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An Innovation System Perspective on Adaptation Strategies to Climate Variability and Water Management in India

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To Kamanda: my friend, philosopher and guide, and

To my mother, who has a dream for her daughter

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1. Introduction

1.1 Background

Agriculture in India accounts for 14% of the GDP with about half of the population relying on it as the principal source of income (GoI, 2013). During 2011-12, inspite of a drought situation in most parts of the country, there was record production of food grains at 259.32 million tons, of which 131.27 million tons was during Kharif season[1] and 128.05 million tons during the Rabi season[2] (MoA , 2013). However, there was stagnation in Indian agriculture in the beginning of the 20th century. The productivity was revived after 1951 as a result of persistent and dynamic policy interventions, following the realization of the need to food secure a growing population amidst an increasing shortage of food immediately following independence. The introduction of new seed-fertilizer technology during the mid-1960s through the Green Revolution was a breakthrough that transformed the rural agriculture scenario in India (Bhalla and Singh, 2001).

With the threats related to climate change being apparent in India and across the globe, the productivity of agriculture is at maximum risk. The agricultural community is going to be among the worst hit in the coming future. It has been estimated that there will be a decline of at least 6.7% in the yields of rain-fed crops because of increasing water stress by 2050 (Nelson, 2009). Dry areas cover more than 40% of the world's land surface and are home to 2.5 billion people which amount to one-third of the global population. Poverty, food insecurity, biodiversity loss, frequent drought and environmental degradation are widespread in these regions. In recent decades, food production has fallen significantly in most dry areas, while demand has increased due to high levels of population growth. Water scarcity is a constant and growing problem for dryland countries. The dry lands have less than eight per cent of the world's renewable water resources and are challenged by extreme temperatures, frequent drought, land degradation and desertification (CCAFS, 2012).

Out of the net cultivated area in India, approximately 141 million hectares, about 85 million hectares (60%) falls under the dryland/rain-fed zone (CCAFS, 2012). Accordingly, to realize the enormous agricultural growth potential of the drylands in the country and secure farm-based livelihoods, there is a need to prevent declines in agricultural yields because of increasing climate variability (National Action Plan on Climate Change; Government of India, 2008). This increasing variability in climate makes the livelihoods of the agricultural community in the semi-arid tropics particularly vulnerable as it is the most drought-prone of all the regions in India. With the recognition of the agro-ecological constraints that Indian agriculture faced, the Indian Government started supporting the development of watersheds since 1973, following the Drought-Prone Area Programme (DPAP). It was started to address two major challenges of soil and water conservation and improvement of livelihoods in rural areas (GIZ, 2011).

It is frequently assumed that if climate change is gradual, it will be a small factor that the farmers will have to deal with. However, it cannot be overlooked that agricultural systems do not evolve in response to changes in average conditions, but to changes in variable and largely unpredictable conditions, including extreme weather events thus making adaptation to climate change a part of the current and ongoing adaptation to climate variability (Smith, 1996).

Adaptation is a possible option for increasing the resilience of marginalized communities, who have a high dependence on natural resources (Adger et al., 2003). In a study carried out in 6 villages in Maharashtra and Andhra Pradesh, it was seen that the farmers perceive increasing climate variability in the form of untimely rains with unpredictable intensities and uneven

[1] The monsoon growing season from June to September in India
[2] The winter growing season from October to February in India

distribution (Banerjee et. al., 2012). Village level historical timelines indicate that there is correspondence between these perceptions and recorded weather data. Based on this, they are exhibiting adaptation behavior that is dependent on their inherent capabilities but also shaped by external factors. This adaptation and agricultural development in general is fundamentally a social process in which people construct solutions to their problems. It goes beyond technology and economic principles as it is determined within social, political and cultural realms, i.e., every process is determined simultaneously by every other process in society (Yapa, 1993). Innovation involves putting ideas, knowledge and technology from many different sources to work in a manner that brings about a significant improvement in performance and ultimate realization of socioeconomic benefits (Hall et al., 2000).

The relevance of water as a resource and its management is of paramount importance for sustainable agricultural practice; hence the need to constantly look for innovations in improving methods to conserve soil and water. These innovations emerge either from within a rural community or from external intervention, either due to the need for adapting to changing situations or as an alternative to existing technologies or institutions, which in some form have not been able to provide the desired outputs. India's National Action plan on Climate Change (NAPCC), released on 30th June 2008, outlines measures on climate change related adaptation and mitigation while simultaneously advancing development. Eight national missions are outlined, one of them being the National Water Mission, for long-term and integrated strategies for achieving goals in the context of climate change. The issue of water related innovation and technical change consequently sits at the heart of agricultural development and remains a potentially critical driver of social and economic transformation in the agrarian based economy of the semi-arid tropics in particular and the county in general. However, case studies show that in addition to having appropriate technology, it is also necessary to have viable arrangements for production, marketing, retailing, collective action and inclusiveness of various sections of community if a particular technology has to work (Hall et al., 2007a; Kulkarni, 2003).

Successful adaptation, thus, depends on a variety of interrelated factors including farm level conditions, institutional context, technological capacity and other socio-economic factors. Institutions and culture can determine the perceptions, subsequent adaptation strategies and resilience of a community to climatic shocks. It is therefore important to understand community perceptions and actions in response to climate change and variability. Special attention should be paid to constraints faced in the adaptation process, especially with regard to access to technologies water management that support adaptation.

However, knowledge gaps still remain in understanding the role of institutions in the development of agriculture in India over time and the productivity enhancement. In addition, there needs to be a further understanding on how effective agricultural water management can support the adaptation process at the local level.

1.2 Objectives

The current study aims to understand the context, needs and models for linking developments and outputs from agricultural research with local systems of institutional innovation, especially with regard to technological paradigms and their application in adaptation to increasing climate variability in India. Hence the specific objectives of this particular study that has beenundertaken in the semi-arid regions are:

- Understand perceptions of farmers on climate variability and change.
- Identify local level innovations for water management to address climate variability, and various actors involved in interventions to preserve and introduce new forms of technologies.

- Understand the process of inclusion or exclusion of certain segments of the population in the adoption of innovations in water management.

1.3 Theoretical and analytical concepts

Adaptation to Climate Change

Adaptation includes actions and adjustments undertaken to maintain the capacity to deal with stresses induced as a result of current and future external changes (Banerjee et.al., 2013). Rural communities are at risk from climate change, and adaptation is a necessity (Boko et al., 2007; Smit and Wandel, 2006; Parry, 2009). These communities for generations have used a variety of strategies to respond to environmental stresses, with coping strategies having significant cultural implications (Davies and Bennett, 2007). Some of these strategies are tacit, demanding interaction between farmers, operating at a specific climatic conditions, and their supporting institutions, while others are based on scientific knowledge embedded in the institutions that are designed to minimize uncertainties at the decision level (Chhetri et. al., 2012). The role of technology in adaptation to climate change becomes crucial in countries like India where food security remains a struggle for significant portion of the population and impending climate change is expected to make it even worse. Among small farmers, who are 700 million of the Indian rural population, traditional practices of water harvesting, switching crops, conserving soil and water have been the main technological adjustments to both short and long-term climate change (Berman et.al., 2012).

While there is an increasing recognition that many adaptation actions are local and build off experience of managing past climatic risks (Christoplos et al., 2009), there can be barriers and limitations to adaptation. These can come from several fronts including inadequate climate information (Deressa et al., 2009), partial understanding of climate impacts and uncertainty about benefits of adaptation (Hammill and Tanner, 2011), path dependency (Chhetri et al., 2010), disconnect between climate science and policy leading to a lack of use-inspired research (Moser, 2010), insufficient credit access (Bryan et al., 2009), and weak market systems (Kabubo-Mariara 2009). In order to tackle these issues, the Indian Government released its first National Action Plan on Climate Change (NAPCC) for India in 2008. One of the mandated of the action plan was that each of the states in India come up with the State Action Plans to Climate Change in order to operationalize the NAPCC (GIZ, 2011).

Water resource management

Scarce water availability is the key limiting factor for food production in most developing countries as these countries suffer from severe groundwater depletion and salinity, compounded with rapid natural resource degradation and desertification (IPCC, 2007). In dry lands, strategies involving local communities are emerging to develop water security where there is no water. These strategies include rainfall harvesting and underground storage (CCAFS, 2012). The success of these initiatives, however, depends largely on collective action and adequate training and the involvement of the farmers from the outset (Sturdy et al., 2008). .

In order to mainstream climate change issues in the water sector, the Indian Government came up with the National Water Mission as one of the main pillars under the National Action Plan on Climate Change (NAPCC) in 2009. The main objectives of the mission are conservation of water, minimizing wastage and ensuring its more equitable distribution both across and within states through Integrated Water Resources Management. In addition, the National Water Policy of 2002 stressed the importance of multi-stakeholder participation and multi-sectoral analysis in planning and implementing water resource projects. It laid major emphasis on information systems that encourage knowledge generation, management and sharing as well as monitoring projects to ensure necessary corrective action (GIZ, 2011; NAPCC, 2009).

Institutions

The word 'institution' has been used to describe either organizations, human relationships or the rules that are used in relationships among individuals (Goulden, 2005; Jordan and O'Riordan, 1995). North(1994) defines institutions as the rules of the game: the humanly devised constraints that structure human interaction. They are made up of formal constraints such as rules, laws, constitutions; informal constraints such as norms of behavior, conventions, self-imposed codes of conduct, and their enforcement characteristics. They may be defined as the institutional frame-work within which environmental decisions are made, and as institutional arrangements through which such decisions are implemented (Adger et al., 2003). The importance of institutional support for any form of adoption of technology is crucial as an adaptation strategy to climate variability or change which in this case are the methods, mechanisms and practices for better water management.

Institutions underpin the functioning of markets, local governance of common-pool resources and land tenure and access (Ellis, 2000), all of which are important for daily coping strategies of rural communities. Public, civic, and private institutions are all relevant to local adaptation (Agrawal et al., 2008). They are often interlinked and shape not only how households and communities are impacted by climatic variability and change, but also how they are able to respond. Institutions link local systems to larger spatial systems (Agrawal, 2008): it is important to understand how all types of institutions at all levels influence the ability of a community to respond through short term coping, as well as to adapt over the longer term. Ostrom (2008) also suggests that we should consider how social and ecological systems link not only across scales, but also across different sectors.

Agriculture Innovation Systems

A series of complementary approaches have been developed allowing research to better understand and effectively collaborate with a range of stakeholders to solve problems, generate knowledge and learn together with the aim of fostering sustainable development. These approaches rely on a social process of interactive learning where the idea is to reach the poor through non-food routes, with the involvement of actors at various levels. The process of innovation goes further in putting knowledge into use and suggests that it needs to be suited in a broader set of relationships within a system of innovation (Lizuka, 2013). The concept of innovation systems emerged as an alternative way to explain the innovation process, improving on an earlier view that considered this process as a simple linear progression of scientific research. The innovation system considers innovation as an outcome of interactions among organizations and institutions, in the historical, cultural and socio-economic framework (Soete et al., 2009). Innovation in agriculture is of vital importance in improving the productivity but it needs to be continous and requires to remain competitive (OECD, 2013)

The Agriculture Innovation Systems (AIS) along with the Agriculture Knowledge and Information System (AKIS) approach therefore treats agricultural research as part of a wider process of innovation requiring productive interaction which should be supported by the right sort of relationships. This approach postulates that interaction is important for problem solving identifying and responding to new challenges and opportunities, as learning causes the evolution of patterns of interaction and ways of working. The process of interacting and innovating is shaped by specific contexts, by recognition that it is a social process; hence the outcome would be lessons on how to do it better (Hall et al., 2007a and b).

Therefore, the approach is towards action research through fora like LINK (Learning Innovation Knowledge), ILAC (Institutional Learning and Change) and GFAR (Global Forum for Agricultural Research), where the methodologies aim at developing new capacities experimentally and learning lessons through a non-linear approach. This includes rigorous investigations of processes and capacities to produce International Public Goods (IPGs) with openness to partnerships, consensus and dialogue, respecting views of stakeholders and ensuring that reliable knowledge and information is available at the right place and the right time through knowledge brokers.

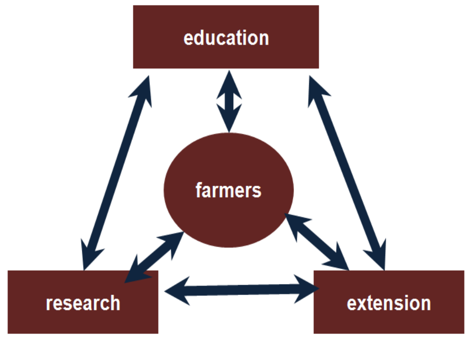

Figure 1. Agricultural Knowledge and Information Systems

The AIS and the AKIS (Fig.1) approach is therefore relevant in linking local systems of innovation in the context of climate change adaptation, as farmers have been traditionally and are continuing to develop coping strategies to shield against the climatic uncertainties for a very long time. These mechanisms represent options that are effective and acceptable at the local scale.

Entitlement and Capability Approach

The Capability Approach addresses this idea of self determination through the argument that people have freedom which is more than what citizens are given or is written on paper. The core characteristic of the capability approach is its focus on what people are effectively able to do and to be, based on their capabilities (Sen, 1992; Nussbam, 2000). The capabilities and entitlements framework is useful in understanding whether entitlements such as information and financial access, governance, technological inputs and infrastructure shape adaptive capacities and hence the level of resilience of particular groups against climate variability and change.

Social Capital and Collective Action

Social capital is made up of norms and networks that enable people to act collectively (Woolcock and Narayan 2000, cited in Adger, 2003). It is a necessary element of economic transactions and collective action on scarce environmental resources. The study of institutions and organizations can reveal information about the nature of social capital (Goulden, 2005). One of the key concepts of collective action is the *'zero contribution thesis'* which states that no self interested person would contribute to the production of a public good, unless the number of individuals in a group is quite small, or unless there is coercion or some special device to make individuals act in a common interest (Ostrom, 2000). For this study, the objective was thus to examine whether a community indeed comes together for a greater good, in this case conservation and management of water for the future, looking at the increasing variability, or does only a certain monetary incentive drives a community to say run a Water Users Association effectively.

Local Political Economy

The implementation of rural development and agricultural extension programs, including those relevant for climate change adaptation e.g. water-related infrastructure if faced by governance challenges at the local level (Birner and Anderson, 2009). In the case of water distribution, patronage is often seen as a necessary requirement to get access to a technology, e.g tube wells or surface pond. 'Elite capture' is also observed when powerful farmers with political influence tend to divert water to their own fields and the other farmers cannot do much about it. While community empowerment is seen as a viable option for the management of resources, it is clear that it has its own challenges that need to be assessed.

1.4 Outline

Government policies play a major role in determining the adaptive capacity and the adaptation strategy that a community would take. Government policies play a critical role in influencing market conditions, institutions, and overall agricultural productivity (Isinika et al., 2005). The second chapter therefore looks into the history of agriculture development in India, which has had deep roots of socio-economic and political influence. Taking a political economy perspective, the historical account looks at significant institutional and technological innovations which were carried out in pre-independent and post-independent India, and the driving forces with regard to the same.

Further investigating the promotion of agricultural productivity, the third chapter focusses on the Green Revolution in Asia, as even forty years after the agricultural community is still faced with the task of addressing the recurrent issue of food security amidst emerging challenges, such as climate change. This chapter examines the Green Revolution that took place in India during the late 1960s and 1970s in a historical perspective, identifying two factors that have been relatively neglected in the debate about technology adoption: institutional change and political leadership.

Climate change in agriculture development has become a major concern to farmers, researchers and policy makers alike. However, there is little knowledge on the farmers' perceptions of climate change and of the extent they coincide with actual climatic data. Chapter four, using a qualitative approach, looks into the perceptions of the farmers in four villages in the states of Maharashtra and Andhra Pradesh. It looks at climate change aspects in terms of the onset of rainfall, and the distribution of rainfall along with the impact that farmers perceive. While exploring the adaptation strategies, the chapter looks into the dynamics of who can afford a particular technology and who cannot, and what leads to a particular adaptation decision thus determining adaptive capacity in water management.

The fifth and final chapter looks into the devolution of authority for natural resource management to local user groups through the Water Users' Associations (WUAs) as an important approach to overcome the long-standing challenges posed by centralized state bureaucracies in India. It addresses the knowledge gap of why some local user groups are able to overcome governance challenges, such as elite capture, while others--that work under the design principles developed by Elinor Ostrom—do not. The chapter draws conclusions on how local leadership, a factor that has been neglected in the current literature on common pool resources, can be promoted to facilitate participatory irrigation management.

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2 Historical Overview of Agricultural Development in India[3]

Abstract

Taking a political economy perspective, this historical account looks at significant institutional and technological innovations which were carried out in pre-independent and post-independent India, and the driving forces with regards to the same. It shows that the process of agriculture policy development was a combination of individual preferences of maintaining power, a show of collective action under the leadership of Gandhi against the British rule, along with a combination of both price support and input subsidies, as well as policies which favored or disfavored liberalization measures. The chapter starts with describing the reforms that took place in British India after the mutiny of 1857. It goes on to give an account of post-independent events and examines the influence of some of the pre-independence policies touching upon some of the emerging issues and approaches to agricultural development. The chapter concludes with some lessons that can be learnt for countries that are also struggling with issues of food security and climate change as impending threats for sustainable agriculture development.

Introduction

India is one of the fastest growing economies in the world with an estimated GDP growth of 7% p.a. However, it is being faced with development challenges, with more than 800 million people (79.9 percent of the population) still subsisting on less than US $ 2 per day (Sinha,2010, CIA Factbook 2013). Following independence, the share of agriculture declined from 50% in 1950 to 18% in 2007-08, with a current share of 14.1% in the GDP as of 2011-12 (Business Standard, 2013). Further, there has been an ongoing debate in India on the reasons of the decline in the growth rate in Indian agriculture since the second half of the 1990s (GOI Government of India, 2007) at the same time the rising level of subsidies given to agricultural inputs, especially power, canal irrigation, fertilizers, and credit (Fan et al., 2008). According to the study by Fan et al. (2008) it was seen that there was significant changes in different areas of spending in agriculture in India. Public agricultural research expenditure increased from INR. 1.6 billion in 1964 to INR. 7.1 billion in 1990, at an average annual growth rate of 5.8%. As a result, the national agricultural research system was strengthened and released many new technologies through its collaboration with international agricultural research centers. The adoption of high-yielding varieties by farmers was at about 50% in the 1990s, when in the early 1960s farmers were still growing the local varieties of seeds. However, in 1995 government spending in agricultural R&D increased only marginally above the 1990 level, to INR. 7.3 billion. As a percentage of agricultural GDP, public agricultural research spending increased from 0.21% in 1964 to 0.50% in 1987. After 1987 it stagnated, and even dropped to 0.43% in 1995, with some recovery only in later years (Fan et al., 2008; Birner and Resnick, 2010).

The development of Indian agriculture has been divided by scholars into four phases with the first phase immediately after independence i.e., 1947- mid 60s, where agricultural policies witnessed tremendous agrarian reforms, institutional changes, and development of major irrigation project and strengthening of cooperative credit institutions (Tripathi and Prasad, 2009). The second phase which started in the mid 1960s with a new strategy of adoption of high-yielding varieties of crops, multiple cropping, modern farm practices and spread of irrigation facilities, with renewed focus on research, extension, input supply, price support and spread of technology (Rao, 1996). The third phase, which began in the early 1980s, along with diversification to non food grains, also saw an increase in subsidies while at the same time a decline in expenditure in infrastructure and institutional

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development in agriculture (Chand, 2003). The fourth and the final phase of agricultural policies was as a result of the economic reforms of 1991 involving deregulation, reduced government participation in economic activities, and liberalization. A new agriculture policy was launched in 2000 with the release of a national agriculture policy which aimed at a growth rate of 4% p.a. in the agricultural sector based on equity and sustainability. (Chand, 2003).

The history of agriculture development in India has deep roots in socio-economic and political traditions, whether technological or institutional. This chapter explores the history of agriculture development from a political economic perspective. In doing so it looks at significant institutional and technological innovations which were carried out in pre-independent and post-independent India and the driving forces with regards to the same. It shows that the process of agriculture policy development was a combination of individual preferences of maintaining power, a show of collective action under the leadership of Gandhi against the British rule, along with a combination of favor of both price support and input subsidies, as well as policies which favored or disfavored liberalization measures (Birner and Resnick, 2010). The chapter is divided into three parts with the first part describing the reforms that took place in British India after the mutiny of 1857 till the independence of India in 1947. The second part gives an account of post-independent occurrences and examines the influence of some of the pre-independent policies. The third part touches upon some of the emerging issues and approaches to agricultural development. The paper concludes with lessons that can be learnt for African countries in what could be done best, especially as these countries are also struggling with issues of food security and climate change as impending threats for sustainable agriculture development.

2.1 Pre-Independence Reforms in Indian Agriculture

In 1857, there arose an armed sepoy uprising which was termed as India's first war of independence. It was ruthlessly crushed but the shock was such that Britain took some drastic steps. The rule of the British East India Company was abolished and the Crown took direct charge of its Indian dominion. A new institution of the Secretary of State for India was established together with a Council for India. This led to a number of important social and political changes. After the mutiny, alliances between the Englishmen and the locals were discouraged. All higher administrative posts were reserved for the Englishmen. The bureaucracy was expanded and a large number of English administrators arrived in India with their families. India thus became the source of revenue and trade and not a place for English settlement (Perkins, 1997).

2.1.1 Agriculture Research System

Institutional Changes

After 1857, the British government established a number of new scientific institutions in India, one of them being the process of development of independent agricultural research and education institutions which was initiated by Lord Mayo, the then Governor General of India. This lead to the establishment of the Department of Revenue, Agriculture and Commerce in the Imperial and Provincial Governments in 1871 (Sharif, 1986; Roy, 2007). The Department was strengthened by adding staff after the report of the Famine Commission in 1880.The main functions of the Department of Agriculture, as per the resolution of 1881, was agricultural enquiry, improvement and famine relief. During the last decade of the 19th century, experts were recruited in the Department of Agriculture, and research and teaching in agriculture and forestry was started at a few places (Sharif, 1986).

With Lord Curzon becoming the Viceroy of India in 1899, the Government of India took up the task of conducting agricultural research in a systematic and ongoing manner and accelerating the process which was started by Lord Mayo. As part of the aftermath of the 1857 mutiny, Curzon realized very quickly that if the British Empire had to hold its dominance in India, it was necessary that there was human improvement. His comprehensive agricultural reforms became the characteristic feature of his term as Viceroy in India (Perkins, 1997). In addition to promotion of irrigation development and the extension of Indian railway networks, he set up a Board of Scientific Advice (BSA) to coordinate all scientific research in India. The most significant milestone was the establishment of the Imperial (now Indian) Agricultural Research Institute (IARI) at Pusa in Bihar in 1905 in collaboration with the provincial Government of Bengal, which after an earthquake was shifted to Delhi in 1936. An annual grant of INR. [2 million was to be devoted for agriculture education, demonstration and research in the provinces which resulted in establishment of six agricultural colleges in 1905 at Pune (Maharashtra), Kanpur (Uttar Pradesh), Sabour (Bihar), Nagpur (Maharashtra), Faisalabad (now in Pakistan) and Coimbatore (Tamil Nadu). These colleges were adequately equipped with staff and laboratories and were charged with the responsibility of research and teaching (Roy, 2007; Perkins, 1997). Such crucial investments in agriculture research during the tenure of Lord Curzon was a strategy applied to ensure enhanced yields and better prospects of commerce, which in turn would enhance the economic and the political strength of the British empire. The thrust for agricultural mechanization came under the Viceroyship of Lord Irwin starting in 1925, who was sent by the Stanley Baldwin's conservative government in Britain to counter the growing challenge of MK Gandhi's Indian National Congress pressing for the independence of India. Lord Irwin, like Lord Curzon, saw the importance of promotion of prosperity of India Agriculture. In 1926 he appointed the Royal Commission on Agriculture to better study the organization of agriculture research and education. The result of this was the creation of an apex body called the Imperial Agriculture Research Council (IARC)[4] to promote, guide and co-ordimate agriculture research throughout India (Perkins, 1997).

Mechanization of Farming

During the time of Lord Curzon, Albert Howard, a young botanist, was hired in IARI in 1905 to consider the question of whether or not the average fertility of the soil was declining, though it found no definite evidence of declining return to land. Under the leadership of Albert Howard, till 1924, studies were taken up on wheat production to provide the best solutions. This was followed by the appointment of Daniel Hall as part of the Royal Commission, who advocated mechanization of Indian agriculture. Agricultural scientists working with him advocated heavy and deep ploughing for dry areas, with the agricultural research stations and departments vigorously advocating the iron plough. The government's own propaganda machinery was inadequate, given the size of the task alongside a practically non-existent efficient equipment market. In 1925, several Indian firms were making implements according to designs and prototypes supplied by the Agriculture Department, but these firms were based in the towns and had weak networks in the villages (Roy, 2007).

Water Management

Much of South Asia was water-poor with the greater part of the subcontinent combining three months of monsoon rain with extreme aridity in the rest of the year, drying up much of the surface water. The rains were usually favourable for one sowing but growing another crop dependent on irrigation required expensive systems of harvesting and storage of water; the monsoon in a tropical region making subsistence earning rather easy, but improvements in yield difficult. Reporting shortly after the famine of 1876-78 in the Deccan plateau, the Indian Irrigation Commission concluded that a tank as a drought insurance would involve a wastage of water through percolation and evaporation, and was not an economical proposition. Apart from technical considerations, tank maintenance was seen as an organizational challenge on a large scale, with inadequate response.

[4] Later changed to Indian Council for Agricultural Research (ICAR) post independence in 1947.

The answer sought to the challenge for providing irrigation to the winter crop by breaking the dependence of the well on the level of the subsoil water was through bore wells combined with a power-driven pump (Roy, 2007; Randhwa, 1979).

The most popular form of irrigation was through the use of wells, as they avoided the capital cost involved in constructing and maintaining canals and tanks, in addition to avoiding the evaporation and percolation losses involved with tanks. Around 1900, well irrigation was a complement to, and not a substitute for canal irrigation (Roy, 2007; Randhwa, 1979) .

The Royal Commission of Agriculture in 1928 reported that the research efforts were being directed completely towards irrigated crops with the rain-fed areas being largely neglected.. The IARC was established to conduct crop and agronomic research with focus on food crops; whereas the research on commercial crops was with the Commodity Committees set up in 1920 with assured financial support under the Commodity Cess Act of 1923 (Randhwa, 1979).

Investigations were initiated in 1934-35 at five stations in the famine-stricken areas of the Presidencies of Bombay, Mysore, Chennai, Hyderabad, and Punjab. The locations were Sholapur, Bijapur, Hageri, Raichur and Rotak. The research was funded by the IARC till 1943, after which funding was suspended post independence. However, such a study attempt was representative of an organized endeavor at the development of dryland farming systems based on traditional and subsistence agriculture for drought prone areas, and set the trend for Farming Systems Research in India (Kanwar, and Das, 1991).

2.1.2 Gandhian Movement

By the beginning of the 20th century, the Indian National Congress[5] with the influence of MK Gandhi was demanding self rule from the British empire. Inspired by leaders like Gokhle and Tilak's motto of self rule and self sufficiency, Gandhi introduced the concept of kahdi (hand-spun, hand-woven cloth). He mobilized resources through the promotion of village self–sufficiency by organizing public rallies, holding marches and travelling across the country. This social mobilization soon became a political capital (Birner and Wittmer, 2003) with Webb Miller's (the famous war journalist) coverage of the *Salt Satyagraha,* eventually leading to the world opinion turning against the British Empire rule in India.

Through the collective action of khadi, Gandhi and his followers attempted to establish a different textile science by placing faith in the axioms of indigenous cloth manufacture. The response of the kahdi movement to colonial science and technology was not just a cultural response, but also a technological response to the quality aspects of Indian cotton. By insisting on hand-spun yarn in decentralized manufacture, Gandhi introduced a new dimension to the swadeshi (self–rule) movement. Swadeshi was not just a boycott of mill yarn, but had to focus itself on providing a technology to rework a system of decentralized cloth manufacture that had gone out of use. It meant replacing the inefficient processing methods and wasteful transportation of cotton by techniques that could be done at the farm and cottage levels, and finally to varieties of cotton that would suit decentralized manufacture. It was an attempt to create local markets and make the village economy self-sufficient. Laboratories were set up in what came to be called as the Satyagraha Ashram, where tests on all aspects of cloth manufacture were conducted. It gave itself a formal structure by calling itself the All India Khadi Board. Heading the technical department of the All India Khadi Board (later the All India Spinners Association) was Maganlal Gandhi (Johnson, 2006).

[5] This party was the face of the Indian freedom struggle and continues to be the single largest party till date in India. It is also seen as the face of secular and globalised India and also a consortium of the elite and the educated. It should be noted that during the freedom movement, most of the party members were lawyers and educationists, a part of them were also Oxford returned.

It should be noted that agriculture was very much part of the political agenda of the Congress party as the workers were urged to bring all varieties of cotton grown in their region with particulars of soil, climate, rainfall, etc., for the annual khadi exhibitions during the Congress Plenaries. The scientific experiments carried out on the Indian hand processing techniques in the Ashram (sanctuary) were first validated through experience of use in the field, thus validating science in the farmers' fields rather than being confined to laboratories. The skill/habit of observation was considered as a valuable acquirement as it was necessary for the examination of the quality of the cotton. The process was connected with education and the political context of the times by suggesting that village schools be the 'model farms', while keeping in mind superior quality and not forsaking it for greater production (Prasad et al., 1999).

2.2 Post Independence agricultural policies and development

The large scale movement led by Gandhi was eventually successful in getting India freedom in 1947, but with it came the creation of the Islamic Republic of Pakistan. This spelled doom for the Indian agricultural economy, as it lost major irrigated wheat areas in the west and rice producing areas in the east along with important education and research facilities. To top it all, decline in food production from 1920s onwards, mismanagement of food supplies because of conflicts between the central and partially autonomous provincial governments, resulting in the Great Bengal Famine of 1943, created a very complex situation for independent India. In the first four years of independence, there was an increase reliance on the import of food grains which was a continuation from the 1920s British trade policies, resulting in draining of foreign exchange in order to feed a growing population (Perkins, 1997). These conditions had a very strong bearing on agricultural policy decisions.

2.2.1 Land Reforms

Jawaharlal Nehru became the first Prime Minister of India at independence, with a vision to lead India as a socialist democracy. However, he was faced with pressing problems of food shortage, uneven distribution of land and resources and a failing village economy (Perkins, 1997). To manage the needs of a growing Indian population, 'A Grow More Food Campaign' was started in 1943 which gave impetus to increased food crop production, along with cash crops such as cotton, sugarcane, jute, though with little attention to the overall development of agricultural production systems (Randhwa, 1979; Kanwar and Das, 1991). The farming systems were based on low inputs and extensive agriculture, with irrigation being used as a productive input aimed at stabilizing production rather than increasing it. With regards to fertilizer trials, as there was little indigenous fertilizers being made by the time India got independence, the fertilizer trials were conducted mainly on research stations, where conditions were different as compared to the farmers' fields. In addition, lack of industrial infrastructure, poor communication and transport facilities resulted in further stagnation of Indian agricultural production with an annual compound growth of 0.03% between 1931 to 1947 (Sethi, 2001). At the same time, agriculture extension post independence still followed the colonial administrative structures, with focus mainly on production and marketing of export crops (Anderson et al., 2006)

It was argued by Nehru and his supporters within the Congress party that agriculture could be improved through institutional reform and innovation rather than through investment. This signified redistribution of wealth which meant large scale land reforms that would arise from the reorganization of agricultural production on cooperative lines. The land reforms which took place post independence was an important event in the social history of India, as it was not just an effort at economic reforms but it was also a step taken towards abolition of intermediaries who were the main collaborators of the British (Perkins, 1997).

With the introduction of the land tax under the Permanent Settlement Act of 1793[6], the British popularized the zamindari system in the northern and western part of India and the Ryotwari system in the south (landlord system) at the cost of the jajmani (land sharing) relationship that the landless shared with the landowning class[7] (Ghatak and Roy, 2007). The latter was an example of a 'moral economy', as it ensured the material security of those without land (Sethi, 2001). At independence the ownership and control of land was highly concentrated in the hands of a small group of landlords and intermediaries. The ownership of the land was distributed on one hand with a few large landholders comprising 4% of the rural population holding half of the land in the rural areas. On the other hand, there was 75% of the rural population which only owned 16% of the land, of which 27% of the population were landless and 53% had land less than 5 acres (Sethi, 2001; Sharif, 1986).Therefore the consideration of land reforms were based on the premise of social justice and the unwillingness of an exploited cultivator to take up improved methods of farming (Perkins 1997).

With the first five year plan, the Planning Commission of India in 1950 introduced the land reform movement with the promise of equitable society leading to better prospects of development (Sharif, 1986; Perkins 1997). A degree of success was registered in certain regions and states, especially with regard to issues such as the abolition of intermediaries, protection to tenants, rationalization of different tenure systems, and the imposition of ceilings on landholdings. However, loopholes in land tenure legislation facilitated the evasion of some of the provisions in land ceiling reforms by large landholders who wanted to maintain the status quo. In addition, delayed implementation at the bureaucratic level and a political hijacking of the land reform agenda, by both the state and private interests, posed impediments in the path of effective land reforms (Sethi, 2001).

The land reforms were seen as comprising of compulsory takeover of land by the State from the biggest landowners to be redistributed to those with little or no cultivable land, with partial compensation to the former. It was also an effort at consolidation of land held by various landholders in various parts of the village along with an effort towards getting higher agricultural output in food grains. The State had the discretion to give, sell or even rent out the land for private cultivation in smaller units under distributive reforms, or the land could be jointly farmed and its benefits shared through co-operative, collective or state farms as part of collectivist reforms (Oldenburg, 1985; Lipton 1974). Furthermore, the government pushed for land ceilings and, in 1952, the Planning Commission accepted the Agrarian Committee's suggestion and recommended the ceilings on the current land holdings of that time. The principle behind the land ceiling was that there should be absolute limit to the amount of land which an individual may hold, and the land in excess beyond that limit be distributed among the landless agriculturists. The second five year plan (1956-61) laid a lot of urgency in getting this implemented though it exempted tea, coffee, rubber plantations, and certain sugarcane farms owned by sugar factories (Sharif, 1986).

The most important contribution of land reforms was abolition of intermediaries and giving land titles to the actual cultivators. This released productive forces and the owner cultivators put in their best to augment production on their holdings. Even though land reforms were important in increasing agricultural production during the first period, the increase in output was because of large investments in irrigation infrastructure. Thus, along with institutional changes, irrigation technology was an important instrument of growth. However, the most important limitation of land

[6] Permanent Settlement, which was instituted by Lord Cornwallis on March 22, 1793, transformed agrarian relations by conferring private rights of land ownership to zamindars (landlords having large volumes of land), effectively creating a new class of absentee landlords who lived in cities and extracted large incomes from the peasants.

[7] Under this system the relationship changed from an equitable system of sharing the produce between the tiller and the land owing class to more of a bonded labour and working as a servant for severely low wages and very high taxation.

reforms in various states was its failure in implementation of land ceilings enactments. This resulted in skewed land structure as a consequence of half- hearted land reforms (Perkins, 1997; Lipton, 2005).

2.2.2 Food self-sufficiency, institutional and technological reforms

Along with the land reforms, the 'Grow More Food' Programme from 1943 -1951 was expected to improve the food situation in the years following independence. However, this programme was only partially successful, as even though it stabilized the internal food production to 3 million tons a year, imports steadily increased at the same time reaching to 4.8 million tons a year. Thus the failure of the 'Grow More Food' Programme, led to the Nehru government get into extensive talks with the United States for an exchange of food grains to minerals at very low rates by the time the first five year plan was coming to a close. Under the Gandhian influence and the vision of Nehru, though the aim was on building a robust agrarian economy along with high industrial production, there was a glaring lack of the use of research and development or science to promote higher production (Perkins, 1997). It was believed that land reform, additional land, better use of underemployed labor, and extension advice about existing practices would be the right combination to bring India to food self-sufficiency. This belief was out of a common perception that policy makers and agricultural officers had during that period, that farm productivity was essentially constrained by farmer backwardness, inadequate organization, and deficient local leadership (Anderson et al. 2006), This perception continued till almost the mid 1960s, till India embraced the promotion of high yielding varieties through science under desperate circumstances.

Events leading to the Green Revolution

The mid-1960s were not only an important milestone for Indian agriculture, but for transformations in agriculture in major parts of the "developing world". Prior to the Green Revolution, things were not looking so good in the Indian sub-continent. According to the FAO[8] database, the per capita grain production in Asia was 194 kg in 1961, compared to the 868 kg of the US (Zeigler and Mohanty 2010). By the 1960s India was desperate for a breakthrough as Jawaharlal Nehru was aging, almost retired from active politics resulting in looming political uncertainty. Food crises were endemic in India as the total food production was around 50 million tons, with marginal increases through bringing more land under cultivation and not through increases in productivity. The Indian Food Corporation had no food reserves at all, and the deficits had to be met with imports of PL480 wheat variety from the US (Bhagat, 1998,.

Eventually, three events triggered the Green Revolution. The first one was the death of Nehru in 1964, the succession of Lal Bahadur Shastri and his enthusiasm to make India food sufficient through the use of science. This was a lot due to pressure which was being faced by India, and foreign policy that India shared with the US. The second were the two consecutive droughts of 1965 -66 and 1966-67 which had a fatal blow to the domestic food grain production leading up to the import of 10 million tons of food grain and hence a compromise to both pride and national autonomy. The final event was the decision to use the HYV variety developed by Norman Borlaug through the Rockefeller Foundation in Mexico, which had the capacity of tripling the wheat production in India (Perkins, 1997)

Reforms through the Green Revolution process

C. Subhramanium, who was appointed as the Minister of Food and Agriculture in 1964, made the political importance of high yealding varieties (HYV) very clear by equating the development of agriculture science and the development of India to its national security. This is was further backed

[8] Food and Agriculture Organization of the UN

by Prime Minister Lal Bahadur Shastri, who in a radio broadcast stated that *" self-sufficiency in food to be of no less importance than an impregnable defence system for the preservation of our freedom and independence"* (quoted in Perkins, 1997, 243). Having got the backing of the Prime Minister, Subhramanium carried out some radical, systematic institutional reforms to see the process of food self-sufficiency through. He started off by the appointment of Dr B.P. Pal, a renowned scientist and plant breeder, as director-general of the ICAR (Indian Council for Agricultural Research) in 1965, got pay scales of scientists improved, and went in for targeted and time-bound research as a result of recommendations by a report submitted by Dr. Marion Parker of USDA in 1962 (Subramaniam, 1995, 122). He further came up with a remunerative price policy for farmers, which gave birth to the Agricultural Prices Commission and Food Corporation of India in 1965 (Gulati, 2012).

Subramanian realized early enough that the introduction of agricultural technologies is not a mere question of buying seeds; conducive policies and delivery systems have to exist. With the help of USAID, land-grant universities were set up, the Rockefeller Foundation helping in the development of the National Agriculture Research System (NARS) and the Ford Foundation aiding in the development of farm-extension work (Zeigler and Mohanty 2010). Under the supervision of Dr. Swaminathan, trials of the imported varieties were carried out in collaboration with the farming community (Jewitt and Baker, 2007; Spitz, 1987;Yapa 1977).

All these efforts were met with strong opposition both within as well as outside the government, especially from the left wing as it was seen to be giving up the sovereignty of the nation to the capitalist ideology. It is said by the people who knew Subramanian well that, if he had not defied the Indian bureaucratic structure, and not made Shastri and then Prime Minister Indira Gandhi his allies, the entire proposal would have collapsed when he left the scene (Bhagat 1998, cited in Banerjee and Birner, 2013 unpublished)

The period from 1965-75 marked the turn from subsistence agriculture to market-based agriculture in India. The aim was, with 130 million hectares under crops, 13 million hectares or $1/10^{th}$ to be covered under the HYV Programme. The state governments were given the opportunity to fix their own targets. The areas selected were to have progressive farmers and assured irrigation as it had to be ensured that the technology would be a success. The introduction of new technology also required that there were confident village level workers who could be trusted in terms of reliability of knowledge where the farmers were concerned. In order to do so, some of the village level workers were retrained with the sole purpose of looking into agriculture operations. In order to disseminate knowledge of the new technology as fast as possible to the extension workers and the farmers, Subhramanium initiated the programme of national demonstrations in 1965. As part of this program, large scale information campaigns were organized by the government in 1966 using radio, press, and even cinemas (Subhramanium, 1995, 155).

Broadly, there were four major components of the Indian extension or transfer of technology system: (i) agricultural extension service with the state governments, (ii) extension education system of ICAR and SAU (State Agriculture University) system, (iii) extension programme of input industries in public and private sectors and NGOs, (iv) special rural development programmes of the central and state governments. However, the main responsibility of transfer of technology rested with the state governments, as agriculture was a state subject. The ICAR developed an All India Coordinated Research Project for Dryland Agriculture (AICRPDA) in 1967, which comprised of a network of 24 research centers. The objective of these centers was to cater to the needs for technology development for different agro-ecological regions, especially in the arid and Semi-Arid

Tropics[9] (SAT) as it was relevant to 80% of the geographical area of the country. The project was approved by the Government of India, with an initial budget of. 5 million Indian Rupees (INR) for soil conservation research, and a training centre directly under the ICAR management. The budget was increased to INR. 18.7 million, from 1970 onwards to extend the support for research to all 24 centers as a national priority, with the coordinating centre of AICRPDA being headquartered in Hyderabad, India. The Green Revolution further led to the setting up of the International Crop Research Institute (ICRISAT) under the CGIAR[10] system. ICRISAT gave priority to strategic and basic research, with the aim of understanding principles and processes, developing conceptual models for improving farming systems. It was directed at identifying constraints, diagnostic surveys, development of components and packages of component technology with the aim of enhancing productivity, sustainability along with economic viability and a soil and climate-specific farming system (Goldman and Smith, 1995)

Role of Electricity in Promoting the Green Revolution

Initially the usage of electricity was given high preference for industrial development and for the first two five year plans, rural electrification receiving marginal importance. Though the third plan from 1961-1966 laid stress on village electrification, like the first two plans, it failed to recognize the importance of rural electrification in the development of food production and agricultural economy (Neiz, 2010).

Following the consecutive droughts of 1966 and 1967, the government came up with annual plans for three years (1966-69) as a means of finding respite from the calamity which had shaken the agricultural sector to the core. There was an urgent need felt to have small scale irrigation to stabilize agricultural production and a decision was taken to shift the emphasis from rural electrification to pump sets electrification to promote the Minor Irrigation Program. The Minor Irrigation Program ensured that a source of irrigation was located in the farmer's own field and under his control. The Fourth Five Year Plan (1969-1974) emphasized on giving precedence to electrifying tubewells and pumps for irrigation. It was expected that area plans for small scale irrigation would be prepared to reach the optimum level and these plans would be closely linked with rural electrification programs designed to provide electricity to clusters of wells or tubewells. Following the fourth five year plan, the National Commission on Agriculture which was set up in 1976 made a strong recommendation for stepping up rural electrification to make electricity available for pump sets and rural industries in all villages within the next two decades (Samanta and Sundaram, 1983).

Thus with a blend of institutional and technological changes, in the growing season of 1983-84 India was proudly announcing itself as a self–sufficient food grain producing country (Rosenberg, 1976; Shrum, 2000).

Soon after the success of the Green Revolution, the Congress government comprising of Indira Gandhi as Prime Minister and C. Subramaniam as the Minister of Food and Agriculture were defeated in the general elections of 1977, and a new government led by Morarji Desai of the Janata Dal came into power. The new government which took over in 1978 suspended the five year plan and in turn introduced two annual plans for the remaining period. A Committee on Power was appointed by the Ministry of Energy, to examine the functions of the Sate Electricity Boards and Central Organizations engaged in the electrification process along with the functions of the Rural

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[9] The SATs are defined as areas where the mean monthly temperature exceeds 18ºC and where precipitation exceeds potential evaporation for two to seven months (Troll, 1965). The SAT environment is characterised by strongly erosive and variable rainfall, by soils that are generally of poor quality, by numerous biological constraints and by complex risk-reducing farming systems which combine crops and livestock.

[10] Consultative Group on International Agricultural Research.

Electrification Program.[11] According to this Committee it felt that rural electrification should cover broader fields other than just power for agriculture like domestic and street lighting, and power for a rural based industries program (Samanta and Sundaram, 1983)[12].

2.2.3. Post Green Revolution reforms

Decline of extension services

The role of extension services was seen to be pivotal when it came to technology diffusion during the period of the Green Revolution; which resulted in the development of the Training and Visit (T&V) Program in the 1970s by the World Bank, and was implemented in the Chambal Irrigation Command of Rajasthan and Madhya Pradesh in 1974 through funding of the World Bank. Though it was greeted with enthusiasm and even spread to 13 states by the end of 1982, it started to show decline once the funding of the World Bank stopped. The funding was given in as a pilot start to the concept, and in the second phase it was expected to have already been mainstreamed. With the T&V programme being run only on state budget, there was often lack of regular training sessions, research was of low quality, most visits were faked, and above all the T&V programme was used as a mechanism of obtaining enhanced resources associated with the project (Anderson et al., 2006).

Era of liberalization and politics of input subsidies

Inputs like electricity constituted a significant share of agricultural subsidies in India as it began to be driven by the influence of pressure politics (Jain, 2006). When electricity connections for pump sets were first introduced, they were metered, and farmers had to pay a volumetric price. In any case, subsidies in support of the Green Revolution were initially part of a strategy to achieve the national goal of food self-sufficiency. They gained prominence again in the late 1970s as a political strategy to win farmers' votes (Birner et al., 2011). As agricultural production and the need for a stable water supply increased during the Green Revolution, the farming workforce organized into a powerful political coalition. The actual rate of electrifying pump sets was modest in India until 1975 when a movement was launched in Karnataka seeking supply of subsidized power to agriculture as water supply for irrigation provided from surface irrigation sources was charged at highly subsidized rates (Badiani and Jessoe, 2011).

The mid 1980s marked the comeback of the Congress Party[13] to power under the leadership of Rajiv Gandhi following the assassination of Indira Gandhi in 1984. The plan focused on the boost in food production by increasing the availability of irrigation facilities and subsidies increasing at 7.6% per year for major, medium and minor irrigation schemes (Fan et al., 2008). It aimed at a significant reduction in poverty and improvement in the quality of life for the poor in the villages through better access to electricity and the emphasis on local self governance resulting in the 73rd and the 74th amendment to the Indian Constitution (Neiz, 2010).

In the meantime, because of decline and an almost empty foreign exchange reserve, the Narsimha Rao government in 1991, with Manmohan Singh as the Finance Minister, under the guidelines of the World Bank, went for structural adjustment programmes. The objective was to have a liberalized market, though India went about it gradually since most of Indian agriculture was dominated by small holder farmers (Deshpande and Sarkar, 1995). .

During the 1980s and 1990s, public expenditure on irrigation declined consistently. While the costs of creating additional irrigation through major and medium-sized surface-irrigation schemes went up, resources to complete these schemes shrank (Fan et al., 2008). This was also a period of high

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[11] Point worth noting is that the new Government which was led by Morarji Desai was a non Congress Government who until 1978 has been in the center since independence

[12] This was done with the scope for developing non-agricultural demand through the establishment of village, cottage and small scale industries

[13] The Congress was the single largest party in the country till 1994 when coalition governments became the order of day.

political instability in the country with coalition politics taking birth, ending the era of single party rule. As a result, growth in irrigated areas through publicly funded schemes slowed down, creating severe shortages of irrigation water on the one hand and a large number of unfinished irrigation projects on the other. In 1996–1997 under the Prime Ministership of IK Gujral of the Janta Dal, the Government of India introduced the Accelerated Irrigation Benefits Programme (AIBP) in order to help states complete pending irrigation schemes through central loans and grants. A similar programme was introduced in 2002 by the Bharatiya Janata Party (BJP), called the Fast Track Programme, though with modest success (Fan et al., 2008).

As part of the continuing reforms to the power sector, towards the close of the 9th plan the central government introduced the Electricity Bill 2001. The bill was intended to replace the previous Indian Electricity Act of 1910, the Electricity (Supply) Act of 1948, and the Electricity Regulatory Commissions Act of 1998 (Torero and Chowdhury, 2007).

This was passed under the name of The Electricity Act 2003. The new act gave impetus for further reforms by allowing increased competition in the sector and making the state regulatory commission as a mandatory requirement. It allowed open access to distribution and transmission (Torero and Chowdhury, 2007). It provided the framework for the power-sector reform at the state level. Among other provisions, it required the establishment of an independent electricity regulatory commission at the state level and the separation of its transmission activity from the state electricity board (Birner et al., 2011)

2.2.4 Farming Systems Research.

Prior to the mid-1960s, very few station-based experiments were subjected to any economic analysis, and it was not surprising that many existing recommendations were poorly designed or irrelevant, especially to farmers. It was found that many farmers were natural experimenters (Biggs and Clay, 1981), that the production environments of the farmers were more heterogeneous as opposed to the requirements of the recommended technologies, often resulting in inability to adopt the particular technology because of the incompatibility of the socio-economic and institutional environment within which they operated (Norman et al., 1982).

With the lessons of the Green Revolution emerging from the mid-1970s onwards, there was a general recognition of the need for participatory approaches to working with poorer rural households, with financial support from donor agencies to encourage anthropologists and economists to work with natural scientists on issues related to the role of technology and sustainable agriculture development. Field experiences showed that policy and development practice was at its heart a very political and culturally defined process. The economic policies explored were limited as the set of economic and institutional policies relating to the distribution of assets, power, and control in the markets and the regulatory regimes were not investigated in the modeling exercises (Biggs, 2008).

Emphasis was on normative and prescriptive issues through application of techniques such as budgeting, linear programming, and other tools for applied decision analysis. Thus agricultural economists armed with these analytical tools and with a strictly neoclassical orientation dominated the farm management-type studies undertaken in the low-income countries during the 1960s (Johnson, 1981). Thus many agricultural economists, particularly those associated with research stations in Africa, Asia, and Latin America, began to evaluate recommended technologies.

Following the Green Revolution, there was a seemingly paradigm shift in India. The farming systems approach worked on the notion that one had to begin with understanding the problems of farmers from the perspectives of farmers; and that solutions had to be based on a proper understanding of their objectives and their environments, including both biophysical and socioeconomic components. A central principle of the new approach was that not only did farmers have a right to be involved in the technology development and evaluation process, but that their inputs were essential. Other significant features were its holistic perspective, the fact that scientists involved in the process should represent both technical and social scientists, and that the process was by nature iterative. However, a number of limitations became increasingly apparent as farmers' participation was still limited largely to roles assigned by researchers and methodologies for obtaining and systematizing farmers' knowledge. Although some linkages had been developed between the different disciplines, there was still a lot of room for improvement. The application of the farming systems approach (FSA) to livestock enterprises was particularly weak (Biggs, 1981).

Factors relating to the policy/support system were treated as parameters within which the search for improved technologies took place. This was partly because the mandates of the technology-oriented institutions in which most farming-systems-related work was based did not include objectives of influencing the policy context and support systems. As a result, this severely constrained the types of technologies that could be developed or evaluated. In the early 1990s institutional changes were carried out at various points of time to encourage more collaborative and collegial relationships between the farmers and the researchers. Farmer groups (both formal and informal) were used to help empower farmers and improve the efficiency of the research/development process by providing a focal point for interaction with farmers and by facilitating farmer-to-farmer interaction (Heinrich, 1993).

Other major changes involved developing technological options rather than standardized packages for farmers and increased transparency in providing information on the conditions in which technologies were most likely to fit and perform best. There were yet major challenges when implementing farming systems with a natural resource focus: i) large investments were required to address complex processes that were manifested differently across locations; ii) it was a time consuming affair as a long time frame was needed to improve ecological sustainability and assess progress; iii) because of the precarious existence of many farmers and their households, ecological sustainability initiatives were likely to be attractive only if they simultaneously improved short-run welfare; and iv) there were deep-rooted cultural and political complexities involved (Norman, 2000).

One such initiative was the participatory maize initiative, where a much-respected maize breeder at Pantnagar (Uttar Pradesh, India) organized an on-farm research programme of trials, surveys, and meetings, and published the findings each year, starting in 1979. These reports showed that the problems of poorer households were often very different from those of richer households, and thereby questioned the prevailing research and extension strategies of recommending a general 'one size fits all' 'package of practices' and the adoption of technologies from demonstrations. These reports raised a lot of eye brows and were controversial at the time, as they were legitimizing different ways of doing research from the mainstream national paradigm. There were attempts to have the activities stopped, and it was only because the director of the maize programme at Pantnager was an influential and respected plant breeder that he was able to argue the case to continue with on-farm research. However, after a few years, the programme lost momentum as it fell prey to the established managerial bureaucracies of the Indian agricultural research system which were very difficult to change, even if alternative approaches were available (Biggs, 2008)

In the 1980s, there were a number of formal reviews, assessments, and consolidations. Much of the way forward in the participatory mainstream was couched in development-intervention and managerial terms. However, the mainstream did not engage in ethnographic or political-economy analysis of its own involvement in S&T practice. Some of the work of the 1970s and early 1980s revealed that participatory research itself was deeply embedded in broader political issues of national and international scientific institutions and aid donors, which in themselves were part of a broader international political economy. It was clear that the issues were not so much about the development of new toolkits of methods and frameworks, but about effective institutional innovations in the political/social arenas where S&T took place. The supposed poor performance of the projects served as a good excuse for some people in policy circles, who had little sympathy with engaging in the complexities of pro-poor and social equity issues, to rationalize withdraw of support and funding (Biggs, 2008). With the ushering in of the 21st century, there was a recurring theme of political embeddedness of science and technology. While the language of participation was being used, the actual practice of science was determined by the behavior of international and local actors. Interestingly, some of the most important changes in agricultural research-policy practice in the early 2000s came about, not as a result of a planned project with this intent, but as the result of the persistent efforts, going back thirty or more years (Biggs, 2008).

The FSA, as it evolved is diagrammatically represented below :

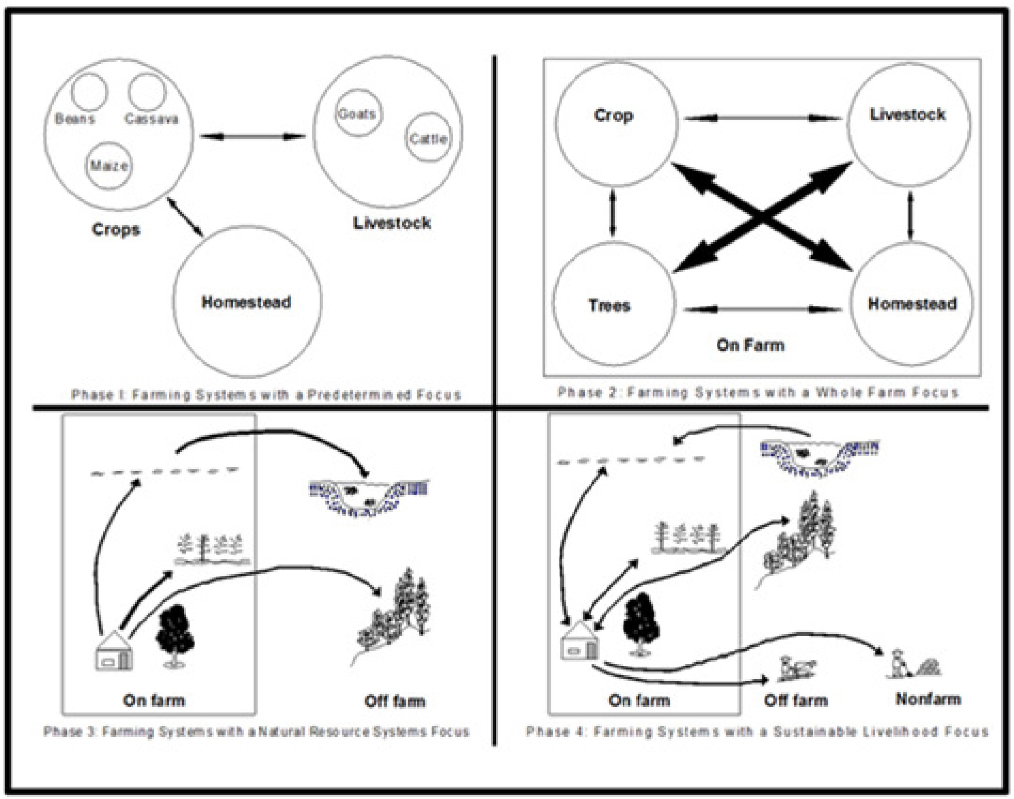

Figure 2 Progression in Farming Systems Thinking (Source: Norman 2000).

Agricultural Innovation Systems (AIS) perspectives

With the changing context of agriculture development, ideas of investment and innovation also changed. The Agriculture Knowledge and Information System (AKIS), in 1990, recognized that research was not the only means of generating or gaining access to knowledge. More attention began to be given to demand for research and technology along with the development of linkages, enabling attitudes, practices, governance structures, and policies that allowed knowledge to be put to productive use (World Bank, 2006). The agricultural innovation systems (AIS) perspective emphasized careful coordination among the many stakeholders involved in a dynamic innovation process. It considered innovation as the result of a process of networking and interactive learning among a heterogeneous set of actors, such as farmers, input industries, processors, traders, researchers, extensionists, government official and civil society organizations. In addition, the role of gender in agriculture development started gaining significant importance with respect to decisions on ownership, allocation and disposal of resources and benefits accruing from them. The innovation system framework distinguished the institutions from the organization, the former being a set of common habits, routines, practices, rules or laws that regulated the relationships and interactions between individuals and groups (Edquist, 1997).

2.3 Emerging Issues in Agricultural Development.

About thirtyfive or forty years after the Green Revolution, the agriculture community is still faced with the task of addressing the recurrent issue of food security amidst emerging challenges, such as climate change, land degradation, loss of biodiversity, rising food prices, increasing energy demand, and population explosion. Income growth contributes to increasing demand for foods such as animal proteins. Because of increasing energy costs, there is also competition between food production and the drive for biofuels (UNCCD, 2007). In addition, the United Nations and the Intergovernmental Panel on Climate Change (IPCC) recognized that the biggest challenge of humankind till date is climate change with threats to food security. In the 2000 report published by the IPCC, it specifically mentioned the threats that South Asia was going to be faced by in the form of severe water stress and scarcity in the future. About 2 and 2.5 billion people will be facing water availability problems, either through water stress or through water scarcity, by 2025 and 2050 respectively (IPCC, 2001). Over the years, there has been an attempt made to mainstreaming adaptation actions into development programmes with initiatives like the National Action Plan for Climate Change (NAPCC), which was initiated in 2008 by the Prime Minister's Council on Climate Change, and the amendment of the National Water Policy in 2012, as it is estimated that India is likely to be water scarce by 2050 with many part of India already water stressed with the possibility of the problem worsening due to climate change (NAPCC, 2008). However, a lot is still to be desired in dealing with issues of social marginalization, service delivery and governance issues, especially in the public institutions which are the main interface between policy and implementation in agriculture development (Banerjee et al. 2013).

2.4 Lessons learnt.

Through the historical overview, an attempt has been made to show the important milestones that Indian agriculture development went through from the beginning of the 20th century to the present. From the agricultural reforms initiated by Lord Curzon and subsequently followed up by his successors, the main objective was to ensure that the political dominance of the British was maintained in the sub-continent. At the same time, leaders like Gandhi used the very same tool of agriculture research and technology to mobilize communities and groups eventually turning it into a political capital (Birner and Resnick, 2010) becoming responsible for India's independence in 1947. In the initial years of independence, the vision of building a nation on socialist ideas, though it promoted important institutional steps like land reforms, it neglected the importance of science in the field of agriculture thus leading research to a virtual stagnation, and leading to another famine situation where food production was concerned (Perkins, 1997). The threat of losing face as a global player, autonomy as a nation state, and pressure from powers like the US dictating India's foreign policy, made the leaders in the 1960s and the early 1970s to get in their best men, and use science to create an institutional and food revolution which had far reaching political implication in the international arena (Zeigler and Mohanty, 2010). Riding high on the success of the Green Revolution, though a lot of participatory agricultural programmes were initiated, it often fell victim to the lack of political will, rent seeking, or even means of accumulating resources in the name of participatory action research (Biggs, 2008). The only thing that remained constant in the formulation of the agricultural policies after the Green Revolution was the provision of subsidies in agriculture production.

The policy approach to agriculture since the 1990s was to secure increased production through subsidies on inputs such as power, water and fertilizers, and increasing the minimum support prices (MSP) rather than working on better infrastructure facilities for irrigation, better access to credit for small farmers or focusing on new drought-resistant technologies which were affordable. One of the important reasons of introducing the minimum support price and subsidies in inputs during the process of the Green Revolution as a policy towards food self-sufficiency in the late 1960s, was to ensure that small holders adopted the new technologies as they are often the losers in the initial adoption stage of a new technology (Fan et al., 2008). However, since the time of the Green Revolution, there was stagnation after 1987 in agricultural research and development, dropping to as low as 0.43% of the GDP in 1995, with some recovery only in later years (Fan et al., 2004).

Subsequent governments irrespective of ideological affiliations have focused more on subsidies rather than research and development. This is a concern because studies have shown that subsidies necessarily do not improve the situation of a farmer in terms of access to technologies, and sometimes the subsidies are mainly used by the large land holders instead of the small ones (Stancanelli, 2009). Reducing subsidies or moving towards targeted subsidies has been difficult because of the increasing income gap between the agricultural and nonagricultural sector, making it an instrument to reduce "agrarian distress" (as quoted in Birner and Resnick, 2010). Another issue of importance has been the policy debate of the role of the state in agriculture as countries like India were forced to adopt structural adjustment policies due to economic and financial crises, during the 1990s. Though India adopted a far-reaching liberalization policy, liberalization in the agricultural sector remained only partial (Mooij, 2005)

In addition to these issues still prevalent in the Indian agriculture sector, there are issues like water management that have been a concern especially at the farm level and now seem to be aggravating because of climate change. Therefore, there is a need to understand the institutional and the technological alternatives which a local community can adopt, given that governance challenges such as 'elite capture' and patronage, especially when it comes to maintaining common space for storage or access to water resources, often pose a constraint.

Conclusion

The threat of climate change continues to increase, with predictions on increase in variability and further incidence of floods and droughts which will lead to major crop losses and more loss of arable land, escalating the risk of food security further. Therefore, there is a need for further understanding the context, needs and models for linking developments in agricultural knowledge with local systems of innovation, especially in response to technological paradigms. For this to be successful, complementary investments in policies and institutions are needed, if the desired impact is to be achieved. Concerted research and development efforts are thus required, from the global to the local level, to ensure that the right institutional settings are in place. The lesson and the policy implication - if policymakers and governments were to take from the story of the Indian agriculture development sketched in the preceding pages would be to adopt the strategy of pursuing whenever possible a long-term perspective on agricultural growth. In order to achieve this, it is important that governments build strong infrastructures and institutions, while creating capacities and developing policy environments where leadership and driving forces are created, both at the local and the policy level, which emphasize 'learning by doing' while cutting subsidies and increase investments in agricultural R&D, rural infrastructures, and education (Fan et al., 2008; IAC 2004).

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3 How to Promote an Agricultural Productivity Revolution? A Historical Case Study of the Green Revolution in India[14]

Abstract

Forty years after the Green Revolution in Asia, the agricultural community is still faced with the task of addressing the recurrent issue of food security amidst emerging challenges, such as climate change, land degradation, loss of biodiversity and population increase. This chapter examines the Green Revolution that took place in India during the late 1960s and 1970s in a historical perspective, identifying two factors that have been relatively neglected in the debate about technology adoption: institutional change and political leadership. The chapter highlights the efforts of those actors who made the Green Revolution possible, in particular the role of Chidambaram Subramaniam, the visionary and the real player who orchestrated the implementation of the Green Revolution. The chapter concludes with summarizing insights that can be gained from the Indian case for technology adoption and draws lessons that are relevant for other regions, particularly Africa, the continent that is now poised to make a new Green Revolution happen.

Introduction

There are only three events in the world history of agriculture that were characterized by such a large jump in agricultural productivity that economic historians have come to call them "revolutions": the Neolithic revolution brought about by the domestication of plants and animals that started some 13,000 years ago (Goper et al., 2001), the British Agricultural Revolution that preceded the Industrial Revolution in the 18th century, and the Green Revolution, the massive increase in wheat and rice production in Asia in the mid of the 20th century. There has been a strong drive to support an agricultural productivity revolution in Africa for almost a decade now, marked by the Maputo Declaration of African heads of state in 2003[15]. A high-level action group with the launch of the Alliance for a Green Revolution in Africa (AGRA) has been formed. Yet, the empirical results have been rather mixed, so far (Ron, 2013). Against this background, this chapter attempts to take another look at the Green Revolution in Asia, taking India as an example, in order to complement the existing research on the question of what it actually took to make this revolution happen. By providing a detailed account of the role that key decision-makers played in the course of the Green Revolution, the chapter aims to throw light on some factors that may have been neglected in earlier studies, but which could provide important lessons for African countries.

At the centre of the Green Revolution were new varieties of wheat and rice, developed from crossing existing varieties. They were short strawed and characterized by considerably higher yields and rapid maturity, often permitting more than one crop to be grown in the growing season (Salvi et al., 2011). Such modern varieties were input-efficient by being highly responsive to fertilizers. To realize their yield potential, seeds for high-yielding varieties (HYVs) had to be promoted as part of a package of practices. Not only fertilizers were required, but also crop-protection inputs such as pesticides, herbicides and fungicides. Owing to short growing seasons and high cropping intensities, a closely regulated water supply was frequently also essential to the achievement of high yields (Resenberg, 1976; Yapa, 1997). As the densely-populated Asian countries were not short of labour at the time of the Green Revolution, mechanization was, apart from pump irrigation. It might,

[14] A revised version of this chapter, co-authored with Regina birner, has been submitted to the Journal of Public Administration and Development

[15] In July 2003 in Maputo, African Heads of State and Government endorsed the "Maputo Declaration on Agriculture and Food Security in Africa" which among other important decisions made the commitment to the allocation of at least 10 percent of national budgetary resources to agriculture and rural development policy implementation within five years. http://www.nepad.org/nepad/knowledge/doc/1787/maputo-declaration

however, be essential for a Green Revolution in the more sparsely populated countries of Africa, where labour, rather than land is the most constraining factors (cf. Binswanger, 1986).

Existing explanations of the Green Revolution identified research-based technology as a main source (cf. Rosenberg, 1976), while acknowledging a broad set of changes that altered the aspects of the local agriculture economy. It has also been recognized that interlinkages among various individual components were responsible for the transformations to take place in such an extraordinary short period of time in the Green Revolution countries, as compared to other industrialized countries (Goldman and Smith, 1995). With few remarkable exceptions, such as Djurfeld et al. (2005), less attention has been paid to the institutional and political factors that accompanied the Green Revolution.

In this regard, it is useful to take a brief look at the second agricultural revolution mentioned above: the Agricultural Revolution that preceded the Industrial Revolution in England. Most explanations focus on the technological innovations that made this revolution possible, such as the integration of legumes in the crop rotation, and advances in breeding (Burchill et al., 2013), However, some of these technologies, such as legumes, were already known since Roman times. Hence, it has been argued that political and institutional factors, rather than the availability of a new technology as such are essential for an agricultural productivity revolution to happen (Akande et al., 2005). The debate about the role of political and institutional versus technological and demographic factors also features strongly in the so-called "Brenner debate", which was sparked by a seminal paper by Robert Brenner published in 1976. Brenner showed that productivity-increasing technologies were adopted in Western Europe, where family farms had achieved some independence from their feudal lords, while they were not adopted in Eastern Europe, which had retained a feudal structure, and it was not in the interest of the politically powerful landlord class to incorporate them into their farming systems (Brenner 1976:82). This debate throws light on the need to consider institutional and political factors when trying to understand what it takes to make an agricultural revolution happen.

The Green Revolution that started in the mid-1960s had a major impact on crop production in parts of Asia and in Latin America. As indicated above, it was made possible through the introduction of fertilizer-responsive, high-yielding varieties of rice and wheat, and, especially in Latin America, also maize. Its spread was limited to more favorable and relatively homogeneous production environments (Zeigler and Mohanty, 2010). As indicated above, there has been an ongoing attempt in Africa to promote a Green Revolution, which has also sparked a debate on the question as to why a Green Revolution could not take place in Africa during the time it did in Asia and Latin America. Some of the explanations focus on physical limitations of the African environment (Buddenhagen, 1992), low population densities along with poor infrastructure in many areas (Pingali, Bigot, and Binswanger, 1987), and political economy reasons (Birner and Resnick, 2010). In addition, the literature pointed to the effects of numerous flawed economic and political policies, lack of proper and appropriate research along with lingering effects of colonialism and post-colonial dependency (Bates, 1981; Lele, 1989; Lipton, 1988; Watts, 1989; IAC, 2004), which were identified as factors that prevented a transformation of the magnitude of an agricultural revolution from taking place. Further, it was pointed out in a special event on the 'Green Revolution in Africa' as part of the 31st Session of the Committee on World Food Security in FAO Rome that there was an urgent need for Africa to overcome a key structural limitation of inadequate investment on basic infrastructure besides substantial investments in modern inputs. This would require increased investment in research and technology, supported by favorable policies and institutional arrangements that will provide the basis for the Green Revolution in Africa (FAO, 2005).

To complement the research on the driving forces of the Green Revolution, this chapter examines the Green Revolution that took place in India during the late 1960s and 1970s in a historical perspective that throws light on two neglected factors in the current debate: Political and administrative leadership and institutional reform. It looks into the importance of the leadership exercised by committed individuals and identifies what it actually took to make the Green Revolution happen. The paper takes a specific look at the role of C. Subramaniam, the Minister of Agriculture at the time, and the visionary leader who orchestrated the implementation of the Green Revolution. He fought an uphill battle to make this revolution happen, a role that is widely acknowledged in India, but hardly recognized in the international literature. The chapter shows that the use of the HYV seeds and the supporting inputs was just one aspect of this revolution – the technical aspect. In order to better understand what might make a Green Revolution in Africa happen, it would be important to extract from the Indian case some insights about the other factors that mattered: vision, leadership, and institution-building. The chapter is divided into two sections: the first describes the context and driving factors for the Green Revolution, illustrating the emphasis of the political leadership to fight hunger and not just to churn out new technologies through certain personal accounts of Subramaniam.The second section describes the processes by which the institutional innovations were carried out in a systematic way by Subhramanium and his dedicated team while rolling out the adoption of the HYVs.

The success in introducing the high yielding varieties of wheat and rice significantly enhanced domestic food production, which was far from adequate after independence. Importantly, it allowed India to gain political independence from the USA, the country that India relied on most for its food imports after independence – and the country that decided to use food as an instrument of foreign policy. The chapter concludes with summarizing insights that can be gained from the Indian case for technology adoption, addressing issues that are relevant for other regions, particularly Africa, the continent that is now poised to make a Green Revolution happen as well.

3.1 The Unfolding of the Green Revolution: Context and Driving Factors.

The Rockefeller Foundation, in the 1940s and the 1950s, decided on rural development and agricultural development programmes overseas. The programmes involved creating new institutions. In the middle of World War II, three American professors; Paul Manglesdorf of Harvard, E.C Stakman of Minnesota and Richard Bradfield of Cornell had been commissioned to Mexico to determine whether the foundation could help to increase its agricultural productivity as in the mid-1940s Mexicowas importing half the wheat for consumption. The three professors spent two months travelling through, talking to farmers, officials, academics, and ordinary citizens. They came up with recommendations which came to be the principles of the Foundation's overseas programme. The first principle was to rely on experienced people and give them an opportunity to carefully consider the situation on the ground before making recommendations. The second was based on research aimed at increasing agricultural productivity; the third principle was to hire outstanding people with experience prepared to make a career commitment. The fourth and final principle was to 'help train by doing', with the goal of turning over the work to those with national responsibility. The report further emphasized the need to first build research capacity and explore potential unused information. As a result of these insights, Norman Borlaug, who was an agronomist by profession and specialized in plant pathology and genetics, was hired to get the job done in Mexico, and eventually in India. Norman Borlaug, often known as the father of the entire Green Revolution phenomenon, went to win the Nobel Prize for his contribution in seeing it through (Herdt, 2012).

Prior to the Green Revolution, things were not looking so good in the Indian sub-continent. According to the FAO[16] database, the per capita grain production in Asia was 194 kg in 1961, compared to the 868 kg of the US (Zeigler et al., 2010). By the 1960s, India was desperate for a breakthrough as Jawaharlal Nehru, India's first Prime Minister, was aging, almost retired from active politics, resulting in looming political uncertainty. Food crises were endemic in India as the total food production was around 50 million tons, with marginal increases through bringing more land under cultivation and not through increases in productivity. The Indian Food Corporation had no food reserves at all, and the deficits had to be met with imports (Bhagat, 1998).

In 1963, C. Subramanian, the then Minister of Food and Agriculture inquired whether the Rockerfeller Foundation would assist India in obtaining hybrid wheat varieties. This was a time when India was in a political turmoil, with a humiliating defeat by the Chinese on one side, a looming food crisis, and the United States threatening to cut food aid (Herdt, 2012; Borlaug and McNamara video 2005). Norman Borlaug, on his arrival in early 1963, was on constant travel in India accompanied by the team of Subramanian on most occasions. In his conclusion, he was convinced that a wheat variety conducive to the agro-ecological conditions of India could be produced (Borlaug and McNamara video 2005). The Foundation's agriculturalists realized that what had worked in Mexico may not work in India as the agro-ecological conditions were different. Therefore, a research team was set up to evaluate the research capacity of India. This was to play a critical role in the evolution of India's research capacity. As had been the case earlier in Mexico, an officer of the Rockefeller Foundation, in the Indian case, Ralph Cummings, spent six months to get to know India's agricultural conditions, its people, and the leadership anatomy before recommending any action (Herdt, 2012).

The situation worsened in India with two consecutive droughts in 1965/66 and 1966/67. 'With the falling of the global stocks, there was widespread speculation on the capacity of the Indian sub-continent surviving a food crisis. It was then that with consultations with Norman Borlaug, C. Subramanian, the then Minister of Agriculture, took the decision to import 18 thousand tons of seeds and corresponding amounts of fertilizer (Das 2002, Herdt 2012, Singh 2000, Zeigler et al., 2010). Meanwhile, a 'Treaty of Rome 1965' was signed by Subramaniam and Oliver Freeman, US Secretary of Agriculture during a FAO meeting, which both of them happened to attend. This treaty was kept a close secret, in the words of Subramanian, keeping in mind the political sensitivity of the communist attitude towards taking US aid back home in India (Subramaniam, 1995: 184).

In the diplomatic context, the Treaty of Rome served as an opportunity for the US to potentially influence Indian foreign and domestic policies. As it was the time of the Cold War, India was trying to shield itself from being name tagged as either communist or capitalist and took a non-aligned stand. However, some policy decisions of India, such as greater emphasis on the role of the public sector in the economy, stringent laws with regards to privatization, and the import of heavy agricultural machinery, such as tractors from the USSR, made the USA panic on the perception that India would be taken under the communist wing. When India realized that the country was in a crisis with regards to feeding its people and was asking help from its developed nations allies to manage this crisis, the USA stepped up to the occasion through the Rockefeller Foundation and USAID (Zeigler et al., 2010). The then US President Johnson, following a meeting with Subramaniam in December of 1965, was on board about lending India the Pl-480 variety, though under very stringent conditions of seeds being released on a month-month basis (Subramaniam, 1995: 206). In his words, *"I subsequently learnt from reliable sources who had access to the US official documents that the US version of the meeting was more revealing. According to this source, Freeman's mandate was to have me 'over the barrel' and 'squeeze' me with a view to securing*

[16] Food and Agriculture Organization of the UN

India's capitulation to a variety of political and economic pressures and most importantly from the US standpoint, soft-pedaling criticism of the US and not flaunting our independent approaches to issues of concern to the US" (ibid, 184).

In December 1969, the export of Pl-480 variety was presented to the U.S. Congress as a major tool of American foreign policy that provided bright market prospects to the pesticide, fertilizer, seed, and tractor industries, while keeping India in the capitalist camp (Spitz, 1987; Cleaver, 1973; Perkins, 1997). The term 'green revolution' was coined in 1968 by former United States Agency for International Development (USAID) director William Gaud. This term was used by Gaud to differentiate and promote the uniqueness of the development paradigm, thus reflecting the political and economic context of that time (Hall et al., 2000 cited in Parayil G, 2003). The US had to be concerned with agriculture, food supplies and the living conditions of rural populations in Asia, since food shortage and poverty, it was argued, would make people susceptible to communism (White, 2007; Perkins, 1997).

3.2 The Green Revolution: Institutional Innovations and the Process of Implementation

3.2.1 Shift from Heavy Industries to Ministry of Food and Agriculture

With the demise of Jawaharlal Nehru in May 1964, Lal Bahadur Shastri became the Prime Minister of India. C. Subramaniam was shifted from the Minister for Steel, Mines and Heavy Engineering in Nehru's cabinet, to the Minister of Food and Agriculture, a sector which was weak and under severe pressure because of low-yielding varieties of seeds and an exploding population. As described in his autobiography, this portfolio at that time was described as the "political graveyard" (Subramaniam, 1995: 105) – reflecting the low attention to agriculture at the time, and there was a lot of speculation of a conspiracy against Subramanian. However, the real story was a different one: the results that C. Subramaniam had achieved while being the Minister of Heavy Industries prompted Lal Bahadur Shastri to get his best man to resolve the task that had emerged to the top of the political agenda due the events described above: achieving food self-sufficiency to remain politically independent. In his own words, Shastri insisted that he attached great importance to the agriculture sector, given the food aid situation. Subramanian eventually accepted the portfolio based on the advice given to him by his spiritual leader, who said that he was getting an opportunity to mobilize farmers because they were a neglected lot with no proper leadership (Subramaniam, 1995: 106).

After assuming office in 1964, Subramaniam began to systematically set the stage for an overhaul of the way food grain was grown, sold, and distributed. He started off with a remunerative price policy for farmers, which gave birth to the Agricultural Prices Commission and Food Corporation of India in 1965 (Gulati, 2012). After some study, discussion and analysis, he came to the conclusion that as no industrial unit could progress or succeed unless it was a profitable concern, a similar approach had to be used for the agriculture sector as well. *"My going from Steel and Heavy Industries to the Food and Agriculture was a change so far as the nature of the work and the job were concerned and that itself proved to be an advantage because I was able to look at agriculture from a completely new perspective"* (Subramaniam, 1995: 107). This insight was quite remarkable since it was still a widely held policy belief that prices in agriculture had to be kept low in order to foster industrialization (ibid.,110).

3.2.2 Policy and Institutional Reforms

Subramaniam soon realized that Indian agriculture was a losing concern for the farmer, as he was not receiving returns equivalent to the investments. *"Apart from the uneconomic price which was being given to the farmer while procuring the foodgrains for the public distribution system, there was the other factor that whenever there was an increase in production, prices slumped because the farmer was at the mercy of the traders and since they had no retaining capacity, were forced to sell* *the produce at a low price. Therefore there was no incentive of the farmer to produce more"* (Subhramanium, 1995: 109). This was due to a pricing policy, a legacy which was adopted during the Second World War. Based on his insights, Subramanian prepared a paper and presented it in front of the cabinet, pointing out that the farmer was not getting an economically attractive price and that, if production had to increase, it was absolutely essential that the farmers were assured of an economic price. What followed was a very intense policy struggle on the price front between the Food Ministry on one hand, and the Finance Ministry and the Planning Commission on the other, with the Food Ministry finally getting its way through thanks to the support of the Prime Minister (Subramaniam, 1995: 107, 108). Subramanian as part of an inclusive strategy, thought it would be wise to 'canvas' the support of the Chief Ministers of the different States. On his request, the then Prime Minister Shastri called a meeting of the Chief Ministers, where Subramaniam outlined and explained his agriculture policy proposal. Prasanta Chandra Mahalanobis, who was known as the architect of the "Neheruvian model" of economic development, was also present for the meeting. As an unexpected turn of events, Mahalanobis supported the policy, even though it was radically different from the Neheruvian model that laid emphasis on land reforms and co-operatives as ways to develop agriculture. This model was opposed by Subramaniam's proposal, which prescribed a continuous provision of the minimum support price to the farmers, incentives and investments in new technology and organizations in order to implement the policy following the lines of development of the heavy industries (Subramaniam, 1995: 114).

At the same time, Cummings along with Borlaug met Subramaniam, conveyed that Indian scientists and bureaucracy needed urgent restructuring if the type of success achieved in Mexico was to be repeated in India. This was further confirmed when Subramaniam called an unconventional meeting of all agricultural scientists available in Delhi and asked them to report about the state of affairs freely. The response from the scientists was of complete discouragement and demotivation, as apparently agricultural scientists were considered second or third class scientists. In addition, the Indian Agriculture and Research Institute (IARI) and the Indian Council for Agriculture Research (ICAR) were run by bureaucrats instead of scientists. Following the Parker Committee[17] recommendation of 1962, Subramaniam appointed Dr B.P. Pal, a renowned scientist and plant breeder, as director-general of the ICAR. He also got the pay scales of scientists improved and promoted targeted and time-bound research (Subramaniam, 1995:122). This high powered committee comprising of Indian and American educators and scientists recommended strengthening indigenous research efforts, college level training as well as establishing agricultural universities in all states of the Indian Union (Zeigler et al., 2010). C. Subramaniam layed out the plan of transferring responsibility from the state research organizations to the agricultural universities in a meeting with the Chief Ministers of the States. The plan was met with strong resistance from some of the State governments. However some of the States like Punjab, Haryana, Uttar Pradesh, and Orissa, to name a few, were progressive enough and accepted the proposal and put their universities in charge of agricultural sciences (ibid). The USAID invested in the start-up of the land grant universities, the Rockefeller Foundation helped with the development of the National Agricultural Research System (NARS). The role of the Rockefeller Foundation was seen as important as the NARS was to be the catalyst for the growth of the national research capability. The Ford Foundation helped fund and operate the Intensive Agricultural Districts Program where they financed farm inputs, staff and farm credit (Herdt, 2012)

Subramanian realized early enough that the introduction of agricultural technologies is not a mere question of buying seeds: conducive policies and delivery systems have to exist. He met severe opposition to importing new varieties in Parliament and public fora, especially from left parties, sociologists, some economists, and bureaucrats. *"Political controversies rose with the communists*

[17] The Parker Committee was set up in 1962 to examine the reorganization of agriculture sciences in India.

group in particular projecting it as another way of bringing in American domination to the field of agriculture" (Subhramanium, 1995, pp135). His resistance and fight with the politicians with backing from key leaders like Shastri and later Indira Gandhi was fundamental to the success of the process (Bhagat, 1998). He also oversaw trials of imported varieties under different climatic conditions carried out by Dr. Swaminathan, who was then made the Director of the IARI, and other scientists under his leadership. The Green Revolution thus turned out to be the first example of a multilateral collaboration, where different institutional actors from various level of regional, state, center and global powers were involved. These actors included central research bodies, like the ICAR,[18], donor organizations, like USAID and the Rockefeller Foundation, and the State Agricultural Universities as extension service providers. The final and most important collaborators were the farming communities themselves to whom the agricultural advisory services were going to be provided (Jewitt and Baker, 2007; Yapa, 1997) .

3.2.3 Extension and Input Supplies

Subramaniam prepared a paper titled 'Application of Technology in Agriculture', and despite objections from the Finance Ministry, he was able to go ahead with the massive exercise of importing 10,000 tons of high-yielding Mexican variety seeds for wheat cultivation (Bhagat, 1998; Herdt, 2012). However, before he put his plan into action, he travelled across the country and met farmers to gauge their response since he knew that the proposed "revolution" would not succeed without the support of the farming community. Farmers' clubs were formed all over the country; Subhramanian's earnestness and conviction propelled these clubs. Scientists like Swaminathan at the helm of the scientific community spearheaded the project, and Sivaraman who was the Agriculture Secretary to Subramaniam provided the required administrative support (Bharat, 1998). It is said by the people who knew Subhramanian well that if he had not defied the Indian bureaucratic structure, and not made Shastri and Indira Gandhi his allies, the entire proposal would have collapsed when he left the scene (ibid).

During the initial role out in 1965-66, the feedback from the interactions with the people made the scientists realize that the Indians were not pleased with the texture and the color of the new wheat varieties. They preferred an amber look to the wheat that they would consume. Subsequently, the Indian scientists quickly got down to the job of indigenizing the Mexican varieties, which were a reddish color, along with indigenizing their baking qualities. M.S. Swaminathan, G.S. Athwal, S.P. Kohli, V.S. Mathur, to name a few, took the lead in overseeing this process. Athwal and his team in Punjab Agricultural University brought out a cross-bred variety called Kalyan, named after Athwal's village. At the same time, the Indian Agricultural Research Institute in Delhi, under the leadership of Swaminathan and Kohli, brought out Sona. Kalyan and Sona were in fact derived from the same breeding material, and therefore it was decided to release them together as KalyanSona. Sonalika was another variety developed by Indian scientists from the Mexican seeds (Parayil, 1992).

The Green Revolution in general involved the use of high yielding varieties, commonly called the HYV[19], seeds for rice and wheat. The varieties introduced in India were the IR-8 and the Taichung Natve 1 of rice which was produced in IRRI[20] based in Manila (Jewitt and Baker, 2007; Yapa 1997). The main goal of breeding these varieties was increased yields, but the genetic potential for these yields was only possible through the adoption of a package of improved agricultural practices involving fertilizers, pesticides, and controlled water. In line with the theory of induced innovation, this type of technological innovation was well suited for land-scarce economy, where increasing the

[18] Consultative Group on International Agricultural Research
[19] The High Yielding Varieties are defined as early maturing semi dwarf types which, given intensive agricultural inputs like irrigation, fertilizers, pesticides and so on provide a significantly high yield in comparison to traditional varieties.
[20] International Rice Research Institute.

productivity of land was the main goal. It did not require mechanization, except for pump irrigation, which made it economic to use in areas where production had not been profitable before. Otherwise, mechanization was only introduced on a larger scale in Green Revolution areas when relative wages started to increase (Binswanger, 1986).

Along with the increase in production, the period from 1965-75 also marked the turn from a largely subsistence-oriented agriculture to market-based agriculture in India. The aim was, with 130 million hectares under crops, 13 million hectares or $1/10^{th}$ to be covered under the HYV Programme. The state governments were given the opportunity to fix their own targets. The areas selected were to have progressive farmers and assured irrigation as it had to be ensured that the technology would be a success initially. This kind of introduction of new technology also required that there were confident village level workers, who could be trusted in terms of reliability of knowledge where the farmers were concerned. In order to do so, some of the village level workers were retrained with the sole purpose of looking into agriculture operations. This was part of putting into place the KVKs[21]. Subramaniam was aware that he was racing against time as there was not only the food crisis looming, but there was also skepticism even in global scientific circles that it was a highly ambitious and perhaps undoable plan. Therefore, in order to disseminate knowledge of the new technology as fast as possible to the extension workers and the farmers, Subramaniam initiated the programme of national demonstrations in 1965. As part of this program, large-scale information campaigns were organized by the government in 1966 using radio, press, and cinemas (Subramanium ,1995: 155). In addition to convincing the farmers to use the new varieties, there were questions raised by the administrative panel about the possibility of the losses that the farmer might incur in case this experiment 'did not click'. In order to overcome this hurdle, it was decided that a minimum of two hectares of each field would be selected for the new technology, and in the eventuality that it did not provide a bumper harvest, provisions were made for compensation to the farmer. This was one of the unilateral decisions, which was taken by Subramaniam without waiting for the approval of the Finance Minister (Subramanium, 1995; Shrum, 2000). These parcels of land were entrusted to the extension officers, who were to be based on site and provided training on a regular basis. With the first round being a success, the farmers' demand for the new varieties grew, which led to the import of another 18,000 tons of HYV seeds. Many farmers' organizations came into existence to assist the implementation of the second round of the new strategy. The farmers of Punjab particularly showed a lot of enthusiasm, and one of the farmers' organization set up by them was called as the 'Tonnage Club'. A farmer was only entitled to become a member of the club if he produced not less than one ton of food grains per acre. According to his autobiography, Subramaniam recalls that there was apparently a stiff competition between the farmers to achieve this target and become members of this association. In addition to production, the members of this club also took up propagation of the new strategy among farmers in the neighboring states of Punjab, that is Haryana and Uttar Pradesh (Subramaniam, 1995: 162). It was claimed that four years after the introduction of the HYV on a large scale, the production of wheat had doubled (Perkins, 1997). This was followed by demonstration of new rice varieties, but not on a scale as the demonstration for wheat was done (Parayil, 1992; Shrum, 2000).

3.2.4 The Final Trigger to the Revolution and Food Self- sufficiency

The reforms, along with the idea of introducing the HYVs, were met with opposition from several "old timers" both in the government, which included members of the Planning Commission, and in the ICAR. However, the Minister of Agriculture along with his set of advisors went ahead with the decision to import tons of HYV wheat and kick-started the Green Revolution. Even with the stage set for the revolution to take motion, there were political controversies, which were brewing

[21] Krishi Vigyan Kendras (Farmer Science and Extension Units)

especially with the Communist group, which argued what they perceived as American dominance in the field of agriculture through the import of the Pl-480 variety of seeds. *"The Communists took the stand that I was following the dictates of the United States of America from whom we were getting food aid, in formulating the new policy. As this new agriculture could be fertilizer-intensive, the Communists argued that we would become more and more dependent on the Western countries for agriculture chemicals. I replied that while this was true that in the initial stages we would have to import fertilizers and chemicals, we would take up the production of these chemicals within the country as part of the industrial development"* (Subramaniam, 1995:115).

Though there were no such firm views taken within the Cabinet, a few of Subramanian's colleagues expressed apprehension of introducing an additional uncertainty to agriculture in terms of the unfamiliarity of the particular variety where the farmers were concerned, which may, in their perception, lead to disastrous consequences. This apprehension was further acknowledged by the experts from the Ford and Rockefeller Foundations, who thought that Subramaniam was being over-ambitious. They thought it was an impossible task to get such a large-scale acceptance of the new technology by farmers of far less land holding size as compared to the United Sates where the farmers had farms of 1600-2000 hectares with high level management (Subhramanium, 1995: 157). Taking cognizance of the situation, Subramaniam adopted the strategy of keeping the Cabinet completely informed about what was being done by presenting a paper. However, he was not asking for a Cabinet decision, but rather tried to get the complete backing of, initially, Shastri, and later on Indira Gandhi. Even when he was the Food and Agriculture Minister in the Indira Gandhi Cabinet, the discussions continued, and it was decided that the growing season of 1964-65 would be allowed to pass without the introduction of the high yielding varieties, as another initial year would be used to let all controversies settle and further prepare the ground for the rolling out of the new strategy. Therefore the growing season of 1964-65 was allowed to pass in further preparation of new strategies for the launch in the following year, with great reluctance on the part of Subhramanium. *"The first decision I took was to postpone the large-scale introduction of these new varieties to the farmers' field until 1965-66. I was not happy about the decision but there was no alternative"* (Subramaniam, 1995: 136 and 157).

During the time from 1965-67, India was still importing food grains. Hence, other steps were taken to improve local food production. Kitchen gardens were organized in the area available in large stretches around the official residences of the ministers and bureaucrats, including small stretches in front of ordinary houses for growing vegetables. In Subramaniam's words: *"I myself utilized the entire land around my bungalow to grow wheat, corn and vegetables. The Prime Minister and other Ministers also followed suit"* (Subramaniam, 1995, pp 200). Unfortunately, the 1966 monsoons were a failure, and during that period, Bihar was the most affected along with other states. As a result, the Indian government had to plead with US President Johnson to continue the import of food grains. At this stage, President Johnson introduced the wheat supply on a 'short tether', with the expectation that the Government of India would submit its food needs every month, and his clearance would depend on how far India was implementing its agricultural policy based on the monthly food requirement that the Indian governemnet was submitting to the US government (Subramaniam, 1995, 205). To make matters further complicated, the second Indo-Pak war broke out in October 1965. This led to the suspension of American aid to India, and when it was resumed after the war, it was with conditionalities of policy requirements, not only with regard to agriculture but also to economic policies. As Subramaniam pointed out: *"The short tether policy continued until the spring of 1967. During that season fortunately there were signs of good weather returning and the possibility of India producing a record crop. Dependence on US wheat thereafter continued to decline. On 31st December 1971, we unilaterally terminated the PL 480 agreement declaring to the world that India had become self-sufficient in food grains"* (Subramaniam, 1995: 206-207). In the growing season of 1983-84, India was proudly announcing itself as a self –sufficient food grain producing country (Rosenberg, 197; Shrum 2000).

3.3 Discussion

When Subramanium entered the central political scence, he found himself in a country which had faced a humiliating defeat at the hands of the Chinese. The effect being that Prime Minister Nehru was so demoralized that he almost retired while still in office from active politics and policy decisions. In addition, India trying to feed its millions was faced by two consecutive severe droughts in 1965-66 and 1966-667. This was almost a death-knell when it came to food security, as there was no stock left in the IFC (Indian Food Corporation) and all it could do was to import food grains. With an economy that depended mainly on agriculture, importing food to that proportion was not only not sustainable, but painted a very bad global picture on India's capacity to survive as a nation state, as it was on the verge of another replication of the 1939 famine.

Such extraordinary circumstances required an extraordinary response, which meant a complete overhaul of existing systems and doing what was necessary, even if it meant making some experienced and important people of the Government, and members of the opposition, unhappy. It was in this respect that the will and the vision of C. Subramanian and his strategy of taking trusted scientists like S. Swaminathan, the bureaucracy, Prime Ministers Offices, international organizations and most importantly the farmers, paid off. With the creation of new institutional mechanisms in the form of State Agricultural Research Centers, extension service systems in the form of Krishi Vigyan Kendra, and farmers' groups, Subramaniam set the stage for importing and testing a new system for Indian agriculture. It is usually claimed that the superior nature of the technology was the trigger of the Green Revolution. There is no doubt that a Green Revolution in India could not have happened without the important technical innovation of HYVs. However, as the account of Subramaniam makes it clear, this was a necessary, but not a sufficient condition. Given the restrictive policy environment that India had post-independence till it adopted the liberalization policy in 1991, it would not even have been possible to import HYV seeds. The vision, insights and dedicated efforts of Subramaniam and his team of scientists, along with the support of the respective Prime Ministers, made it possible to override the import policies and change the then existing bureaucratic system which had given more importance to seniority than to merit and expertise.

Starting with the first trial in the late 1960s and early 1970s, India achieved complete food self-sufficiency by the 1980s. The short tether policy of the US Government continued until the spring of 1967. With good rains that particular growing season, there was a production of a record crop. This led to the gradual decline of dependence on US wheat. On 31st December 1971, India unilaterally terminated the PL-480 agreement declaring India's self-sufficiency in foodgrains. The opinions on Green Revolution remain contested. Some look at the Green Revolution as a Cold War anti-communist agenda of the USA. Others glorify it to the level of it being a "sacred cow." What remains undisputed is that the Green Revolution was a necessary and probably the only solution that could address the socio-political and the economic situation of India at the time.

There is no doubt that the Green Revolution was a roaring success. However, like every new method, it had its share of drawbacks. Box 1 summarizes these drawbacks. One of the major concerns is the fact that the Green Revolution led to environmental problems, such as a reduction in soil fertility, excess use of fertilizers and pesticides leading to water pollution, and loss of agro-biodiversity. The fathers of the Green Revolution are well aware of this fact. M.S. Swaminathan has called for an "Evergreen Revolution", which takes environmental problems into account. Since the Green Revolution could only be realized in irrigated areas, it increased the regional inequalities between those areas and the already poorer and more disadvantaged rainfed areas of India. One also had to acknowledge that, in spite of having achieved food self-sufficiency, India still has alarmingly high child malnutrition rates (Abraham, R., 2013). Obiously, increasing food production does not solve all problems that a nation may face in the food and agricultural sector. The Green Revolution was also criticized to favor large-scale farmers at the expense of smallholders. Subsequent research did, however, not support this claim (Box 1).

What has remained undisputed is the fact that India never had to ask for food supply from other countries again. The technological innovations and the institutional reforms that made the Green Revolution possible allowed India to move from the brink of starvation to food self-sufficiency in an unprecedented short period of time, thus helping the country to fully realize what the Indian Independence Movement had fought for almost a century: political self-determination. Perhaps, this is one of the most important lessons that other countries aspiring for a Green Revolution can learn from the Indian case: It is only the combination of a supreme technology with sustained political will and dedicated institutional reforms that can make an agricultural revolution happen.

Box 1. Contested Views on the Impacts of the Green Revolution

- The Green Revolution was criticized for being and remaining as pocketed achievements in the parts of conducive agricultural conditions (Zelger and Mohanty 2010, Yapa 1997)
- The use of the HYV varieties and the accompanying, excessive use of fertilizers and pesticides had led to the degradation of land and irrigation water. This contributed to the pollution of ground water, and weakened natural protection systems by diminishing essential flora and fauna along with having an adverse effect on the health of the farmers (Yapa, 1997, Sobha, 2007)
- It has also been argued that the introduction of HYVs, instead of solving problems of poverty and hunger, was actually making them worse. This argument holds that the new agricultural technology required substantial investments that the great majority of smaller farmers were either unable to make, or if they did so, it was probably only by taking cash loans on such terms as ultimately to impoverish them (Das, 2000, Larson et al. 2004, Pears, 1980)
- However, the research by Jweitt and Baker (2007) challenged the early critiques of the Green Revolution's resource neutrality and accessibility to different land holding groups. This research indicated that, contrary to the popular belief, the large farmers were not the only early adopters of this technology, but some small farmers were early adopters too. By 1972, farmers from all the landholding sizes were cultivating at least some HYV wheat in their fields in Uttar Pradesh (Hazell, 2009; Jweitt and Baker ,2007)
- There were three clear patterns that had emerged as an impact of the Green Revolution in the villages under study. The first one was the significant decline in the proportion of landless households; the second was the reduction in the number and proportion of large landholders and, finally, the increase number of small and marginal farmers (Jweitt and Baker, 2007).
- The Green Revolution had given an opportunity to several landless households to pool together enough money generated from agricultural labour to buy small amounts of land, even though of poor quality, but not stopping them to add in resources and manage it to grow their own cereals and food crops (Jweitt and Backer, 2007)

Maintaining the momentum of the Green Revolution proved to be more difficult after food self-sufficiency had been achieved remained a challenge. One of the important reasons of introducing the minimum support price and subsidies in inputs by Subramaniam as a policy towards food self-sufficiency was to ensure that smallholders adopted the new technologies, as they are otherwise often the losers in the initial adoption stage of a new technology (Fana, Gulati and Thorat, 2008). However, after achieving food self-sufficiency, there was stagnation. After 1987, investment in agricultural research and development dropped to as low as 0.43% of the GDP in 1995 from 0.50%, as the subsequent governments focused more on subsidies rather than research and development. There was only some recovery in later years (Fan et al., 2004), when the growing disparity between agricultural and non-agricultural incomes led to a widespread recognition of agrarian distress.

In hindsight, it also cannot be denied that the support measures to promote the Green Revolution, such as input subsidies and minimum support prices, gave rise to populist and vote-bank strategies for political parties to win elections (Birner, Gupta and Sharma, 2011). Agricultural research and development were neglected in the process. The lesson and the policy implication, if policymakers and governments were to make a Green Revolution in Africa, is to adopt a strategy of sustaining long-term agricultural growth. In order to achieve this goal, it is important that the government builds strong infrastructures as well as institutions by creating capacities and making policy environments where leadership and driving forces are created both at the local and the policy level emphasizing 'learning by doing' while cutting subsidies and increasing investments in agricultural R&D, rural infrastructure, and education (Fana, et al., 2008; IAC, 2004)

Conclusion

The case of the Green Revolution in India underlines how important it is to recognize that investments in agricultural research, both nationally and internationally, are critical to generate technologies that will enhance productivity. However, the historical overview of the Green Revolution and its implementation illustrates also shows the need for complementary efforts in introducing conducive policies and promoting institutional reforms that allow smallholder farmers to adopt the technological innovations. These reforms require political will and visionary leadership at both the political and administrative level, if the desired impacts are to be achieved and maintained. The lessons of the Green Revolution continue to be of utmost relevance in contemporary times, where technologies and solutions are often already available, and yet low productivity and food insecurity looming in front of us, as is the case in major parts of sub-Saharan Africa. The Green Revolution in India makes a compelling case for the need to address the policy, governance and bureaucratic challenges that prevent technology adoption by smallholder farmers. In the Indian case, these challenges were handled in the face of uncertainty under impeccable leadership and assertiveness to make a nation food self-sufficient and guarantee its political independence.

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4. Farmers' Perception of Climate Change, Impact and Adaptation Strategies: a Case Study of Four Villages in the Semi-arid regions of India[22]

Abstract

Climate change poses a major threat to the semi-arid tropics (SAT), which are characterised by scanty and uncertain rainfall, infertile soils, poor infrastructure, extreme poverty, rapid population growth and high risks. These conditions present serious environmental, economic, and social impacts on the agricultural community. In recent years, adaptation to climate change has become a major concern to farmers, researchers and policy makers alike. To enhance policy towards tackling the challenges that climate change poses to farmers, it is important to have knowledge of their perception on climate change, potential adaptation measures, and factors affecting adaptation. There is however little knowledge on the farmers' perception of climate change and on the extent they coincide with actual climatic data. This chapter, using a qualitative approach, looks into the perceptions of the farmers in four villages in the states of Maharashtra and Andhra Pradesh. It looks at climate change aspects in terms of the onset of rainfall, and the distribution of rainfall along with the impact they perceive. It also looks into the accuracy of these perceptions to actual available climatic data. Using the Grounded Theory approach, while exploring the adaptation strategies, the paper looks into the dynamics of who can afford a particular technology and who cannot, and what leads to a particular adaptation decision, in this case improved water management, thus determining the adaptive capacity.

Introduction

Agriculture in India makes up for 14% of the GDP and provides for nearly 50% of the employment (MoA, 2013). Climate is one of the main components that influences agriculture production in India, with large scale impact on food production and the economy (Shukla et al., 2002). The incidence of climate related disasters are on the rise and India, having diverse agro-ecological zones, is prone to more varied kind of climatic shocks like droughts, cyclones, floods, hailstorms, frost, high winds and extreme temperatures which make the farmers more vulnerable (Dhaka et al., 2010). With a population of 700 million small holder farmers the issue of adaptation becomes of paramount importance (Berman et al., 2012). Farmers have been adapting using their traditional methods of coping, of crop rotation and conversation of soil and water, but a lot still has to be understood and documented on how they adapt and the factors that drive them to do so (Banerjee et al., 2013).

Most of the agricultural area in India falls under the semi-arid region (Ryan and Walker, 1990). Climate change poses a major threat to the semi-arid tropics (SAT), which is characterized by scanty and uncertain rainfall, on which agricultural production largely depend: infertile soils, poor infrastructure, extreme poverty, rapid population growth and high risks (Ryan and Spencer, 2001). In such uncertain scenarios, which pose serious environmental, economic, and social impacts on the agricultural community, it is important to understand how the farmers in India perceive climate change and the coping strategies that they resort to, based on their perceptions to change. In the course of this study, it was acknowledged by one of the officials interviewed that the only way effective policies for food sustainability could be made was if the adaptation process of the farmers at the local level was taken into consideration (Banerjee, 2013).

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[22] A revised version of this chapter, is being submitted in the Journal of Natural Hazards

Vulnerability and adaptation strategies are seen to be linked to poverty reduction measures (Halsnæs and Trærup, 2009). Bryant et al. (2000) report that adaptation in agriculture is how perception of climate change is translated into agricultural decision-making process. Studies in Africa have shown that adoption of new technologies identified farm size, tenure status, education, access to extension services, access to market and credit availability are the major determinants of adaptation (Maddison, 2006). To enhance policy towards tackling the challenges that climate change poses to farmers, it is important to have knowledge of farmers' perception on climate change, potential adaptation measures, and the factors affecting adaptation. There is however, little knowledge on the farmers' perceptions of climate change in India and to the extent they coincide with actual climatic data. Further, though research on climate change interactions has evolved from a "top-down" approach to a "bottom-up" approach, (Bryant et al. 2000; Wall and Smit, 2005; Belliveau et al., 2006), there are still certain assumptions that the adaptation measures that the farmers resort to are profit driven rather than climate change driven (Maddison, 2006 and Nhemachena and Hassan, 2007).

One of the biggest threats posed by climate change in India is water scarcity both for agriculture use and for domestic purposes. Climate change threatens to alter the quality and the distribution of water and is having adverse effects on water-sensitive sectors like agriculture (NAPCC, 2008). Using a qualitative approach, this chapter looks into the perceptions of the farmers in four villages in the states of Maharashtra and Andhra Pradesh focusing on climate change in terms of the onset of rainfall, and the distribution of rainfall along with the impact they perceive. It also looks into the accuracy of these perceptions to actual available climatic data thus providing further ground in considering their importance in the adaptation process. While exploring the adaptation strategies, water emerged as one of the key areas where coping mechanisms are being practiced. The chapter therefore looks into the dynamics of who can afford a particular technology and who cannot and what leads to a particular adaptation decision, thus determining the adaptive capacity in water management.

4.1 Literature Review

4.1.1 Impacts of climate change

Climate change in India is expected to have serious environmental, economic, and social impacts, particularly on rural farmers whose livelihoods depend largely on rainfall (Vlek & Manschadi, 2010). In a study done by the Indian Council of Agricultural Research (ICAR), it was estimated that the increase in temperature may lead to decrease in yields of leguminous crops, though may lead to marginal increase in yields of cereal crops. It was further estimated that increased incidence of droughts and floods may lead to the possibility of increase in pest attacks and diseases (Aggarwal, 2009). The increase in pests and diseases may lead to higher use of pesticisides, thus creating higher and unsafe levels of pesticide residues in the food supply chain thus posing a major threat to food security (FAO, 2004). The impact of climate change on Indian agriculture is likely to be negative over the short- to medium-term, estimated at about 9% by 2039 (Guiteras, 2009). The Indian Government's National Communications (NATCOM) report of 2004 identifies the impacts of climate change from 2011 to 2100 to be a decrease in snow cover with erratic monsoons affecting the rainfed agriculture, water and power supply. It is estimated that wheat production will drop by 4-5 million tonnes, with a rise in temperature of only one degree centigrade (GIZ, 2011). A study done by The Energy and Resource Institute (TERI), has estimated that a sea-level rise of one meter could inundate 0.18% of land in the Maharashtra risking the lives of 1.3 million people. In addition, it could adversely effect sugarcane production because of changing climate (TERI, 2009). The Andhra Pradesh State Action Plan on Climate Change (SAPCC) report further points to the risk of loss of livelihood because of airborne and water diseases along with health effects due to extreme weather. The reports further states that impact of climate change will be further manifested through acute water shortage and loss of crops due to extreme weather conditions and rise in temperature (SAPCC, 2011).

4.1.2 Farmers' Perception to climate change

Earlier studies in Africa have shown that farmers' perceptions of change relate to the increased variability and uncertainty of specific climatic parameters (Gumbo, 2006; Mertz et al. 2009; Osman-Elasha et al., 2006; Thomas et al., 2005). Some of these perceptions include late onset of rains, shorter wet monsoons characterised by slight but intense rainfall, strong winds with excessive rains, more intense summer heat and unpredictability in the pattern of the seasons. However, there are only a few studies in India which highlight the importance of recording the perceptions of the farmers. One such pilot study study was conducted in two villages in the state of Uttarakhand in India. It was found that almost all the households interviewed felt that rainfall had declined in quantity and timely onset of monsoons could no longer be relied on. Respondents noted a decrease in scattered light rainfall, useful for percolation, and an increase in intense rainfall which destroyed crops and increased run-off rates as well as soil erosion. They also observed a decline in groundwater with increase in heat intensity (Kelkar et al., 2008). Further, very few descriptive studies on perceptions have been conducted in the drylands of India (Dhaka et al. 2010). One such study which was conducted in South Africa, observed that for farmers and other land users, drought and extreme rainfall were not necessarily sufficient to determine the characteristics of climate variability (Gbetibouo, 2009). Within the general phenomena of rainfall variability, intra-seasonal factors (Tennant and Hewitson, 2002) including the timing of the onset of first rains, which affects crop planting regimes, the distribution and periodicity of rain events within the growing season (Mortimore and Adams, 2001), and the effectiveness of the rains in each precipitation event (Usman and Reason, 2004), represent the impact that it could have on the success of farming (Levey and Jury, 1996). Therefore, more descriptive and qualitative studies are needed in India to understand the perceptions of the farmers in the drylands.

4.1.3 Adaptation

Adaptation includes actions and adjustments undertaken to maintain the capacity to deal with stresses induced as a result of current and future external changes (Banerjee et al., 2013). Given the scenario, understanding adaptation at the local level becomes very crucial especially in the SAT region where most of the rural livelihood is dependent on agriculture. In order to explain this adaptive capacity, the use of the capability approach becomes helpful especially in understanding adaptation to vulnerability. The approach attempts to look at equity and justice issues of households who spend a major part of their lives collecting resources to meet their basic survival needs (Liverani, 2009). The process of adaptation is complex as it involves many interconnected actors and factors, and their interaction with their environment including the resources available to them and the institutional set-up. (Edwards and Steins, 1999, and Mehta et al., 1999, both cited in Adger et al., 2003, pp 1100).

Recognizing the imminent threat posed by climate change the Indian Government came up with the National Action plan on Climate Change (NAPCC), which was released on 30th June 2008. It outlines measures on climate change related adaptation and mitigation while simultaneously advancing development. (NAPCC, 2008). A survey conducted in the small village of Spitti in the Indian state of Himachal Pradesh demonstrated that most farmers had been made aware of the changing climatic conditions by the problems they faced in their day-to-day life. Though farmers were already adapting to these changes using their own capacities, there was further need to make them aware and get accessibility to new technologies in order to increase their adaptive capacities towards efficient adaptation strategies.

Food production in India consumes the largest amount of water (IWMI, 2007). In order to mainstream climate change issues in the water sector, the Indian Government as part of the NAPCC came up with the National Water Mission in 2009. The mission highlights conservation of water, minimizing wastage and ensuring more equitable distribution through Integrated Water Resources Management (NAPCC, 2009). In order to achieve this it will require building the capacities of both the local community as well as the institutions responsible, as strengthening the capacities of the local community is vital towards the building of adaptive capacities and overall resilience towards climate change (GIZ, 2011).

4.2 Methodology

4.2.1 Study areas

A combination of literature review and inductive research was used to be able to identify in an inductive way from empirical cases those factors that may have been neglected in the literature on perceptions and adaptation to climate change. Following a comparative approach, four villages were selected, two each in the states of Maharashtra and Andhra Pradesh which fall in the semi-arid regions of India. Two villages in Maharashtra were chosen in the Nasik district, in collaboration with the Society for Promoting Participative Ecosystem Management (SOPPECOM) and the two villages in Andhra Pradesh were identified in the Guntur district with IWMI (International Water Management Institute).

4.2.2 Methods

The study began with a conceptualization based on uncertainty and variance of climate , and the recognition of this uncertainty as a risk of water shortage or unavailability for agriculture as a livelihood practice. With that knowledge, the actions to overcome or cope through technical and institutional innovations were elicited. Through the use of an adaptive management approach, an attempt was made to develop the history of a particular initiative over a certain period of time by groups and individuals across gender and class of farmers. The focus was on identifying key innovations that took place (or are taking place) and investigating how they would allow the objective of coping against climate variability to be achieved. In the process of analysis, however, the importance of adaptive capacity emerged in determining the dynamics of who could afford a particular technology and who could not and the process that leads to a particular adaptation decision. A qualitative approach was used to further study these factors based on information received from the field. The method of analysis used was based, as already mentioned, on inductive research (Strauss and Glaser, 1967). For this particular study, it was imperative to begin the research with an explorative and iterative approach to data collection. The gaps that appeared in the theoretical representation of initial interviews, documents, and observations were filled by follow-up visits and interviews. Adopting this approach gave the flexibility and methodological rigor needed to guide the research to fit the data collected in the field (Banerjee et al., 2013). The process was iterative whereby attempts were made to keep clarifying the understanding of climate change by the respondents. It freely allowed the respondents to give their own interpretation of ‘why’ and ‘how’ the process was happening and ‘where’ and ‘what’ was their role in the process of adaptation based on this understanding.

Purposive sampling was used to identify different categories of farmers, women, and other key informants and compare their perceptions of climate change and consequent water management practices. The farmers were separated into large, medium, and small on the basis of landholding size. The categorisation was based on the understanding that each group might have different levels of vulnerability and adaptive capacity based on their resource base and factors affecting the same (Table 1).

Table 1 Landholding size (ha) across four study villages

Category	Nas 1	Nas 2	Gtr 1	G tr 2
Small	0.2-2.0	0.2-1.8	0.2-1.2	02.-0.9
Medium	2.0-5.3	1.8-5.3	1.2-3.2	0.9-2.1
Large	>5.3	>5.3	>3.2	>2.1

Source: Adapted from Walker and Ryan (1990) in Banerjee et al. 2013

Focus group discussions (FGDs) and individual interviews were carried out with the guidance of semi-structured questionnaires. The information gathered was triangulated by means of narratives, timelines and transect walks. A total of 16 FGDs and 273 individual interviews were conducted as part of the process (see Table 2). Based on the principle of theoretical sampling, additional interviews were conducted in the study sites to further explore the influence of adaptive capacity in water management practices that had emerged from earlier interviews and FGDs. Since no new information emerged from this, the data was deemed "theoretically saturated" from the earlier designed FGDs and interviews.

Table 2 Breakdown of FGDs and personal interviews

	Nas 1	**Nas 2**	**Gtr 1**	**Gtr 2**	**Total**
FGDs	Timeline Medium + large farmers Small farmers Women	Timeline Medium + large farmers Small farmers Women	Timeline Medium + large farmers Small farmers Women	Timeline Medium + large farmers Small farmers Women	
Total	**4**	**4**	**4**	**4**	**16**
Individual interviews	25 Large farmers 21Medium farmers 21 Small farmers 1 Key informant	25 Large farmers 21 Medium farmers 24 Small farmers 1 Key informant	20Large farmers 21Medium farmers 21 Small farmers 1 Key Informant	21Large farmers 20 Medium farmers 21 Small farmers 1 Key informant	
Total	**68**	**71**	**62**	**62**	**263**

The interviews recorded during the process of data collection were transcribed in verbatim. The coding process was the most important part of the analysis as it formed the basis of the emerging findings related to adaptation strategies in management of water in the community, the governance challenges and most importantly the driving factors that lead to a particular adaptation decision. The coding process was done with the help of NVVO. The field notes served the initial memos which were integrated in the final stage of analysis as a way of filling the gaps (Emerson et al., 1995).

4.3 Findings

4.3.1 Profile of the study sites

The district of Nasik is located in the northwestern part of Maharashtra with an average rainfall of 600-1500mm, varying from one block to another. The main crops grown are pearl millet and maize with some paddy grown in the tribal regions of the district (M. Government, 2011) . The village Nas 1 is located in about 25kms from the main Nashik city and falls in the Niphad block. This village has been subject to regular variances in weather and was claimed to be facing acute water shortages both for agriculture and drinking, which was rectified to a large extent after the formation of the Water Users Association in 1991. The village Nas 2 on the other hand is located about 120 kms from the main city and comes under the Yewla block. Primarily known for being a rain shadow area, the overall infrastructure is poor and accessibility of transport on a regular basis is difficult. The unique feature of this village has been a perennial canal which was constructed during the colonial times in the mid-1900s, to supply irrigation water for agriculture.

Guntur district is located along the eastern coast of Andhra Pradesh with an average rainfall of 830mm and decreasing from the east to the west. The main crops grown in this district are paddy, tobacco, cotton and chilies, though in both the study villages the cultivation of tobacco has been stopped by the farmers (A. P. Government, n.d.). The village Gtr 1 is located about 40kms from the main city of Guntur and falls on one of the state highways of the district. Most of the agricultural land is under irrigation. The village Gtr 2 on the other hand is located about 100 kms from the main city and is relatively isolated. At its first appearance, it appears as a village which has been neglected both socially as well as infrastructure-wise. Availability of water is an issue of constant conflict with patronage and preferential treatment playing a very crucial role in accessing it, thus rendering the role of local institutions unclear. A brief socio-economic profile of the study villages is given below (Table 3).

Table 3 Socio-economic profile of the four villages as of 2011

Characteristics	Nas 1	Nas 2	Gtr 1	Gtr 2
Cultivable land (Ha)	1500	4528	1061	2050
Total number of households	1250	1200	600	700
Average family size	5	4	4	4
Literacy rate (2001-04)	50%	60-70%	60%	25%
% Below poverty line	20%	24%	25%	50%
Average annual rainfall	550-600ml	500-550ml	890mm)	650-700ml
Soil type	Blac, Semi-sandy	Sandy, Black, Lime, Mix Alluvial	Black Cotton Soil, Red	Black, Red
Sources of irrigation	Well, Canals, Borewells (Conjunctive Use)	Wells, Borewells	Canals Lift Irrigation	Well, Borewells, Canals
Major crops grown	Grapes,	Soyabean,	Cotton,	Cotton, paddy,

	soyabean,on ion, vegetables, wheat	onion,veg etables,su garcane, maize, cotton, wheat	paddy chillies	chillies

Source: FGDs and from Local Village Offices 2012

4.3.2 Perceptions of change in climate across four villages

In the four villages under study it was established that farmers perceived and responded to climate variability and extreme conditions rather than the long-term change (Fig 1 and 2) .

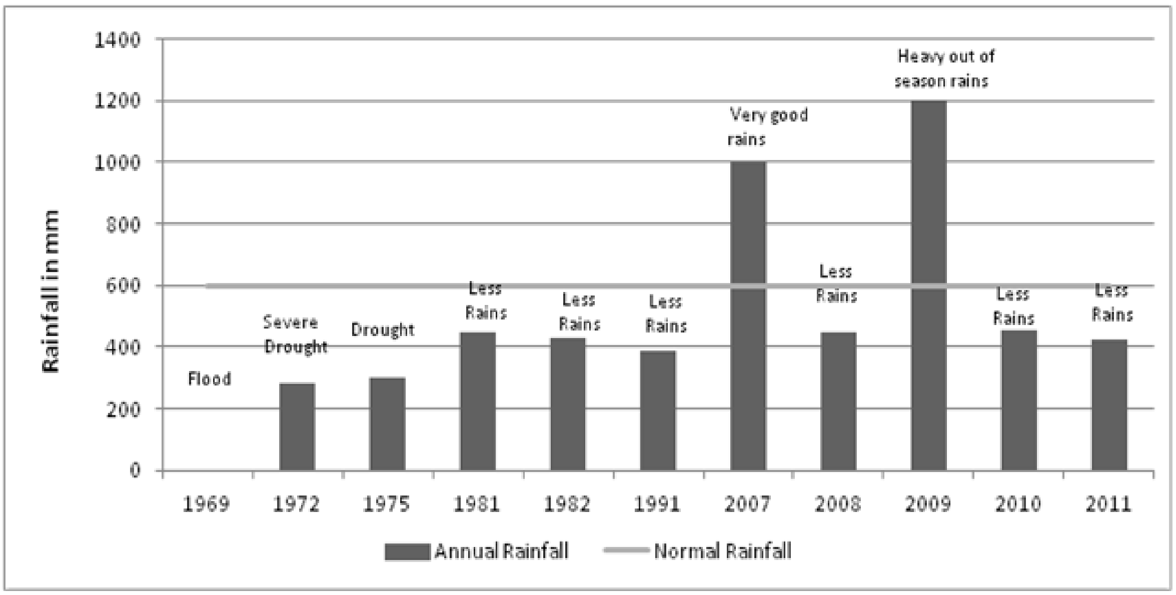

Figure 3 Nasik District Meterological Data vs Perceptions of Farmers to Climate Shocks

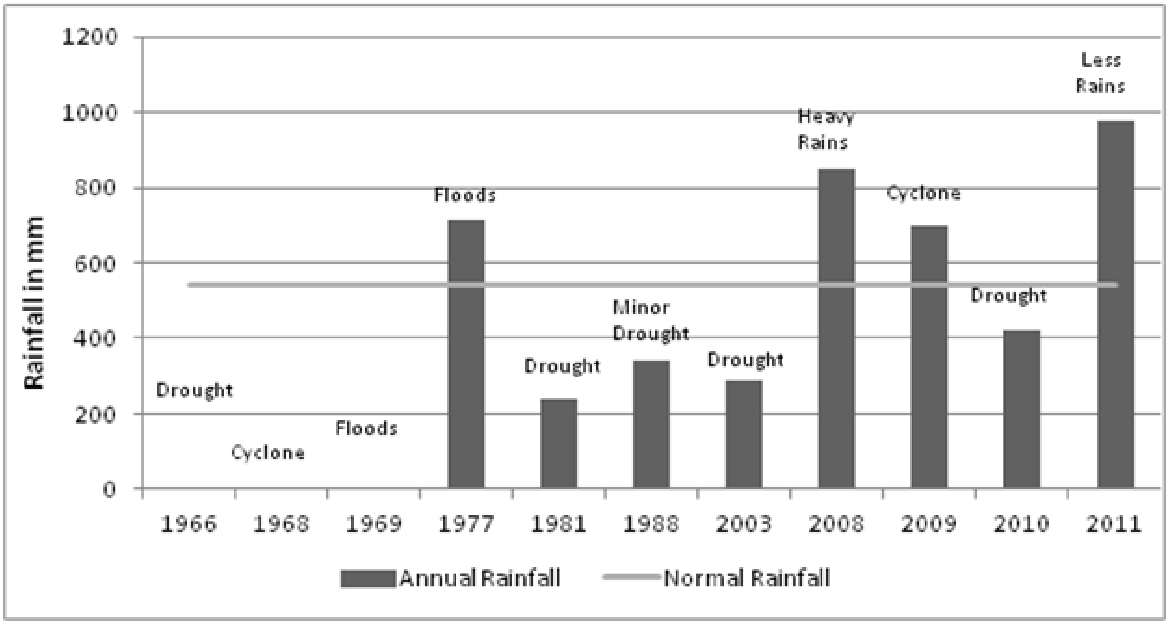

Figure 4 Guntur District Meteorological Data vs Perception to Farmers to Climate Shocks

As can be seen by the figures 1 and 2, the level of accuracy of the meteorological data and the perception of the farmers which was recorded through the timeline exercises in the study areas matched quite accurately. It was interesting to note that the farmers could trace back climatic shocks to dates for which even the Department of Irrigation in Nasik and the Agriculture research station in Guntur did not have available data.

The effects of climate variability were most felt in the villages of Nas 2 in Maharashtra and Gtr 2 over the years in Andhra Pradesh. These were villages which had poor infrasturture facilities as compared to the other study villages and accessibility to these areas was quite tough. The farmers had increasingly noticed variability in climate over the past five years. Farmers felt that there had been an increase in temperature and the women confirmed it by expressing that it was getting difficult for them to work in the fields because of extreme heat and unprecedented cold temperatures (Table 5). The farmers also perceived that there had been significant variations in the quantity and distribution of rainfall over the years. They believed that the rainfall was more intense, with fewer rainy days, and had an extremely erratic distribution.

> *There is rain in one part of the field whereas it is absolutely dry in other parts. We also sometimes see that there is rain in my field whereas my neighbor's field is absolutely dry. When we discuss amongst ourselves, there was this farmer who was telling us that the way it rains and it is so concentrated and erratic that when the bullocks are out in the field and the rain comes, one horn gets wet and the other horn of the bull remains absolutely dry. That's how bad the distribution..*
>
> \- *School Teacher also small Farmer (Nas 1)*

Compared with the 1970s, when rainfall accounted for 120 days on average, it was perceived by most to have currently reduced to an average of 45 days across the four villages (Table 5). Most of the respondents expressed concern about unseasonal rain in the months of May and October in the villages of Maharashtra and December and January in the villages of Andhra Pradesh, which according to them was becoming common since 2008. For the villagers, the fact that the months of June, July and August did not bring much rain in terms of quantity and distribution especially in the past five or six years indicated that climate had become more variable, rather than suggesting a consistent change. Though most of the respondents attributed the variability to cutting down of trees and pollution, a few of the farmers thought the phenomenon was as a result of global warming.

Table 4 Perception of farmers on changes in rainfall patterns and temperature

Respondents	Rainfall				Temperature			
	Onset		Number of rainy Days		Summer	Winters		
	Late (> 30 days)	Both Early* and Late	Same	Reduced	Increase	Fluctuation **	Decreasing ***	No opinion
Nas 1	76%	24%	44%	56%	100%	59%	37%	4%
Nas 2	62%	38%	38%	62%	100%	54%	55%	0
Gtr 1	83%	17%	16%	84%	100%	65%	29%	6%
Gtr 2	79%	21%	1524 %	76%	100%	15%	85%	0

Rains coming mid May instead of 7th June ** Sudden waves of cold then warm again ***Warmer winters than usual
Source: Individual Interviews taken in study villages across respondents

4.3.3 Perceived Impact of climate variability on crop production

Climate variability was perceived as presenting a risk to the farming communities amid concerns that income through agriculture had drastically reduced. Though primarily irrigated areas, in 2009, farmers in Nas 1 lost about 70% of grape crops and Gtr 1 lost most of the chilly crops; the worst sufferers being the farmers without irrigation. 80% damage was sustained by? the onion crops in Nas 2. This was as a result of untimely, unseasonal rains which came during the harvest time of the mentioned crops. However, the respondents of the four villages were quick to inform that some of the farmers, who were able to save some of their produce from the untimely rains, took advantage of the situation and sold their produce at higher rates than what they would have got under normal circumstances.

Concern regarding the availability of water for household and drinking purposes and rearing livestock was evident in the poorly connected and developed villages, where it was mentioned that in case of Nas 2 the wells were dry and they were receiving water from the local authorities once in every 8 days. In case of the Gtr 2, the water from the wells was contaminated and they were relaying on tanks to receive drinking water, which was about 4km accessibility from the village. With regards to crops like soybean and cotton, farmers have had to resow seeds because of the uneven distribution of rainfall and delay in the onset of rains followed by dry spells. In all the four villages, farmers complained about the increases in pest attacks and diseases; which were attributed to the delay in the monsoons, increase in temperature, less water availability during sowing season and subsequent delay in sowing. The attacks were further escalated by humid and cloudy conditions[23]. Higher temperatures were also seen to cause second-order impacts. With the increase in temperature, some of the micro-organisms which were there in the soil and were useful for the health of the crops had been killed. Women in all the four villages expressed concern that, because

[23] White fly was identified as one of the pests which was observed to have increased in the past 5 years for the paddy crops by the respondents in Gtr 1

of higher temperatures, grain that was stored in the houses was beginning to spoil at a much faster rate than previously.

Farmers expected a good harvest if the onset of rains was timely and crops were planted at the right time. However, the indigenous variety of cotton was felt to yield hardly any worthwhile production in the current situation. On speaking to the local veterinarian in Nas 2, he confirmed that the availability of fodder was seen to be decreasing over the years, thus affecting the production of milk and the capacity of the animals to work in the fields. In addition he informed that the increased use of pesticides was having a negative effect on the health of the livestock and quality of the milk produced.

4.3.4 Adaptation behavior and capacity

As the farming community identified the issue of water shortage as one of the major impacts besides increase in pest and disease attack, further probing was done to understand the adaptation decisions and the perceived capacity across the study villages.

Cropping Patterns

In all four villages, there was a diversification in cropping patterns which had taken place, a shift from food crops to vegetables and commercial cropping. In Nas 1 it was observed that about 90% of the respondents across land holding size had shifted to grape production along with vegetables and some fruit orchards. In Nas 2, sugarcane emerged as the major shift in cropping patterns along with maize, soyabean and leafy vegetables dominating the cropping scene. In the villages of Andhra Pradesh, the respondents informed that the proportion of paddy had gone down to almost 20% from 50% in the last 20 years and was replaced by increase in areas of chillies and wood plantations; the barks of which were used as pulp in the nearby paper factories. In addition, horticulture was being promoted with the help of government schemes in Gtr 1. The influence of the local Water Users Association was seen to be playing a major role in determining the cropping decisions of the farmers in Nas1 and Gtr1, whereas in Nas 2 and Gtr 2 the cropping decisions were based more on 'learning by doing' on an individual basis, market demand and better yields with less usage of water.

Water management practices

In Nas 1, the usage of drips was seen as a common phenomenon primarily due to grape production and vegetables. The influence of the WUA has prompted most of the respondents to work on means to conserve water either in their wells, or dig small pits in the their fields to prevent water from running off; thus economising on the water usage as well as the water tax that was levied by the WUA on each rotation of water given. Some of the more enterprising farmers invested in creating a surface pond inspite of land constraints and lack of formal financial access, as a means of storage facility of water for future use given the perceived scarcity of water resulting from the variability in climate. The issue of drinking was taken care of in Gtr 1 through collaboration of the WUA with one of the leading NGOs in the southern region, and was transforming waste water to mineral water and selling it in the community at a nominal price of Rs. 30[24] per 5 litres. The mineral water plant was claimed to be run collectively by the villagers. The use of drips was limited to only a few of the respondents who were into fruit orchards, and the reason for the low usage, inspite of acknowledging its advantage of less water requirement, was attributed to the blockage caused in the pipes by the waste water which was also used for agriculture purpose through lift irrigation.

Individual efforts of building furrow channels, usage of drips were seen in Nas 2, though it was claimed that the presence of the perennial canal in the village was a solution to water problems at

[24] Equivalent to 50cents in USD

least where agriculture was concerned. The construction of the surface ponds were dominated by the large farmers having land size over 10 acres; according to them this was seen possible since they had the necessary influence with the local government officials to get the required benefits. In Gtr 2, there was a minor attempt seen in water management practices. Most of the respondents relied on a check dam and the availability of the canal water for irrigation. Some of respondents, who had surface ponds, had done so either because traditionally it was present through generations, or because they had large plots of land and the necessary 'contacts'. Most of them claimed that they had applied for drip irrigation but the lack of initiative from the local authorities to issue the subsidies had made it unaffordable at the current stage. However, in both Gtr 1 and Gtr 2, the practice of building bunds was seen as a continuous practice because of growing paddy.

When asked to identify the best water management method, most of the respondents across the study villages, felt that check-dams were the best solution as it did not require much initial investment as compared to surface ponds; nevertheless they were of the opinion that it was the government's responsibility to ensure that they be maintained. The reason cited was the difficulty of collective action towards its maintenance by the community because of class, caste and ownership differences.

Other means

Besides the use of drips, furrows, surface ponds and ditches to manage water and occasional checkdams, some of the farmers in Nas 1 and Gtr 2 had taken up the use of 'shed-nets[25]' to grow their vegetables. Though the initial investment was claimed to be quite high, the reason for this was cited as the ability of the farmer to control the use of water and temperature. This prevented the crops from being exposed to the untimely or out of season rains and variations in climate, which were claimed to be on the rise. The election of a female village head in Nas 2 had led to the organization of a Farmer Field School in 2011 which provided training to the female farmers on integrated crop management practices with particular reference to the Sorghum crop, though sugarcane and onions were the main crops of the particular village. In addition, some of the traditional practices like mulching and crop rotation were seen as effective ways of conserving both the moisture and the soil fertility in the study villages.

> *Whatever was taught to us in the FFS was no doubt very good and also very useful to us but you see we are not really Jowari growers, we grow onions, sugarcane, soya bean, maize and wheat mainly so in the next FFS if they could give us training on either one of these crops in terms of how to use water efficiently and what to use and what not to use that would be really very useful to us*
>
> *-FGDs Women Farmers (Nas 2)*

4.4 Discussion

Studies over the years have acknowledged that for the farming community which largely depend and utilise natural resources for livelihood (Thomas, Twyman, Osbahr, & Hewitson, 2007), climate change may pose a significance threat through occurrence of extreme events. Though, there have been various climate models and predictions, which have suggested a widespread impact especially in the SAT regions, and a knowledge gap has always remained in terms of understanding how the farming community perceive these changes and the influence these perceptions have in the adaptation decision making process.

Through a qualitative study and carrying out a timeline exercise with the respondents of the four villages it was seen that the farmers have been perceiving climate variability through late onset of

[25] Shed nets comprise of the use of a nylon net to cover the particular area of the vegetable crops along with polythene strips. The initial investment for setting up a shed net is about $500.

rains and out of season rains. The most concerning for them has been the change in the distribution of rainfall and the intensities that they come with. The recorded scientific data often do not acknowledge the distribution of rainfall as an important indicator of increase in variability. The perceptions of the farmers were further corroborated with the meteorological data showing almost complete accuracy on the year of the climatic shocks. It was seen that largely the perceptions of the community to changes in rainfall patterns did not differ much within gender or farm size, however the women emphasised the change in temperature as it had adverse health effects on them. The actual temperature data was unavailable in the district offices of both Nasik and Guntur and thus prevented a comparison with the observation of the respondents.

The observed impact in terms of the increase in pests and diseases due to uncertainty in rainfall and climate along with loss of yields because of untimely out of season rains, is consistent with scientific assessments (Moorhead, 2009). In addition, what needs attention is that such unpredictability has led to the loss of a cropping pattern where the farmers are concerned. Most of the farmers in all the four villages had diversified to short duration crops like vegetables, following the spontaneity of the weather to sow their crops; thus showing that the cropping decisions were being largely dominated by the weather and the climatic conditions rather than seasonal routines, explaining the sharp decline in the production of food crops.

Though the areas studied fall largely under irrigation, the concern that there is a potential water shortage has led the farming community to explore either individually or through an institutional set up for judicious water use; one of the way being shifting to short duration crops. However in Nas 1 decisions like growing grapes, orchards sugarcane in Nas 2 or even wood plantations in Gtr 1 and Gtr 2 raise questions on the decision making of the farming community, as all of them are high investment crops. It appears that the ones who have made these choices, which in the case of the study villages are cross section of farmers irrespective of land size, is because of one-time, long-term investment along with usage of less water. The usage of less water has been through the utilising drips and getting returns for at least 5 years on an average through growing the aforementioned crops. Such insights from the field, leads to re-examining definition of judicious water use from the community's point of view and warrants further research into the economics of such adaptation strategies.

Of the four villages, the ones which were well connected with roads and seemingly better infrastructure, were those where the WUAs seem to be playing a significant role in determining the crop choices and also driving people to make choices of water management practices. The leadership and the faith of the community in the institution of the WUA, and the expectation that it should be guidance for future water management practices, seems to be making these WUAs as mediators between the individual and collective responses to climate impacts (Adger et al., 2000 cited in Banerjee et al. 2013). On the other hand, though initiatives of conducting Farmer Field Schools (FFS) by the local government in collaboration with the Department of Agriculture(DoA), was welcomed by the farming community in Nas 2, the irrelevance of the training given in integrated crop management for sorghum as stated by the respondents, is an example that both local authorities and the DoA have to adapt based on the needs of the community, if they are to respond to climate risks in a better way as Nas 2 was practically a non sorghum growing area.

If one were to compare the findings of the study with the objectives of the National Water Mission of the NAPCC, access of information still remains a problem in all four villages. Even though two of the four villages were well connected by roads, information asymmetry remained an issue and most of the farmers relied amongst themselves or were enterprising enough to attend exhibitions and demonstrations which were being held in other parts or states of India. In the other two villages, there were only a handful of farmers, especially the big farmers who had access to information as the extension agents were choosy in picking their clients. This had led to prevalence of patronage among the local community. It was seen that entitlements like financial and information access, technological inputs, and infrastructure support, while playing a critical role, were of importance only if there was access to land. In most cases of Gtr2, where most of the small farmers were working on leased lands and did not have much say on the cropping or technological decision, there is evidence that access to instrumental freedoms, namely political freedom, economic facilities, social opportunities, transparency guarantees, and protective security (Nussbaum, 2003; Robeyns, 2005 cited in Banerjee et al. 2013), is necessary for a better quality of life.

Though some of the enterprising farmers in all the four villages irrespective of the land size were adopting methods of water conservation through building surface ponds, it cannot be ignored that formal financial access and credit continue to be a major constraint which also largely determines the farmers' capacity and willingness to take risks or adopt a particular technology as part of the adaptation process (Banerjee et.al., 2013). Further, the insinuation by some of the respondents especially in Nas 2 and Grt 2, the villages which were poor in infrastructure, that being of a particular caste entitles or deprives them of certain benefits and schemes, raises concerns of adaptive capacity being determined and the continued prevalence of discrimination based on caste in the study villages. Further looking at the issue of ownership of land and decision making by women in the study villages of Andhra Pradesh through the capability approach, the women showed that there was willingness among them to explore and adopt, assuming they had the required institutional support to do so. This becomes particularly an important area to be looked into especially considering that in Andhra Pradesh women have no land entitlements.

Indian agriculture, especially in SAT India, is extremely sensitive to climate change and its impact is increasing over time (Bantilan et al., 2006). Therefore, there is a further need in understanding the process of local adaptation and innovation especially in the area of water management based on the perceptions of the farmers on climate change. In addition, government policies should work on schemes which enhance farmers' access to affordable credit, along with land entitlement to women as they form the core and a very important aspect of household decision making. Furthermore, given the inadequate extension services and the total loss of faith in it by the farming community, improving the knowledge and skills of extension service personnel about climate change and adapted management strategies, increasing extension farmer ratio, and making the extension services more accessible to farmers are consideration that the policy framework should look into as key components of a successful adaptation program. Moreover, enhancing the capacities of the institutions which are being the service providers to the farming community also needs to be addressed on an urgent basis, if a holistic adaptation strategy and mitigation process is to be achieved to tackle the increasing effects of climate variability and shocks.

Conclusion

It is been increasingly recognized that institutions and innovations promoting water efficiency have great potential for improving livelihoods and increasing food security in areas which are most vulnerable because of changing climate (Rockström, 2000, 2003; Ngigi et al., 2005). For a small holder farmer in the drylands to have the adaptive capacity to invest in a technology, he/she should have a very clear idea of the risks and benefits of the potential of the technology (CCAFS, 2012). Therefore, there is further need for facilitation of participatory decision making processes and experimentation through the process of Institutional Learning and Change (ILAC). For this it is important that there be a robust extension system since in the drylands, where most often than not the education level is low, it is the extension system which can instill confidence in a farmer to adopt a technology which will help him/her adapt towards a secure livelihood system. Moreover, such a robust extension system can only be in place if there is an enabling national policy environment which supports investments in agriculture research and development, drives sustainable productivity growth, and supports local best practices for water management in particular and natural resource management in general.

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5. The Role of Individual Agency in Participatory Irrigation Management: Lessons from India[26]

Abstract

The devolution of authority for natural resource management to local user groups has been an important approach to overcome the long-standing challenges of centralized state bureaucracies. In India, this approach has been implemented through the creation of Water Users' Associations. The literature on common-pool resources, following the seminal work of Elinor Ostrom, has identified important design principles that can enhance the efficiency, equity, and sustainability of local user groups. However, in spite of intensive research on this issue, knowledge gaps still remain regarding the question as to why some local user groups are able to overcome governance challenges, such as 'elite capture', while others--that work under the same design principles--are not. The paper addresses this knowledge gap by conducting a qualitative case study, using the Grounded Theory approach. The study covered four villages, two each in the states of Maharashtra and Andhra Pradesh. It was found that two villages were able to minimize governance challenges such as elite capture, rent seeking, and patronage, which enabled water distribution to become a community activity. The other two villages have, despite local governance guidelines and incentives, failed to live up to the participatory approach and they are dealing with challenges such as lack of collective action and accountability as well as social exclusion. The Grounded Theory approach identified individual agency as a major factor that plays a significant role in the success of participatory irrigation management. The study draws conclusions on how local leadership, a factor that has been neglected in the current literature on common pool resources, can be promoted to facilitate participatory irrigation management.

Introduction

The issue of water related innovation and technical change sits at the heart of agricultural development and remains a potentially critical driver of social and economic transformation in the agrarian based economy of the semi-arid tropics. However, case studies show that in addition to having appropriate technology, it is also necessary to have viable arrangements for production, marketing, retailing, collective action, and inclusiveness of various sections of community (Hall et al., 2007; Kulkarni, 2003).

Participatory Irrigation Management (PIM) therefore has been conceived as a way for effective irrigation management by involving and associating farmers in planning, operation and maintenance of the irrigation system. However, institutional aspects of farmer participation in irrigation have received less attention. Like many countries, many states in India, through the devolution of authority, are looking at higher levels of involvement of farmers in the operations and maintenance through irrigation management transfers (Madhav, 2007). The devolution of authority for natural resource management to local user groups has been an important approach to overcome the long-standing challenges of centralized state bureaucracies. In India, this approach was implemented in irrigation management through the creation of Water Users' Associations (WUAs), following the guidelines issued by the Ministry of Water Resources in 1987 that aimed to enhance the farmer participation in irrigation management. WUAs are also expected to facilitate local adaptation to climate change through improved irrigation management.

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[26] A revised version of this chapter co-authored by Regina Birner, is has been submitted in the Journal of Society and Natural Resources. In the view of the publication of this chapter as a stand-alone paper, some of the information provided in the preceding chapter has been retained for this chapter as well.

The literature on common-pool resources following the seminal work of Elinor Ostrom has identified important design principles that can enhance the efficiency, equity and sustainability of local user groups. Ostrom introduced the institutional analysis and development framework (IAD), which is a multi-tier conceptual map identifying the action arena, the resulting patterns of interactions and outcomes, and eventually evaluating these outcomes (Fig.1).

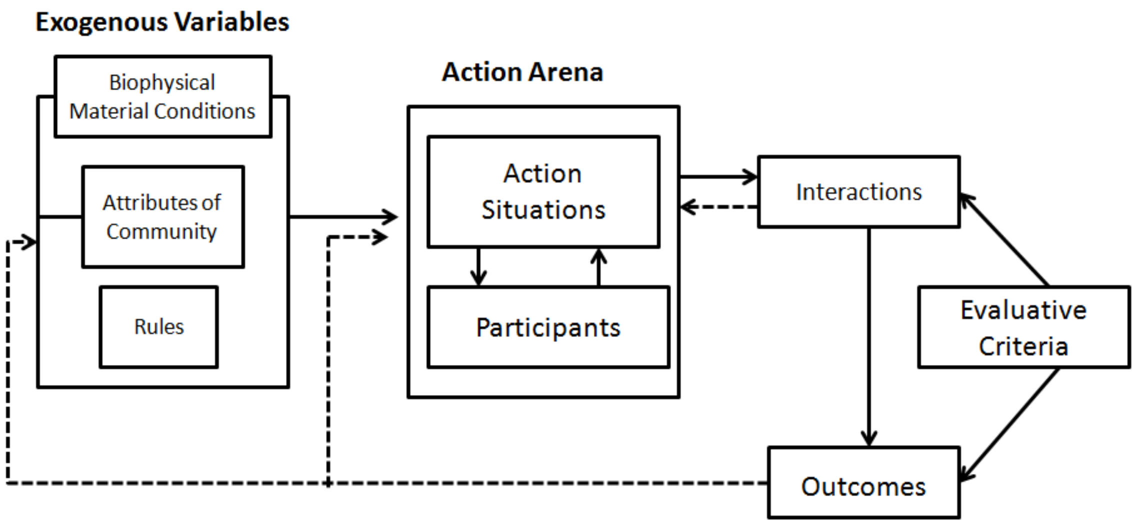

Figure 5 Framework of Institutional Analysis: Ostrom, Gardner and Walker (1994)

The model focused on 'fallible, norm-adopting individuals who pursue contingent strategies in complex and uncertain environments' (Ostrom 1990: 185). The institutional design principles followed North's (1990) conception of institutions as mechanisms for reducing such uncertainties, thus building trust and norms of reciprocity and therefore the possibility of collective action (Cox, Arnold, and Tomás, 2010).

However, in spite of intensive research on this issue knowledge gaps still remain regarding the question as to why some local user groups are able to overcome governance challenges such as elite capture, while others, which work under the same design principles, are not. The critical question therefore still remains; what are the conditions and who are the driving forces which drive successful joint irrigation management. The role of seemingly 'idiosyncratic' features such as involvement of particular people and their motivation is often neglected and holds particularly true of leadership (Ruth Meinzen-Dick, 2000).Teske (1992) along with several scholars have alluded to the idea of political entrepreneurs and social entrepreneurs inspired by the likes of Muhammad Yunus (Martin and Osberg, 2007). Nevertheless, these concepts have been used to describe the influence and its applicability at the national level as leaders who develop innovative ways to galvanize the otherwise dispersed citizens to work to support certain policies (Schneider and Teske, 1992) . This chapter hence addresses this knowledge gap by zooming into the action arena (Fig.1) at the local level, by conducting a qualitative case study in four villages in the semi–arid regions of India, using the Grounded Theory approach and identifying individual agency as a major factor that plays a significant role in the success of participatory irrigation management and implementation of the design principles formulated by Ostrom (Cox et al., 2010). The chapter draws conclusions on how local leadership, a factor mentioned (Meinsen–Dick 2005) but neglected in the current literature on common pool resources, can be promoted to facilitate participatory irrigation management. Moreover, with twenty years almost since the concept of PIM was implemented in India, it becomes worthwhile to explore the role of the individual agency, especially in a time when solution to water scarcity and adaptation to climate variability are being sought through best practices in water management (Kelkar, Narula, Sharma, and Chandna, 2008).

5.1 Literature Review

5.1.1 Co-management of water as a common pool resource

Co-management aims at the sharing of power and responsibility between the government and local resource users. Co-management is usually combined with learning-based approaches (Berkes, 2009). Co-management and decentralization, in general often lead to reinforcement of local elite power or to strengthening of state control. Regarding the former, the exclusion of marginal stakeholders who are poor and politically weak may have negative impacts on equity and community welfare (Agarwal, 2001; Nayak and Berkes, 2008). The concept of co-management gains particular importance when it comes to management of common-pool resources, which are understood as a sub-set of public goods. Canal water is a common-pool resource as it can be used jointly, because of the high cost of excluding a landowner with command land, and its consumption is subtractive in the sense that water applied to one farmer's land means that the other farmer does not have the availability of water at that same moment. Hence, issues of conflict arise when water is scarce and if there is a delay in the arrival of water, there is a possibility of congestion and likelihood of yield reductions where water arrives too late (Wade, 1987).

In a study conducted in the late 1990s in four countries in South Asia and two Latin American countries, it was seen that, as compared to the Latin American countries, in the Asian countries management transfer involved only a partial devolution of responsibilities by the respective administrations. Most transfer units were sub-sections of irrigation systems that were managed by farmer organisations, while the main system continued to be managed by a government agency. It was further stated that in almost all countries where transfer programmes took place, the water rights for both the parties was very blurred (Vermillion, 1997). However, according to the literature, in most cases WUAs are legal entities and are essentially single-purpose organisations concerned mainly with O&M of the irrigation facilities. They have the authority to formulate O&M plans and budget, and set and collect water fees depending on the crops grown in the region in addition to right to contract and raise funds (Vermillion et al., 2000; Garces-Restrepo et al., 2007). Indian examples indicated that though there was potential, there were administrative along with political difficulties when it came to implementing and sustaining redistribution of water. It was seen that the canal managers were under pressure to allocate water to minimise conflict and trouble for themselves. This then prompted permissive releases to upper reaches with consequent starvation in the tails. In addition, Wade and Chambers pointed out that much of the causes and the remedies of poor canal performance was based on the assumptions that the problems were more 'technical' rather than institutional, the problem arise mainly 'below' than 'above'[27] the outlet and the institutional problems identified, are mainly the problems from areas which are managed or run by the farmers (Wade & Chambers, 1980).

5.1.2 Policy Trends in Participatory Irrigation Management

The emergence of Irrigation management transfer (IMT) or joint irrigation management started in the early 1970s when there was a general disappointment with the performance of the irrigation systems at a time of heavy international aid in most of the developing countries, during the 1950s and the 1960s. Though irrigation agencies were set up with the purpose of supplying water to the systems, they often failed to deliver because of the rigid top-down approach. Farmers began to

[27] The reference to below is made at the level of the farmers at the downstream and the above is at the main outlet channel at the level of the irrigation department where the water is initially released from.

falter in payment of the services and in turn even asked for better delivery mechanisms, leading to a vicious cycle of non-payment and deteriorating infrastructure (Garces-Restrepo et al., 2007). Thus the reforms, when they were initiated, were largely driven by the understanding that there was a need to dismantle state control over the sector, as they were unable to effectively operate and maintain the irrigation schemes. The solution proposed was the transfer of these responsibilities to water users associations, through a process of Irrigation Management Transfer (Garces-Restrepo et al., 2007; Samad, 1997; Siva Mohan, MVK. Scott, n.d.) .Though at the beginning of the 1980s there was a large-scale programme to turn over irrigation management from government agencies to organized WUAs in a number of countries such as the Philippines, Indonesia, Senegal, Madagascar, Colombia and Mexico (Vermillion 1990), in practice many countries did not turn over their water allocation function to user groups, providing users with significant formal water rights (Vermillion 2001;(Gulati, Ashok. Ruth Meizen-Dick. Raju, 2005; Ruth Meinzen-Dick, 2000), thus leaving allocation relatively unclear, uncertain, and unaccountable. Since the 1990s, a number of countries adopted the irrigation management transfer (IMT) strategy which provided the impetus for reform of water laws.

In India, the irrigation management transfer was being implemented under the broader framework of participatory irrigation management, after guidelines were issues by the Ministry of Water Resources in 1987. Being a federal nation, water was a state subject; therefore irrigation constitutionally became the responsibility of the states and not the central government. There were considerable variations in the institutional framework relating to participatory irrigation management between the various states. These ranged from changes in Haryana where farmer involvement was only below the outlet, to more comprehensive efforts in Maharashtra and Gujarat where WUAs were vested with the responsibility of managing minor canal commands. The most far-reaching irrigation management reform programme was being implemented in Andhra Pradesh where the Andhra Pradesh Farmers Management of Irrigation System Act of 1997 provided for the formation of WUAs in all surface irrigation systems in the state (Garces-Restrepo et al., 2007; Jack, 2009; Mahapatra, 2007; Organisation, Directorate, Planning, Wing, & Commission GoI, 2010)

5.1.3 The Role of Individual Agency in Participatory Irrigation Management

In the case of India, the technological changes in the mid-1960s brought forth the importance of irrigation along with seeds, fertilizers, pesticides, and improved cultivation practices (Subramaniam, 1990). The transfer of irrigation management was seen as a means to reduce pressure on the State finances and address environmental sustainability. The issue of management of irrigation became prominent as the irrigation sector continued to consume a considerable amount of budgetary resources and therefore has in most occasions run into liability. In addition, irrigation being the largest user of water, its influence on environment and resource degradation has become a concern (Pal, Joshi, & Saxena, 2003; Samad, 1997). The main driving force of creation of the WUAs was either through initiatives from a few NGOs functioning in certain regions or by interested individuals. These WUAs were initially registered as co-operatives for ease in administration and efficiency (Pal et al., 2003). A growing number of case studies and synthesis reports are attempting to identify principles for success in farmer participation in irrigation (e.g. Goldensohn 1994; Meinzen-Dick et al. 1997; Ostrom, 1992; Parin and Lusk, 1991; Tang, 1992; Upoff, 1986; Vermillion, 1996, 2001). As devolution policies and programs are being adopted in several countries and resource sectors, it is becoming crucial to examine the reasons for success and failures of the initiatives undertaken. Success depends, in large part, on having some strong WUAs that can fill in the vacuum by assuming a management role after state withdrawal, thus preventing disinvestment in irrigation systems (Vermillion, 1996). However, the role of seemingly 'idiosyncratic' features such as involvement of particular people and their motivation should not be neglected and this is particularly true of leadership. The involvement of a charismatic or trusted individual reduces the transaction costs of organizing and provides assurance that makes people more willing to participate in collective action (Baland and Platteau, 1996; Kolavalli, 1995; Ruth Meinzen-Dick, 2000), especially in the initial stages where particular leaders can be critical, both for mobilizing support within and outside the group, and modifying the behaviour of members (Shah, 1993; White and Runge, 1995). Trusted leaders can provide the assurance that is necessary for people to be willing to cooperate. It appears that the presence of influential[28] persons had significant positive effect on irrigation organization (Ruth-Meinzen-Dick, 2000). These leaders can be deemed as political entrepreneurs who develop innovative ways to galvanize the otherwise dispersed citizens to work to support certain policies (Schneider and Teske, 1992).

5.1.4 Water Users Association provision in Maharashtra and Andhra Pradesh

The WUAs were initially registered under the Societies Act of 1960 as a co-operative society (Patil & Belsare, 2011) and there was still a significant state control in the process of irrigation management. In the interest of the functioning of the WUAs and further devolution of power to the local bodies, the Maharashtra Irrigation Act was amended in 2005 and came to be called the Maharashtra Management of irrigation Systems by Farmers act 2005 (Maharashtra State, 2005).
The Andhra Pradesh Farmer Management of Irrigation Systems (APFMIS) Act, enacted in 1997 and further amended in 2008, provided for the establishment of water users associations in the irrigation sector. In order to reduce the role of the government in the direct management of irrigation systems, the Act provided the framework for the setting up of water users associations. These associations were to be composed of all the water users who were land holders in a water users area and where there was a tenant, then the tenant of the land holder. It provided for every farmer's organization to be a body corporate with a distinct name having perpetual succession and a common seal, vested with the capacity of entering into contracts and could sue or could be sued, its corporate name represented by a Chairman or the President.(Andhra Pradesh, 2008; Madhav, 2007).

5.2 Methodology

5.2.1 Study areas

A combination of literature review and the Grounded Theory was used to be able to identify in an inductive way from empirical cases those factors that may have been neglected in the literature on common-pool resources. The process of selection of the study villages was done in the similar premise as mentioned earlier. For getting a better basis for comparison, all four villages that were chosen were in the tail end of the canal distributory in the irrigation management system.

5.2.2 Methods

In the process of analysis of the collected data for the study, the role of individual agency as a driving feature in the process of institutional innovations emerged as a critical factor leading to the success or the failure of similar initiatives taking place in different study sites; in this case the Water Users Association. A qualitative approach was used to further study these factors based on information received from the field. The method of analysis used was based on Grounded Theory (Strauss and Glaser 1967). For this particular study, it was imperative to begin the research with an explorative and iterative approach to data collection. The gaps that appeared in the theoretical

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[28] An "influential" person refers to someone who has external recognition and influence, such as an MLA or other politician, retired army officer, or other official.

representation of initial interviews, documents, and observations were filled by follow-up visits and interviews. Adopting this approach gave the flexibility and methodological rigor needed to guide the research to fit the data collected in the field (Banerjee et.al 2013). The process was iterative whereby attempts were made to keep clarifying the understanding of the water distribution process and the functioning of the Water Users' Associations by the respondents. It freely allowed the respondents to give their own interpretation of 'why' and 'how' the process was happening and 'where' and 'what' was their role in the entire process based on this understanding. The process helped determine two villages as successful and two villages as not so successful in the management of the Water Users' Associations and its role in the process of adaptation to climate change.

Purposive sampling was used to identify different categories of farmers, women, and other key informants and compare their perceptions of water management practices. Office bearers from various government and non-government organizations were interviewed to understand their roles in facilitating these practices in the community.. Based on the principle of theoretical sampling, additional interviews were conducted in the study sites to further explore the role of the individual agency in water management practices that had emerged from earlier interviews and FGDs. Since no new information emerged from this, the data was deemed "theoretically saturated" from the earlier designed FGDs and interviews. For the breakdown of the FGDs and Personal Interviews along with the profile of the study villages, see Table 2 and 3.

The interviews recorded during the process of data collection were transcribed in verbatim. The coding process was the most important part of the analysis as it formed the basis of the emerging findings related to water management systems, water distribution, the role of the government and support organizations in participatory management of water with the community, the governance challenges and most importantly the role of the individual agency in facilitating the processes mentioned and overcoming the governance challenges. The coding process was done with the help of NVVO. The field notes served the initial memos which were integrated in the final stage of analysis as a way of filling the gaps (Emerson et.al 1995).

5.3 Findings

5.3.2 Success Indicators in Water Management

As already mentioned, one of the common features of all the study villages, besides being in the semi-arid region, is that, they all fall in the tail end of the distributary channels. Being in the tail end region, they have faced constant problems of water availability as a result of upstream-downstream externalities (Jack, 2009). Before 1991, when the management of the irrigation water was completely in the hands of irrigation department, there were often complaints of the tail end regions not receiving water because of either faulty irrigation channels or issues of water theft or diversion of water by users at the head of the distributary channel. This was leading to farmers being reluctant to pay up for the water they were using resulting in increasing disparate situation between the government and the community and the community often blaming the department for inefficiency and malpractices in the water supply process[29]. With the introduction of the participatory irrigation management, it was anticipated a lot of these issues would be solved and the community would take up responsibility of the management of water and its irrigation systems. All the four villages adopted the irrigation management transfer process more or less at the same time after the guidelines were issued in 1987, though under different circumstances of facilitation and community participation. Of these, the two villages Nas 1 and Gtr 1 were indicated as success

[29] As told by the government officials of the two states

stories and Nas 2 and Gtr 2 as more or less failures (see Table 3) to adopt the PIM process, as it was found that the former two villages came relatively close to adapting the design principles which were formulated by Ostrom (Cox, et al., 2010)

Table 5 Comparison on functioning of the WUAs

Indicators	Nas 1	Gtr 1	Nas 2	Gtr 2
Water Distribution System	Usually 2 rotations during rabi (winter)and 1 during summer from tail to the head	Usually 3 rotations during paddy season) using lift irrigation	Usually 1 rotation but subject to claims of water availability	No track of rotations as claimed to receive water when required
Collective Choice Arrangements	Farmers consulted before water cuts in case of water shortage	Cropping patterns discussed depending on water availability	No visible involvement of farmers	Farmers claim of complete absence of meetings
Monitoring	Farmers measure water to their fields using application on mobile phones	Farmers measure water in the fields in terms of designated inches to their field (5 inches)	No existing mechanisms	No existing mechanisms
Graduated Sanctions	Peer pressure applied or fines levied	Peer pressure applied or fines levied	Non – existent systems	Complete lack of collective action
Conflict Management	Meetings organised of members to sort problems	Water stopped to neighbouring fields	Conflict within the WUAs itself	Use of WUA to strike against DoI*
Elite Capture and Free riding issues	Minimal instances	Minimal instances	High levels of elite capture and accepted form of water access	High levels of elite capture and accepted form of water access
Role of Support Organization	Claims of high level of involvement	Claims of partial involvement	Claim s of minimal involvement	Claims of hostility

Source: Individual Interviews and FGDs with farmers and key informants 2012

****Department of Irrigation***

5.3.3 Participatory Irrigation Management

The success story Nas 1 comes under the Waghad project and it is claimed to be one of the biggest irrigation projects in the state. The unsuccessful village, Nas 2 on the other hand comes under the Palkhed project where it gets 40% of its share of water from the Waghad project as per the dam water sharing rules of the Government of Maharashtra. According to the committee members of the three WUAs in Nas 1, it was learned that during the 1990s the then district magistrate, after the end of the tenure in office, started an organization where he was conducting a survey on the supply and demand of water in agriculture. This initiative was taken up by him as he realized that the implementation of the Participatory Irrigation Management was just being followed in paper, and problems of water access still persisted. According to the respondents he, with the help of some village elders, mobilized the community to come together to form an association which can work together with the irrigation department, and thus take responsibility of managing their own water for irrigation. Since the former district collector and founder of this organization was also in the board of SOPPECOM, he involved this technical support group along with WALMI to train and support the community to establish the WUAs. The officials of the Irrigation Department were made to get involved in the process and it was agreed upon that the water when it was released would be released first to the tail-enders and then get supplied to the middle and the head regions of the distributary channels[30]. This practice is still being followed in Nas 1 because of the active involvement of the present Executive secretary and the person in charge of the NGO, to whom the leadership was handed over by the founder member of the NGO.

Nas 2, as mentioned earlier, falls in the rain shadow area. This is just not in terms of geography but also in terms of accessibility and getting the attention of the government, as was felt by the respondents. When asked on the formation of the WUA and the role of the government and other organizations, some of the committee members shared that the WUAs were created as a result of the mandate by the government. According to one particular respondent, *'it was just on paper as the people had to still run after officials from the Department of Irrigation (DoI) to get water'*. The respondents were of the opinion that the distance from the main city and the inaccessibility of the village was one of the main factors that played against them as the government or the NGO did not want to take the effort to mobilize or educate the community.

The two villages in the Guntur district come under the Nagarjunasagar project, one of the largest in Andhra Pradesh and the water for irrigation is supplied from this dam. In Gtr1 and Gtr 2, the issue of access to irrigation water continued to prevail inspite of the presence of WUAs. As an alternative solution, the successful Gtr 1 with the initiative of former village head and the former president of the WUA of the village, sought to take up the Lift Irrigation Scheme which was introduced during the term of NT Rama Rao as the Chief Minister of the state. The unique feature of this lift irrigation scheme was that it was waste water being recycled to be used in the fields for agricultural production. By adoption of this method, the village has more or less solved the problem of being self-sufficient where irrigation water is concerned, and is now looking into diversification of cropping patterns with the support of the Agriculture Department.

In the case of unsuccessful Gtr 2, initiative from the community seemed to be clearly lacking as the committee members blamed the government completely for the inefficiency in water management. The current and the former president of the WUA felt that, more than the community initiative and committee responsibility, it was the duty of the Irrigation department to come up with a solution for the water problem and there was nothing in particular they could do to solve the current situation of water non – availability.

5.3.4 Role of the Support Organizations in Participatory Management

> *Now they know that nobody but they are responsible for how much of water they get and they have to manage with the amount of water they have and they cannot blame anybody else. Earlier they used to blame the government now they cant blame anyone. The key is with them. If they don't use it very well they are at a loss and if they use it well they are at an advantage.*
>
> \- *Official Department of Irrigation, Government of Maharashtra*

The main actors as part of the support system in creation and facilitating the process of the

[30] As per the amendments made to the PIM act, the rule is for tailenders to get the water first and then the people in the head region.

PIM, besides the Department of Irrigation, in both the states are the Water and Land Management Institutes known as WALMI in Maharashtra and WALMTARI in Andhra Pradesh. Established during the late 1980s, when the PIM was being considered in India, their role was important in the process of management of the water by the community, as they served as the training centers for the farmers. In the case of the success stories, the respondents of Nas 1 claimed that because of the efforts of influence of the Executive secretary (the current manager of the NGO), there were regular trainings being conducted by WALMI for the farmers on better management techniques of water ,which in turn was being implemented in the functioning of the WUA. This initiation of farmers' training was initially started by the ex-bureaucrat who was also the founder of the NGO. Similarly, in Gtr1, it was said that the current president of the WUA was involving WALAMTARI through its field offices in identifying 'progressive' farmers to be trained in efficient water management practices and in turn become an advisor in the community. On talking to the office bearers of these organizations, there appeared to be a clear enthusiasm where these two study villages were concerned. However, when it came to the not so successful villages, Nas2 and Gtr2, the officials claimed that every attempt in involving them had been unsuccessful as the community itself has been reluctant to send its representatives for training programmes or workshops even if they have been all paid for by the respective institutes. On the other hand, when the respondents in these villages and the office bearers of the WUAs were spoken to, they claimed that there was no effort from these institutes to create any awareness and they were often sidelined as there were no influential people involved to put their case forward.

5.3.5 Water Distribution

Allocation of water

Two of the four study villages appeared to have a well documented and systematic process of water allocation among their respective association. In the case of Nas 1, it was explained that the allocation of water to various WUAs in the area was decided at the federation level of the WUAs. Based on the availability of water, each of the WUAs were assigned a particular quota with the agreement that the water would be first given to the WUAs at the tail end. This decision was taken in the month of October every year.

At the local level, the Nas 1 WUAs had devised a method of calculation of water which was released through an application in the Nokia mobile phones and using this most of the farmers were able to calculate the amount of water they would be receiving during the time of the 'rotations'[31]. The water tax was charged based on the number of hours a farmer took to fill up his field. It was said that the cropping pattern decision was left on the individual farmers, though the WUA did advise them when there was a situation of shortage of water. However, the committee members did agree that the rotations were calculated based on the water requirement for grapes as this was the major crop grown in the area.

In the case of Gtr 1, though there was no mention of a Federation, the system of water distribution was based more on the availability of recycled waste water and electricity for supplying the water. Usually three 'rotations' were given for paddy and there seemed to be a clear demarcation on the amount of water allocated for short duration and long duration crops. The water charge was based on the number of inches a farmer filled in his field and like Nas 1 the cropping pattern decision was mainly left to the farmers. It was also mentioned that the farmers had the liberty to use both the lift irrigation system as well as the canal water provided by the Irrigation department, as long as they paid for the water used.

[31] Rotations was the term that was used when the water was released from the minor gate to the fields of the farmers.

It was worth noting in Nas2 that the President and committee members when asked about the system of measurement and the process of allocation of water claimed that such a system did not exist and was the responsibility of the Irrigation department to provide them with the mechanism. The farmers felt that the lack of system was leading to some of them getting water whereas others were excluded. Similarly in Gtr 2 the system of measurement was absent. Even though the President of the WUA in Gtr 2 could not identify any mechanism of monitoring the distribution of water to the farmers, he claimed that they were getting 350 cusecs of water from the Irrigation Department.

Social sanctions and Conflict Management

Both the villages claimed that the incidences of water theft and conflict was almost absent, though some sporadic incidents occurred from time to time. In the event of such occurrences, it was said that social sanctions were used and were claimed to be effective in solving issues of both water theft as well as disputes among farmers regarding the amount of water entitled to each of the individual farmers. The social sanctions in the case of village Nas 1 was in the form of group pressure to make the concerned farmer find collateral in case he was unable to pay for the water charge. The Executive head was of the opinion that this made the farmers responsible to each other to make sure the payment was done, otherwise the particular farmer would be termed as a ‘defaulter’ and would earn an unfavorable reputation in the community. Where Gtr 1 was concerned, in case of a conflict between two farmers, the water supply to the particular field was temporarily stopped till the conflict was sorted. Therefore, according to the WUA president, he felt that the particular farmer in the interest of not looking ‘bad’ in front of his fellow farmers would settle the conflict as soon as possible.

> *No one is going to steal the water as they are all their own brothers and community members. There might be there but as far as the department is concerned, it is more of the job of the WUA to monitor it. So if there is anything that is going wrong, one fellow will complain and then they have their own meetings so that if someone is doing wrong, the other person will point out there itself. Then depending on the severity of the issue, some penalty will be levied like 500 rupees or something like that. This is usually between their system but between us we control it and co-ordinate things well amongst ourselves.*
>
> \- *President WUA Gtr*

On the other hand, a sharp contrast was seen in Nas 2 and Gtr 2. In Nas 2 it was claimed that though the WUA was the only source from which they got water for irrigation, they felt that the government was not living up to its responsibility. It was mentioned that when the WUAs initially came into existence in the village and also in the nearby villages, there was a Federation that was formed. However, a lack of initiative and motivation from the President and the committee members led to the disintegration of the Federation. In Grt2 there was a feeling among the committee members that the WUAs were means to protest and strike against the government on unavailability of water.

Information Asymmetry

Farmers’ perceptions on the functioning of the WUAs in the four villages was also elicited. In Nas 1 and Gtr 1, though the issues of patronage and elite capture were not that apparent, there did seem to be an element of information asymmetry among the smaller farmers and the working of the WUA. Though they were aware of the system of water distribution, they claimed that they were not aware about the reasons why water cuts were done on occasion. In the case of Nas 1, though there was a woman chairman in one of the WUAs, she claimed she was not clear on how the WUA was supposed to function. Most of the farmers in Gtr 2 agreed they were concerned with regards to the functioning of the WUAs as they claimed that there were no general body meetings, information sharing or even consultation done with the farmers on the water management system.

Patronage and Elite Capture

In Nas 2, the farmers were of the opinion that the WUA was gradually losing its importance as a water distribution mechanism since there was no certainty whether they would be getting water when required. This had led to some serious issues of patronage especially in Gtr 2 where the farmers agreed that either if it was a big farmer, he 'paid something extra' to the officials to get the water or the smaller farmers 'who knew the bigger farmers' were guaranteed of getting some amount of the water. In the case of Nas 2, there were high incidences of water theft, where people were using pipelines to 'lift water' from the perennial canal which is mainly used as a drinking water source for livestock. In terms of entitlements and exclusion, it was mainly the small farmers in Nas2 who were being deprived of the water and though on principle women were supposed to be part of the committee of the WUA, there was no women representation. In case of Gtr 2, women were not part of the committee as they were not the land holders, therefore there was no presence or representation in the committee at all.

5.4 Discussion

The concept of Participatory Irrigation Management was introduced in order to: i) achieve a collaboration between the farmers and the Department of Irrigation through the creation of the Water Users Association at the community level; ii) create accountability between both the users and the service providers of water, reduce fiscal availability in the form of operations and management cost and recovery of irrigation charges; and, iii), in the process ensure good governance, agricultural productivity and inclusiveness of marginalized groups (Deshpande and Mini, 2003 in Pal et al., 2003). The performance of the PIM has been examined on various accounts of collective action, following the design principles which were introduced by Ostrom (Ostrom, 1990). In a synthesis study (Cox et al., 2010), it was highlighted that these design principles partly explained the success of management institutions. Most of the conditions mentioned by Ostrom and other scientists were merely characteristics of the community or institution. In the case of India, there were studies which showed that many farmers had organized themselves at lower levels within the state–run systems. The influence of religion as a means of generation of collective action was also seen in the cases of Rajasthan and Karnataka when it came to natural resource management. (Meinzen-Dick, 2007).

Further literature on irrigation systems in India highlights the role of leadership and acknowledges its importance (Ruth–Meinzen Dick 2005), but does not address how it makes a process successful. The use of Grounded Theory approach in the study of these four villages, addresses this gap by collecting empirical data that digs deeper into the element of individual agency. The institutional analysis and development framework conceived by Ostrom (Fig.1) is then modified and discussed, highlighting the role of individual agency in management of water user associations.

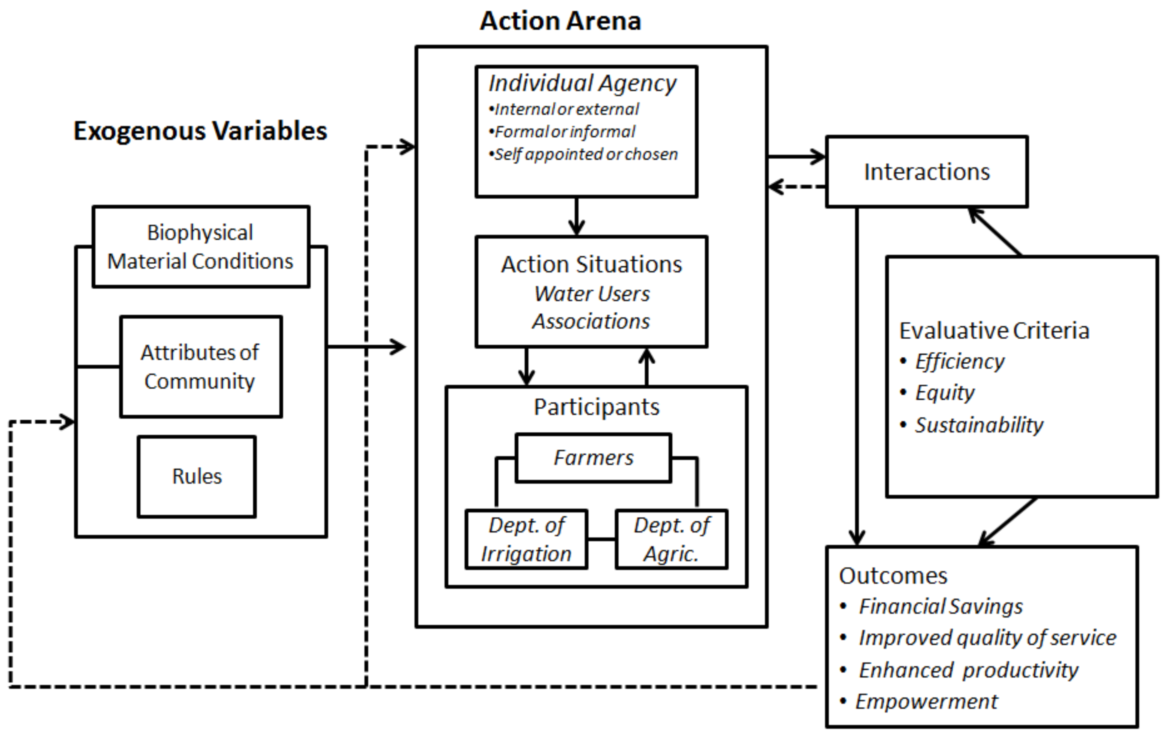

Figure 6 Role of Individual Agency in Management of WUAs: Adapted from Ostrom, Gardner and Walker (1994)

The study shows that out of the four villages, two villages were mostly successful in following most of the design principles and being innovative in their own ways especially when it came to keeping check on water theft and elite capture. The other two villages, inspite of the Water Users' Associations being created, could not maintain and function as intended. The assumption is that it is the action arena (Fig.2) which makes the difference, and the co-ordination of the action situation and the participants was the reason of the success in the two villages. The effective collective action was brought about by the leaders either through a high incentive or a strong individual force. The success stories, Nas 1 and Gtr 1, had a working water management system because of the efforts of certain individuals who were instrumental in facilitating the process of collective action, and passing over leadership to carefully identified successors to carry on the process forward. On the other hand, in the unsuccessful villages Nas 2 and Gtr 2 there appeared to be a system collapse with high levels of corruption and lack of motivation even within the Water Users Association, as there was no obvious or strong form of leadership which could get the community together, further validating the observation that the presence of an organization does not necessarily lead to greater farmer participation in irrigation management (Meinzen-Dick, 2007), if it is not backed by strong driving force and leadership.

It can be argued, however, that one of the crucial reasons for success of the WUAs in the successful villages could be because of the location and the infrastructure facility it was already equipped with. Nevertheless, it should be noted that even after the WUAs were officially mandated to be formed, nothing really happened till the intervention of the ex-bureaucrat in the case of Nas 1 and the former village head in the case of Gtr 1. The ex-bureaucrat by forming the NGO was able to pool in resources and act as a facilitating factor to make the community, the Department of Agriculture and the Department of Irrigation work together (Fig.2). With a certain group of people who held respect in the particular village, he mobilized the community to come up with systems of monitoring and accountability not only within the community but also with the Irrigation Department; the system of measurement of the amount of water released was one such mechanism along with the release of water to the tail-enders before the farmers at the upstream received it. His successor, the executive secretary of the NGO, went further to ensure that women were given representation in the committees and even elected Chairmen to ensure gender participation in the decision making process. Whether some of the women committee members who became the Chairperson were really aware of their responsibilities is of course something that requires further probing. Hence the key attributes which were at play here were a sense of trust and legitimacy which the community had given to these two individuals in the form of social mechanisms (Cox et al., 2010).

In the case of Gtr 1, the method of cutting off water supply to areas where there were conflicts between farmers was thought to be an innovative strategy which got about under the leadership of the present President of the WUA. Through interactions with him it was clear that the system worked as it was the social standing and the credibility of the farmer which was at stake. Furthermore, initiation of the demarcation of plots of short and long duration crops ensured that the farmers were optimizing the use of water and hence cutting down on their costs of water charges. Through their efforts, it was clear that they had been able to a large extent to achieve the desired impact of the rational with which the Participatory Irrigation Management was rolled out (Fig 2). Literature also states that these leaders more often than not are driven towards such mobilizing activity either because they have certain personal agendas of their own which eventually works towards serving the greater good, or they may just have the activist nature in them where they work towards the rights of the community. Studies also show that such leaders usually have charismatic personalities or the necessary resources (Gulati, Ashok, Ruth Meizen-Dick, Raju, 2005). In the case of Gtr 1, the President of the WUA was using the management of the WUA to serve his bigger political ambition, whereas in the case of Nas 1 the executive secretary had been the prodigy of the ex-bureaucrat, where the former had been part of the student movement against the 1970s Emergency rule of Indira Gandhi. The evidence that these particular individuals were able to sustain a partnership with the Department of Irrigation and manage their water supply was the one extra rotation that was being given to the farmers in the hot season. This water rotation was as a result of the saving of 20 cusecs of water from the 100 cusecs, because of the monitoring systems which had been put in place under the leadership of the two individuals in the two villages.

In the case of the failed villages where irrigation management was concerned, they were a reflection of a typical situation where there is tension between traditions of farmer involvement and traditions of dependence on the state. For many farmers in irrigation systems, it is the government's 'duty' to provide them with water. Any change requiring them to do more of the system management themselves constitutes a fundamental change in the social contract of the state. The willingness of the people to provide the extra time and effort depends on the strength of community ties, how bad people perceive their present situation to be, the motivational campaigns and how much confidence they have in the regular government agency to provide the necessary support (Gulati, Ashok, Ruth Meizen-Dick. Raju, 2005) The fact that the concerned presidents and the committee members of the WUAs of both Nas 2 and Gtr2 felt that accountability of the water management system was entirely on the part of the Irrigation department was evidenced by the lack of water measuring devices when the water was released. Through interactions with respondents across the community, it was found that possibility of change appeared as a threat to the status quo which was enabling them to enjoy patronage and favors. In Nas 2, since there was a perennial canal, and most people were able to get water from there, there was little consideration for maintaining or creating an effective water management system. However, a certain section of the community, like the small farmers and the canal inspectors of both the villages felt that one of the main reasons for the system failure was a lack of leadership and motivation to get the community together.

In all the four village sites it was observed, irrespective of whether the WUAs were almost successfully running or were almost a failure, there was consensus that it was an important part of their local institutions. Facing the issue of lack of information and also accessibility with the extension services by the Agriculture department, the WUAs were taking up the role of information dissemination in addition to organising workshops and awareness programmes along with centers of seed and fertilizer distribution as was seen in in the sucessful villages and to some extent in Nas 2. Particularly in Nas 1 and Gtr 1, it was the expectation of the community that the leaders of the WUAs should facilitate training and capacity building where water management was concerned, involving advise on cropping patterns as well. This they felt was a crucial aspect of the roles of the WUAs, given the extreme varaibility in the climate they had been experiencing over the last ten years. In the words of the respondents '*water is what makes agriculture run, if there is no water, there will be no crops*'. However, whether the leadership can steer the WUAs to take up such a role as a parallel system and become the replacement of the extension systems in their particular communities needs further investigation as time and budget constraints did not allow this particular study to explore that aspect.

Conclusion

Irrigation management transfer (IMT) has been adopted in the 'industrial countries' as well as in many developing countries within Latin America, Asia and Africa (Uysal & Atış, 2010). Earlier approaches to irrigation were based on the assumption that a combination of "correct" technology, "efficient"markets, and "capable" agencies would result in the best performance. However, the prevalence of technological, market and agency failures and the ensuing poor performance of irrigation systems have shown that in most cases this combination does not result in effective irrigation services (Meinzen-Dick et al., 1997).

Through the case study of the Water Users Assiciation of the four villages, it was seen that the local social capital and leadership potential, if used to advantage, are likely to lead to more active organizations (Gulati, Ashok. Ruth Meizen-Dick. Raju, 2005) and to a large extent achieve the desired goals of good governance, finanical solvecy and inclusion of the marginalised as the desired impact of the PIM (Fig.2). However, it needs to be acknowledged that collective actions that become dependent on particular individuals may not be as robust in spite of the existence of an instittutional framework. Therefore, it is worthwhile - in further understanding the conditions under which these particular leaders are created – to consider the motivations that drive these leaders and the ways to sustain such leadership as a continuous process in the community in the management of common pool resources. This will further help in understanding the social effects of PIM, and focus further research on WUAs in the wider context of agrarian relationships. This will entail, no doubt, further studies and documentation of innovations in the given social system at both the technology and institutional levels, aimed at establishing better agricultural practices and improving the adaptive capacity to climate change.

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Conclusion

Systematic technological advancements which have favoured a better and unprecedented utilization of land and water resources were first introduced in India at the beginning of the 1960s. These technologies were mostly embedded in inputs such as they could be regarded as seemingly easy to disseminate as well as to adopt (Pal et al., 2003). However, the role of institutions in the process has been underemphasized by earlier studies. The main objective of this thesis has been to highlight the importance of institutional innovations in agricultural development,from pre-independent India to post independence. Even while addressing the relevance of the farmers' perceptions of climate change and their adaptation strategies, or the functioning of the Water Users' Associations, we have claimed that either existing or new institutions have been prominent in the process.

This thesis has also drawn attention on an area which often is either taken for granted or not really emphasized. This is the role of individual agency when it comes to promoting institutional innovation. If one looks at the second chapter, though the main focus has been on the political economy of the history of agriculture development, the underlying point of each of the stages that Indian agriculture went through was the setting up of institutions or the restructuring of existing ones. Such creating and restructuring was done because of a particular driving force, where either the leader was appointed by the British to carry out reforms, as in the case of Lord Curzon, or was chosen by the people, as in the case of Gandhi, to lead the freedom struggle, or appointed by the State, as was the case of C. Subhramanium leading to the Green Revolution. The political economy approach to agricultural development in India adopted throughout the thesis thus brings out a very significant issue of political will, mingling with agricultural reform and investments. Whether it was to maintain the dominance of British rule in India by Curzon and Irwin, or to get self rule from the British by Gandhi the tool used was often agriculture research and investments. Furthermore, although there were a lot of initiatives started after the Green revolution, it was the lack of political will that often led to a phase of stagnation in Indian agriculture development, as the focus shifted towards populist politics rather than investments in agriculture research and development.

The importance of individual agency is further highlighted in the third chapter of the thesis focusing on the efforts of C. Subhramanium, where the Green Revolution is examined from an institutional innovation point of view rather than just a technology revolution. At a time when India was faced with an impending food crisis it took a very strong leadership, along with a group of dedicated scientists and bureaucrats, to make a country self–sufficient with regard to food. The re-examination of the Green Revolution carried out in the thesis acknowledges that there were environmental issues at stake, and that it may have been restricted to only the irrigated areas, but it would not be wrong to say that it was an initiative which was aimed, above all, at smallholder farmers. There is no doubt that one of the biggest success factors in the Green Revolution was the technical innovation of the high yield varieties, but from the accounts of C. Subhramamun it is clear that without institutional innovation and the restructuring of the old institutions the Green Revolution would not have been possible. Therefore, as a lesson for countries who are now striving towards a Green Revolution, it is important that policies promoting institutional reforms and technology innovations are made which are smallholder farmer friendly. . This requires political will along with visionary leadership, both at the political and administrative level, and not populist politics as is being seen in the present times in most parts of the developing world.

Coming to the fourth chapter, it addresses the central theme of the thesis: climate change and adaptation to climate change. Though the chapter focuses on the perception of the farmers in four villagesin India, and it elicits the importance of their perceptions of changing climate while focusing on their adaptation strategies, the chapter also looks into what drives an individual to adopt a particular water managing technology, and why do some members of the community adopt a particular technology and some do not. It brings out the attributes of the individuals more likely to be dynamic and entrepreneurial when it comes to the preservation of livelihood against the variations in climate, irrespective of constraints like information asymmetry, inadequate extension services, and lack of access to financial sources.

The fifth and final chapter goes further in understanding the adaptation process through water management techniques from an institutional perspective by examining the functioning of the WUAs. Through the Grounded Theory approach, the importance of individual agency is further highlighted at the local level when it comes to a collective action in irrigation management. It is acknowledged that collective actions which are only dependent on particular individuals may not be sustainable in spite of the existence of an appropriate institutional framework. It is therefore critical, in the study of natural resource management, to further delve into understanding what the conditions are that favour leadership and make it pervasive through the community.

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Appendix

1. Questionnaire for Individual Interviews

The purpose of this questionnaire is to merely serve as a guide towards trying to understand the perceptions of the farmers across groups in the SAT villages to climate change and different kinds of institutional and technology innovations as an adaptation strategy to the same.

It is to be noted that since the idea is to get in-depth understandings, the questions are just leads to further interactions and probing with the subject

Impacts of Climate Change and Variability

1. Have you noticed any changes in weather patterns compared to what it was when you were a child, 50 years ago, 30 years ago and 10 years ago?

    a. Have there been any changes in temperature? Is it getting hotter or colder?

        i. When you were a child

        ii. Around independence

        iii. In the last 30 years

        iv. In the last 10 years

    b. Have you noticed longer spells of dry weather? Have you noticed any changes in the annual rainfall cycle?

Characteristics	Descriptions	Possible Reasons
Quantum of rainfall		
Distribution of rainfall		
Number of rainy days		
Rainfall outside rainy season		
Onset of rainfall		

2. Do you think different categories of farmers in your village are able to get their due from agriculture in the face of these changes[32]?

3. Could you describe the weather related shocks that your village has faced in the past 30 years

    a. What were the immediate effects of these shocks?

    b. Do you still feel the effect of the shocks till date? If yes in what way?

    c. Were all the households in the villages affected?

        i. Which of the households were the most affected and why?

        ii. Which of them were least affected and why?

        iii. Were there any households that were moderately affected and why?

    d. Did the damage caused by the climatic shocks recur? If yes then why?

    e. Was there a shortage of food in your household?

        i. If yes, which months was the food shortage the most acute?

32 This question could be a way of getting answers for different levels of farmers and landholders

ii. How many months did the food shortage last?

iii. Which was the worst month and how many times did the adults and the children in the household not eat?

4. How have these changes affected the lives of the women in the village?

5. Have they been part of the decision making process in the household? If yes or no has it had an effect on them?

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6. What factors determine the capacity of the individuals of households to adapt to this change?

7. Are you aware of the concept of sustainable agricultural practices?

    a. If yes, do you think they are effective as an adaptation strategy? How and why?

        i. Has there been a distinct change in attitude towards adaptation of the villagers in the past few years? How has it changed? Has this change in attitude been for the better or worse?

8. Have you resorted to alternate forms of agricultural practices because of unreliable weather patterns?

    a. Do you think there is any connection between the management of natural resources with climate change?

    b. Would you agree to adopt methods that would be less profitable but more environmental friendly and sustainable and help reduce the pace of impact of climate change in future?

    c. How cost effective or not have these alternatives been

    d. What was the cost of adoption of this technology and under what circumstances did you have to adopt the technology?

    e. What are the risks and constraints involved in these methods and do you think it is worth shifting to these forms

    f. Are these temporary alternatives that have been sought as a mitigation strategy or are they permanent in nature

    g. Has there been any changes in your production/ productivity/ profitability after adopting these alternative means

9. What is the source of information/who do you rely on when it comes to adopting a particular technology

    a. Did you get information on them through external sources or within the village itself. Incase of the former and the latter which and who were these sources

        i. If it was introduced externally were you a part of the development and implementation process?

    b. What were the difficulties and the constraints you faced in adopting the technologies and management practices? How were they overcome?

10. Has this technology increased your profitability?

11. Is it being handed over to the coming generation? If no, what are the other sustainable practices that you know of that could be used for improving agricultural production?

a. How much do you still rely on local technology that is being passed on from generations and how effective has it proved as an adaptation/mitigation mechanism against climatic shocks? Please give us instances of the same?

12. Among the water management and soil conservation techniques that you use which are the methods you think are most appropriate as an adaptation mechanism to climate change and why

Institutional

13. Was it a collective decision of the village to use the technology or is it being used only by some sections of the population in the village?

14. Do you see any relationship between adoption of a certain form of technology and factors such as i) tenure arrangements ii) socio-economic status iii) biophysical conditions at a household level

15. What is your opinion on the methods which have been introduced for effective water management

    a. What are the factors/determinants you look at before you make a decision to take up a technology
    b. How much do you rely on extension services and workers when you decide to adopt a particular technology

16. Are you part of any association? If yes how did you become a part of this association

    a. Do you know if this association works with any other organization
    b. What kind of role do you play in the activities of the association
    c. How is the membership decided in the association? Is it free of cost or do you have to pay a fee
    d. Do you receive any benefits from this association? If yes, what are these benefits and are they useful for agricultural purposes
    e. Is the association involved in matters related to water resource management? If yes could you tell us how it functions
        i. Is the water management related to both domestic and agricultural use
        ii. How involved is the association in terms of water and soil conservation practices
        iii. Does it have any regulatory practices when it comes to usage of water for agriculture?
        iv. If yes on what basis were these regulations put into place and how have they changed over time
        v. Does your association carry out any extension work

17. Do you feel that the activities carried out by the association related to water resource management is anyway an aid towards adaptation to climate change? If yes how is it so, if no why not?

18. Are you aware of a Water Users' Association (WUA) in your village

    a. Are you a member and are you aware of how and who manages it
    b. How does the membership work in a WUA, who fixes the criteria for the same
    c. Are they linked to any of the associations or groups in the village?
        i. If yes which are these associations? Are they linked to the association you are part of
        ii. How did the linkage take place? Who facilitated the process

iii. Do you know why did the WUA start in your village, why was the need felt to set up a WUA

d. Did you face any hurdles to become a member of the WUA; if yes what were they

e. Is there a system of allocation of water that the WUA follows? Are you aware of it

i. If yes, how is the allocation of water decided

ii. What is the maximum size of the land that the WUA allocates water to

iii. Incase of water requirements exceeding more than the earmarked size of land where do farmers procure the water from

f. Which is the main institution which is involved in soil and water conservation and how? What are the techniques that it promotes

i. Does it give any incentive to its members who practice efficient water conservations methods

ii. If yes, what are these incentives

iii. Have you been a received any such incentives

g. Has the WUA benefited the whole village or only some part of the village? If so how?

h. How important do you think is the presence of WUA as an adaptation strategy, in the context of increasing climate variability

2. Questionnaire for Focus Group Discussions

The purpose of this questionnaire is to merely serve as a guide towards trying to understand the perceptions of the farmers across groups in the SAT villages to climate change and different kinds of institutional and technology innovations as an adaptation strategy to the same.

It is to be noted that since the idea is to get in-depth understandings, the questions are just leads to further interactions and probing with the subject

Perceptions[33] *of Climate Variability and Change*

1. Have you noticed any changes in weather patterns compared to what it was when you were a child, 50 years ago, 30 years ago and 10 years ago ?

c. Have there been any changes in temperature? Is it getting hotter or colder?

v. When you were a child

vi. Around independence

vii. In the last 30 years

viii. In the last 10 years

d. Have you noticed longer spells of dry weather? Have you noticed any changes in the annual rainfall cycle?

Characteristics	Descriptions	Possible Reasons
Quantum of rainfall		
Distribution of rainfall		
Number of rainy days		

[33] Defined as what people understand, relate to, judge or associate from a given observation or situation

Rainfall outside rainy season			
Onset of rainfall			
Gap between two rainfall seasons			
Temperature	Day		
	Night		
	Summer		
	Winter		

Effect of Climate Variability and Change

2. Have there been any droughts or floods in the village? Could you give us a year wise account of them

Drought Years	Flood Years

3. Within a period of 10 years how many favourable years, normal years, moderate drought and severe drought years did the village experience[34]

Characteristics	2001-2011	2000-1990	1990-1980	1980-1970	1970-1960
Favourable year					
Normal Year					
Moderate Drought					
Severe Drought					

4. What according to you is the cause of the droughts or floods?

5. Which of the following has the most significant effect on climate?

    - Natural
    - Human activities
    - Increase in population
    - Others

6. Do you think that this phenomenon or changes in climate are exclusive to your village or have these kinds of changes taken place in your neighbouring villages as well?

    a. How have they affected your neighbouring villages?

[34] Favorable year is defined as when the crop yields are above normal year crop, normal year is when the crop yields are above average, moderate drought is when the yields are below average and severe drought is when there is nearly a total crop failure.

b. Do you think your village is better than your neighbouring village or worse off in facing these changes and why is it so?

c. How has availability of water been affected in your village because of the changing weather patterns?

d. Has there been any change in the water table due to changing weather patterns?

e. How is the water supply in the village?

   i. Have the sources for water reduced or increased over the years? What causes shortages - insufficient groundwater/ reduced rainfall?

   ii. Has there been intervention from the Panchayat or the Government over time that has increased the availability of water

   iii. How is the quality of the water that is available?

   iv. What do people do to obtain drinking water during times of shortage (i.e. can water be purchased, or carried from a more distant site)?

   v. Who fetches the water from the sources and how long does it take?

   vi. Have women in the village had to travel longer distances to fetch the water than what it was before? How does it have a bearing on their health?

7. Could you give us an account of the Changing Sources of water for irrigation in your village in the last 50 years

Source	**Total Number in Village**					
	2011	2000	1990	1980	1970	1960
Wells						
Borewells						
Tank						
Pond						
River						

8. How have the changing weather patterns affected agriculture?

a. Who are the ones (caste/class/women/children/old) that have been affected the most and how?

   i. To what levels do you think this effect has been? Could you describe to us in detail?

   ii. Have there been instances that harvests have been affected adversely?

      o What were these instances?

         ✓ Pest Attacks
         ✓ Untimely rainfall
         ✓ Change in temperature
         ✓ Intensity of Rainfall
         ✓ Lack of rainfall?

   iii. What has been the most severe outcome of these instances

      o Decline in crop yield
      o Loss of entire crop

- Death of livestock
- Loss of asset
- Loss of income
- Food Shortage
- Effect on the quality of land

iv. Were there any extreme steps[35] that the farmers took?

b. How has the changing climatic conditions affected your crop production

c. Have there been any changes in the production level of crops and cropping patterns in your village?

i. What is the proportion of food crops to cash crops that is grown in your village? Has this changed as a result of changes in climate or market demand?

ii. Has your village been in a capacity to produce surplus or has it been subsistence? Would you say it has changed and if yes, would you say it is because of the climatic conditions?

d. How have the changes in weather patterns affected livestock production?

e. During an unfavourable situation what is the first asset you would sell and why?

f. How do you evaluate the viability of agriculture as a future source of livelihood given the phenomenon of climate change? How has this changed over 50 years and especially in the last 10 years? Is this a concern to you and why?

g. What kinds of changes in sources of income have taken place? Would you say that changes in sources of income are because of climate change or any other reason[36]?

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9. How is soil and water managed in your village?

10. Why is it important to manage water and soil?

11. Do you have any mechanisms of water harvesting in your village? If so could you tell us about it

a. What are the methods of water management you use which have been used by your fore fathers

b. What are the new techniques of water management that you have adopted and how

c. From whom do you get information regarding such new techniques

d. Do you use a combination of the old and the new techniques

e. Which of the methods do you think is more efficient and why

12. What are the key innovations that have taken place in the water systems in your village in particular and in your area in general

a. What led to the choice of these water systems and for how long have they been in use.

b. What led to the innovations to the water systems

[35] Incidences of suicides, mortgaging of land and permanent migrations
36 These reasons could be industrialization as well which can be probed into through PRA and see how things were earlier and how they are now

c. Have the innovations you mentioned in the water systems had an effect on your cropping patterns. If yes how

13. What kind of farmers adopt the technologies? Why is the situation different so that they are able to adopt?

14. What constraints do other farmers face in adopting the technologies? What conditions can be put in place to enabling them to adopt?

    a. Do you see any relationship between adoption of a certain form of technology and factors such as i) tenure arrangements ii) socio-economic status iii) biophysical conditions at a household level

15. What is your opinion on the methods which have been introduced for effective water management

    a. What are the advantages that you see in the technology? Are there any additional advantages from the previous practices carried out by you
    b. Is it compatible with the resource base you have or did you have to put in additional investments
    c. Is it a simple and efficient? If yes, could you explain how
    d. Have you seen or noticed any significant difference in your crop production output or soil and water health or both after practicing these methods
    e. What is the source of information/who do you rely on when it comes to adopting a particular technology

16. Were any new methods adopted which have been useful to you where farming is concerned

    a. Were you consulted before these methods were adopted

17. Do you feel that these technologies will in anyway help you to adapt against climate change

Institutional

18. What are the different associations that are active in your village? Who are the members of these associations and who manages it

    a. How did these associations come into existence? Was there a particular reason why these associations were formed
        i. Is there any other body which supports these organizations or do they work independently with local support
        ii. Are women part of these associations or do they have separate bodies of their own
        iii. If they are part of these associations, what kind of role do they have in the functioning of the association
        iv. How is the membership decided in these associations? Is it free of cost or do you have to pay a fee
    b. Are these associations in anyway involved in matters related to agriculture and water resource management? If yes, could you tell us more on how it functions
    c. How did these associations get involved with matters related to water resource management
        i. Is the water management related to both domestic and agricultural use
        ii. How involved are these associations in terms of water and soil conservation practices

iii. Do they have any regulatory practices when it comes to usage of water for agriculture?

iv. If yes on what basis were these regulations put into place and how have they changed over time

d. Do you get any benefits by being part of this association? What kind of benefits are they

i. Do these associations carry out any extension work

19. Do you have a Water User's Association (WUA) in your village

a. How are the farmers in the WUA organised?

b. Who are the members and who manages it?

c. How does the membership work in a WUA, who fixes the criteria for the same

d. Are they linked to any of the associations or groups in the village?

i. If yes which are these associations

ii. How did the linkage take place? Who facilitated the process

iii. Why did the WUA start in your village, why was the need felt to set up a WUA

iv. Did you face any hurdles while establishing the WUA; if yes what were they

e. Is there a system of allocation of water that the WUA follows?

i. If yes, how is the allocation of water decided? Do you think it is fair?

ii. Is the water sufficient? Incase it is not how is allocation prioritised?

iii. Incase of water requirements exceeding more than the earmarked size of land where do farmers procure the water from

f. How is management of the WUA chosen? What incentives are there to participate in the leadership?

g. Which is the main institution which is involved in soil and water conservation and how? What are the techniques that it promotes

i. Does it give any incentive to its members who practice efficient water conservations methods

h. Has the WUA benefited the whole village or only some part of the village? If so how?

i. How important do you think is the presence of WUA as an adaptation strategy, in the context of increasing climate variability

3. Questionnaire Basic Household information

The purpose of this questionnaire is to merely serve as a guide towards trying to understand some basic information regarding agriculture and climate change from the farmers' perspective

1. Name:______________ Age:_____ Male: □ Female: □
2. Number of family members: ___________ ___________________________
3. Do the children go to school: Yes: □ No □ If yes then which class do they study in: ______________________
4. Number of generations of your family living in the village:_______
5. Do you belong to this village originally: Yes: □ No □ If no which village do you belong to (1) and reasons for coming here (2): 1.____________2:___________
6. Do you have your own farming land: Yes: □ No □

7. If yes, what is the land size (in acres): 0.2 -2.0 □ 2.0 – 5.0 □ >5.0 □

8. What are the kind of crops you grow:

   1. Kharif ____
   2. Rabi ____
   3. Hot weather ____
   4. Two seasonal (for example cotton) _________________________
   5. Perennial (sugar cane, banana, etc.) _________________________

9. What proportion of your cultivated land is:

   1. Irrigated: 0-10% □ 10-25% □ 25-50% □ >50% □ 100% □
   2. Rainfed: 0-10% □ 10-25% □ 25-50% □ >50% □ 100% □

10. Do you leave any portion of your land fallow: Yes: □ No □

    1. If yes what proportion of your total land holding ____________________
    2. Reasons ____

11. What are the sources of water for irrigation available to you: Open dug Wells □ Tube Wells □ Dams □ Canal □ River □ Any Other please describe

12. What are the methods of irrigation that you use : Lift □ Diversions □ Furrow □ Flooding □ Drip □ Sprinklers □ Any Other please describe

13. What are your sources of information regarding input supplies in agriculture from the most used to the least: TV □ Radio □ Internet □ Mobile Phone □ Other Farmers □ Extension Workers □ Output Buyers □ Input Dealer □ Government Demonstrations □ Neighbours □ Weekly Market □ KVKs □ Newspapers □ Gram Panchayat □ Co-operatives □ SHGs □ NGOs □ Farmers' study tour □ Any other please describe

14. Do you have any water storage facilities: Yes □ No □

15. What methods of water storage do you have: Underground storage tanks □ Over head tanks □ Surface Pond □ Any other please describe

16. Have you noticed any changes in weather patterns compared to what it was 30-50 years ago/ when you were a child?

Characteristics		**Descriptions**	**Possible Reasons**
Quantum of rainfall			
Distribution of rainfall			
Number of rainy days			
Rainfall outside rainy season			
Onset of rainfall			
Gap between two rainfall seasons			
Temperature	Day		
	Night		

	Summer		
	Winter		

17. Are there many fluctuations in the weather conditions in the short run: Yes □ No □
18. Have these variability been increasing over the years: Yes □ No □
19. Which is a major concern for you with respect to climate/weather: Long term change □ Season to season variability □
20. Which do you think your household can manage better: Long term change □ Season to season variability □
21. Could you classify your household according to the capacity it has to cope with current climatic variability and water stress: Good Capacity □ Medium Capacity □ Less Capacity □
22. Please rank the following management techniques from important to least important as an adaptation strategy to climate change: Zero tillage □ Crop Rotation □ Crop mulching and compost use □ Conservation tillage □ Small ponds for micro irrigation □ Surface water capture □ Field levelling and drainage □ River diversion □ Rainwater harvesting □ Bunds and Check dams □ Poly – drip method □ Others □