, withdrawal and management of RWHS from the people by altering the property rights system. The transfer of rights for provisioning of RWHS from community to the panchayat who did not have adequate funds to manage these systems led to decline of RWHS in Alwar. The *khudkasht* tenants who already possessed land were not granted land from the *shamilat* (common land) at the time of independence.[85] From 1959-1972, the cultivators who cultivated on common lands were given *khatedari* rights with full rights to sale.

Our field work in Alwar revealed that the RWHS were better maintained in *khalsa* lands than *jagir* lands because the *jagirdars* used to collect tax on usage of water from common lands and exploited people rather than contributing in maintenance of RWHS. The *jagirdars* used to collect money from every household of village for construction of RWHS. After the formation of panchayats in Alwar district, out of 126, the management of 100 dams were given to the panchayat and these declined because the panchayat did not have money to repair those. 26 dams were supposed to be maintained by the State Government out of which 20 dams were encroached between1950-1980. Alwar city had 117 wells till independence. In 1954, water works department was formed which took control of these wells but never got them repaired and these wells declined as by then pipeline supply system of water had taken over which catered the water requirements of people.[86] At present, urban Alwar has 3 surviving dams, Siliserh, Jai Samand and Vijay Sagar dams. Siliserh and Jai Samand were constructed on *shamilat* (common land) for irrigation purpose, Siliserh was also meant for providing drinking water supply to Alwar. Vijay Sagar was constructed on *khalsa* land which was taken over by the government in late 1990s after which it has been used for supply of water for irrigation purpose. Thanagazi tehsil had 6 dams built from 1898-1934. At present all of these have declined.

We have already discussed in section 6.4., TBS revived the RWHS in form of *johad, anicut and baandh.* Next we discuss the bundle rights in changed institutional set up.

In Gopalpura, Hamirpur, Gadhbasai villages of Thanagazi tehsil, there was an external, but voluntary intervention with the help of a group of local people for revival of

85Discussion with Chauthmal, retired officer of Land Revenue Department

86Discussion with Mr. Harishankar Goyal.

RWHS in Gopalpura village by TBS.[87] The rights to access, withdraw are held by the community as also discussed by the regulations of panchayat in which the *Gramsabhas* are supposed to manage the lands.[88] The panchayat is the owner of the land, the panchayats were given the authority to sell or lease out the lands and utilize the income for public utility works.[89] The villagers contributed in provisioning activities which constitute the management rights of the villagers and cannot exclude anyone from the village from the above mentioned three rights. The rights of alienation do not lie with the people of the village. Although, as a community they can exclude other villages from accessing their *johad*, they seem not to do so because of the social norm which considers it appropriate to let everybody access water of common lands. They believe that water is sacred and it should be shared with everyone. Interestingly, however, people also site very 'rational' reasons for non-exclusion, especially in common lands. According to some of them, these rainwater systems are made in forests and are at located at far-off places from the village which makes it difficult to monitor the appropriation activities of others. Indeed, they are not very generous in sharing water reserved through *anicut* in their private lands. People have constructed *anicut* to stop mud cut-off by water coming from the hilly terrain of the village. People have also made wells in their private lands. In private lands, water is shared only when there is adequate rainfall and wells are adequately recharged. So, we see different social norms related to accessing water harvesting systems, in common and private lands.

6.5.2. Property rights in Bikaner

The land records of Bikaner district prior to the foundation by Rao Bika is lacking. That time most of the territory was occupied by *Bhatis* and various tribes who were recorded as original settlers and claimed all the land around their villages as exclusive possessions and ownerships. Rao Bika upheld these rights but later in the 15th and 17th centuries his descendants initiated the policy of exercising their sovereign authority over the entire area. The land of former Bikaner was divided into three groups: *Khalsa* (Crown land), *Jagir* (held

87 The discussion on rural Alwar refers to post independence period, after 1985. As a result, the motivation behind the intervention of an external agent, as posed by Ostrom, becomes redundant.

88 It is also in order to point out that access and withdrawal rights are perhaps the same thing for water harvesting facility. In other words, access would automatically imply withdrawal (consumption) of the same resource. The Gramsabhas constitutes at least one member of every family.

89 Demarcated pasture lands have also been transferred to the village panchayats.

by grantees) and *Sasan* (carved out for religious institutions during the reign of Maharaja Ganga Singh). The *khalsa* land comprised near about 32 percent of the total area of the State. The *jagir* lands comprised major portion of remaining area, were two types; first, those held by near relatives of the *Maharaja* on revenue-free basis and second those held by *jagirdars* in lieu of their pat services. The second category of *jagirdars* paid *rekh,* besides other cesses to the State. The *Sasan* was granted for maintenance of temples in charity to Brahmins and *Charans* and were held free in perpetuity. The *jagirdars* were divided into two categories, *Tazimi* and non *Tazimi*. The number of *Tazimi* nobles varied during the reigns of different rulers. Most of them were employed on important assignments in the State administration (Sehgal, 1972). There are no evidences of categorisation or discussion of common property in the literature of pre British period in Bikaner district although the common property resources like wastelands, grazing lands, ponds etc. always existed and were maintained by the *jagirdars* of Bikaner as mentioned in archival records in section...

A rough summary settlement of *khalsa* villages was done in 1884.The first regular settlement was done in 1892-93 for a period of ten years and then extended upto 1911.Nosettlement had taken place in the *jagir* areas till 1941. The *jagirdar*s used to fix rent arbitrarily and the rates were twice as much in *khalsa* areas. During the reign of Maharaja Ganga Singh (1887-1943), a regular system of payment of land revenue in cash in *jagir* was fixed. The settlement operations in the *jagir* villages commenced on 1st January 1942 and were completed in 1951-1952 after the merger of the Bikaner State into Rajasthan in 1949. Before the formation of the state of Rajasthan, full rights of transfer were recognised in the case of occupancy tenants on *khalsa* lands in the State for acquiring land for Gang Canal. The *khatedari* rights were changed to occupancy rights with full rights to sale in the *khalsa* land (Rudkin 1921). The tenants had to pay *Nazrana* as the price of acquiring rights of transfer. Even after the payment of *Nazrana,* transfers were subject to the prior sanction of the Maharaja. In 1942, as per Bikaner State Government orders, tenants holding land for 20 years or more had been declared *khatedars* and the remaining tenants were recorded as *Ghair-Dakhilkars* (temporary cultivators). The tenants in the *jagir* areas could not acquire occupancy rights at all. The *jagirdars* for all intents and purposes were owners of the *jagir* lands and payment made by them to the State had no bearing on the amount realised from their tenants. In most of the *jagir* areas rent was taken by taking a share of produce. In the unsettled *jagir* areas, the tenants were supposed to pay other kinds of levies (Sehgal 1972).

During the Colonial period, a tenant of *khalsa* land enjoyed greater security of tenure than his counterpart of *jagir* land. He paid a fixed rent in cash, while a tenant of *jagir* land was open to harassment by *kamdars* of the *jagirdar*. He was liable to ejectment by the intermediaries and had no right to appeal to the Maharaja. The situation improved during the reign of Maharaja Ganga Singh who ordered the grant of occupancy rights to agriculturists in unirrigated villages of the State in 1941. These privileges were also given to the tenants in the *jagir* areas (Sehgal, 1972).

Bikaner was a princely state and the ruler of the state funded for the construction and maintenance of RWHS. The rights of exclusion and alienation was held by the *chaudhary* of the villages in Bikaner, the *chaudhary* of village Bidasar, stopped the *chaudhary* of village Masuri to draw water from their village well[90], but generally State facilitates for drawing water of other village if tax is paid but *pattedar* usually does not permit people of other villages to take water even after paying tax[91], for instance in village Morwania, the village head prevented villagers of village Manaksar to fetch water from their village well; after which, *darbar* strictly directed Morwania village head to maintain earlier practice by allowing villagers of Manaksar to withdraw water.[92] Villagers of Sansardesar were stopped from taking water from village *talai*, the *darbar* directed the *chaudhary* of village Talai to not stop villagers of Sansardesar from drawing water.[93]In Bikaner, the *darbar* provided assistance of Rs 25 to the village Longewala in Hanumangarh to complete the work of under constructed well.[94] There are evidences of giving relief in tax for repairing of well, Rs 50 was given to the *chaudhary* of village Nibrasar, Bikaner to repair well of the village[95]. During summer season the King gave order for digging new wells and irrigation was prohibited from those wells constructed for drinking purposes.[96] To provide water to caravans and traders, the State imposed taxes on travellers who were using water for drinking or for other uses. In

90Kagad bahi no. 33-2, VS 1884/1827 Aashadh Sudi 7

91Kagad bahi no. 33-2, VS 1884/1827, pg 23A

92Kagad bahi no 33-2, VS 1884/1827, pg 23A

93Kagad bahi no. 2, Kartik Budi 6

94Kagad bahi No. 12, VS 1859 pg 214

95Kagad bahi no. 27, VS 1878 35

96Kagad bahi no. 10, VS 1854 pg 22

1771, Re 1 tax was collected by the *darbar* from the traders who used water of well of village Rajgarh on the way to Bikaner.[97] The demand for digging of new well for fulfilling needs of people of villages was provided by the *chaudharys* who had right to repair the wells during emergency from other budget expenditure.[98] The *darbar* also extended financial support to people for digging or repairing personal wells which fulfilled the need of water for all village people[99] and the State extended financial and material support looking at peculiar environmental conditions for the construction and maintenance of water appropriation mechanisms. The *chaudhary* was authorized on behalf of the *darbar* to pay for maintenance and construction of wells and other water bodies of the village.[100] In village Garabdesar, construction of village well required stone which was given by state's mines for preparation of mixture with lime.[101]

The *chaudhary* of a particular village in Bikaner possessed all five bundle rights but on interference of the *darbar*, the right to exclude and alienate could also be changed, the change in rights of people from *khatedari* rights to occupancy tenants (full rights of sale) in the *khalsa*land (Rudkin, 1921). The rights to access and withdraw was held with a group of people and right to manage was held with people possessing specific knowledge for construction of RWHS while the rights to exclude and alienate was held by the *chaudhary* of the village. Our field work revealed that the right to manage in Bikaner was held by a specific group of people possessing specific kinds of knowledge of construction of RWHS which has been discussed in section 6.3 of this chapter. In the literature on bundle rights, it is generally assumed that the owners have the authority to sell or lease the property which reflected ownership of the land. Also, 'owners' automatically meant possession of all four kinds of rights (access, withdrawal, management, exclusion) including alienation right. In rural Bikaner, the *jagirdars* appointed *chaudharys* who had the right to alienate people of other villages from access or withdrawal of water from RWHS but the owner of the land was the State and on order of the State, the *chaudharys*' right of alienation of people from their access

97Sawa bahi,Rajgarh, no 1 , VS 1828, pg 2B

98Kagad bahi no. 13, VS 1861 pg 50

99Kagad bahi No. 50, VS 1900, pg113

100Sawa bahi, Rajgarh no.1 VS 1828 pg 43A

101Kagad bahi no 30, VS 1881/ 1824 AD

and withdrawal rights could be changed. In urban Bikaner, the rights to access, withdraw, manage,and exclude were held by the particular community or caste to which a RWHS belonged.[102] The people of that community or caste could decide who would access the RWHS for an aesthetic purpose and who would withdraw from it. They contributed to the provisioning activities as well, which were a part of management rights. They could not exclude anyone from the RWHS from the above-mentioned four rights, because water was considered sacred. So, the right of alienation did not lie with them.[103] For instance, the State charged money for using water of Sursagar *talaab* (State owned *talaab*) for his daughter's marriage during reign of Ratan Singh.[104] Therefore, in Bikaner, it can be argued that layers of rights for appropriation of water existed on common lands where RWHS were constructed. The control of water was mostly with the peasant families of dominant castes who dictated local power over lower castes and untouchables. Our field work in villages of Bikaner revealed that wells of lower castes and untouchables existed separately at places where well digging was not very difficult and at places where well digging was difficult, hardly two or three wells existed in villages and the untouchables had the right to withdraw water from the well of higher castes but a separate tank called *khelia* was constructed for them where they could store their share of water and withdraw from it.

Here we discuss the post-independence reforms in land tenure. The State Land Revenue and Tenancy Acts, 1945 were made applicable to *jagir* areas also. The number of villages surveyed in Bikaner *tahsil* was 128. Due to the resumption of *jagirs* (between 1952 and 1959), settlement operations were again undertaken in 1959 in *jagir* villages and completed and approved by the Government of Rajasthan in 1963. The Rajasthan Land Reforms and Resumption of *Jagirs* Act, 1952 was brought into force from February 18th, 1952. The original act was amended by the Rajasthan Land Reforms and Resumption of *Jagirs* Act, 1954. Cash *jagirs* or grants of money by way of *jagirs* were also abolished under the Rajasthan Cash *Jagirs* Abolition Act, 1958. All the *jagirs* were resumed and compensation was paid to all the *jagirdars.* After formation of the state of Rajasthan, the

102 It is also in order to point out that access and withdrawal rights may mean the same thing in water harvesting.
In other words, access would automatically imply withdrawal (consumption) of the same resource.

103 Rather the right to alienate was held by the *darbar*.

104 Byah ri bahi no. 13, VS 1827/1770, Chait Budi 3

Government protected the rights of the tenants in many ways. According to the Rajasthan (Protection of Tenants) Ordinance, 1949 no tenant was liable to be ejected otherwise than in accordance with the procedure of the law. This came as a boon to the tenants securing them possession of land cultivated by them which resulted in the accumulation of *khatedari* rights to them in their holdings. This was followed by Rajasthan Tenancy Act 1955 and the Rajasthan Land Revenue Act, which conferred several rights to the tenants and security of their tenures. The most important feature of the Tenancy Act was that all those who were cultivating their holdings as tenants on 15th October, 1955, automatically and without payment of any compensation acquired *khatedari*rights with full powers of decentralization and transfer and could not be ejected. These rights also conferred on sub-tenants if they were recorded under certain circumstances through payment of small compensation to the land-holder. As per the Census Report of 1961, the total number of landless agricultural workers in the district was 846 in rural areas and 116 in urban areas. The Government took steps to allot land to them. The *BhoodanYajna* Act, 1954 started functioning in January 1955 where lands were donated to the *BhoodanYajna* Board. Further developments necessitated legislation for the establishment of *Gramdan* and for the constitution of the *Gramsabhas* to manage the land received as *Gramdan* and to perform other functions. The Rajasthan *Gramdan* Act was passed on 18th December 1959, which permits the land holders to donate their rights to the *Gramsabhas* (Sehgal, 1972).

The above discussion follows that the tenants of *jagir* lands became *khatedars* in the post independent period. While the tenants of *khalsa* lands were given occupancy rights (right to alienate) during the British period we did not get any information regarding the common lands. Our interviews during field visits revealed that the RWHS which existed in Bikaner city were left for maintenance to the communities by themselves without any State support. However because of piped water supply the idea of commons, as discussed by Gudeman and Rivera (2001 which is embedded in a community of shared and indivisible knowledge, experiences and interrelationships came to a threat. This led to encroachment of the catchment areas by land *mafias* and by the government for urbanising Bikaner under UIT scheme (Joshi 2005).[105]

105Discussions with Dr. B.R. Joshi and Mr. D.L. Chagani.

6.5.3. A summary

As we have discussed in chapter 3, in India, since pre-British period, property reflected individual ownership on cultivable land and shared rights on common land. Although the *zamindars* or the ruler could sell or lease the land but could not sell various other rights people had on land. Shared rights on common lands continued to exist in the British period in Alwar and Bikaner. In the British period, the *jagirdars* were given ownership of the estates and our field work revealed that they did not take care of the RWHS of their estates in Alwar. The British financially supported construction of these RWHS in *khalsa* areas. The peasants were given the right to sell their cultivable land on intervention of the State both in the pre-British and the British period but no one had the right to sell the common land. We observe a different case in Bikaner than Alwar in terms of access and withdrawal rights of water. Bikaner lies in arid zone of Rajasthan where water is extremely scarce so there existed practice of charging tax by *chaudhary* of the village for withdrawing water from people of other villages. The *chaudhary* also used to alienate people of other villages from withdrawing water from RWHS of their villages. But on the intervention of State, the people could be given permission to appropriate water from RWHS of other villages. In Alwar the users of RWHS of a particular village do not stop or charge any kind of tax from users of other villages probably because Alwar lies in semi-arid zone of India where water is not very scarce and also monitoring for appropriation of water from RWHS of common lands (forest lands) is difficult as forest is located at far-off places from the human settlement. In both the cases of Bikaner and Alwar, the RWHS were constructed on common lands in *khalsa* area the responsibility of which was held by the State. In *jagir* villages these were constructed on common lands of villages, the responsibility for maintenance of which was held with the *jagirdar* of the area. For instance, the land on which the tank was built was State property but was used by the common people, *Sursagar talaab* in Bikaner is an example of land granted by the State for construction of *talaab* and used by local people.

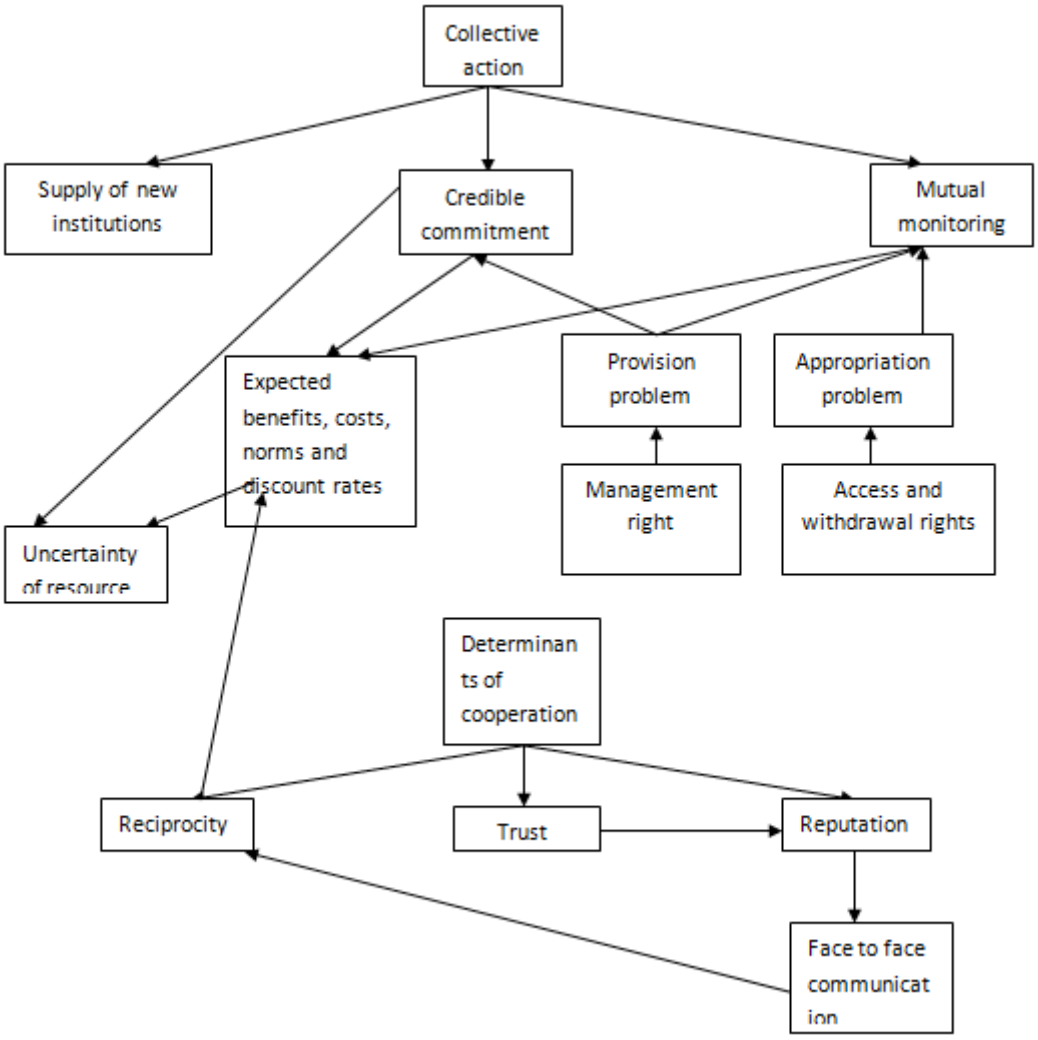
The discussion follows that community alone cannot manage the commons, it has to get engaged with the State for acquiring the land for constructing the RWHS. Before independence, the State supported the community in maintaining the RWHS while after independence the State came up with its own policies (UIT scheme) which were not in favour of the management of RWHS especially in urban areas of Alwar and Bikaner. We have

already discussed in section 2.3., chapter 2 that Ostrom introduces the concept of polycentrism which suggests that local decision making groups must often be nested within State structures at a higher level so that the higher structures can provide coercion and other resources which make local negotiation efficient. Our field work also supports the argument by Ostrom (1990) that the community and the State have to work in harmony for successful management of RWHS.

6.6. Changing rules of monitoring, credible commitment and related institutions: An Analysis

As we have discussed in section 2.3., chapter 2 that there are three basic problems required in order to solve the collective action problem where communities are involved in the governance of CPR. The problems are of a) supply of new institutions, b) credible commitment and c) mutual monitoring. Supply of new institutions provides rules which try to solve problems of credible commitment and mutual monitoring. The problems related to supply of new rules are addressed by studying institutional changes which occur at the level of nesting of operational, collective-choice and constitutional rules; the problems of credible commitment and mutual monitoring shape the provisioning and appropriation behaviours of CPR. Credible commitment and mutual monitoring of the resource users shape expected benefits, costs, norms and discount rates. Credible commitment and discount rates of the resource users depend on uncertainty of knowledge of the system; if credible commitment for provisioning activities of CPR would be high among users, uncertainty of knowledge of system will reduce, which will also reduce their discount rates; if the discount rate of the resource users is high then uncertainty of knowledge is also high. Reciprocity of the resource users in provisioning activities affect the discount rates, if the users reciprocate in provisioning activities of CPR then the discount rate will reduce. The management rights of the users are related with the provision problem which in turn depends on credible commitment and mutual monitoring. The access and withdrawal rights are related with the appropriation problem which is related with mutual monitoring activities of resource users (Ostrom, 1990). The following figure gives a schematic expression for collective action for governance of CPRs.

Figure: 6.1. A sketch of collective action for governance of CPRs



Source: Own compilation

We have argued in section 2.3., chapter 2 that unconscious processes of rule change is the technological change which can erode rule systems over time and practices have to be adopted. Technological change is induced at constitutional level of rule analysis and affects the operational level of rule analysis. We have discussed in section 1.1.of chapter 1 that free-ridership is the key reason for decline of CPRs (Ostrom 1990) and the issue of free ridership arises when property rights are distinguished between 'private' and 'not-private', the latter being vulnerable to free ridership. Thus, making free ridership a key reason for the destruction of any common property system, independent of a community's overall system of property rights, seems to rely on a-historic and a systemic understanding of the issue. In Alwar and Bikaner we argue that apart from free-ridership, decline in knowledge led to the demise of RWHS. The decline of RWHS because of loss in knowledge has been discussed in sections 6.2.and 6.3.of the chapter.

We have discussed Ostrom's framework for solving CPR problems which constitutes of supply of new institutions, credible commitment and mutual monitoring. These depend on a number of factors which is presented in figure 6.1. It has been discussed in section 2.3.of chapter 2 that the supply of new institutions occur at the level of operational, collective-choice and constitutional levels of rule analysis. The access and withdrawal rights affect the operational level of rule analysis. Operational level of rule analysis is also affected by boundary, position, authority and payoff rules. Appropriation, provisioning and monitoring also affect the operational level of rule analysis. Rights to manage, exclude and alienate occur at collective-choice level of rule analysis. Aggregation, scope and information rules affect collective-choice rule of analysis.

6.6.1. Changes in institutions in Bikaner

In Bikaner the resource unit was scarce and therefore very valuable. There is no other source of water except these RWHS so people relied only on these systems and therefore the appropriators were very large in number.[106] At operational level of rule analysis, it is assumed that rules of game and technological constraints are given and would not change. However

106 The discussion of Bikaner mainly refers to the pre-British period which continued in line with the British period.

we argue that both technology and rules do change. In Bikaner, a new knowledge system was introduced in form of Gang Canal in 1921 by the British. Because of introduction of this new knowledge system, the rights of management of people changed from *khatedari* rights to occupancy tenants (full rights of sale) in the *khalsa* land (Rudkin 1921). The change in *khatedari* right to occupancy tenant was change induced in the information rule[107] which affects the collective-choice level of rule analysis. For laying the Gang Canal, the land was classified as cultivated and waste land in *khalsa* areas. The resumption of waste lands in exchange for occupancy rights on the cultivated lands was proposed by the State. The cultivators received a permanent tenure with defined rights over the areas they held and the State resumed the waste lands in which no efforts at cultivation had been made by the new-comers. The State was able to acquire the waste lands and the tenants received permanent rights over the cultivated holdings (Panikkar, 1937). This was done because land acquisition was required for construction of Gang Canal. The Gang Canal which was known as Rajasthan Canal Project and IGNP later provided pipeline supply of water to people in Bikaner.

There were two major factors which led to credible commitment of people for the provisioning activities of RWHS in Bikaner. First, was lack of rainfall and extreme dryness of the region and RWHS were only sources of water till the advent of Gang Canal in 1927. Second, was the social norm that water is sacred. The maintenance of RWHS in Bikaner was age old. There were no rules which people were supposed to follow in maintaining these structures. The concept of voluntary contribution of labour by the people was called *shramdan* which existed in the society for maintenance of these structures. *Shramdan* was practiced at times of famine and drought. People got benefited for getting involved in provisioning activities on two grounds. First, they had access to water and second, they gained knowledge of maintaining the RWHS. This drew frequency dependent action of people which reduced their discount rate. For provisioning activities, credible commitment is required for which monitoring might be required but in case of Bikaner, people are paid for their work for provisioning activities either by communities' contribution by the *darbar*[108] for

107Note that this rule is important when resource units are very valuable and size of group is larger, more and more requirements are added regarding the information that must be kept by the appropriators or their officials.

108Kagadbahi no. 83 VS 1939, pg 4 (a), Kamthanabahi no. 9, VS 1829, pg 98(1)

instance in Bikaner, the *darbar* helped *jagirdar* of village Ratanpura village with Rs 150 for construction of well so there was no issue of monitoring for provisioning activities of RWHS. A tank beside Amarsar well was constructed for which Rs. 33 was invested. 94 labourers were employed for this work which included a number of castes. Every labourer was given equal payment.[109] The untouchables were not allowed to enter the *talaab* and work for provisioning activities.[110] These included *veldar* and *varidar* who carried material and *chunigar* who mixed lime for construction *talaab, kund*and wells.

It can be argued that the management rights of people which affect the collective-choice level of rule analysis are indirectly related to their discount rates which in turn depend on uncertainty of knowledge of the system (as shown in figure 6.1.). The RWHS which existed in the *khalsa* areas declined because waste lands in these areas were resumed by the State in exchange of occupancy rights. After the implementation of Gang Canal, the people started getting easy access to water through canal and did not take care of the RWHS which perhaps led to its decline. Earlier people had only *khatedari* rights on cultivable land. So they were also involved in maintenance of RWHS located on the common lands. The people residing in these areas were accountable for maintaining the RWHS and they had the access, withdrawal and management rights on the common lands. The supply of water from Gang Canal raised discount rates of people as people were secured that they will water from the canal. Since their discount rate is high, they did not get involve in provisioning activities for maintenance of RWHS, hence their credible commitment for working for RWHS was null which led to decline of the RWHS in Bikaner.

Collective choice rules allow users to transfer management, exclusion and alienation rights and these are used by the appropriators, their officials, or external authorities in making policies as to how CPR should be managed. Management right affects provisioning activities of CPRs and provisioning activities affect operational level rule analysis. In Bikaner, the provisioning activities for RWHS were shaped by rights to manage the RWHS which was held with a particular community possessing specific knowledge for different kinds of work for construction of RWHS which has been dealt in section 6.3 of this chapter.

109Kamthanabahi no. 8 V.S. 1829 pg 113(2)

110An informal discussion with a researcher in the archive of Bikaner.

The rights of ownership in land were vested in the State and the cultivators were recorded as *khatedars* in the Revenue Records. In the year 1916, occupancy rights were conferred on the *khatedars* in some parts of the area to be brought under the irrigation of the canal on payment of small *nazrana*. In the year 1931, proprietary rights were granted to the occupancy tenants on payment of further *nazrana* recoverable on instalments. Direct proprietary rights were conferred on the *khatedars* of nail area now included in Raisingnagar and Padampur tehsils in year 1935 on payment of *nazrana*. All the occupiers of the area are proprietors with exceptions of *barani* villages and a few holdings with small areas who had *maurusi* rights. In old days village communities were, as a rule, strong and united bodies generally cultivating most of the land themselves and bound together by ties of common descent of a community or tribe, clan or caste. The fragmentation of holdings, resumption of land in default of payment of government dues, allotment of land and new addition of land by *nautor* have broken the old bonds and ancestral and customary shares do not exist. Each holder of land is owner of specified land he holds including right to alienate. The new purchasers of land do not have any communal ties. With the exception of 7 *zamindari* villages, all villages are purely *bhaichara* type in which possession is sole measure of rights. Out of these 7 villages, 4 villages are *khalis* in which full proprietary rights are vested with a single owner. *Mustarka zamindari* comprises of 3 villages in which the whole land is jointly held and managed in common. Although the right of alienation by new purchasers was recognised by the State, the State had imposed some restrictions on their right of alienation. Under Notification No. 108, 1943, issued from Revenue Minister, the owners could sell their land to members of same community residing in same village without obtaining permission from the Revenue Commissioner while permission was necessary in other cases. The Notification was slightly modified and in 1945, the owner could sell his land to any member of same community who holds the land as proprietor, occupancy tenant or *khatedar* in Bikaner State. In case of sales to others, the sanction of Revenue Commissioner was necessary (Lal, 1946).

As mentioned earlier, position and authority rules affects the operational level of rule analysis. The position rule which meant assignment of guard for appropriation activities for RWHS was that a watchman was appointed for saving the pond of Sujangarh village from

dead human and cattle, was paid monthly salary and given dhoti for guarding the pond.[111]*Mali*, a farmer community usually worked as caretaker of the wells in Bikaner.[112] Authority rules impose sanctions on rule violations for appropriation activities. Water was stolen from *kund* of an old lady which was locked, *darbar* punished offenders who broke the lock and the *darbar* asked the offenders to pay fine to the lady.[113]

6.6.2. Changes in institutions in Alwar

In Alwar, after intervention of TBS, there are several factors which led to credible commitment of people for the provisioning activities of RWHS. The first factor was the drought which struck the region in 1986. In fact, drought also forced TBS to work in the water sector. Second, people were given incentives (wheat from CASA[114]) for working for these RWHS'. The occurrence of drought made people work for provisioning of RWHS. CASA had given 400 quintals of wheat for "*Mewalo ka baandh*" construction and on the work which started on1st October 1986. People got jobs and food to eat when there was no crop productivity. People were supposed to dig 100 '*man*' (approximately 3700-4000 kilograms) mud for an area of 100 (10x10x1) cubic feet. Around 8 kg of wheat was given for this work. Payment was supposed to be done within 8 days. People from other villages also came and worked for this project. The rules which were made by TBS for their implementation are as follows. (1) Food for work programme which existed for 1-2 years for digging a bund of 100 (10x10x1) cubic feet. (2) Money for work programme in which the same amount of mud digging paid Rs. 55-60 and this rule existed for 3-4 years. (3) In both the programmes, the TBS also introduced the concept of voluntary contribution of labour (*shramdan*) by the villagers, where villagers would contribute 50% of the total cost of construction by providing labour 50%, and the rest 50% was paid by TBS. Later the *shramdan* was increased by TBS upto 67% and rest 33% was paid by TBS. The rule change was made by TBS because the villagers observed that the wells started getting recharged by construction of RWHS. The benefit gained drew frequency dependent action of the people

111 Sawabahi, Sujangarh no. 7, VS 1908/1851 pg 27A

112 Kagadbahi no. 12, VS 1859 pg 12

113Kagadbahi, no. 53, VS 1903/1846

114A UK based organization which works in partnership with TBS.

which reduced their discount rate. Consequently, more number of people came and worked for provisioning activities of RWHS. We can argue that the motive to work was self-interest of the people which gradually changed to collective action through efforts made by TBS such as street plays, regular *Gram Sabha* meetings and *padyatras* conducted for generating awareness programmes regarding importance of water and rainwater harvesting in Alwar. These efforts also led to frequency dependent behaviour of people which consequently motivated more number of people to work for the provision of RWHS reducing their discount rate. As discussed above, supply of new institutions provide rules and rules try to solve problems of credible commitment and mutual monitoring. The rules in the present study for *shramdan* for the provisioning of RWHS were provided by TBS.TBS does not impose graduated sanctions on the people who are not involved in provisioning activities. The appropriators in Gopalpura village are committed to contribute for the provisioning activities because they realise that it is in their self-interest to work for RWHS.[115]

However, this realisation only came after they observed the consequences of RWHS in terms of recharged wells in their private lands. An appropriate monitoring mechanism is necessary to achieve credible commitment which depends on discount rates of the individuals. Some individuals who created institutions mutually committed themselves to follow rules and monitored their own conformance to their agreements as well as their conformance to the rules in a CPR situation. In Alwar and Bikaner, no mutual monitoring mechanism for provisioning activities was required because people were given incentives for provisioning activities for RWHS. We argue that such a step does not always guarantee that people be driven by self-interest, but reflects the people's credible commitment. It also depends on their discount rates which consequently depend on uncertainty of knowledge which perhaps made people suspicious about the outcome of their labour. Indeed, after the construction of *Mewalo ka Baandh*, the impact was seen in terms of raised level of water in the wells which reduced their discount rates[116] and uncertainty of knowledge of RWHS and also made people more confident about the outcome. TBS eventually reduced their contribution in *shramdan*, and yet could evoke positive responses from people. Local norms

115One can argue that the actions of the villagers are in line with what Olson had suggested. For him, smaller groups can organise collective actions, which jointly optimise their self-interest more easily than large groups. Note that Gopalpura Village has only 47 households.

116When the discount rate is low, the appropriators will contribute for the provisioning activities of RWHS.

seem to have helped in shaping discount rates as well, which in turn helped in raising commitment of the people. In the present study, the norm that water is sacred may have also made it easier for TBS to motivate local people for its provision and maintenance, which reduced the cost of monitoring. The drought had also raised their fear about the possibility of water shortage, making them more involved in provisioning activities of the system. Thus, we can say that strong local norm of the society helps buffering the consequences of uncertainty of the knowledge to some extent. While in Bikaner the local norm being water is sacred and extreme scarcity in the region perhaps would have raised the commitment of people for provisioning of RWHS.

The people, who participated in the construction of RWHS, are also involved in maintaining the system. The benefit which they gained was the knowledge attained during the construction work of RWHS which helped them in the long term to 'manage' the systems and reducing their discount rates. There existed no mechanism of mutual monitoring for appropriation activities of water harvesting from RWHS.[117] Regarding construction of the RWHS, in Alwar, almost every family from the village contributed in *shramdan*, families from other villages also came and work as they were getting crop for doing the job in drought. Later when the drought was over, in the construction process, mostly families whose lands were nearby the systems contributed in *shramdan* but such families were very few in numbers. The discount rates applied to future yields derived from particular CPR may differ substantially across various types of appropriators. In Alwar, discount rates of people are seen to vary with proximity of the land to RWHS and land size of the household. The appropriators contribute labour more when their private lands are near the RWHS. However, in decision making process, people's contribution is not dependent on proximity of land to RWHS. People who have a large land size contribute less to provisioning activities of RWHS because they apparently have to spend more time in their agricultural fields. Discount rates were not dependent on gender.

We have already discussed in section 2.3., chapter 2 that Baland and Platteau (1996) discuss that appropriate leadership in the group with changing external environment

117The primary reason being the shared norm of the society which considered water to be sacred and it should be shared with everyone. One cannot rule out self-interest driven action here as well. People in their private lands share water only when there is adequate rainfall.

connected to a local traditional elite is an important factor in the management of commons. In contrast Lejano (2013) suggests that external coercion is a solution to the problem of credible commitment of people. A stiff sanction should be imposed by an external enforcer to ensure credible commitment of people for provisioning activities of CPR. Ostrom (1990) argues that a self-organised group must solve the commitment problem without an external enforcer. In recent scholarship these people are often termed as sympathetic outsiders (Thomas 2010). In Alwar, we observe case of revival of RWHS by TBS which was an external agent. Vani (2005: 207-208) states that the emergence of many kinds of 'movements' by external agents such as Chipko movement, Narmada Bachao Andolan directed at protecting the rights to natural resources, has opened up the concept of self-governance in recent years. It has been discussed in chapter 4 that "recent policy and public debate on the importance of RWH has generated response from the corporate sector, educational institutions, technical institutions of research and application, religious institutions etc. The 'public management' in water-related activities, particularly RWH has come with experience of reducing availability of water for basic necessities and failure of the State in supplying water for various needs." The (Non-Government Organisation) NGO sector has been able to take up many of these problems seriously and precisely which the State has not been able to do. "The NGOs constitute a vital link between the citizens and the government working for the transfer and development of information, funds, capacities, skills, institutions and processes." There are many NGOs who work on natural resources management sector such as WOTR Maharashtra, Sadguru Foundation Gujarat, TBS Rajasthan, GVNML Rajasthan, Arghyam Karnataka. The present study deals with the revival of *Johad*, a traditional rainwater harvesting practice in Alwar district. *Johads* were revived by the community with help of TBS. Tarun Bharat Sangh[118] was set up as a Non-Government Organization in Jaipur University Campus in 1974. Its principal objective is to work for combating disaster situations in Rural Rajasthan, and to re-energize the problems facing the loss or deteriorating the village communities' common property resources.

TBS identified water in 1985 as one of the most pervading and challenging problems in rural India. Delving deep into the problem, they happened to discover how significantly ancient Indian peoples had ingeniously solved the problem of water scarcity which was almost a regular feature of their life world. They found rainwater harvesting could be

118A literal English translation would be Young India Organization

managed on a small scale or village community level involving the local residents themselves without much monetary expenses. This indigenous technique, however had been generally lost during last two centuries. TBS, therefore, undertook the task of reviving the knowledge of rain water harvesting with help of community participation for coping up with the prevailing problem of water scarcity in Gopalpura village in 1985.

The objectives of the TBS are:

- "Expansion and involvement of social cultural values by setting examples in welfare action, which benefits the entire society."
- "Energizing human power, especially youth power, to harness energy to value-based work with an orientation to physical labour."
- "Finding a balance between human and natural resource development."

The TBS strengthened the third objective (which is the most important for analysis of this particular study) by bringing together the members, being in constant contact with villagers around the Bheekampura and began to evolve a method of working with people for the peoples own benefit.[119]After identifying *Johads*, for the purpose of bringing fundamental change in the area, the next task for TBS was to ensure community's involvement and participation in repairing damaged structures on one hand and constructing new ones on other hand. This task was difficult for them because migration had reduced the number of men and women in the village. People were sceptical about getting involved in fresh construction work. TBS workers had to approach the village elders for recollecting the existence of *Johad* in villages. On insistence, some village elders agreed to show the existence of oldest tank in the area to TBS workers. Several discussions were held for reviving such traditional RWHS. It was also important for TBS to ensure that each household felt the need for collective effort to build the system. This was a bit difficult task in view of the fact that such a rich tradition had long disappeared and people had only faint memories of their collective efforts (Samantaray 1998: 3). Their strategy gradually crystallizes into five themes.

First, they emphasise that the entire effort is a collective participatory work involving villagers. Second was that this collective wisdom could be conceived in an atmosphere where informal communication was the usual feature. Third, all decisions collectively made would

119http://www.tarunbharatsangh.org/vision%20&%20mission.html#objective<DOA: 03/17/11)

be strictly enforced. It was an effort at building mutual consensus. The fourth was that each person in the collective community would be individually responsible to carry out the tasks to be performed for inclusive benefit to all in the community, and finally the community would only use outside help as a catalyst for their guidance. After discussions with the villagers, they reached the consensual decision that villagers could provide most of the labour and other materials required, except technical help. TBS always insisted that in some way or another, the community would have to bear at least 25 percent of the cost of repair and maintenance of *Johad* and they could work out the benefits, as to how the community at large could share. Sustainable water provision was required to supply drinking and domestic use as well as to serve the agricultural needs.[120]

6.7. Decline of RWHS: An Analysis

The research on commons in India has dealt with the reasons for decline of commons. We contextualise these reasons of decline of commons in our study. Brara (2006) discusses the conversion of legal pasture lands was permissible for institutions like schools, institutions and dispensaries. Extension of these pastoral tracts was allowed upto 5 acres per village and this limit for housing was extended in 1995. Pasture lands could also be leased for industrial purposes with the consent of Gram Panchayat. By 1975, pasture lands were made available for agriculture also with the consent of village council. She discusses that in reality the grazing lands were available for private acquisition from 1956 onwards. The tank-beds, ravine lands and saline areas existing in the grazing lands were unassessable for revenue purposes which got privatised gradually. As discussed in section 6.5 of this chapter, the village pastures fell under the non-*khatedari* lands in Alwar and Bikaner. The Rajasthan State's Land Revenue Act, 1956 declared all lands as property of the State which did not belong to individuals. Gram panchayat was given responsibility of maintenance of common lands in Alwar and Bikaner. The panchayats did not adequate have funds to maintain the RWHS existing in common lands. Our field work revealed that extensive encroachment and urbanisation schemes of government in the catchment areas of RWHS in Alwar and Bikaner led to decline of RWHS. We observe similar reasons for decline of common lands in Sikar district of Rajasthan discussed by Brara (2006) and Alwar and Bikaner.

120http://www.tarunbharatsangh.org/vision%20&%20mission.html#objective<DOA: 03/17/11)

One of the major reasons for decline of CPRs in cities identified by scholars in India is population pressure and growing rate of urbanisation. Urbanisation has led to encroachment of common lands which includes the catchment areas of RWHS as well (Unnikrishnan & Nagendra 2014, Prakash, Nagendra & Ostrom 2014, Vij & Narain 2016). Our field work revealed that for urbanisation of Alwar and Bikaner cities, the government legalised the catchment areas of RWHS under UIT scheme.[121] This led to reduced collection of water to the water harvesting bodies as houses have been built in the catchment areas which stops water to flow till the water harvesting structures.

Jodha (2001) discusses that in traditional systems, the community's stake in its natural resources and specific functional knowledge of resources was an important driving force in shaping society's approach to ecosystem. The functional knowledge of the resources was gained through proximity and access to the resources. Region specific knowledge of ecosystem of people helped in generation of folk-technologies and institutional arrangements to facilitate adoption of such technologies. The reasons for decline of resources are wider scattering of users of resource products because of market integration and wide gap between resource user and consumer (Jodha 2001). Jodha's work mainly focuses on Rajasthan, Madhya Pradesh, Gujarat, Maharashtra, Andhra Pradesh, Karnataka, and Tamil Nadu. The decline in common lands has been recorded for community pastures, village forests, waste lands, watershed drainages, fallow catchment of ponds. The reference period for decline in Jodha's work is 1950-52. In our study in Bikaner, the new settlers from Punjab who were allowed to purchase lands from the government were alien to the system of RWH in Bikaner. They probably did not know the knowledge of maintaining the RWHS which might have led to decline of these systems.

Chakravarty (1996) in her study discusses that encroachments in water channels were not allowed by anyone but moment irrigation channels were made, encroachment on RWHS started as these systems gradually became redundant. In Bikaner, we observe similar kind of dynamics. The encroachment on catchment areas of RWHS started when people started getting easy access to water from pipe supply of water. They perhaps did not feel the need of putting their efforts in provisioning of RWHS which was one of the factors that led to the decline of RWHS.

121 Discussions with Dr. Anuradha Mathur and Mr. Harishankar Goyal.

Hence we see that the reasons for decline of RWHS in India are more or less same all over. All these studies reveal that there always existed a relationship between knowledge, technology and institutions. An alteration in any of these components can change the dynamics of governance of CPRs.

6.8. A compilation

In this chapter we have argued that participation of individuals is guided by discount rates which can be in the form of duties, obligations, norms as well as economic incentives. With change in relationship of institutions, technology and knowledge over time, the incentives to participate might change from social to economic incentives. Local knowledge is distributed across social groups and since it is uncodified in nature, it is manifested in form of various types of RWHS. These RWHS are region specific. Hence, we can argue that when local knowledge is put to non-use, it might lead to decline in knowledge and hence decline in the system. The governance literature suggests dealing with uncertainty of knowledge by blending of local and scientific knowledge systems. We argue that not necessarily scientific knowledge is universally applicable knowledge and it might bring in issues of uncertainty in outcomes of supplanting scientific knowledge to a place which is perhaps not suited for it. Local knowledge is an intrinsic component of governance of natural resources which was often dismissed by the British and they replaced local knowledge with scientific knowledge probably without understanding the fact the rainfall in India is erratic, monsoonal and does not occur daily in contrast to the UK where rainfall pattern is temperate.

The transfer in management rights of people to the State forced local people to surrender their rights of managing the RWHS. During the pre-British period, the RWHS were managed by the people and funded by the *zamindar/jagirdar* or the State. The same practice of managing the RWHS was continued in British period in Alwar and Bikaner except some variations. In the *khalsa* areas of Alwar, the State extended its support financially for provisioning and donated land for construction of RWHS, while in *jagir* areas, the *jagirdars* left the management of RWHS to the people. The *zamindars* and *jagirdars* of Bikaner contributed financially for the management of RWHS as water was an extremely resource unit. In the post-independent period, the panchayat was held responsible for maintenance of common lands which included RWHS also. Transfer of management rights of common land

from the community to the State had important implications for provisioning activities of RWHS.

The RWHS in Alwar during the British period were managed by the PWD followed by the Irrigation Department who did not embody local knowledge of people for provisioning of RWHS. In Bikaner the RWHS were being managed by the local people during the British as these systems were not sources of irrigation for agriculture. The British introduced the Gang Canal and our discussions reveal that perhaps local knowledge was not embodied for its provisioning. The same policies of non-use of local knowledge in provisioning of water works led to decline RWHS in the post-independent period. The Community Development Works initiated in 1952 were given responsibility to do works in agricultural fields and promote growth of panchayats. RWHS were never given importance for their existence which used to help in social interaction of people as discussed by Narain (2014) and Joshi (2005) who argue that RWHS were places of interaction of people and especially women for collecting water together which provided an opportunity for them to socialise. In villages where pipeline supply of water has not reached, the RWHS are still in practice.[122] We also argue that pipeline supply of water reduced access to RWHS leading to less social interaction and reduced collective action.[123]

We give our concluding remarks in next chapter.

122 Discussion with Dr. B. R. Joshi.

123 Social interaction among individuals helps in exchange of knowledge of management of RWHS.

Chapter 7

Conclusion

The objective of the thesis was to understand the dynamic nature of rainwater harvesting governance systems in Alwar and Bikaner, understand the institutional frameworks and knowledge system around RWHS, factors responsible for the decline of RWHS in Alwar and Bikaner and to understand how uncertainties around knowledge, and institutional framework shaped the process of revival of RWHS. We tried to analyse the objectives in pre-British (Mughal period), British and post-independence periods. These objectives were analysed taking five major research questions. The first research question was to understand the motivation of individuals to participate for provisioning of RWHS in Alwar and Bikaner. Second was to understand the distribution of local knowledge across groups and its manifestation in form of RWHS in Alwar and Bikaner. Third research question was to understand the knowledge uncertainties, knowledge complexities and power relations in governance of RWHS in Alwar and Bikaner. Fourth research question was to understand the nature and scope of common property rights in Alwar and Bikaner. Fifth research question was to study the collective action for governing RWHS in Alwar and Bikaner.

We find that the participation of individuals was guided by complex system of duties, norms and obligations and incentives when a notion of commons with interrelationships and shared knowledge systems existed. Their participation was also guided by the forms of knowledge they possessed. The individuals who possessed higher forms of knowledge called propositional knowledge were mostly motivated to participate by duties, obligations and norms. The individuals whose knowledge was driven by propositional knowledge were mostly motivated to participate for incentives. We also find that with change in knowledge, institutions, and property rights changes the motivation of individuals to participate Hence, the nature of participation of individuals for CPRs might change from social to economic motivation with change in relationship of knowledge, technology and institutions.

We find that local knowledge of people is experiential, tacit, and uncodified in nature. We discussed this knowledge was manifested in various forms of RWHS. These systems were made according to specific use of water. We also find that local knowledge embodied in these

RWHS is distributed across social groups. Social groups varied in form of castes and groups possessing different kinds of knowledge accustomed to particular kind of work. They were all forms of propositional and prescriptive knowledge and their sustenance depended on continuous use of local knowledge. Non-use of such experiential knowledge can lead to its decay which can have implications on maintenance practices which are dependent on local knowledge.

The relationship of knowledge, technology and institutions is mediated by power relations. The notion that scientific knowledge was superior to local knowledge shaped the introduction of Gang canal in Bikaner. The hierarchy of knowledge which pre-supposes power relations damaged the blending of knowledge which perhaps led to decline of local knowledge. Canal system of water supply brought easy access of water to people which led to reduced accountability for provisioning activities for the commons. Various other complex systems such as change in property rights introduced by the State altered people's rights on management of RWHS. All these changes shaped their perceived utility of RWHS, and reduced their participation in provisioning activities, in turn, leading to decline of these systems.

A shift from centralised management of water to decentralised management of water was recognised by acknowledgement of plurality of knowledge in 1990s. However, we argue recognition of local knowledge merely cannot solve the problem of revival. The local knowledge which was manifested in RWHS had been lost because of non-use. Its revival is the main concern for reviving the RWHS and solving the problem of water scarcity. Reviving such knowledge entails severe uncertainty issues. Uncertainty in outcome might arise when people are involved in the provisioning activities of RWHS but are not sure about the outcome of their efforts. The provisioning of RWHS involves blending of local and scientific knowledge. We observe that the blending of knowledge by TBS in around 1986-87 was possible because plurality of knowledge had been recognised by that time. But in blending of local and scientific issues of revival of knowledge also comes in. Revival of local knowledge which has not been preserved for generations is a difficult task. We argue that revival of knowledge is not possible in its old form, especially when such knowledge is experiential and undocumented. Long periods of non-use make such knowledge difficult to revive in their original forms. As a result, revival crucially depends on successive interaction of scientific

codified knowledge and experiential knowledge. However, such an interaction is not easy for common people to understand. Experiential knowledge faces more threats of extinction in these situations (change in property rights) because of their undocumented nature.

Revival of RWHS will require revival of knowledge in close connection with institutions and technology. We argue that the RWHS, which existed until 1980s in Alwar is not similar to what is found now and the RWHS have declined. Rather, it has a different form, structure and different kind of rules (participation of people). In its new form, we also see more integration of experiential and modern scientific knowledge, and an attempt to codify the knowledge of these practices. The present study sought to analyse how uncertainty in knowledge of governance can shape modalities of supplying new rules and ensuring credible commitments further. Our study reveals that uncertainty in knowledge makes self-organisation more difficult because people discount the future highly as they are not sure of their efforts. Over time, self-organisation can become easier when uncertainty in knowledge gradually reduces and people can realise benefits of their efforts. The study also proposes that external interventions are possible in such cases, provided the external agents internalise the costs of uncertainty; self motivation (of the external agents) can be a key factor in such cases.

We find that transition from common to public (State) ownership of land can lead to change in management rights for provisioning of CPR. We argue public property is more vulnerable to free-ridership than common property. We also argue that with change in institutions governing the RWHS, knowledge changes. We find that transfer of bundle rights, especially management rights, on CPRs, from communities to the government, can lead to destruction of property if the knowledge of community is not incorporated in the governance of these systems. Hence a shift from common property (whose ownership rights are vested with the communities) to public property (whose ownership rights are vested by the State), might lead to decline of CPRs. We also find that accountability for provisioning of CPRs reduces when people are alienated from their property. Perhaps, they might not possess the knowledge of maintaining CPRs at all places; local knowledge being experiential in nature.

We find that when the management rights of users were transferred from community to the State, provisioning activities for RWHS by individuals reduced. Hence credible commitment of people for provisioning of RWHS also got reduced. In another case, we find

that the credible commitment of people for provisioning activities increases when people are sure about the outcome of their efforts.

Our study revealed that an intricate relationship between knowledge, technology and institutions existed. The notion of the commons embedded in communities' knowledge, property rights, and the way they interacted with each other. The 'ideas' of the commons disrupted with introduction of new forms of knowledge and new property rights arrangements. We also find that interaction of different forms of knowledge gives rise to new knowledge system which might bring about new forms of property and changed interaction between the communities and the State.

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Appendix-4.1.

The Gang Canal

⌈ The Gang Canal

The tract of the Gang Canal forms part of the vast Indo-Gangetic Plain which comprises of the greater part of Sind, northern Rajputana, greater part of Punjab, the United Provinces, Bihar, Bengal and half of Assam. The Gang Canal Colony forms the north-western part of the Bikaner State. The area is composed of two blocks of uneven size between which a strip of *barani* land passes through. The main blocks are Tehsils of Ganganagar, Karanpur, Padampur and Raisinghnagar and on the north western part by the Bahwalpur State, on the east by Fazilka Tehsil of the Ferozepur district and certain *barani* areas of Ganganagar, Padampur and Suratgarh Tehsils lying outside irrigation zone and in the south by the *barani* areas of Suratgarh and Anupgarh Tehsils. The total area of the entire Colony is 1482 square miles out of which 1209 square miles are cultivated (1103 square miles irrigated and 106 square miles unirrigated). The remaining 273 square miles are uncultivated (178 square miles *banjar* and 95 square miles unculturable). The soils differ according to their local origin and vary in consistency from drift sand through loams and fine silts to clays, the drainage is entirely prevented and injurious salts of soda and magnesia accumulate reducing the soil to sterile condition called *kallar*. The slope of the tract is from north to south. The only natural drainage is the bed of old Ghaggar river known as Nali. The river is extinct now and been brought under canal irrigation. The irrigation from Canal commenced from *rabi* 1928. *Nahri* crops represent 82% of the matured area of *rabi* and *kharif* harvests while *barani* crops represent only 18%. In *kharif* season, *barani* crops cover 15% only of the matured area while in rabi it is 20% (Lal, 1946).

The boundaries of all the Tehsils were revised in the year 1927 and following five Tehsils were created, Ganganagar, Karanpur, Padampur, Raisinghnagar, Anupgarh. The Gang Canal Colony comprises of major portion of old Mirzewala Tehsil and portions of Suratgarh and Anupgarh Tehsils.

Table 1: Villages lying in the command area of Gang Canal

Tehsils	Old Tehsils from which villages were transferred	Number of old villages transferred	Number of villages (*chaks)* carved out of the old villages and included in the Gang Canal Colony
4. Ganganagar	Mirzewala	56	Perennial 268 Non-Perennial 34 Total 302
5. Karanpur	Mirzewala	37	Perennial 238
6. Padampur	Mirzewala Suratgarh	36 9	Perennial 166 Non-Perennial 56 Total 222
7. Raisinghnagar	Mirzewala Suratgarh Anupgarh	17 24 25	Perennial 160 Non-Perennial 70 Total 230
8. Anupgarh	Anupgarh Suratgarh	47 15	Perennial 101
Total		266	1093

Source: Ramanathan and Rathore (1994)

There was annual average rise of water-level in wells near *johads*. The rise in water-level of wells is attributed to the Canal. There was no problem of water logging in the Bikaner State because of Canal. The rise in water level was 8 to 12 feet in Bikaner and if same rate of water rise level is maintained, there should not be problem of water logging. According to 1944-1945 records, the total area of the tract was 949.42 square miles. The details are given below in the table.

Table 2: Irrigation through Gang Canal

Type of land	Details	Areas in square miles
Cultivated	*Nahri*	706.39
	Barani	67.81

	Total	774.20
Uncultivated	*Banjar jaded*	10.78
	Banjar kadim	103.56
	Banjar mumkin	60.85
	Total	175.20

Source: Ramanathan and Rathore (1994)

Tehsil Ganganagar leads in cultivation having 93%, next is Padampur tehsil with 90%, Karanpur with 88% and Anupgarh with 71%. Raisinghnagar tehsil has lowest cultivation of 61%. The cultivation of Anupgarh and Raisinghnagar Tehsils is below average of the Colony which is 81%. The advent of the Canal in Bikaner shows that the irrigation has increased from 192.74 square miles in 1928-29 to 530.68 square miles in 1944-45. The average of *kharif* crops being 43% and *rabi* crops being 57% of the yearly average.

For colonising the tract of Gang Canal, the whole area was divided into squares of 25 *bighas* each, the length of each side of a square being 825 feet. The Gang Canal in 1927 and the Indira Gandhi Canal in 1961 were initiated with aim of diverting water from eastern rivers of the Indus system. On the introduction of canal water, the traditional crops like pearl millet, green gram, cluster bean, and sesame have been replaced by irrigated crops including cotton, sugarcane, groundnut, rice and pigeon pea grown during the *kharif* season and wheat, mustard sugar beet, chickpea and fodder crops grown during the *rabi* season. Bikaner receives and annual rainfall of 264 m and the long-term annual rainfall trends for Bikaner showed decreasing trend of 0.3mm/year, reduction in rainfall being attributed to the droughts experienced after 1961.

Ramanathan & Rathore (1994) argue that irrigation leads to intensive agriculture which is unsustainable on arid lands. Arid lands are suited for extensive agriculture, a combination of pasture based animal husbandry. Jodha (1990) argues that animal husbandry has placed pressure on land resources aggravating the arid conditions and suggests that an integrated farming system, comprising crops and livestock in tune with local resources and farmers' needs could be sustainable on arid lands. Gang Canal is an example of bringing a sustainable irrigation in the region. Gang Canal was continued in the region as IGNP. Rajasthan has undertaken many measures for agricultural development with expansion of irrigation. In 1956, the end of First Five-Year Plan, only 12.7% of the gross area was

irrigated. By 1990, the end of the Seventh Five-Year Plan, the proportion had increased to 24.9% as a result of IGNP.

Appendix-4.2.

Johad technology

1. Introduction

This discussion is a translation of an unpublished memio of TBS. Human relationship with water has been essentially very intimate, although complex and difficult in many ways. Man has been engaged in an incessant struggle for adequate supply of water for fulfilment of three essential needs, i.e. potable water for drinking and other domestic chores, for producing food, and for generation of power. There are many countries and territories where forest water supply poses a great problem, either in dry seasons, or even all through the year. India as a typical monsoonal country, also suffers in many parts of its several habitational and agro-climatic zones from wide fluctuations in rainfall regime, seasonal and/or annual, and hence water supply. The problem becomes very acute in the arid and semi-arid parts like Rajasthan, and also whenever and wherever, rainfall fails in its normal behaviour. Infact, in most parts of India including regions of good annual total rainfall, agriculture needs supplemental irrigation water in several ways. These experiences led over ancestors to develop into a hydraulic society, i.e. to capture, control, and manage rainwater for sustained use over the year by devising the construction of a wide variety of rainwater impoundments. Variations in types of impoundments arose necessarily because they had to adapt to the erratic local rainfall regimes and general climate regimes (i.e. temperature) and tailored to the local or regional relief, river directions and drainage systems and hydrology , cheaply available local construction materials, soil types, crop types and animal stock types to be raised. These impoundments speak eloquently of the genius of ancient hydro-engineers who devised such well-suited indigenous techniques. Adaptive, low-cost, labour-intensive, economical, techniques to be constructed according to the conditions of each locality. We describe some such systems which still exists in several parts of India, although most are in disuse.

2. Johad/Tal/Talaab/Talaiya/Pokhar/Pukur,Anicut,Sar/Sarovar

2.1. Introduction

The above-mentioned water holding impoundments spread throughout the Indian landscape in several varieties well up to the 19th century have gone into disrepair in many parts. Variations in form occurred in different environments with growing knowledge, experience, and techniques adapted to the local water conditions. They were all invariably small-scale, local structures, devised by local hydraulic experts, who were readily available in almost every village community or locality.

Lakes (non-man-made reservoirs) are natural water bodies and are fed by streams, and rivers (if large), rainwater flows or even melt water, if located in high mountainous areas, and groundwaters, if deep in touch with aquifers. Mansarovar, Chilka, Sambhar, Dal (Srinagar) are examples of sizeable lakes, different in size, depth and waterholding capacity. Smaller size natural water impoundments like *Tals* or much smaller talaiyas and such like are more frequently met with in the Indian landscape, particularly in good rain-fed regions. Most of the earth's surface, even in flat great plains and river valley areas does provide local as well as regional relief features. As water naturally seeks its own level, it tends to flow along slopes of the local or regional relief from higher to lower areas, i.e. lakes, streams, rivers, swamps, pits or ditches in the interior areas and concentrates there in. All such water holding reservoirs are almost invariably comparatively deeper in the middle parts down from the both way sloping edges. Etymologically, *Tals*, or *Talaiyas* are relatively much narrow in width but much more extensive in length, holding elongated shape. Many of these run for hundreds of metres in length or even more, depending on the available relief and size of catchment area. In many areas, local village communities have maintained such natural areas for their benefit. However, most of such reservoirs available have been artificially constructed by human labour. People shape and size these excavations or dugouts according to sites, terrain, estimations of rainwater flow-in into these ditches, held on side/sides by raised embankments/barriers to hold the flow. Many of these are seasonal, but quite some are deeper and extensive to retain water for the whole year. Tanks or Pokharas are such examples.

The techniques used by the local hydro-experts look to be quite simple today in hindsight. Village experts were locally known differently in different local language or dialect areas. In Rajasthan they were known as Gajdhars. Usually they select the proper sites for such constructions, preparing first the outline of the possible rainwater runoff flow slopes or directions into the dugouts for holding water. Quite naturally these ditches would be accordingly sized and shaped. Likewise, the shape, elongation, height and width dimensions would be chalked out to raise barriers or dykes laterally opposite the water flow-in ditches. The excavated materials would be used for raising the barrier, and also as per need, externally procured materials would be added. The experts also looked for suitable sites for constructing drainage outlets to take off overflows or flood waters so that no or least damage, if any, was done to the barrage. Diversion outlets were also present at suitable sites in the barrage to take up the water for irrigation purposes on the side off the barrage. Such outlets are known as Nali or Gul few inches deep to flush the water into cultivated plots down. The embankments have to be raised higher up to hold larger amount of water in the deeper and wider reservoir. In most cases, embankments are made only on one side, but if necessary on very even plain surfaces, on three sides in particular cases. Such reservoirs are termed differently in different language or dialect areas- Johad in Rajasthan, West U.P. and Haryana, Tal or Talaiya in East U.P., West Bihar and adjoining parts of Jharkhand, Pukur or Pokhar in West Bengal and even Bangladesh. When more well designed reservoirs are constructed to be more deeper, and embanked on all four sides, high enough masonry walls or otherwise, they are known as Pokharas or Talaab (tanks) in Bihar and U.P. They are planned to be perennial reservoirs, holding enough water for the year-round. Many of these constructions are made up to five to ten or even deeper in the midway with parts approaching in touch with groundwater aquifers. Embankments are extensive and wide enough to be planted with one or two rows of shady trees, and some are adorned with steps, bricked or sandstone slabbed, down to the waters for bathing and cloth-washing purpose on one or even two sides. On one side steps are used by male-folks, while the opposite bathing ghats (step series) are reserved for the women folk. In traditions, there were also areas reserved for lower caste people. In Rajasthan, there are many such constructions known as Baolis or Bawlis, which are accessed through a flight of bench like steps.

3. Johad tradition of Rajasthan

Johads in Rajasthan have been very significant, anciently devised and maintained indigenous water reservoirs. Even modern well trained engineers marvel when they observe these ancient or medieval hydro-technically highly suited structures, so well locally adapted to the grade of terrain and sources of the water flow catchment areas. The people indigenous to Rajasthan value every drop of water to be more precious than a grain of silver, realising that water is the nectar that holds the sustenance of all life in this (semi-arid and arid Marusthali state) with precarious and erratic annual or seasonal rainfall regime. Well up to the 19th century, almost every village community and locality had its own one or even two hydro-technical experts. They were known locally as Gajdhars, and irrespective of caste or birth and states, they were regarded respectfully by the society. Infact, the tradition viewed the Gajdhars as an essential village institution to plan, and build and care for the upkeep and maintenance of the system. Since the Colonial British administration take-over, this institution slowly decayed or died out by neglect and indifference, and only few very aged people could have some knowledge about such upkeep at present. This decay is also due to the general dying out of the old traditions of rural communities' social and cultural solidarity and cohesiveness as a viable unit. The people have become more self-oriented, and the village communities in general in India divided on sub-caste factions, losing the general ethos of traditional days.

3.1. Construction of a typical Rajasthani Johad and its parts

A Johad as noted is an indigenously built rainwater impoundment in Rajasthan, anciently built to supply water for domestic water-needs as well for irrigation for production of crops and rearing of animal stocks. It is a sizeable dugout or ditch, usually elongated in shape. (Figures 1 and 2) Actual water-fill port in a Johad is termed Jal-Bharao (water-fill) area or simply Bharao area. It is laterally embanked or dyked to hold the rain or runoff water into the Bharao and disallow or check any outflow of water from the area on its own. Such

dyke is termed *paal*. It is generally non-masonry, made of mudcake or excavated materials from the ditch, if masonry, bricks, lime, *surkhi,* cement or stone/rock pieces and bentonite clays are assembled from outside, and constructed by experienced masons. In case, if the reservoir is almost filled-up to the brim, there is every danger of damage or breakage of the *paal,* the usual arrangement of drain outlets are given to take-off the extra water. Such drain outlets are termed *apara. Aparas* are deeper and little wider channels and are well maintained. Then an equally essential system is that of *Gul* or *Kuhal (Nali),* one or more as "irrigation outlets" made through well-water outlet for irrigation purposed lying beyond the *paal*. These are narrow channels, few inches deep and little wide to take up the water to the cropped areas. If the *paal* is high enough to hold higher water level into the reservoir, *gul* can carry water through the outlet made in the Paal by itself; if the water level is low then some techniques to lift up the water becomes necessary. Technically, whenever a farmer or farm worker fills and lifts the bucket of water to pour down upon the crop or plant roots, he is known as an irrigator. Humans anciently devised several different kinds of simple mechanical means to lift up the water. Often as in construction of water reservoirs, human muscle power was used for several thousands of years before the animal power for the purpose.[124] We may think in hindsight from the current view, that the whole purpose was technically not very sophisticated, but only meant simply to capture water, concentrate it into reservoir ditches or deeps, barred through raised walls, channelizing it onto the cultivated plots for irrigation and taking care of the surplus or excess water.

124 Smith 1975: chapter 1, pp. 1-18

FIGURE 1: CONVEX SHAPE OF JOHAD

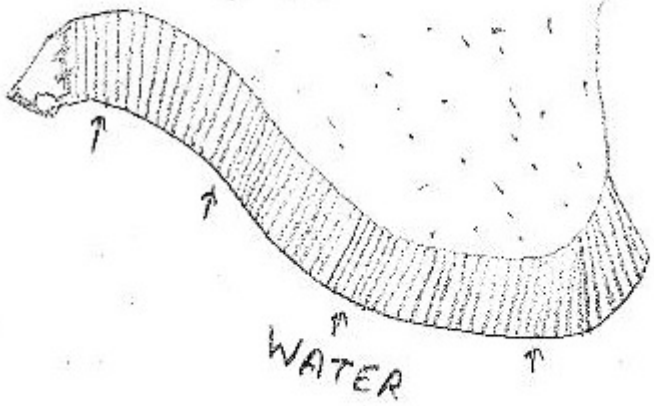
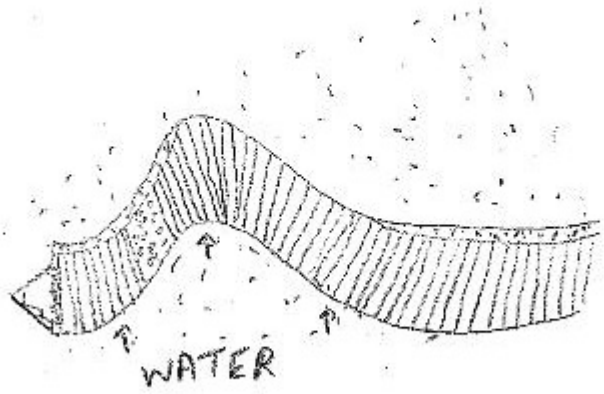


FIGURE 2: CONCAVE SHAPE OF JOHAD



3.2. Benefits derived from Johad

As already noted above, these water impoundments like Johads, Pokhar, Talaab, or Anicuts have been the source of great benefits not only basically to the domestic purposes and to the agricultural and food economy, but to other aspects of life system of people as well

as to the entire landscape and wildlife systems. Some details of these wide-flung benefits are as follows:

9. These frequently spread small-scale water impoundments and embankments alongside as well as devices of drain outlets functioned suitably to minimise the damages by exceptional flashfloods induced by heavy downpours to the standing crops, and human settlements. It is well known physical fact that the range of variation in rainfall regimes in arid and semi-arid areas is very high and Rajasthan well experienced it anciently.

10. These systems intercept and slow down the velocity of runoff waters, thereby minimizing the erosion of fertile soil from the field and land. Furthermore, while the floodwaters are partly entrapped into the Johads and by their ridges, they happen to drop part of their suspended silt and clay loads, which are deposited. So also, while passing through the cultivated lands and croplands or groves, these moving waters deposit part of their load. These fresh and fine silt and clay materials add much to the fertility of soils. When Johad water partly dries up or recede back to confine only in narrow mid-channel, the spared upper Johad lands are covered by winter season (Rabi) crops, which provide better yields partly due to fresh silt deposits on soils.

11. Held up water in Johad serves to steadily recharge the groundwater aquifers. Thus, enriched recharged groundwater can be used by taking off from wells, etc. for various purposes.

12. Johad water serves several purposes of the society. People can use them for bathing and washing, and other domestic purposes, irrigation, watering their stocks, and even for their hemp crops to rot and decay so that their outer skins or fibres can be used for making ropes.

13. The mud and clay material deposited at the bottom of the Johad are taken out for use in making bricks, earthenwares, tiles for hoof cover of dwellings, and even build them.

14. If Johads are deep and hold water over the year, these can be used for growing Singhara or lotus plants or even fishery purposes.

15. Any dirty, polluting or contaminating materials flown in waters are held up so that further drainage systems as streams and river waters can flow with cleaner waters.

16. Water-bodies near the landscape add to maintain greenery around and thus help the environs to maintain quality and beauty. Infact, ridges and embankments are used at places for planting certain leafy trees which add to the beauty and their branches, leaves and woods serve certain purposes.

17. These waterbodies and green embankments serve as recreational purposes too.

We visualise how these Johad traditions have been so important and beneficial for over rural populace in various ways. As such, we should look into the issue why and how these social structures met their demise in many areas and fall into decay and disuse in others, particularly over the last two centuries. The reasons are mentioned below.

3.3. Causes of destruction/decay and disuse of former *johads*

The principal cause of this decay and disuse is traced out in the slow deterioration in the rural community's traditional social solidarity during the British Raj and continued even after Independence of the country. The British administration in various direct and indirect ways induced the element of individualism and even helped the denigrate the interests and ethos of the communities' collective benefits and interests. The traditional prevailing code of conduct in the populace was to accord priority to serve the general community purposes, even by ignoring or postponing the individual's or family's private interests to a certain extent, and for the time being. Situations began to reverse over time due to several internal and external reasons. The community began to lose its solidarity and social collective attitude. There remained as if almost no people's programme, no common cause, even in the maintenance of Johads or such like features, which served everybody's interests in one or other way, as outlined above. Traditionally Johads represented among others, an important symbolic element of collective self-reliance of

the entire community. One evidence of this growing apathy and indifference of most residents towards the general communal interest, in such institutions as Johad was traced to be the concentration of arable land in fewer hands through time. Infact, apart from the traditional social caste hierarchy, there also evolved land-based hierarchy, and the two hierarchies were breeding clashes in ranking order of prestige and respect among various sections of the people.

3.4. Construction phases of *johad*

Introduction

We have noted earlier that irrigation probably gave some stimulus to the development of astronomy, mathematics, agricultural calendar, land surveying, accounting, and some instrumentation, all of very simple and elementary kind, as compared to the present age. Certainly, these systems evolved steadily in larger irrigation societies and economies, nevertheless some of these have played also significant role in small scale areas. Land surveying was involved in levelling exercises, for smoothening the water flow, creation of drainage channels, or distributaries. Calculation of taxes and crop yield, required some accounting. The measurement of areas and demarcating boundary lines across settlements for each community's territorial occupance, as types of lands, i.e. arable or crop able land, banjar (waste) land, grassland etc. for each village or hamlet or even each of the landholders, was also part of such works. Some level of mathematical knowledge seems to have been involved in estimation of such water/irrigation systems as Johads, dams or dykes, Tanka, wells and such like arrangements. Particularly important was the role of mensuration, that is process of measuring or mathematical rules for finding length, area and volume. Several aspects have to be calculated, even if not very precisely in early days. Construction and maintenance of these water structures naturally involve certain costs and benefits. Society has to incur expenses in digging the ditches, compacting the bottom of the reservoir, materials of construction of Paal, Apara, Gul, and other related outfits, apart from voluntary labour.

Phases in construction of Johad

There is a series of steps in the construction of a Johad. These are as follows:

⁃ Selection of proper site and location of Johad to be constructed. It is naturally very important to look into how the site is most suitable in the village territory for a reservoir.

⁃ Estimating/measuring the area and size of rainfall catchment zone from which the incoming water will slope down into the Johad to be constructed.

⁃ Calculation of normal average total and annual, seasonal, rainfall as well as possible exceptional flash torrential heavy downpour into the Johad under construction. The Johad needs to be made to accommodate normal water coming in, while related arrangement could be made to flush out excess water through Apara system.

⁃ Contouring of the indicative catchment area- normally in any relief, levels of land could be found out through contouring map to outline the slope categories, and find out the direction of water flow.

⁃ Contouring serves several purposes- while it demarcates the site and size of a Johad by indicating the possible quantum of water flow-in, it also may lead to determine the elevation of the barrage, thereby indicating size, shape and depth of the reservoir.

⁃ Estimating the elevation of the embankment based on the possible volumes of incoming waters from the catchment area, and water retaining capacity of the water-filled reservoir or Johad.

⁃ Size and shape (length, thickness or width) calculation of the selected elevation of the embankment for its construction.

⁃ Selection of the site for the Apara or drainage channel and designing of the same.

⁃ Finding out the source and volume of materials for construction of embankment.

⁃ Calculation of cost of materials/items (such as of digging tools) used in construction of Johad

⌈ Estimating the volume of water collected into Johad, its utilization, benefited area, profits, and input-output (cost and benefit) analysis.

⌈ Arrangement of the required materials, labour and other resources.

⌈ Finalisation of Johad construction.

The details of the above steps are described below:

2. **Selection of site for construction of Johad:** great expertise and qualified experience is required for the site selection for Johad construction, as the whole foundational edifice and capability of Johad depends on this site. Several factors needs to be looked for the purpose:

⌈ Potential availability of adequate size catchment area from the point of annual and rainwater income into the Johad. If the incoming sources of this water is sourced from two streams or sides it is desirable to construct Johad on the site of their confluence or meeting points. Infact, a large-size Johad may result under such opportunity. Such extensive and large size Johad can be desirably constructed on the downside slope of the incoming water sources. Larger volume of water can be available for the purpose. Sometimes, two smaller size Johads can be constructed on the upper reaches above the down lying larger Johad. This measure can be cheaper, simpler and durable.

⌈ Site selection from various benefits: Johads as outlined serve several purposes. Smaller Johads are to be necessarily constructed closest to the area of their water utilization, such as nearest possible around the village site for water to be used for domestic purposes and watering of animal stocks. Johads on higher level site can eminently serve to raise the water level of the village wells and even to be used for irrigation of plots a bit downward. Water lifting from lower level Johad waters for irrigation can be a laborious, expensive and time-and-energy-intensive task. As such higher level area for Johad is desirable to maintain higher water level.

⌈ Type of soil: if the objective is to utilize the Johad water for the entire year for domestic use or for watering animal stocks, it is better to dig deep bottoms of Johads and compact the flow with clay materials. If the purpose of waters is to allow

their seepage for recharging the groundwater, sandy loams, sandy soils or rocky stony elements can serve the purpose.

⌈ Construction of dyke/embankment in relation to the slope of the water-fill (Bharao or Doob area) of the Johad: dyke with least width constructed on some higher surface level, if available, can be very cheaper. Lesser step-wise-step sloping down into the water-fill area on the back of the dyke does allow coverage of an extensive area as water-fill, filling-in larger volume of water in the Johad. Such a situation would require low-height dykes, involving less cost. In opposite case, a higher, more costly dyke would be required, or if not the Johad would be accommodating lesser volume of water. Actual size of water-fill area in Johad is its most important feature. It is required to be extensively large to accommodate larger volume of water in tune with the height of the dyke. There must not occur any problem arising from the existence of contentious land ownership or land use pattern or presence of somebody's barn or any other thing of value such as big trees, etc. in the water fill area.

⌈ If the area is rocky, it is good that the water-fill area is more or less leakage-proof. Rock-layers should be oriented outside-in from the dyke wall, as shown in figure.3. In no case, the rock layers should be inside-outward, as they will allow leakage of water from the reservoir figure 4. If there are certain gaps in the rock pieces, they need to be cemented out. If the dyke is non-masonry, it does not make any problem, whatever the physical conditions on the sideways. However if, it is fully or half-masonry, then the foundation must be stone-or-brick laid, permanent structure and laterally both side leakage proof. All types of earth-materials, sands, stones, lime, and bricks required for use in the construction of Johad should be assembled and arranged closest to the construction site, to be easily procured. Such arrangements minimize unnecessary labour involvement in construction. It is notable that the society or the people who are to be benefited by the construction of Johad should be well participating in the decision-making process of the construction site, and the entire plan and its technical and economic aspects.

FIGURE 3: LAYER OF STONES ON INNER SIDE

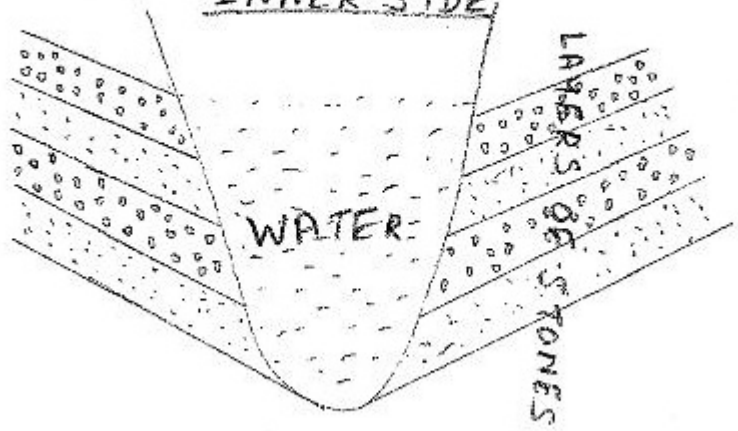
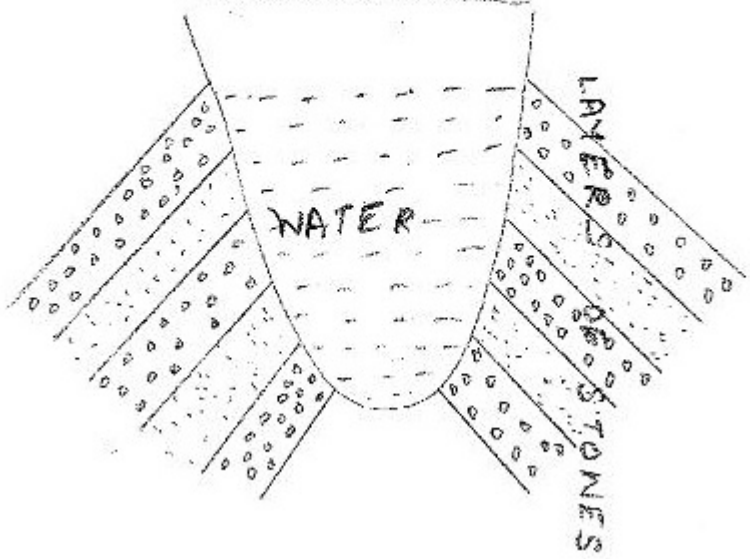


FIGURE 4: LAYER OF STONES ON OUTER SIDE



3. **Measuring the area of the catchment of Johad:** the entire area from which the rain waters will be flowing into the Johad is termed as its catchment zone. The catchment area is demarcated from other catchment areas by the hypothetical line

known as the water divide or water shed. The watershed dissects all the contours drawn for the area in a vertical cross section. One has to select the lowest spot on the contour map figure 5 and draw vertical line across the other contours of higher elevation at both ends till these vertical lines from both ends meet each other. Thus one gets on the map the area demarcating the spatial coverage of the catchment area. This area can be measured most conveniently by a planometre, or otherwise dividing it into a maze of squares, rectangles and triangles and adding their areas together. In case of smaller size Johads, the catchment area can be mapped right at the field site by observation of the situation, or at best handling a hand spirit level. Area of such an observational map can again be measured by dividing it into squares, rectangles and triangles. All catchment areas are indicated into square metres (m^2) or, if large, into hectares (ha).

Figure 5

4. **Construction of Johad:** rainwater in any given region is naturally diverted as it flows as surface runoff. Some of it is evaporated, some is soaked by vegetational litter and root zone of plants and grasses on its way, some seeps into groundwater, and some part is held up in ditches and pits on its way. Only the

remainder runoff reaches into into the Johad, or streams and rivers. Runoff volume is larger if it passes through rocky steep slopes, particularly through (Aravali-like) devegetated terrain. In contrast, if the rain occurs in lighter rhythms, less water will be available for runoff, as through a slow process substantial part filters down into the groundwater, while if it rains in heavy downpour, runoff will be naturally more voluminous. An estimated share creating runoff volume available to water reservoir (smaller-size Johad) in a tabular form is given:

Table 1: Rainwater as runoff available into a small Johad

S. No.	Type of terrain	Type of rain in the catchment area			
		Annual rainfall	Rainfall during rainy season	Rainfall in a single continuation regime (3-4 days)	Rainfall during an exceptionally high rainfall occurrence
1.	Cemented or built-up surface	0.75	0.80	0.90	0.95
2.	Denuded hilly/Rocky surface	0.75	0.80	0.90	0.90
3.	Undulating rocky surface with medium-level vegetal cover	0.45	0.50	0.66	0.75
4.	Cultivated area/grazing	0.33	0.40	0.50	0.60

	area/sandy surface land				
5.	Dense forest-wood land, gentle slope land surface	0.25	0.30	0.40	0.50

The table provides a very rough and crude estimate of the runoff actually incoming into the Johad passing after multiplying with the given fractions of total rainfall occurring within the catchment zone. However, the above figures may be used only for estimating small catchment area less than 10 hectares. If the catchment area ranges from 10 to 100 hectare, runoff amount into the Johad should be reduced by 10 percentage points. If the catchment area ranges between 100-1000 ha, the reduction in runoff needs to be upto 15%, and if larger, it should be reduced by 20% points. Such incidents may be adopted for the region covering India's north-western parts (Panjab, Haryana, Rajasthan, U.P., Bihar, Gujarat), M.P., Andhra Pradesh and Maharashtra plateau areas.

It is worthwhile to note that these rainwater runoff interceptions by evaporation, groundwater filtering, on-the-way pits and ditches, take some time to occur. However, there do occur such eventualities in nature that these interceptions and entrapping situations do not occur in certain exceptional rainfall regimes, as all of these are saturated already because of earlier rainfall. Supposedly, these exceptional rainfall occurrences appear as sudden cloudbursts or downpours, once a while in a year, or even after a few years, and create havoc, overflooding all that stands on the landscape. It is advisable therefore to take prior planned efforts to manage things in such a way that even such flash floodings do render least damage to the Johad or embankments or standing crops and houses and property, if at all.

Under the situation, if supposedly the entire rainfall in the catchment area turns up into runoff and drops into the Johad, the same may be calculated. If per minute rainfall under such cloudbursts is known in millimetre, then the total runoff (per minute in cubic millimetre per second) = Total catchment area (in square metre) * rainfall speed (per minute millimetre) * 1/60,000

This amounts to one cubic metre per second runoff calculated as 1 mm/minute or 6.0 cm/hour rainfall speed, in 6 hectare or 60,000 sq. metre (m^2) area. Infact, this quantum is beyond expectation of occurrence of rainfall or ever occurring in northern India. Some formulae: some experienced hydro-engineers have given some formulae for calculating maximal possible runoff rate/quantum. Some are given below:

Formula given by Dickens: Maximum runoff discharge into the North Indian rivers (in m^3/per second) = 1/3 (catchment area) times 0.75. If calculated on this formula, a catchment area of 6 hectare would generate a maximum of 1.25 m^3/sec runoff, which may even be slightly on plus side. This formula should be used normally for catchment area larger than 100 hectare.

Formula given by Rives: this formula suits conditions in Central/Peninsular parts of India. Maximum runoff (m^3/sec) = 0.4 (catchment area given in hectare) times 0.66. This formula calculates the maximum runoff of 1.3 m^3/sec (more than that given by dickens formula) and is suitable only for a catchment area size larger than 100 hectare.

Formula given by English: it suits the Western parts of India. Maximum runoff (m^3/sec) = 1/6*catchment area in hectare

This formula also calculates higher quantum of maximum runoff for smaller catchment area. Therefore, smaller catchment area in North India can be truly served by maximum runoff as 1/6*catchment area (in ha) m^3/second

5. **Contour mapping of the water impounded area:** preparing a detailed contour map for the entire network of Johad/Baandh is most desirable which all include site of the barrage/dyke, height, calculation of quantum of earth materials etc. in raising the barrage, area covering water impoundment, actual water holding capacity, drainage channels, etc. contour mapping of the catchment area can be best drawn by close observation, and if it is larger, it becomes a more tedious effort. Since actual water-impounding area is normally much smaller in size, its contour mapping is very much essential. Such a contour needs 1cm=10m scale for small Johads and 1cm=50m or 1 cm=100m scale. Contour interval for a small Johad in flat ground area may be 1m or an undulating area at 2metre. For longer Johads, these interval scales can be 2m plains and 5m in hilly area.

6. **Measuring water impoundment area and its water-holding capacity:** such measurements depend on desirable level of water in Johad. Higher the level, larger the water-fill area and higher the water-holding capacity. So also stronger and higher will be the barrage and more the cost of construction. Some methods are given below for measurements of water holding capacity.

Methods given below for measurements of water holding capacity:

e. Find out the height of the lowest point of the contour map

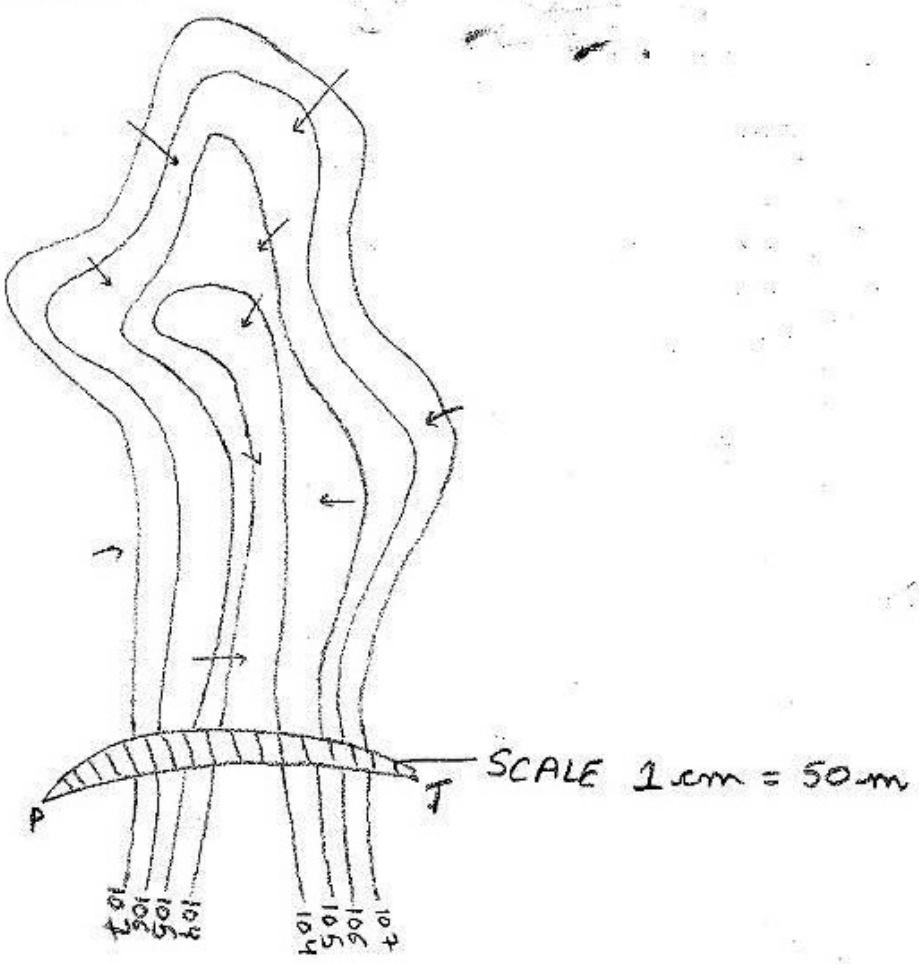
f. Water-holding capacity upto the level of contour 1: water holding 1=1/2 (water-fill area upto contour 1)*(contour 1height – height of lowest point)

g. Next level water-holding from contour 1 upto 2= water holding capacity 1+1/2*(contour interval)*(contour 2 water-fill area+contour 1 water-fill area)

Such an exercise can be continued till one reaches the desired water-fill capacity. If the desired water level does not occur on any particular contour, and happens to occur between two contours, may be little down on point P, and little above point T, then water holding capacity=P+1/2(water-fill area at contour P+water-fill area on water level)*(height of water-fill level above contour P)

Illustration: Figure 6 illustrates the exercise. A mud barrier for a Johad is shown joining two P and T. The lowest point in Johad has a height level of 100. If water is filled upto a height upto contour 101, the maximum depth of Johad will be 1, while the water-fill area would be about 7500 m^2 (on paper 3 m^2 * 2500 m^2 in the actual cover area). On the given map, the enclosed area on paper by contour 101 is measured about 3 cm. water holding capacity thus=1/2*(7500 m^2)*(101-100)=3750 m^3.

FIGURE 6:



The water-holding capacity if filled upto the level of other contour heights will be:

- Upto contour height 103=on paper 15 cm^2=3.75 hectare
- Upto contour 105=on paper 34 cm^2= 8 hectare
- Upto contour (107)=on paper 60 cm^2=15 hectare

Accordingly, water-holding capacity of a Johad will amount to:

- Upto 101=3750 m^3 as calculated above
- Upto 103=water holding capacity (101) + ½*(contour interval*water-fill area (101) + water fill area (103)=3750 + ½ *2 (7500+3,7500)=48.750 m^3

Thus calculated upto contour 105=water holding capacity will be 1,71,250 m^3 and upto contour 107, it will be 4,06,250 m^3. Upto 10 feet or 3 metre depth of Johad, water fill level will go up 100+3 or contour 103 to retain 48,750 m^2 water-holding capacity. If water capacity is required upto a depth of 12 feet or 3.6 metre, then water holding capacity will be 75,525 m^3, and the water-fill area will cover 5,175 hectare.

7. **Deciding the height of the barrage:**

Phase I- Deciding the desirable height of the barrage: this is the most crucial decision in a Johad construction project. It is also most expensive feature in the project, and as such, it must fall in tune with the water required by the society with an eye on maximal water level and water-fill area.

Phase II- If water from Johad is to be lifted upto directly through the irrigation channels (naali, gul) or electric pumping set or Rahat (water-wheel) or other mechanisms like Pur (Purwat) or Boka, to the cultivated plots, about 1000 m^3 of water is required for single irrigation operation covering per hectare crop area. Thus the project maker can calculate the entire required water amount in the Johad. He or she must allow 50% of water for animal stocks and other needs, and such other interceptions as evaporation, filtering down into the groundwater, and vegetation and possible sediment deposits on Johad bottom upto 0.5 metres depth. Notably, such Johad water may be only serving irrigation for Kharif crops, or possibly at most for first level irrigation of Rabi crops or to allow their sowing. There will be little water after January or so in most of them.

Phase III- if the objective of Johad waters is to use it to serve the summer-time needs for stock watering or other such needs, maximum possible available water will have to be held up and it will require higher barrage and deeper Bharao area in Johad.

Phase IV- if the objective of Johad is to allow maximal rainwater to filter down to recharge the ground water aquifer for land conservation purposes, holding up the maximal rainwater of the heaviest possible cloudburst regime into the Johad will suffice. This is because enough water will have possibly filtered down till the next heavy rain showers will be coming along. Assuming one heaviest rain regime to

provide 150 mm of water in Rajasthan, M.P. and Haryana and 0.66% share to be available, a Johad of 0.1*(catchment area in m^2) cubic metre capacity is sufficient.

Phase V- in choosing the whole outfit, a series of steps is to be taken by looking into the following aspects, like the problem regarding land ownership pattern and land use or any large trees, dwelling or other valuable properties falling in the water-fill area; or the availability of materials for the construction of desired barrage upto a height or whether the raised barrage would be capable of holding the given amount of water, etc.

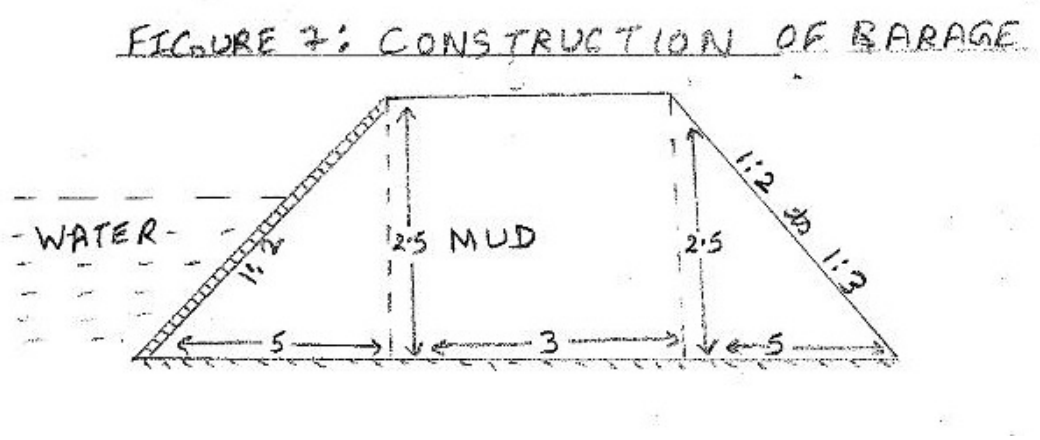
All these aspects require mature, well-experienced practical knowledge and techniques in a village or community. Infact, a collective well-thrashed confidence will be required before the project is undertaken.

Only looking into the above aspects, the required maximum depth of Johad is to be decided. If the maximum depth of impounded water is 2 metre, barrage will be 2.6 metre high. If the depth varies between 2 to 4 m, the barrage will be one metre higher up the water level. In case of 4 to 6 metre depth, the barrage must be 1.5 metre higher up the water level. Deeper and larger Johad is not recommended and it is better and less costly, and environmentally as well socially move friendly to go in for constructing a series of small Johad, than one two larger and bigger ones.

8. Construction and shape and size of barrage

As is indicated above, the maximum depth and related height of the barrage may also be important in deciding its length and the width of its upper most surface (figure 7). The uppermost surface width should be about 3.0 metre to allow the passage of a bullock cart or a tractor. In case of smaller Johad, if the barrage is less than 3 metre high and length may be less than 30 metre, while width of its upper surface may be kept upto 8 feet or 2.4 metre wide. Further, if the barrage is made of mud-sand and broken brick pieces, both lateral sides will have to be slopy. For a sandy material made barrage, the gradient should be 1 to 3 (1 vertical and 3 horizontal), and in case of clayey mud, it could be 1 to 2.5 gradient. For a very sticky clayey mud or broken brick-made barrage the gradient may be only 1 to 2. Steeper gradients may be cheaper but would be weaker. barrage made of sandy material could

be strengthened a bit by clayey mud cakes or plastic cushion filter layer in the middle. Similarly, clayey mud-made barrage could be filtered with mixed sand and broken brick cushion in the middle. If the barrage is masonry, constructed with baked brick or stone-cement or lime-and-brick powdered materials, it can well be strong with 1 to 1/8 gradient on the outer side, it could have steep gradient. If the inner water-facing side could have masonry part, it would also serve the simple mud-made barrages and maintain its duration.

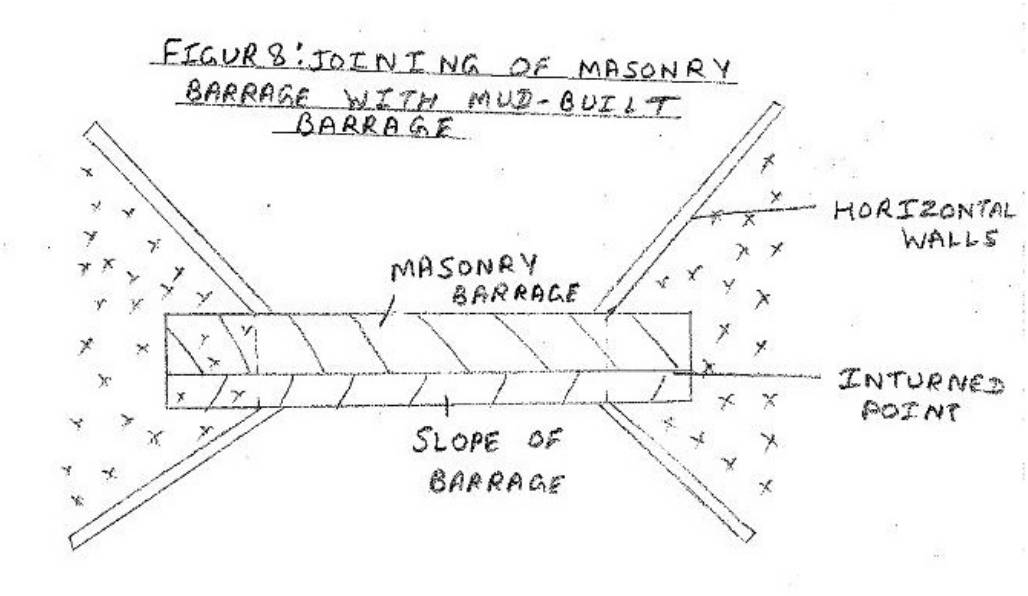


9. **Barrage foundation**

Has to be necessarily strongly laid out. Foundation of mud constructed barrage may be laid out just on surface floor, cleaned off grasses, weeds or vegetal roots if any, and spaded/or ploughed down upto 15 cm down and heavily pressed and beaten to be a smooth floor. However, in case of masonry barrage, the foundation has to go deep down the surface upto one-fourth of the height of the planned barrage, or at least upto 0.5 metre below surface. On such a well pressed and smoothened floor, a layer of 2 cm thickness (1:6 cement/sand mix), topped by 8 cm thick 1:6:12 cement-sand-mud or 1:3:6 lime-surkhi broken pieces concrete, layer may be provided a strong layout for the barrage construction upwards.

10. **Joining the lateral sides of the barrage**

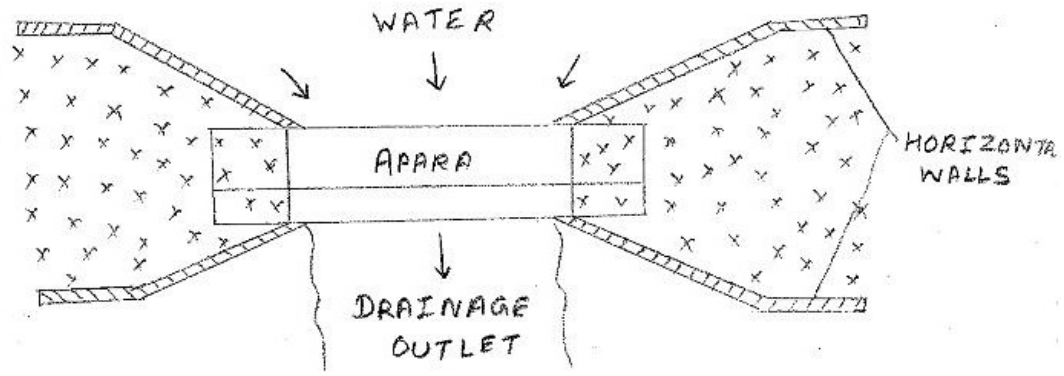
Mud-built barrage does not require the joining of sides, but is necessary for a masonry barrage. Both lateral sides require needs to be cushioned with atleast one metre long inwardly, in-turned mud earth materials. This apart, both sides of barrage need be fortified with atleast 2 metre long by ½ metre thick walls in order to secure it against soil erosion. (Figure 8)



11. **Designing the drainage outlet**

All reservoirs, specially those dependent rainwater impoundment, must have such drainage outlets which could drain out the maximum possible excess of water in the reservoir. It must be a masonry construction. The site of drainage outlet should be either on the left or right side of the end where water pressure is naturally less. There is need for putting some rocky pebbles down its pathway to disallow any downward cutting soil erosion. (figure 9)

FIGURE 9 : DESIGNING OF DRAINAGE OUTLET.

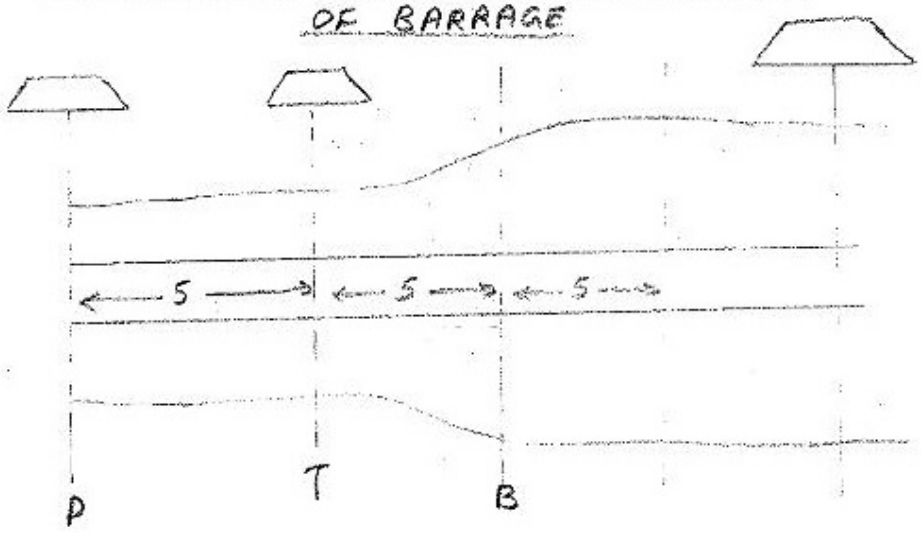


Arranging the construction of Johad

Estimating the amount of construction materials

Volumes of construction materials for each part of Johads, such as the barrage, drainage outlet, horizontal walls, and drainage conduit, etc. has to be measured for the estimated overall cost of Johad construction as a whole. Such estimation is done by measuring the area at interval points, say at every 2.5 metre or 10 metre (figure 10). For instance, volume between section points P and T=5*1/2(area at point P+area at point T). Volume between point T and point B=5*1/2(area at point T+area at point B). If volume is known, one can estimate the amount of mud or clay, sand, stone or rock materials, cement lime, surkhi, etc. as required. Construction materials need to be all clean, free from dirt, dust and vegetal or refuge materials or alkali materials. Materials need be kept nearest at construction site. All points, length and breadth, etc. should be well outlined and clearly marked at the sites. All constructions must be exercised with solid layers, put one after another, each layer preferably 15 cm thick and well pressed and liquefied or moistured. Concrete masonry needs the following, sand, lime, surkhi, cement, brick pieces, bajri (small pellets) should be mixed in right recommending proportions with adequate water, about 25-30 litre for one bag of cement and other associated materials. There should be no hollow space in raising masonry wall. All masonry constructions must be watered at intervals at least for 15 days.

FIGURE 10: CALCULATING VOLUME OF BARRAGE



Cost of Johad, possible benefits, and cost/benefit (input-output) ratio

The cost factor depends on the following:

6. Value of impounded land, and any other thing of value under submergence like trees, vegetation, or dwelling.

7. Loss of otherwise derivable landuse benefits such as grazing, cropping, wood cutting, residential losses etc.

8. Value of land from where sands, or clays are lifted off

9. Cost of construction materials and their transport cost

10. Other costs involved, such as labour, etc. (calculated as per m^3) of construction work

11. Supervisory and management cost (usually 10% of the total cost of the project)

12. Post-construction annual repair and upkeep cost (10% of total cost)

Tarun Bharat Sangh estimated the cost of construction of Johads in Alwar district. It ranges between Rs 1 to 2 per m^3 of water retaining capacity of Johad. If money is taken on an annual interest of 15%, then the annual interest amounts to Rs. 0.30. If annual repair and upkeep cost at 10% of original project is added, total annual cost comes to be Rs. 0.50 per m^3 of water impoundment capacity. As compared to the cost of larger government projects this cost amounts to be only one-fourth or even less than that.

The great benefit of such projects is water availability. Benefits of such constructions are naturally much more to the economy and to the people's standard of living and social happiness. If all water is diverted for crop irrigation., atleast crop yield doubles and even triples per hectare in a well husbanded farm. That is very high benefit which multiplies by years on.

If Johad water is allowed to recharge ground waters, such as to be derived from walls to be used for irrigation or domestic purposes, the benefits are well multiplied socially, economically and environmentally. These groundwater are cleaner and safer for health. Alwar district data shows that recharged surface wells gain 6-8 metre water level in general.

There are several other benefits derived directly and indirectly. Impounded runoff water mean reduced soil erosion, land protection, enhanced moisture in the environs around, tufted with greener landscape, watering and washing off of animal stocks, enhanced air quality, and a host of other invaluable benefits to the life-world. People in general begin to live in a comfort zone with adequate quality water availability in a semi-arid area as Alwar district, Rajasthan.

Appendix-5.1.

Interview schedule

Was their any concept of common land? Who had the ownership of such land? Was there any rainwater harvesting system in common lands? How much area was under common ownership? (common land can be grazing land, find out water harvesting structures in such lands). Who was the incharge of its maintenance? Historically, who used to take decision for its construction? Was it government or villagers? Who used to bring the skills?

Was their concept of zamindar/raja? What were his rights?

Was there enough rainfall from very early times or low rainfall problem started recently? How and when and why did the idea of rainwater harvesting come? How the idea was developed? What were kinds of views shared by the decision makers? Who were the decision makers? How did the problem start and what exactly was the problem? For how long they were looking for the solution?

How did its construction start?

Who were responsible for its construction? Was it based on caste system or economic conditions? Was there any community which was responsible for its construction? If yes how were people mobilised for it?

Were labourers hired for the construction work? Were the labourers paid for work?

What was the system of payment? Was it based on caste or any other parameter?

Were expertises also required for the work? If yes were they of same village? Who pays them?

What is shramdaan? How was it given such a name? Who were the people involved in shramdaan? Were they self motivated?

What is the mode (time, salary, caste) of working at present? Has it changed from the past?

How did the idea of the technology start spreading?

Was it implemented before its complete diffusion or after its complete diffusion?

Was it completely diffused or there were problems in its diffusion and its acceptance? How were people motivated or convinced: were people given economic meaning of its benefit or they were explained in some other way? Why do people work for it: for common good or for private interest?

Are there people who are not convinced, if yes what are the reasons for it?

Was there any initial investment required? Who provided the money?

Did people contribute for it? From where did the funds for its construction came?

What is the present situation for funds?

Were there demonstrations of the technology given by the NGO?

How long did it take to convince people? What were the challenges which were faced while convincing people?

Was there any change over time in the techniques?

What are the main castes and what are their occupations?

How much land was/is considered as common property?

Appropriation rights and provision rights are assigned to families or individuals?

Uncertainty- how dovillagers understand uncertainty-what kind of uncertainties bother them. List all kinds of uncertainty.

Rajendra Singh's uncertainty- to motivate people based on their return of their shramdaan, uncertainty about his knowledge of the system. What was his motivation to come and work at this place? After convincing Mahangu Patel what was the next uncertain situation? When did he (R Singh) start coming in the meetings? What was his mode of motivating people? Did he learn from others? What were the sources of funding? How was the knowledge network built, who all were sources? Which caste was first involved? Was it so that people of that caste were motivated first and were involved first in shramdaan? How was the concept of shramdaan created? Who gave it first? Why was it created? How was the knowledge

validated that it is right? How and why was step well created? From where did its idea came? Who gave its concept? Are they planning to introduce it somewhere else too in the region?

If there is uncertainty in rainfall, in what sense it is uncertain as in uncertainty of time, duration or what? Is their uncertainty in income? Is their uncertainty in crop failure? Is there uncertainty in milk yield? If yes the what are the factors on which does milk yield depend? Are there other components of uncertainty as in seeds (buying and selling), selling crops, buying fertiliser and other things required for agriculture? If yes how were these addressed?

Is there income, occupation or caste wise difference and do these categories have different notions of uncertainty regarding above questions.

What is the objective of rainwater harvesting?- for agriculture, improvement in environment, livestock, personal use of water?

How long does it take for construction of baandh/johad/anicut? Note down all the people who are involved in its construction. How long does it take from construction of baandh/johad/anicut and visible impact of groundwater recharge? Is their difference in period of recharge? If yes which one is earliest and then why the late ones are chosen?

Are there people who do not give shramdaan? If yes what is the reason? Which system involves maximum shramdaan? People who do not own agricultural land also give shramdaan? If yes how do they get benefited? If they do not get benefited do they fight for their rights?

Classify people on basis of caste, occupation, income, age, gender and find who are the free-riders.

What is the monitoring mechanism in this case? What kind of monitoring takes place? Monitoring takes place from which stage of the project? Is there caste based coercion? Is there anybody who is incharge of that? What if anybody is faulter and what happens to the faulter? (here monitoring mechanism will refer to both provision and appropriation, provision will include construction as well as maintenance of the resource and appropriation will include extracting from the system which is addressed in next to next question)

What are crops grown in different seasons? Which crop requires maximum water? List all the crops in order of decreasing water need. Are the crops sown according to need of water as in the crops which require more water should be sown near the rainwater harvesting system? Does the rainwater harvesting technology help in irrigation directly/indirectly? Do people go to sell their crops themselves somewhere or the buyers come to people? Are the crops sold only in market (this will address the market uncertainty as in if they do not get price which should be given by the buyers then they will it somewhere else). Has the yield decreased or increased in few years? Are the crops sown 25-30 years back same as today? (note it carefully as it will also address the problem of uncertainty in terms of crops). Is their any change in economy because of crop change? Has groundwater had any impact on crop profile?

Is monitoring caste based or the panchayat does it? How is it done? How is commitment measured? What happens to those who are not committed to their work (shramdaan)? Check of commitment in appropriation also.

What are the animals reared? Does it differ caste-wise? How many maximum number of animals can be taken for drinking water from common resource? How is it measured? If there is no measurement then is there free-rider problem? How is the free-rider problem solved? If there is measurement then who allocates the measurement of amount of water which can be appropriated? Observe appropriation of water from johad/baandh/anicut (direct appropriation by cattle etc.) and ask people on what basis cattle is allowed to drink water? Is this also based on caste? What about the families those who do not own cattle? Is this dependent on number of cattle?

The people whose lands are nearer to the water harvesting systems are benefited more? How the problem for those is solved whose lands are located at distance? If problem is not solved among themselves then what happens? People do not fight for their rights?

Design principles illustrated by long-enduring CPR institutions-

> Clearly defined boundaries- this defines whether the resource is open access or common property. By closing the boundaries the quantity of resource units to be harvested can be increased. Find out whether the resource is a common property or open access.

Is there any restriction time for appropriation of water by cattle? Also are there particular places allotted for particular families for appropriation of water? Is there particular technology (baandh, anicut, johad) allotted for particular family for particular time period?

Collective-choice arrangements

Monitoring

Graduated sanctions – what is the role of TBS/people/panchayat in monitoring and sanctioning mechanisms? Faulters in monitoring and commitment?

Are there conflicts regarding provision and appropriation rules? What are the conflict resolution mechanisms? This will only happen when there are norms in the society rather than rules.

Are the appropriators given right to devise their own institutions and are these challenged or were challenged by governmental authorities? Are these rights given recognition to the legitimacy of such rules?

How were rules designed? What was the role of panchayat? How much help did TBS get from the panchayat?

TBS- external/internal

Identify strategies/norms/rules. If monitoring and sanctioning taking place then its a rule.

Why certain rules exist? What were the rules for the program? How was it organised? If any of those are continuing?

Mechanisms of rule change- self-conscious an unconscious processes of change.

Is there any external development intervention like training programs etc. and has it led to rule change?

Has it happened that the rules are not written and people forget the rules? Are there unconscious processes of rule change?

Has it ever happened that conflicts led to meeting among people to form some kind of association (collective choice arena)?

Study institutional evolution whenever it happened and reasons behind the change? Did it always lead to improvement?

How is the site of rainwater harvesting technology (Johad) decided? How is the catchment area decided? How is the catchment measured? How is the slope measured? Identify people for all questions. Also identify who did before the NGO intervened and who all are/were involved after the intervention?

Identify each step involved in each of the technologies.

Are instruments used for any kind of measurement? Who introduced these?

What have been recent developments in rainwater harvesting technology? (government and other initiatives)