Social Designs: Tank Irrigation Technology and Agrarian Transformation in Karnataka, South India

Esha Shah

Propositions

1. The world inscribed in the object (artefact) is the world described by it.
(Akrich 1992)

2. It is easier for dominant sections of farmers to accomplish water distribution in their favour through the design of the tank irrigation technology than by drafting a rule or crafting an institution. (this thesis)

3. It is largely accepted among national and international policy makers that the Indian state agencies failed to appropriately manage and maintain many thousands of irrigation tanks. They affirm that only communities have managed and maintained irrigation tanks despite the fact that the state has claimed proprietary rights. The policy makers have thus resolved to attempt the development of a community-based approach to tank management in order to return tanks to communities because tanks have always remained with communities. Communities are considered better managers of tank irrigation resources not because they are better managers, but because history hasn't yet taught us how to manage them otherwise. (this thesis)

4. Modernity requires nothing more than a philosophical rupture with the past and thus it is unending, forever opens onto the unknown. (Amin, Samir. 2000. Economic globalism and political universalism: conflicting issues? *Journal of World Systems Research* 3 (fall/winter): 581-622)

5. One needs reason to counter the fallibility of reason.

6. In *The Republic* – a Platonic Dialogue – Socrates conversed to ultimately argue that justice exists out there and needs to be uncovered through reason. During one of the conversations, Thrasymachus – a Sophist – became impatient and countered Socrates, " I declare that justice is nothing else than that which is advantageous to the stronger." (Stoneman, Richard, eds. 1992. *Plato: The Republic*. London: J. M. Dent and Sons Ltd. p – 14.) In today's world, Thrasymachus would have called "good governance" the advantage of the stronger.

7. The virtual reality of the World Wide Web produced two connotations of the key word "tanks". It presented information on "tanks" – one of the many remarkable achievements of science and technology that can efficiently and economically kill. The other "tanks" are sites where ideas are accumulated and are called "think tanks". The future of humanity demands that wars are fought only with ideas on the sites of "think tanks"; that "irrigation tanks" for agricultural production are promoted; and, that "tanks" for mass destruction are completely eliminated.

Propositions attached to the thesis
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Glossary & Abbreviations

alagu	(usually) middle and lower part of atchakat, often original path of the halla supplying water to the tank
areca	betel nut
aregere	tank half full
atchakat	tank irrigated area
bagadi	(or valadi) higher land in the atchakat
basavanna	bull
bavi	an open well
bhagstru	right to neergati's work divided, sold or transferred
bhatta	rice
bidu	an alloy with which sluice cap is made
bundh	strike
dharana	picketing
dipotsava	festival of light
DPW	Department of Public Works
ery	Tamil word for tank
FTL	full tank level
gachchu	pre-modern substitute for concrete, made by mixing sand, jaggery, water, lime and sap (oozing out of a local tree).
gangemma	water goddess
GOI	Government of India
GOK	Government of Karnataka
gunta	measure of land (100 gunta is one hectare)
halla	natural drainage or stream
halli	village
hankalu	dry land (in the wet region)

hodatha	land and water management practice followed for cultivation of broadcasted paddy
IC	irrigation committee
IO	irrigation organisation
jowar	sorghum
jowgu	seepage, subsurface moisture
kani	right over productive resources – land, water and labour
khushgi	dry land
kisan	farmer
KRRS	Karnataka rajya raita sangha (Karnataka farmers' association)
kudimaramat	maintenance and repair of tank work voluntarily undertaken by community
kunte	wooden implement to uproot weeds and consolidate lightly wet earth in the paddy fields
LBC	Left Bank Canal
madaga	flood gate
mahanavami	local festival
maidan	plain
manegara	watermen, neerganti
megatti	dry land converted to paddy land
melatto	dry/unirrigated land
MID	Minor Irrigation Department
MIDS	Madras Institute of Development Studies
mole bhatta	Paddy cultivated by sowing sprouted seeds
NABARD	National Bank for Rural Development
nati bhatta	transplanted paddy cultivation
navane	a millet
neerganti	irrigators or watermen
NIA	Net Irrigated Area
nunjah-mel-panjah	dry cultivation in wet land
pani books	land registers
Patel	hereditary post of village officer meant to serve as tax intermediary during the British period
patkeri	waterman (usually appointed by the MID)
puja	worship
punaji bhatta	paddy cultivated by broadcasting dry seeds in fields

PWD	Public Works Department
ragi	a staple grain
raita sanghas	farmers' associations
RBC	Right Bank Canal
sara/saru jameen	lower or seepage land in the atchakat
Shanbhoga	hereditary post of village officer meant to serve as tax intermediary during the British period
shashwat	immortal
sowdi	waterman (usually appointed by the MID)
tagu	lower land in the atchakat
taka	literally means strength, in farmers' meaning – nutrition
taluk	administrative and political subunit of a district
tari	paddy land
tithi	a specific date in agricultural calendar
tomtom	a drum
valadi	(or bagadi) higher land in the atchakat
vari jameen	upper land in the atchakat
visti	right to imposition of forced labour
vodda	members of a labouring, artisan caste, known as tank builders
Zilla Parishad	district level political and administrative unit of local government

Preface

I often found my engineering training frustrating.

The time I spent in the engineering institution was also the period of my life when certain personal experiences led me to ask larger questions such as why women were subordinated in our society. In the search for answers, I came up with more questions. In fact, it was this question about women's subordination that began my own journey of making sense of my immediate surroundings and society at large, a journey that led me to the social sciences.

The time I spent in the engineering institution was the time when I started to learn about society and politics through my association with the women's movement, other leftist political organisations and interaction with scholars and friends from the Center for Social Studies in Surat, Gujarat. At that time, it hardly felt (and it still hardly feels) that I was learning the social sciences.

There was another personal reason why I felt more comfortable with the world of social sciences. "Being critical" was not appreciated much in the social and professional environment of an engineering institution. On the social front, asking basic questions such as why do men and women receive unequal treatment in our society could create a storm in a teacup. As a Ladies Representative (and incidentally a Gujarati) supporting a non-Gujarati General Secretary in a college election could result in you being threatened or even abducted on the day of the election. In the mid 1980s, when there were protests all over India against the Mandal Commission's recommendations in favour of reservation for socially and historically disadvantaged groups, you could easily be an outcast in an engineering institution if you supported Mandal. It was easy, in such a climate, to hang out with "social science" friends.

But more importantly, engineering training was frustrating because it was largely textbook oriented. Students had to learn what textbooks said. Any discussion about the social relevance of what was being taught was out of the question. In general, studying the empirical, rule of thumb knowledge of civil engineering, especially when my nagging mind constantly questioned its social relevance, was to a great extent a frustrating experience.

After completing my training, I wanted to run away from the world of equations and drawings, but I also wanted to apply my 'knowledge' to socially relevant situations. This was the challenge in front of me. Taking up further studies in the technology-society interface was one of the options as it would provide an opportunity to combine social and engineering knowledge. But a journey in the direction of interdisciplinary research had many hurdles. It took more than six years to find financial and institutional support to do an interdisciplinary study on "social designs of tank irrigation technology".

My efforts to find institutional support in India for doctoral study failed. A social science professor could not be accepted as a co-supervisor in an engineering institution, whereas without a degree in social sciences I could not register with a social science institution. I applied three times to one of the leading natural science institutions in India but again did not succeed. Once I was told that I was not expected to have my own proposal; most of the students were offered a topic by interested faculty. On the second occasion, I was told that an engineering department would find it difficult to handle my topic which had a strong social science component. The third time around, I was offered a doctoral position but only on the condition that I forget about tanks and instead take up a study in mathematical modeling of ground water pollution. I had no option but to search for support elsewhere.

At the time when appropriateness of large dams was being questioned all over India, understanding the social appropriateness of what was termed as alternative technologies would have been a priority for academic institutions. Alas, I was being romantic.

My introduction to Peter Mollinga proved a turning point after several efforts to find institutional and financial support failed in India. But it took three more years to find financial support in the Netherlands. One of the referees, appointed by a leading research foundation in the Netherlands, wrote in his/her comments to my proposal that studying designs of tank technology may not be a viable idea; management practices could be studied instead. I was not selected. After a long and tedious journey, this project finally took off with the financial support of the Ford Foundation and the Irrigation and Water Engineering Group of Wageningen University.

On the eve of its completion, I feel jittery. Interdisciplinarity indeed has not been easy. The subject of tank technology and agrarian transformation needed to be based on knowledge generated in the disciplines of hydrology, irrigation science, construction engineering, agricultural sciences, and especially social sciences with a labyrinth of theoretical and methodological propositions and contentions. My colleague at the Center for Interdisciplinary Studies in Environment and Development has described interdisciplinary studies as a quicksand area. Each discipline has its own maze of debates; one could be potentially lost in the labyrinth of one debate. Achieving balance may be a key, but that may also result in remaining superfluous. That is what makes me nervous. If this book finds interdisciplinary readers, as I hope, some of the readers are likely to find some of the discussions basic. It is also likely that some discussions may remain impenetrable for some other readers.

Notwithstanding the difficult terrain of interdisciplinary research, personally the journey from civil engineering to the debate on civil society has been a rewarding journey. And I hope to continue it further.

This journey would not have been possible without the support of many people who walked with me, helped and shared my burden and provided crucial inputs.

I begin by thanking the Ford Foundation and the Irrigation and Water Engineering Group of Wageningen University for financial and institutional support.

Without the assistance of Iswaragouda Patil this research would have been much impoverished. Visiting several tanks, not easily accessible through motored vehicles, located in varied agro-climatic locations was a demanding task. It would not have been possible without Patil's guidance. He took travel planning entirely off my shoulders, which given my knowledge of Karnataka, would have taken a lot of time and effort. But more importantly, I learnt a great deal about agricultural, land and water management practices while working with Patil. I perhaps would have missed nuances of some farming practices if he had not pointed them out to me. Being a farmer himself, his knowledge about farming has enriched my research a great deal. His gentle and persuasive way of interacting with farmers earned us social acceptance that made research a rewarding experience. I thank him for all his assistance and input in this research. Wherever in this book I have mentioned "we" or "us", it is Patil that I include as a co-researcher in my journey.

This research would never have been possible without farmers' willingness to share their experiences and knowledge. They not only taught me a lot about water and land management practices, but the interaction with them in general has been a learning and enriching experience. I thank them for their sharing and for their hospitality. I hope to translate my research in the everyday language and idiom of farmers as quickly as possible. Interaction with engineers of the Minor Irrigation Department has equally enriched this research. Without their willingness to take me around and their guidance and valuable input, my understanding of the technical aspects of tanks would have been lacking.

I owe very special thanks to Peter Mollinga for his continuous interest in my project and moral support at the time when efforts to secure funding in the Netherlands were not succeeding and when I had almost given up. His untiring and insightful efforts on every front – from the financial and administrative aspects to the detailed comments on everything I wrote – have played a pivotal role in shaping this research.

It has also been a rewarding experience working as a Ph.D. cholar with Peter Mollinga, Franz von Benda-Beckmann and Linden Vincent. I take this opportunity to formally thank them for their support and for their prompt, detailed, thought-provoking (and often destabilizing) comments and criticism. I would also like to specially thank Nirmal Sengupta for his support right from the time when I wrote the first proposal almost a decade ago. I will always remain indebted to him for providing valuable input and also for often reminding me that writing one chapter on social aspects and another on technical aspects is not real interdisciplinary research; the challenge would be to integrate both. Someshekara Reddy has always been kind and supportive to me. He has not only generously shared his collection of literature, but also has provided indispensable practical guidance during the most demanding initial phase of the fieldwork.

My special thanks are due to the staff of several libraries that I visited in the course of this research. I have used the libraries of: Wageningen University, Institute of Economic and Social Change, Madras Institute of Development Studies, Indian Institute of Management, Bangalore, Dharwad University, Hampi University, National Law School of India, Warwick University, School of Oriental and African Studies and British library.

My special thanks are also due to Trudy Freriks and Gerda Fauw, whose ever-smiling assistance made my troubles melt in thin air.

The stay in the Netherlands was rewarding not only academically but also personally because of several friends. I would like to specially thank Jos Mooij, Anne-Lies and Arnout Risseeuw, Trudy and Herman Freriks, and Job and Joke for their friendship and hospitality, which made me less home sick in the foreign country.

I will always have fond memories of my fellow travellers – R. Manimohan, Vishal Narain, Jyothi Krishnan, Preeta Lall, Bala Raju Nikku, Anjal Prakash, Pushpa Kanal, Suman Gautam and Amrita Regmi. They would always remind me, among many other things, the thunder laughter we had together. Thanks a lot for being with me.

The colleagues at the Centre for Interdisciplinary Studies in Environment and Development deserve very special thanks for their unwavering moral support during the difficult final phase of thesis writing and also for allowing me to concentrate on my thesis when I should have been working with them. I specifically thank Sharachchandra Lele, M. V. Ramana and Ajit Menon for their continuous support and input into my thesis.

I also extend special thanks to my friend Keshav Prasad for making engineering line drawings derived purely from photographs.

I never thought that the purpose of family and friends in life is to provide support. Rather, they have made me the way I am. I have had a life full of enriching experiences thanks to my parents, who never measured us with the yardstick of success and failure, who allowed us to make our own mistakes and learn from them, and who never inflicted any fear into our minds. I feel very privileged to have a brother like Dhaval whose faith in me has been a great source of strength.

I have in fact been enormously lucky to have received affection from two families. Shrungi, Neha, Ghanshyam and Kalpana Shah's family warmly included me as one of them, whose affection has formative influence on my emotional and intellectual self. I grew up admiring Ghanshyam Shah especially for his commitment to his politics and work and for his moral courage to stand up for what he considers right, irrespective of the consequences.

And lastly, a word on Ram, my closest friend and companion. When we met he was writing his Ph.D. thesis and I was daydreaming of doing mine one day. At the beginning of our companionship we were at two different stages – in terms of our skills, understanding and experience – of doing academics. Our companionship has also been a period of apprenticeship for me. Living with Ram has chiseled, scraped, hammered and moulded my romanticism. I will never be able to sufficiently thank Ram for making my journey in academics a great deal more meaningful.

This book is dedicated to my dearest friend Shrungi, whose friendship early in my life taught me the value of human bondage, and whose spirited, non-pretentious and humane approach to life has made such a difference which clever and smart world of reason would perhaps take generations.

Bangalore, May 2003

1

Social Designs

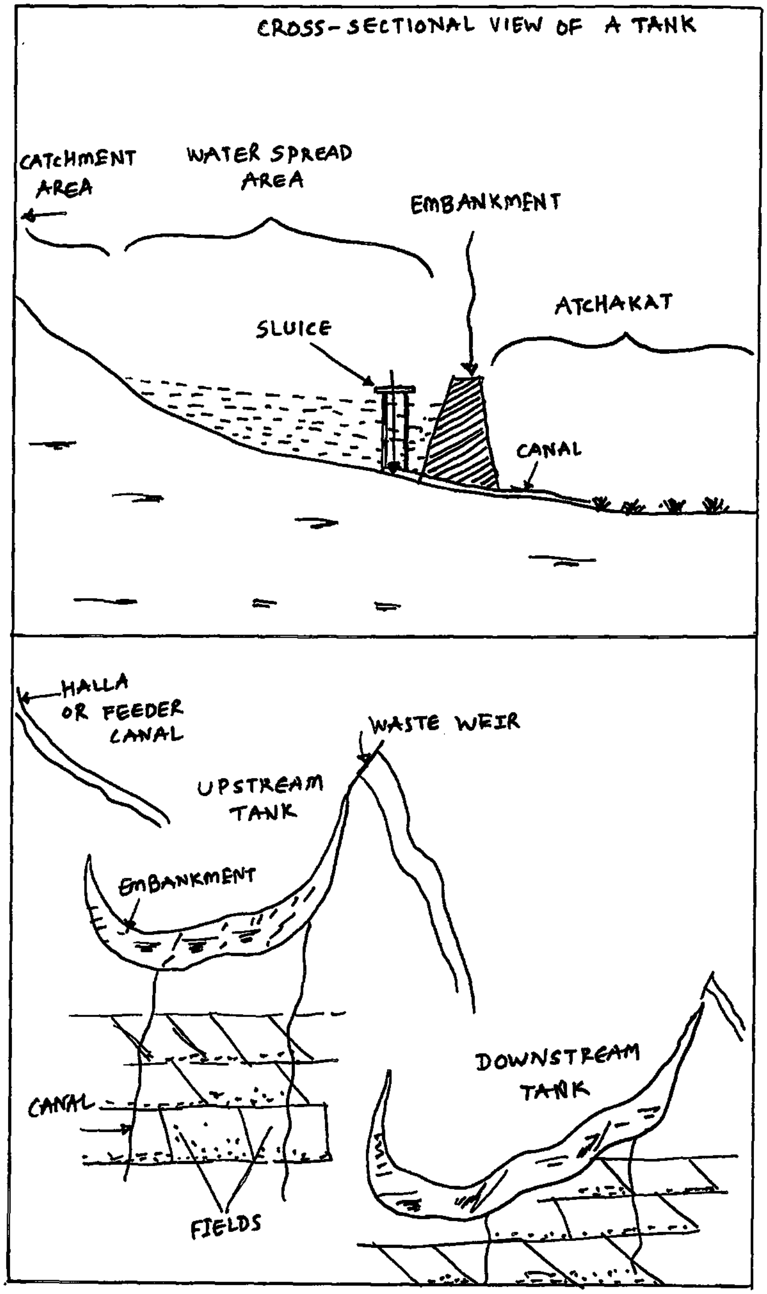
The great import of technology studies to the social sciences is to have shown, for instance, how many features of the former society, durability, expansion, scale, mobility were actually due to the capacity of artefacts to construct, literally and not metaphorically, social order... ... ... They are not "reflecting" it, as if the "reflected" society exists somewhere else and was made of some other stuff. They are in large part the stuff out of which the socialness is made.

— Latour (2000: 109)

I first became curious about tank irrigation systems of south India in the late 1980s during the peak of the movement against large dams in Gujarat. The proposed Sardar Sarovar dam generated heated arguments and pitched debates all over India in favour or against large dams. In Gujarat, especially, extreme emotions spilled into the public domain. The intensity of the debate compelled all politically and socially aware citizens to take a position for or against large dams.

The debate over the Sardar Sarovar dam also resulted in people questioning the appropriateness of the development trajectory that necessitated large dams. It raised another serious issue: what technology other than large dams could provide water in necessary quantities in a timely fashion? In the context of the debate against large dams, several scholars and activists brought to the forefront locally-managed/traditional/indigenous technologies as possible alternative forms of water management. More prominently, since the time of the movement against large dams, the idea of small, indigenous, and environmentally and culturally embedded forms of water management appealed emotionally to many, myself included.

FIGURE 1.1: The technical principle of tanks (not to scale).



Timeless tanks

Tank irrigation in south India is a centuries old technology. Tanks are known to have existed even in 300 B.C., but large scale tank construction activity in south India dates back to around 700 A.D. (Gurukkal 1986). The Hoysala and Vijayanagara dynasties that ruled various parts of Karnataka between 1100 to 1600 A.D. were famous for their tank building activities (Dikshit et al. 1993). The number of tanks built in the British and post-independence periods is almost negligible compared to the number of tanks constructed during the previous centuries. Hence, one can safely say that a majority of existing tanks in Karanataka are several centuries old. There are thousands of tanks, irrigating anywhere between 10 to 1,000 hectares, scattered all over south India, with approximately 38,000 in the state of Karnataka as per the 1986-87 census (Vaidyanathan 1998: 6-7). They irrigate roughly 19 per cent of the net irrigated area in the state of Karnataka (Vaidyanathan 1998: 6-7).

Technically, a tank can be described as a miniature version of a large dam. Water is impounded behind an earthen embankment to be released through sluices into canals to be further distributed to irrigated lands. Excess water from a reservoir is allowed to escape through waste weir/s. Figure 1 gives a schematic diagram of the technical principle of tanks.

Tank embankments are usually semi circular or irregularly curved in shape. They could be a few hundred meters to a few kilometers long depending upon the shape and size of valleys they are bridging. The delta regions of the rivers Godavari and Kaveri in south India are known for tanks with exceptionally long embankments. The longest known embankment is 16 kilometers (Dikshit et al. 1993), but two to five kilometers long embankments are the most common throughout south India. An average sized tank with a 2 to 2.5 kilometre long embankment and a depth of 5 to 7 metres at the deepest point may irrigate around 300-350 hectares of land.

Thus, in their most characteristic form tanks are much smaller than large dam reservoirs. They are constructed by bridging (usually shallow) valleys with earthen dams thrown across the flow of water. They usually receive water from a seasonal drainage channel (locally known as *halla*), a seasonally flowing tributary or a canal supplied from a river. They are almost never constructed directly on perennial rivers. That way they stand apart from large dams, which are almost always constructed on perennial rivers.

Tanks are often described as reservoirs that capture and store every drop of drainage water (cf. Vani 1992: 15). Shankari (Shankari and Shah 1993: 5) poetically describes tanks in the context of rainfall pattern in the Indian subcontinent: "Shower more somewhere, shower less somewhere, but when we rain, we pour." Much of the monsoon rainfall falls within a span of a few hours or days in much of south India, and hence capturing and storing the excess in the rainy days for the non-rainy days becomes crucial for agriculture.

Tanks are usually constructed in chains whatever the source may be of water supply. That implies that overflow from the upstream tank forms the inflow into the downstream tank. Thus, a series of tanks form a chain that successively capture run off from either a seasonally flowing stream or a river during the rainy season. In other words, although tanks are spatially dispersed they actually are hydrologically linked.

Tanks usually are located close to villages. Villages often carry the same name as the tanks. Big tanks may serve more than one village. Tanks also provide water for drinking and other domestic purposes.

It was perhaps a time to search for a utopia as much as alternatives. The "traditional" and "timeless" tanks fitted the image of that ideal.

This research involves a journey in the opposite direction. It intends to question how democratic the patterns of resource utilisation in tank-irrigated areas are. By exploring the diversity of tank designs and their transformation in the wider context of agrarian change the study looks at resource utilisation patterns in tank-irrigated areas.

An Ideal Alternative

The most common view in academic and policy circles, more emphatically so in the aftermath of the movement against large dams, celebrates tank technology as one of the ideal alternatives.[1] In this view, tanks are small, local, ecologically and socially embedded in contrast to the big, modern, western and ecologically disastrous technology of large dams. For the advocates of indigenous technology, tanks are the emblem of continuity in history, tradition and heritage. At the same time, their small size and spatially dispersed nature makes them ideal for decentralised management by local communities.[2] This counter hegemonic role ascribed to tank irrigation technology not only implies a wide ranging criticism of modern technology and modernity in general[3] but also sets the stage for criticism and redefinition, even reconstitution of the way irrigation resources can be institutionalised and managed in general.

In the last two decades, yet another discourse on natural resource management has formed the philosophical background for tank development in south India. Mosse (1999: 305) points out that a policy reform programme to organise local users' associations was initiated on the premise that the present level of resource degradation is a result of the loss of "traditional" and "communal" institutional arrangements for management and use of resources. The notion that communities are better managers of local resources also derives its legitimacy from another influential argument. A large number of scholars have argued that state intervention, beginning with the colonial period, is the cause of the current level of natural resource degradation (cf. Reddy 1990; Agarwal and Narain 1997). This view has found wide currency especially in the last two decades among national and international policy makers. It has been translated into development programmes that intend to reduce state intervention and increase community participation in natural resource management. The policy consensus that communities are better managers of local tank resources has been translated into tank development programmes in the three south Indian states of Andhra Pradesh, Tamilnadu and Karnataka in the last two decades.

More Questions than Answers

This dichotomised - traditional vs. modern, centralised vs. decentralised, small vs. big, local vs. non-local, state vs. community managed - ascription to irrigation technologies raises more questions than it answers. First of all, the claim that the traditional nature of tank systems makes them more amenable to community management raises a fundamental concern. Andre Beteille (1998: 529) defines tradition as "what links the present practices with past ones, it is the past in the present". Many historians have discussed the hierarchically organised social order of the south Indian past, which Ludden (1985: 89) characterised as "anything but egalitarian". If tank technology is an appropriate/ideal form of irrigation because it is traditional and socially embedded, then that proposition raises a compelling question: how does a hierarchically organised and inegalitarian social order distribute its water resources when mediated by tank technology? Guha (1988: 15) correctly points out that advocates of indigenous or traditional knowledge rarely mention the grave inequity of traditional India while romanticising nature and culture of pre-modern science and technology. Agrawal (1995: 416) similarly emphasises that although advocates of indigenous knowledge intend to empower marginalised groups, they rarely acknowledge that in very local contexts, a significant shift in power relations would be a prerequisite for truly empowering those who are on the margins.

Secondly, the proponents of indigenous tank technology most often describe tank technology as no more than an ensemble of a few physical structures, whose technical designs more or less remain unchanging in varied spatial, temporal and social contexts. If change is addressed, it is only in terms of the deterioration of physical structures of tanks (cf. Mukundan 1988). Whereas, as Sengupta (1991: 19) points out, "common property arises from the interface of technical and social features and its extent varies with technological and social changes." The argument about the embeddedness of tank technology is rarely related to the dynamics and complexity of its productive context – social and agrarian. As Agrawal and Sivaramakrishnan (2001: 2) also contend, "the analytical focus on natural resources (water and forests) has created a site for itself that is resolutely separated from the agrarian world." The context in which tank technology acquires a superior stature, if it does, remains largely missing in the debate. The agrarian landscape has radically transformed over the life span of many existing tanks. It has generated new interests and new methods to use the resource. At the same time the old forms of resource utilisation have transformed, more markedly with the diversification and commercialisation of agriculture in the last couple of decades. How agrarian transformation impinges upon tank technology and the pattern of water utilisation is a question that needs to be asked.

Central Concern and Research Question

This study aims to bring tank technology out of its innocuous utopian abode by questioning resource utilisation patterns in tank-irrigated areas. The central concern of this research is to understand how social relations of power in particular historical, agro-climatic and agrarian contexts shape tank technology and how technology in turn shapes resource utilisation practices. Ultimately this research aims to contribute to the debate on democratisation of natural resource utilisation and management.

The central concern of this research raises two issues of theoretical importance. What is technology and in what way do social and political factors impinge upon it? And "how" do social relations of power shape technology? The major strands in the debate on social shaping of technology are summarised in the next section. This is followed by a discussion on technological designs and their formation in a particular context.

The Social Shaping of Technology

The debate on the relationship between technology and society has been divided ever since deterministic interpretations, which perceived technology as an agent of social change, were challenged (Mulkay 1984: 77-80; Staudenmaier 1994: 269-73). One group in varying degrees has argued that technological rationality will lead us in the direction of progress. The other group not only believes that technological rationality is contingent upon social acts but also argues that technological forms or designs imbibe/embody aspects of the social and productive environment. In other words, the question that continues to divide the debate is whether technology and its rationality is subservient to choices made in the social realm or technology by means of its invincible rationality drives the society in the direction of progress.

This debate intensified after a radical critique of science and technology emerged as a result of what is widely known as the social turn in scientific and technological knowledge. Science and technology were increasingly perceived to have been formed out of social and historical contingencies instead of value neutral modes of knowledge. This line of thought came to be known as the constructivist or social construction school. It has acquired varied strands, each with its own understanding of how science and technology are internally, culturally or historically contingent (Hess 1997: 81).[4]

However, beyond the theoretical intervention of the constructivist school that has largely undermined the claims that technology is a rational tool for progress, the role of politics in influencing and transforming technology has generated voices of dissent and concern. The debate on the role of politics in influencing the direction of technological change can be traced back to the beginning of the critical school. Since the advent of the critical school, technology has been viewed as an ideological problem. The question such as how technological domination is related to social organisation, how technology forms a way of life, an environment and in what way political and moral limits should be exerted on it have been intensely debated (Pipin 1995: 45-50).[5]

Critiques of social construction school have also contended that social construction studies have shown little concern about how technology can transform personal experiences and social relations (Winner 1993: 369). Winner (1993: 369) goes on to say that the theory and method of constructivism driven to determine success and failure of an artefact prevents "an evaluative stance or moral and political position that might help expose judgement about the

Defining technology

As part of the debate on what shapes technology – does science shape it, do preceding technologies shape it or is it socially shaped, the question about what constitutes technology has also haunted scholars. There have been several attempts to develop a more comprehensive definition of technology separate from science. Generally, three layers of meaning have been attributed to technology. At the most basic level, technology refers to sets of physical objects or artefacts. Secondly, technology is referred to as human activity as much as an object. Thirdly, technology refers to what humans know as well as what they do and hence technology is knowledge of the practical arts (MacKenzie and Wajcman 1985: 2-3).

Definitions that include an anthropological perspective relate technology to material activities. For instance, Pfaffenberger (1992: 497) provides two definitions of technology, one restricted and the other inclusive of social dimensions. The restricted definition of technique refers to it "as a system of material resources, tools, operational sequences and skills, verbal and non-verbal knowledge, and specific modes of work condition that come into play in the fabrication of material artifacts." However, Pfaffenberger's description of technique sounds more like what other scholars have called technology, for instance MacKenzie and Wajcman's (1985: 2-3) definition referred above. The inclusive definition of technology for Pfaffenberger (1992: 497), which he calls the sociotechnical system, refers to "distinctive technological activity that stems from the linkage of techniques and material culture to the social coordination of labor". For Pfaffenberger (1992: 497), techniques and artifacts are secondary to the social coordination of labor in shaping human adaptations to the natural environment. Hence, he suggests that subjects of the social anthropology of technology should include all three aspects: techniques, sociotechnical systems and material culture.

Noble gives a novel definition of technology (Noble 1986 as quoted in Pfaffenberger, 1988: 240). For him the social construction of technology occurs when one set of meaning gains dominance over the other and wins expression in the technical content of the artifact. A technology is thus, for Noble, "hardened history or a frozen fragment of human and social endeavor" (Noble 1986 as quoted in Pfaffenberger 1988: 240).

Sigaut's (1994: 424) anthropological perspective, on the other hand, defines techniques "first of all as actions, next they are material actions in the sense that they all make a material change in something, and finally, they are not simply material, they are intentionally material."

In my thinking, Pfaffenberger's description and Sigaut's definition of technology aptly describe the technology-society relationship. Pfaffenberger (1988: 241) points out that "no technology can be said to exist unless the people who use it can use it over and over again". According to him, technological behaviour is replicable through social coordination of labour. That means that technology exists because it is reproduced, and also because technological behaviours are replicable.

A similar point is also reflected in Sigaut's definition of technology. According to Sigaut, technology, by definition, exists to make a material difference in something. In Sigaut's definition not only does materiality centrally constitute technology but also human intentions. Human intention to make material change in something is what shapes and defines technology. The materiality and intentionality in Sigaut's definition firmly embeds technology in social action. Both Pfaffenberger and Sigaut demonstrate that technology is a product of social life.

Finally, Noble's definition of technology - i.e technology is formed when the dominant meaning finds an expression in the content of the technology attributes social relations a pivotal role in shaping technology.

present or past technologies". For Winner, therefore, social construction of technology has failed to address the desirable direction of technological change (Winner 1993: 371-373). Russell (1986: 337) argues in a different way. He says that unlike scientific knowledge, technology is a material product with material interests, hence an understanding of the design aspects of technology will need theorising different spheres of social and material life too.

The radical criticism of constructivism and the "social turn in science and technological studies" has also been extended by feminist critiques. There are two issues feminist epistemology has grappled with. First of all, feminists have demystified the objectivity and rationality claim of science and technology.[6] But more importantly, feminists have concretely explored how and from whose perspective moral and political limits can be exerted on science and technology. Feminists have highlighted that it is not enough to show the socially contingent nature of science and technology. Rather, feminist critiques have asked questions such as whose science and whose technology are they (Harding 1996: 11, 312; Haraway 1991: 187)? Feminists thus radically depart from other strands of sociology of science and technology when they insist on a better account of the world. Furthermore, by showing the subjectively formulated nature of knowledge, feminists not only prominently bring the issue of power and its role in forming the background beliefs of science and technology on the forefront of the debate, but also illustrate that alternative forms of objective knowledge can be possible from a different subjective position.[7]

Other scholars also have been concerned that attempts to deny deterministic conclusions about how technology is an agent of change have also resulted into abandoning the efforts to locate technology in the larger social scheme and historical developments. For instance, Yearly (1988: 11) argues that without denying the contributions of constructivism there is a need to include the political economy view to explore how scientific and technological knowledge is shaped by commercial and political priorities. Others have highlighted the importance of appropriation, power, exploitation and domination in understanding technology (Vessuri 1980: 315).

One can further point out that much of the history and sociology of technology is concerned with the problematic of technology in modern times and particularly in post-industrial, western society. Agrarian and irrigation technologies of agrarian societies that have a much longer history than industrial machines have not been significantly theorised, barring some commendable exceptions such as Joseph Needham's extensive work on Chinese science and technology. Although in India, increasing attention is being diverted to the history of colonial science and technology[8] with the rise of post-colonial studies, theorisation of contemporary irrigation and agricultural technologies is scarce.

This Study

This research is a manifestation of a choice, more specifically a political choice in terms of its focus made in the context of the larger debate on the social shaping of technology. The research focuses on equity as a reference point to understand the social shaping of technology. This choice is due to two reasons. Firstly, the fact that tank technology is shaped by social relations of power acquires prime importance given the historical and social context in which tanks were constructed and have been operated. Secondly, the policy reform initiated to transfer tank management entirely to communities has not been based on a detailed inquiry into how fair and equitable the patterns of water distribution in tank-irrigated areas are. The study, in order to achieve its aim to contribute to the debate on democratisation of management and use of natural resources, focuses on material aspects of technological development and change. The study thus chooses to limit its sphere of analysis to understanding how tank technology is related to social, economic and political relations of agricultural production. Moreover, the study approaches the broad spectrum of social relations of production through the lens of "power". The question asked is: "how does a certain balance of power relations, in a particular historical, environmental and agricultural context, shape tank irrigation technology and institutionalise a certain pattern of water distribution".

In order to address the main concern of the research, two layers of analysis are adopted. Firstly, the research locates tank irrigation technology in the wider contexts of agrarian practices and their transformation with a focus on the last three decades in particular. After locating tank technology with respect to social and political order and agrarian practices in the pre-colonial period, diverse tank trajectories across different agro-climatic regions are mapped with respect to agrarian transformation in the last three decades. This part of the analysis focuses on relating changes in tank technology with political, social and commercial choices made in a particular spatial and historical location. The focus for this part of the analysis is to understand how technology is related to changing state-society, market and production relations in the context of wider agrarian transformation. The scale of analysis here is regional (state of Karnataka). In this scale of analysis, the issue of power is kept central, although its manifestations are treated at a macroscopic level mainly in a political economy framework.

The second layer of analysis, in an descending order of spatial and structural specificities, focuses on how relations of power in a specific agrarian and agro-climatic context shape tank designs that produce and reproduce the patterns of water distribution. The second layer of analysis focuses microscopically at the individual tank. The first layer of analysis locates tank technology in spatial, temporal and agrarian contexts, but the second layer of query intends to understand how "power" forms the content or internal logic of the technology.

Having clarified the central concern and quest of this research, I am left with a rather analytical question: how do relations of power shape the internal logic of technology?

How Do Relations of Power Shape Technology?

Although a number of studies have shown the socially and historically contingent nature of technology, what remains to be shown is how technological logic or principles are context dependent. Mulkay (1984: 96) raises a similar point. He proposes that it is important to distinguish between the technical as opposed to the social meaning of technology. While it is fairly easy to show that the social meaning of technology varies with the social context – the same technology performs differently in different social contexts in which it is employed – it is difficult to show how what he calls the working-part of technology is similarly context dependent. To put it differently, the black box of technology is rarely opened to show how the technical principles or the internal logic of the working of technology is shaped by a particular context.

The central aim of this study is to understand how relations of power shape technological designs and how the choices made by the dominant section of society constitute the logic of technological principles. As Elias (1984: 252) observes, knowledge is not capital or a weapon that someone can put in his/her pocket. How then can technology become monopolised thus endowing a group or a person with higher power in relation to others?

The analytical concepts of technological design, technical code and script, and power discussed below can help to decipher how the internal logic or principles, or what Mulkay calls the working part of technology is shaped as a result of choices made by the dominant sections of society.

What is design?

In engineering disciplines, conventionally, design is defined as an idea about an artefact non-textually represented, for instance through a drawing or a set of equations (Ferguson 1993). That means design is an idea about an artefact that is visually or mathematically expressed. In this concept of design, an idea about an artefact precedes the artefact. Although in the real world design may not always be done by expressing an idea on paper, nevertheless what is important about this definition is that a certain degree of "imagination" of an artefact precedes the making of the artefact.

The conventional conceptualisation of designing is also reflected in a somewhat unconventional definition of design. "Design is the conscious and intuitive effort to impose meaningful order" (Papanek 1997: 4). The conscious and intuitive effort may involve imagining an idea about an artefact and representing it. But what Papanek calls imposition of meaningful order through designing is what makes designing a purposive and intentional action aimed at solving a problem, or serving a function, or achieving an outcome.

Ferguson (1993: 3) further comments that the conventional engineering representation of design on a drawing board and the accompanying exactness and precision conceals many choices, judgments and assumptions on which the design is based. Ferguson (1993: 2-3) specifies that designers in the process of designing solve a problem "that has no single right answer but many". Hence the act of designing involves making choices and taking decisions based on certain assumptions and judgements about the world.

The process of designing, thus, according to both conventional and unconventional definitions involves an idea, representation of the idea in non-textual form, and choices, decisions and judgements to achieve an intended outcome.

The above definition broadly covers the way designs are made in the disciplines of industrial engineering or architecture. Designing in these cases is generally carried out by a group of professionals. In fact these concepts of design are based on the assumption that a group of professionals trained in non-textual representation of ideas do designing.

But designing in the real world may not always be carried out by a group of professionals. This is certainly the case when one talks about tanks, a majority of which were not only constructed several centuries ago, but are largely used and managed by farmers. In such cases, the notion that technological design is done by professionals is largely irrelevant. Neither does designing in case of tanks involve a straightforward process of translating an idea into an artefact. In general, in all likelihood matching an idea with the intended outcome would result in a process of trial and error and in many cases the imagination of an artefact may be based on already existing artefacts.

This research adopts a particular notion of design. First of all, the act of designing that puts technology together is intentional, deliberate. It is intentional because it implies devising to make material difference in something in order to serve a function or to achieve an intended outcome or to impose an order. This human intent makes the process of designing inherently social. Secondly, designing involves a process or an act that translates an idea about an artefact into an artefact. In other words, the process of designing entails matching an idea with the intended outcome. The translation requires several judgments and choices to be made based on several assumptions. Thirdly, the process of designing also generates patterns of outcomes. The outcomes of the process of designing could be an artefact with certain physical and engineering properties, along with a rule or a certain type of social arrangement that uses and manages the artefact and consequently reproduces it. In the process of reproducing the technology, the rules and roles and social arrangements are also reproduced. Fourthly, designing involves applying various types of knowledge that are socially generated and held – technical and scientific knowledge generated and held by professionals is just one such form of knowledge.

Designing thus is a social process that involves translation of an idea into an artefact and the making of choices, judgements and assumptions about the world. Designing also assumes certain rules, roles and social arrangements and produces patterns of outcomes. Finally, while reproducing designs, rules, roles and social arrangements and outcomes are also reproduced.

Technical code and script

The analytical concept of design can help explain how social processes shape technologies. However, the central aim of this study is to understand how relations of power shape technologies. The concept of technical code now associated with Langdon Winner and the concept of script used by Latour (1992) and Akrich (1992) can further help decipher the causal link between relations of power and technological designs.

Latour's concept of script or prescription captures a somewhat unconventional account of technology. Akrich (1992: 209) states that, "the world inscribed in the object is the world described by it." This means that for Latour and Akrich technologies are products as well as producers of social life.

Devices and artefacts for Latour are delegated non-human characters that discipline humans and/or perform tasks. Devices and artefacts do not simply replace human labour or effort but also take over the task of ordering, guarding and ensuring the moral and ethical aspects of human behaviour which in the absence of the device or artefact would have to be in the form of verbal or textual instructions (Latour 1992: 225-34). In the absence of artefacts and devices performing certain tasks, a morally loaded message would be needed to make humans confirm to such intended behaviour. For instance, imagine the type and extent of textualised information that would be needed in the absence of a traffic light at a busy juncture to regulate traffic. The devices thus confirm the moral behaviour of users and create an order.

Latour compares devices with text that builders and/or users inscribe in a similar way to how authors and/or readers script a story. The builders/users by scripting a device delegate a character – to maintain a certain order – to non-human characters/devices.

Devices are thus delegated not only functions but also duties, ethics and values (Latour 1992: 232). This is what Papanek (1997: 4) meant by saying that designing imposes an order. The automatic, silent taking over of the task of ordering makes the causal link between the physical system and the use of the artefact – that ensures moral obedience – a concealed and naturalised one.

That artefacts and devices are coded to reproduce a certain social arrangement or order is also argued by others. Langdon Winner (1985) used the concept of technological code to show how artefacts have politics. In his now famous article "Do artefacts have politics?" he showed how the bridge to access Long Island was designed with a lower height to keep away the buses that would have transported especially black and poor people. The design of the bridge with its low height was thus coded with racial prejudice. The bridge, in the form of the lower height, silently took over the task of discriminating between who can or cannot be allowed on the beach.

The concept of technological code was adopted by others before Winner such as Galtung (1979) and further elaborated upon by others such as Feenberg (1991), but none of them conceptually clarified it. As Mollinga and Mooij (1989: 3) have also argued, the notion is not only conceptually vague but also tends to be deterministic when codes only represent and reproduce dominant values and interests.

I attempt to add a few points here in order to make the concept practically usable through a sociological understanding of the concept of code.

In the sociological sense a code signifies rules or a broader range of the values that are permitted or forbidden (Feenberg 1991: 80). Examples are dress codes, codes for appropriate behaviour, codes of greetings, eating and the like (Wolf 1999: 6-7). Coding is necessarily a two way process. It involves conveying the message in a particular manner as well as denoting how the message should be decoded by others in the same cultural, social plane. Coding thus implies four things. Firstly, it involves non-verbal implanting of values and norms that determine appropriate and inappropriate conduct in social life. Secondly, codes structure social communication or exchange in a particular fashion. Thirdly, although codes are not fixed templates (Wolf 1999: 6) for those who share the same social and cultural milieu, codes are largely taken for granted - they are meant to structure communication and exchange in a fashion that makes elaboration, explanation and any other form of expression superfluous. And fourthly, when codes are largely normalised and naturalised, they not only reproduce the patterns of communication, but also the values and norms they represent.

Technical codes, similarly, could 1) non-verbally represent certain values and norms, 2) be largely taken for granted and hence naturalised and 3) structure aspects of social communication and exchange, in other words impose an order or reproduce social arrangements. The concept of technical code thus overlaps with Latour's concept of script and his argument that by means of scripted devices a social order is maintained that precludes verbal communication.

This research adopts the concept of code and script to show how they respectively structure technological designs in certain fashions that reproduce a certain order. In other words, the research focuses on how the task of maintaining social order is delegated to artefacts whose designs are coded in a certain fashion and how reproduction of the coded designs help reproduce the social order. Codes thus both structure designs and social communication. Based on the discussion on design in the previous section, it can be further argued that in the process of translating an idea into an intended outcome several choices are made by those who either do the designs or who influence the design in terms of coding or scripting the artefact.

However, this research does not deal with the process of how an idea is translated into an intended outcome. Rather, it attempts to show how tank designs are coded with values, norms, interests and choices of the dominant section and how they structure the water distribution pattern in a certain fashion. This research aims to show how a certain social order is produced and reproduced by means of design. What this research attempts is to unravel the codes of designs that are taken for granted and naturalised.

Power

Power is usually defined, following Max Weber, in a broad way as the "probability that some actors within a social relationship will be in a position to carry out his or her own will despite resistance" (Elias 1984: 252). Another common definition of power is as Elias

(1984: 251) describes it, namely that "power is an aspect of relationship. It is something to do with the fact that people as groups or as individuals can withhold or monopolise what others need, for instance, material or productive resources or knowledge" (Elias 1984: 251). Wolf (1999: 4) further quotes Elias that, "more or less fluctuating balances of power constitute an integral element of all human relations." However, Wolf (1999: 5) goes further by clarifying two things about power. Firstly, power is a relational term; it is not an asset or property which one can own; it is not a resource; it is an analytic concept that refers to a relation of unequal access to a resource (Wolf 1999: 5; Howe 1991: 450). Secondly, power works differently in interpersonal relations, institutional arenas, and on the level of whole societies. What is important here is to highlight what Wolf (1999: 5) calls the modality of structural power. "Power manifests in relationships that not only operates in settings and domains but organises and orchestrates settings themselves." Technology can be interpreted as one such setting that power organises and orchestrates.

Furthermore, there are other scholars who have focused on developing an understanding of how power operates in the real world. For instance, Sangren (1995) argues in favour of maintaining a distinction between the real operation of power and representation of power (that is, ideologies) to comprehend how power produces and reproduces social processes in order to be reproduced. Sangren argues that power not only reproduces social processes but also is reproduced by means of organising "settings".

However, the notion that power not only organises the settings but also reproduces them in order to be reproduced may suggest a deterministic loop between power and its settings. It may mean that there exists nothing external to power[9] and may also suggest that power and its settings reproduce each other in the absence of change. This aspect of the relationship between power and its settings needs a clarification.

The answer to the paradox of power and its settings may lie in the way one understands "reproduction". Sangren (1995) reflects upon the phenomenon called – social life – to resolve the paradox with regard to power and its reproduction.

> The notion of reproduction, at least as I intend it, refers to the recursive character of social production, that is, to the fact that in producing itself, society produces its ability to produce. This ability

> to produce production, "reproduction", does not exclude change or transformation, but it does enjoin a logical focus on processes of production as the essence of which might change or transform. In other words, to denigrate the focus on production or reproduction in social analysis as neglecting change, creativity, transformation, or resistance is to fundamentally misconstrue *what* the phenomenon is that might change (emphasis original) (Sangren 1995: 8).

Sangren (1995: 5-8) further clarifies that the analysis of the reproductive character of social processes attempts to theorise temporality because an explanation of reproduction has to take the irreversible time frame into consideration. By keeping social time in the centre of analysis, strategies and agencies – precursor to change – are also kept in the centre.

Some other scholars have elaborated the notion of power by using the Gramscian notion of hegemony[10]. Butler (2000: 13-14) argues that "power operates to form our everyday understanding of social relations, and to orchestrate the way in which we consent to (and reproduce) those tacit and covert relations of power", thus emphasising unevenness or asymmetry of power which constitutes hegemonic relations. She further emphasises that, "power is not static or stable, but is remade at various junctures within everyday life" to rearticulate and reconstitute daily social relations (Butler 2000: 14). This notion of power entails reconstitution and displacement of existing power relations – to construct new power, but not its radical elimination (Laclau 2001: 8).

Thus, I too argue, following Sangren and Butler, that power reproduces itself by means of reproducing the societal ability to produce, but not without reconstitution and displacements. Understanding how power shapes the social phenomenon of reproduction of technological designs does not preclude change and transformation in the relations of power, but on the contrary constitute it.

This study focuses on understanding how power relations operate and orchestrate the domain of technological designs (and by that means resource distribution) in order to reproduce, following Sangren – its ability to produce social order. More precisely, the research intends to unmask or decode power laden processes that are behind the prescription of technological designs which are concealed because the causal links between power and orchestration of designs are naturalised, i.e. made objective. One way to show the causal link between power and designs is to decode how tasks of exclusion and discrimination are delegated to technological designs and by that means naturalised. Another way would be to show how subversive practices or direct or indirect contestation decode, challenge and redefine the naturalised state of designs and produce a different constellation of power relations and designs. In order to understand reproduction of designs and power and the role of strategies and agency in the making and remaking of designs, the study analyses social processes in two time frames. Everyday forms of water management practices are explored to analyse how designs form boundaries of inclusion and exclusion in resource distribution. And further, transformation of designs in the past three decades is explored to understand what part of the designs and social order are reproduced in the larger context of agrarian change.

Since relations of power and their products are central to my analysis, the question – whose designs are the existing technologies – is also central to my research. As dominant interests help constitute the background rationality of technological designs, it becomes imperative to identify and name the powerful and the powerless. I do not use pre-determined categories based on economic criteria, especially among the peasantry, in this research. Firstly, such categories usually denote quite a fluid meaning that changes with the changing contexts. Secondly, purely economic criteria to understand the asymmetries of power may not be enough. Thirdly, power may not only be manifested in a variety of – relational – ways, but its manifestations may entirely be situational which escapes a priori categorisation of relations of power. Nevertheless, we need boundaries to demarcate hierarchies, exclusion and discrimination. I have employed vague categories such as rich, wealthy, historically privileged or elites to delineate those who remain in decisive positions, and categories such as small and marginal farmers and landless and historically disadvantaged to denote those who usually remain at the receiving end. In addition, other structural categories such as caste and religion are also employed in particular historical and spatial contexts. This differentiation is further sharpened while discussing power dynamics within a particular tank-irrigated context by bringing in other categories such as those who hold a privileged part of land in the irrigated area and those who do not. Only by remaining this vague can one trace the purely situational modes of manifestations of power.

Designs of Irrigation Technology

Designs and designing occupies a prominent space in the irrigation literature, more so in the last two decades with what can be termed as the "social turn" in the irrigation sciences. Due to the increasing disenchantment with the performance of centrally designed irrigation systems based purely on technical criteria several irrigation experts advocated participation by farmers and consequently the incorporation of socially relevant criteria in the process of designing (cf. Diemer and Slabbers 1992; Uphoff 1986; Meinzen-Dick 1997; Vaidyanathan 1994; Coward and Levine 1980). For these scholars technological designs were at the interface of what is often called as engineers' and farmers' domains, or in other words, technical and social criteria.

After it was recognised in the mid 1970s that socially relevant criteria needed to be included in the design, the question often posed was: how to include them (Scheer 1996: 4). First a socio-economic perspective at the micro and macro level was emphasised to understand the social, economic and political importance of irrigation. Suggestions also were made to improve organisational aspects of irrigation such as better management, better coordination among agencies and better communication between bureaucracy and farmers (Scheer 1996: 3). However, how to include social criteria in the design process remained a question. It was recommended that the focus of designing should shift to the "use" of the system away from an exclusive focus on the physical system because daily use is what unites technical systems with social systems (Ubels 1990 and Horst 1993 as reviewed by Scheer 1996: 4). The properties of technology become evident when physical systems interact with the social organisation of resource utilisation (Kloezen and Mollinga 1992).

Since the 1980s, farmers' participation in the design process and inclusion of farmers' knowledge into the engineers domain of design have also been emphasised (cf. Coward 1980). In general, farmers' knowledge as opposed to scientists/engineers' knowledge has been highlighted (Chambers et al. 1989) and questions such as "whose knowledge counts" raised (Chambers et al. 1989). Several studies also emphasised the "situated" and locally specific nature of farmers' knowledge and advocated inclusion of it as a valid and viable form of knowledge in the scientists/engineers' domain of understanding (Chambers et al. 1989). Also, on the irrigation front, several systems constructed and managed by farmers were studied in detail, under the umbrella name of local/indigenous/farmer managed irrigation systems, and shown to be viable forms of irrigation design and management (cf. Datye and Patil 1987). Some scholars even uphold these systems as user-friendly irrigation systems (cf. Sengupta 1993). The general academic climate since the 1980s, in other words, has been to increase farmers' participation in design and management.

However, by and large, these efforts which began with improving the performance of irrigation systems conceptualised the "technical" and the "social" as separate realms. Technical knowledge involves physical laws and rule of thumb (empirical) knowledge generated under the disciplinary names of hydrology, agronomy, soil science and civil engineering (Scheer 1996: 8), whereas what counts as "social" remains fairly ambiguous. At times it is inclusion of purely socio-economic criteria in engineers' designs, at others it means farmers' participation in the design process, and yet at others incorporation of farmers' or indigenous knowledge in the design process. Nevertheless, the dualism of the social and the technical, the farmers' realm and the engineers/scientists domain, is maintained.

Nonetheless, by advocating the importance of farmers' knowledge, the hegemonic superiority of engineers' knowledge and their exclusive claim to do design have been questioned in the last two decades. Furthermore, how to meaningfully increase farmers' participation in the process of design has been a topic of discussion. Yet, what counts as "design", or what counts as "technical knowledge" (held by engineers or scientists), has not been rigorously scrutinised. By and large, design is described to mean "making an image of something that is realised in future", which in the conventional engineering sense may mean making a drawing or a sketch, for example, of an irrigation structure (Department of Irrigation and Soil and Water Conservation 1990). This notion of design not only assumes technology as primarily an artifact, but the "technical" or what Scheer (1996) calls "technical knowledge" part of technological design (broadly considered to mean physical laws and rules of thumb originating from natural and engineering science disciplines) is not questioned much.

The conventional notion of design that is based purely on technical criteria can be associated with the rise of large-scale, state initiated, created and managed irrigation systems, in the second half of the nineteenth century. Colonial efforts at developing large-scale irrigation technologies became a cradle for the formation and testing of modern irrigation science. With the rise of what David Arnold calls "state technologies"[11], the current and dominant notion of design emerged – something that the experts sitting on the apex of vastly generalised and standardised knowledge do.

Thus, while inclusion of farmers' knowledge and farmers' choices in the process of "design" is envisaged by the dominant model, the validity of conventional disciplinary – scientific and engineering – knowledge and the context in which this knowledge is generated, is not very frequently questioned. This knowledge occupies the "technical" part of designing.

It is my contention that most of the times it would be difficult to precisely show whether a particular "technical" design parameter is shaped as a result of scientific/technical or social and political requirements. Many historians of science and technology have shown how the advance of modern science and colonial rule went hand in hand (Adas 1989). Similarly, modern irrigation science has its roots in motives of colonial expansion and control (Gilmartin 1994). The assumptions and methods of irrigation science that found its full expression in the late nineteenth and the early twentieth centuries under the auspices of the colonial state (Halsema 2002: 4-5) were largely driven by colonial agendas and hence were inherently political. For instance, Jurriëns, Mollinga and Wester (1996) show how the scientific concept of duty in the colonial period was related to the notion of protective irrigation that was geared towards colonial aims of increased revenue and the provision of protection against famine in order to maintain political and social stability. Not only that, but the values of duty attributed to different crops at times were negotiated among the engineers, changed overnight, and thus were not entirely empirically determined (Mollinga 1998: 75). That means, what is considered "technical" derived from laws and empirical knowledge of various disciplines of science and engineering is much more than an empirically tested, rational, generalised body of knowledge; it is inherently social and political. The formulation that irrigation technology is formed out of the interaction between social and technical domains, when technical means application of scientific, rational principles and social means farmers' participation can potentially mask more than it reveals.

The notion of design adopted for this research, which was discussed in the previous section, inverts the dominant notion that assumes social as subservient or an appendage and thus separate from technical. The notion of designing adopted for this research advocates that design involves applying various types of knowledge that are socially generated and held: "technical knowledge of engineers" is just one form of knowledge amongst others. The technical/scientific knowledge generated and held by engineers/scientists from state run institutions is also socially generated with certain political and social agendas. Designing is a social process that among other things involves generating, developing, verifying, refining and choosing from various types of knowledge. All these processes including the process of designing are social processes. Thus, "social" and "technical" are not separate notions that constitute technology and technological designs but are inseparably intertwined.

Summing up, this research aims at showing how tank designs are coded with dominant interests that structure water distribution in a certain fashion and maintain social order. It aims at showing how the task of creating and maintaining social order is delegated to technological designs. And finally, it illustrates how social arrangements or the social order around water distribution are reproduced through reproduction of designs.

Design of the Study

The first round of rapid appraisal of tanks across Karnataka brought out two aspects prominently. Firstly, paddy is largely grown in the irrigated areas of old tanks of southern and western Karnataka. Secondly, even among tanks primarily irrigating paddy, designs vary across agro-climatic zones. In order to understand the spatial diversity of tank designs and their connection with the cropping regime, the state of Karnataka is divided in three agro-climatic zones, namely, the wet region of western Karnataka, the mixed region of southern and northern *maidan* (plain), and the dry region of northern Karnataka. I studied a few tanks located in these agro-climatic zones to map the diversity of tank designs and cropping patterns supported by them. Tanks from Kolar, Bellary and Dharwad districts were studied to understand designs and cropping pattern in the mixed zone of southern and northern Karnataka. Tanks from Shimoga district and Hangal taluk of Haveri district represented the wet region. Tanks from Bijapur were studied to understand designs in the dry region.

Furthermore, in order to comprehend the nuances of how social relations of power in a particular agro-climatic and agrarian context shape designs, four tanks were selected for detailed study. These are 1) a tank irrigating paddy and garden crops in the wet region of western Karnataka, 2) a tank irrigating paddy in the mixed region of southern Karnataka, 3) a tank irrigating paddy and dry crops in the mixed region of northern Karnataka and 4) a tank irrigating dry crops in the dry region of northern Karnataka.

My understanding of the variation in the patterns of designs is based on field observations of several tanks that are more than three to four centuries old. Many of the features of tanks started to make sense only after extensive discussions with farmers that centered on details about various aspects of tank designs such as 1) length of bund, 2) agro-climatic location and hydrology of tank, 3) water availability pattern in tank, 4) type of sluice preferred vis-à-vis cropping pattern, 5) irrigation timings (daily and seasonal), 6) type of crops chosen for different parts of irrigated area, 7) nature of *atchakat*[12] landscape, 8) canal alignment, 9) water distribution method, 10) position and type of outlet structures, 11) sluice operation mechanism, and 12) nature of institution of *neerganti* (water man). In addition, the agricultural practices followed in the irrigated area and in dry land in the region were discussed at length.

Many technical features started to acquire meaning after I visited tanks constructed in the past half century. I have enormously benefited from discussions with several senior and junior, present and retired engineers of the Minor Irrigation Department of Karnataka.

The irrigation and water management practices in each of the four selected tanks were observed intensively for a few days during the peak irrigation season. In addition to observation of water distribution practices, several rounds of discussions with different sections of landholders owning land in different parts of the irrigated area and discussions with the service caste members helped to understand change in designs, cropping pattern and social relations in the past three decades.

I collected water cess demand schedules prepared by the Minor

Irrigation Department in order to construct a rough picture of the landholding pattern in the tank atchakat. Land records at the Revenue Department follow a village wise pattern and do not give a comprehensive picture at the tank level. Based on the landholders list in the water cess demand list, a rough picture of caste wide landholdings in different parts of the atchakat was drawn up with farmers' help. Water distribution and agricultural practices in the atchakat were related to landholding pattern in the atchakat to comprehend the social dynamics.

I gave priority to tanks with large irrigated areas at the time of selecting case studies in order to capture the complexity of the interplaying factors. Although it was not intentional, all chosen tanks are managed by the Minor Irrigation Department. In Karnataka, 35,235 tanks out of a total of 38,128 belong to the size class with an irrigated area of less than 40 hectares; they are currently looked after by the local *Zilla Parishad* (district level administration unit). Of the rest, 2,605 tanks irrigate between 40 – 200 hectares and the remaining 288 more than 200 hectares, all of which are looked after by the Minor Irrigation Department. That means that a majority of the tanks irrigate less than 40 hectares. But the size class of tanks irrigating more than 40 hectares irrigate 58 per cent of the total area irrigated by tanks in the state (Vaidyanathan 1998: 22). Hence, this size class still forms the largest part of the tank resources in terms of total irrigated area.

Limitations

All research is bound to have some limitations; mine is inflicted by several. Here I would like to mention two major reasons that circumscribed the extent to which I could productively spend time in the field. Firstly, mapping the diversity of tank designs in the districts located in three agro-climatic zones fairly far away from each other was a demanding task. Properly functioning agricultural tanks, which are not yet encroached upon by the process of urbanisation, are not located close to town centres. Hence, these tanks are not easily accessible to motored vehicles. A substantial amount of time during my fieldwork was spent in travelling across the state of Karnataka, walking several kilometres and also waiting hours and hours for buses. This time spent was essential but is not productively visible in these pages.

Secondly, three tanks which I studied were located at least 500 kilometres away from each other and had to be visited in one irrigation season. Missing that irrigation season would have meant losing at least a year. Reading through my field notes at the time of writing chapters I several times wished that I had more information on certain aspects. I hope, therefore, that this book is only the beginning of a longer journey in the direction of many more tanks.

The book

The first three chapters of this book analyse the structure of the world that impinges upon tank designs. Chapter 2 shows how tank designs, especially in the southern and western parts of Karnataka in the mixed and wet agro-climatic zones, in a historically specific way were suited for paddy cultivation. The chapter describes how tank designs embody social and productive relations specific to the temporal and spatial context. The chapter looks at the history of tanks in order to seek an answer as to why and how tank technology has perpetuated paddy cultivation and obstructed a shift to dry cultivation. I need to clarify that chapter 2 does not trace the history of tanks. In order to understand how tanks are related to paddy cultivation it heavily borrows from the scholarly work on pre-colonial south Indian history. However, the main focus of the book is to chart change in tank designs in the context of a commercialising and diversifying agriculture in the last two decades.

The next two chapters show how historically specific patterns of tank designs have been transformed in the context of a shifting agrarian scenario, especially in the last two to three decades. Chapters 3 and 4 show that contrary to popular belief that tanks have declined due to the apathy of the state, tanks have been modified in a variety of ways in response to changing state-society relations and agrarian transformations and according to their differing their agro-climatic locations.

Chapter 3 first argues that the decade of the 1980s was a crucial time for state policy in agriculture and irrigation matters as a result of the pressure exerted by the farmers' movement. It argues that in the aftermath of the introduction of the green revolution technology a hegemonic class of owner-cultivators emerged at the all India level and also in Karnataka and that their populist politics ushered in a new era in Indian agrarianism. Furthermore, it is argued that such populist politics succeeded in creating an assured market for superior grains such as wheat and paddy with favourable terms of trade. This made paddy cultivation profitable even for small landowners. Moreover, this favourable policy for cultivation of paddy brought in a whole new range of activities in irrigated areas of paddy growing tanks. In the regions where climate and soil provide greater opportunities for lightly irrigated or dry cash crops, the cropping pattern of irrigated and non-irrigated areas are more diversified. Chapter 4 elaborates that in these areas it is not uncommon to find tank resources in a state of considerable disrepair.

Chapter 3 further argues that the farmers' populist politics also propelled a new era in state politics ensuing a phase of decentralisation and devolution of power to the lower administrative levels. The phase of decentralisation was marked by a sizeable increase in state investment for the management of surface minor irrigation resources. The chapter argues that the state was expected to take care of tank resources in an unprecedented way because the elites at the local level who hitherto were in charge of tanks found greener pastures. For the elites the inherited responsibility of tank management now became a burden. At the same time it became increasingly difficult to mobilise traditional forms of labour especially from the non-landowning castes for maintenance and management tasks. The chapter ends with a note on the challenges to the management of tank resources at a time of diversifying and commercialising agriculture.

Chapter 4 shows that the nature and degree of the change that took place in tank-irrigated areas has not been uniform throughout the state. The choices available to the different landed sections in tank irrigated areas are as much influenced by state policy as they are circumscribed and facilitated by historical and ecological resources. The varied history of different regions has interacted with varied topographical and ecological settings and has produced a varied pattern of change in the designs of tanks. Chapter 4 traces these patterns of change in four agro-climatically and historically diverse regions of Karnataka.

The subsequent four chapters explain designs of the four selected tanks in the differing local contexts. In general, chapters 5, 6, 7 and 8 situate the process of making and remaking of tank designs by exploring every day forms of water distribution and management, and transformation of designs in the context of a transforming cropping pattern. These chapters explore how the designs crystallise a certain balance of power, and how they are coded with certain norms and values.

Chapter 5 discusses a tank located in the mixed region of northern Karnataka irrigating paddy and dry crops. The chapter shows how the task of unequal water distribution is delegated to tank designs. A high degree of rule adherence in this tank area is as a result of tank designs meant to sustain a differential pattern of water distribution.

Chapter 6 discusses a tank located in the mixed region of the southern maidan. One crop of transplanted paddy is cultivated in the atchakat whenever the tank receives water up to full capacity. The chapter discusses the shifts in designs in the context of the changing cropping pattern in the atchakat and the shift in the authority in charge of the management of the tank. The chapter illustrates how the shift in designs and agricultural practices, as a result of choices made by different sections of farmers, emerged together.

Chapter 7 discusses the case of a tank in which the tail end farmers have challenged the established norm of irrigation first supplied to the head reach, and radically redefined the designs to assert a tail end first rule. The tank is located in the wet region of western Karnataka and irrigates broadcasted paddy and garden crops. The chapter shows how the rules of water distribution and the notion of right to water are intricately connected with designs of physical structures.

Chapter 8 is a tale of two paradoxes situated in the tank located in the dry region irrigating dry crops. The tank is newly constructed with World Bank assistance. The social environment of this tank, inflicted with chaos and conflict, illustrates the first paradox, namely that when the MID attempts to form a water users association the farmers claim that water stored in the tank belongs to the government and hence the government should manage water distribution. The mismatch between culturally organised farming practices and the assumptions on which the designs of a newly constructed tank are based is the second paradox.

Chapters 5 to 8 argue that technology emerges as an important variable that creates and sustains the internal dynamics among the community of irrigators. In fact the technology also creates new forms of alliances and sets boundaries for internal differentiation.

Technological designs are thus not only scripted to facilitate the dominant interests of society but they are also sites subjected to contestations and conflicts. Designs thus are shaped in an inherently political field and hence are vehicles for democratisation. This point is briefly discussed in the final chapter of the book.

Notes

[1] As a representative sample of such a view, see Mukundan (1988), Reddy (1991), Shankari (1991), Shankari and Shah (1993), Dikshit et al. (1993), Agarwal and Narain (1997).

[2] The same literature that upholds the suitability of traditional irrigation methods also views them as an alternative to large-scale irrigation systems.

[3] In the last two decades, many social scientists have been influenced by the idea that indigenous ways of knowing are generally better than modern methods of knowledge generation. Ashis Nandy's work (1983, 1987) is the most influential in the Indian context.

[4] For instance, the Social Construction of Technology (SCOT) school describes the development process of technological artifacts as a process of variation and selection in a multidirectional model (Pinch and Bijker 1984: 409-419). Its proponents show that each artefact can be designed in multiple ways. Some of these design variants die and others survive based on the social process of selection by relevant social groups. The influence of relevant social groups on the process of variation or selection of design provides "interpretative flexibility", which means that technological developments are open to more than one possibility; one option could be incommensurable with the other but not inevitable. The approach thus demonstrates that technical principles alone are insufficient to determine the designs of an artefact (Pinch and Bijker 1984: 409-49).

There are also other approaches that have shown the socially contingent nature of technological change. The scholarly ranks of the Society for the History of Technology (SHOT) have debated the history of technological change from a contextual approach instead of unearthing the mechanism of plain success or failure of an artefact. The contextual historians within SHOT argue that technology can not be understood by looking only at internal design because the process by which it acquires a particular design involves political, economic, social as well as technical factors (Staudenmaier 1990: 717).

The sociotechnical approach in a similar way highlights that the social and technical are inseparable; a successful technological innovation occurs only when all the elements of the system, social as well as technical are modified to work together (Pfaffenberger 1992: 497). There have been other studies that have shown the complexity, conflicts, ambiguity and unresolved issues around technology (Staudenmaier 1994: 269).

[5] The ideological bias of technology was understood in different ways by different thinkers of the critical school. At a philosophical level the debate between Marcuse and Habermas on the essence of human-technology relations is particularly significant. Science and technology, for Habermas, are not to be connected with any particular social project, but are rather a project of the species as a whole, i.e. there is a trans-social species interest in prediction and control of nature (Vogel 1995: 28). On the contrary, Marcuse found that this "technological rationality" by its very nature yoked to capitalism and domination (Vogel 1995: 24). Marcuse thus relativised science and technology to the social order; science and technology are not objective forms of rationality but formed out of acts of domination integral to industrial society.

For Habermas, the idea that technology can be radically transformed was a utopia laden with irrational dangers. He argued that it was the fusing of the "technical" with the social and political, not technical interest in itself that had produced and reinforced domination in the first place. He abhorred dissolving the boundaries between science and politics which he feared would produce politicisation of science (Vogel 1995:31; Feenberg 1991: 76-178). For him, the technical rationality inherent in the human species' generic interest was incommensurable with partiality, unfairness and bias; it was the fusing of work and interaction that produced forms of domination.

Many others share the Marcuse-Habermas dilemma. The relativisation of science and technology to social and historical contingencies collapses the ontological distinction between the social and natural, between subjective and objective forms of knowledge and consequently makes technological rationality subjugated to forms of social domination. In fact the issues at stake in the Habermas-Marcuse debate – the neutrality claim of Habermas and Marcuse's proclamation that technological rationality by its very nature is yoked to domination – has raised a crucial question: is technology inherently rational or divisive?

[6] Feminist critiques turned the problem of rationality upside down by showing that there is no problem with objectivity and rationality as such, but rather the problem is that an objective and rational nature is denied to science and technology. In the name of objectivity and rationality science and technology have been representing dominant values and norms. Unravelling the underlying assumptions of such – what Harding (1996: 145-47) calls weak objectivity – should be the focus for science and

technology studies.

[7] Haraway (1991) especially has argued that only from the location of a subjective position can one truly have objective knowledge. The dichotomy of subjective-objective can be resolved from the location of partial perspective, what she calls – situated knowledge (Haraway 1991).

[8] In India, a significant body of literature exists on colonial interaction with indigenous science and technology (cf. Alvares 1991; Baber 1998; Kumar 1997; Qaisar 1998).

[9] For instance, the "other" of power, resistance, has been intensely debated in current times. Especially in India, subaltern historians have been debating to what extent an autonomous domain of subaltern with coherent manifestations, consciousness, protests and organisation can exist independent of the forms of domination. See Ludden (2001: 1-39) for a review of the debate.

[10] Hegemony in the most classical sense describes predominance of one state over others. But in 20th century Marxist writing, following Gramsci, the concept not only stresses the predominance of one social class over the other by means of political and economic control but denotes that the dominant social class by projecting its particular way of seeing the world and social and human relationships as common sense and objective, succeeds in imposing its dominance as natural and legitimate (Bullock and Trombley 1999: 387-388). In the contemporary discussions on democracy and democratisation (further discussed in chapter 9), hegemony is described to mean a gap (or asymmetry) between the projected universal objective and particularity that is contested but never filled, on the contrary, ever reproduced (Laclau 2001: 7). Mouffe (1999) similarly discusses that social objectivity (posed as universal) is constituted through acts of power by means of exclusion. For her, the point of convergence, or rather mutual collapse, between objectivity and power is hegemony.

[11] A short note presented at the meeting of the colonialism and technology subgroup of Tension of Europe project held at Amsterdam 11-12 November, 2002.

[12] Atchakat is a word in the local language (Kannada) to denote area irrigated by a tank. Literally it means "the area that is close to the bund". Instead of "tank-irrigated area", the word atchakat is used throughout this book.

2

Paddy Cultivation and Tank Designs

Continuities and Discontinuities

Try asking serious questions about the contemporary world and see if you can do without historical answers.

— Abrams (1982)

A technology is hardened history or a frozen fragment of human and social endeavor.

— Noble (1986: xi)

> A farmer having land in the head reach of a tank in Kolar district brought soil from outside and painstakingly elevated his piece of land in order to cultivate onion, potato and tomato when the rest of the atchakat cultivated paddy. He kept two pieces of land, one for paddy and the other for vegetables, strictly separate (Field notes 2000, Kolar Amani tank).

> Several farmers who had land in the atchakat of a tank located close to Dharwar town changed the constitution of their lands after spreading soil brought from outside in order to grow mainly vegetables and occasionally cotton. Most of the farmers in the irrigated area of this tank have stopped growing paddy. Main canals in this tank atchakat have more or less disappeared, the sluices were found in disuse, and farmers without wells only occasionally take water from the tank (Field notes 1999, Navloor tank).

A shift from paddy cultivation to semi dry cultivation in a tank atchakat involves a significant shift in the way technology is organised. Oppen and Rao (1987: 25-28) have pointed out that a radical shift away from paddy cultivation in tank-irrigated areas is likely to be difficult because of the relatively high level of physical and institutional investments made for paddy cultivation.[1] What isthis high level of physical and institutional investment made, as observed by Oppen and Rao, that creates a barrier for the shift from paddy to irrigated dry crops? In what way is tank technology connected with paddy cultivation?

This chapter discusses the relationship between tank designs and paddy cultivation. It is an attempt to understand how tank systems, as they were constructed in the mixed and wet regions[2] of Karnataka a few centuries ago, consisted of several technical design principles suited for paddy cultivation in a historically specific way. Although I extensively refer to history to understand the connection of paddy cultivation with tank designs, I do not aim to trace the history of tank irrigation technology. Rather, I intend to offer a few pointers in the direction of history while seeking answers to questions pertaining to the contemporary situation.

In the historical literature, information on the technological designs of tanks is scarce. The design principles discussed in this chapter have been derived from my observations of several new and old tanks located in different parts of Karnataka and from discussions with several farmers and technical and non-technical experts. Nevertheless, the nature of the argument that follows is partly speculative. In order to further my aim of this chapter – to explain the historical and spatial specificity of tank technology and its connection with paddy cultivation – the technical principles are discussed in the main text and all historical and other references, as much as possible, have been relegated to footnotes.

Paddy Cultivation and Water Control

The supply and control of water is the most important variable in irrigated paddy cultivation, even more important than the type of soil (Grist 1986: 21). Apart from supplying required moisture, inundation provides a large part of the nutritional needs of the paddy plant. Inundation not only depletes the free and combined oxygen from the subsoil but also retards root development. It also inhibits nutrient absorption and normal aerobic respiration and causes root rot (Yamada 1965: 41). Prevention of these negative effects requires timely drainage. Irrigation for paddy cultivation requires not only adequate and controlled water supply but also efficient movement of excess water, supply of water at one time and drainage at a later date.

Successful paddy cultivation depends on adequately inundating the fields during the greater part of the growth period of the plant. In Southeast Asia, India and Latin America, where traditionally paddy is grown with little or no application of fertilisers, continuous inundation combined with a short period of draining is considered the most satisfactory. Although the paddy plant prefers slightly acidic (with pH less than 7), heavy soils (containing more clay than sand and silt), in most of the coastal areas – the heartland of paddy growing areas in India, i.e. Bengal, Orissa, and Tamilnadu – paddy is grown on highly alkaline and medium to heavy textured soils (Grist 1986: 26-29). Paddy will not develop on these soils unless water is abundantly supplied at all times and the plant is transplanted (Grist 1986: 28). In a nutshell, the paddy plant on alkaline and heavy to medium textured soils with little manure application relies for its nutrients more on abundant supply of water and sediments than on the soil. That makes the role of irrigation even more crucial. When continuous inundation has to be maintained, water has to be frequently supplied and drained.

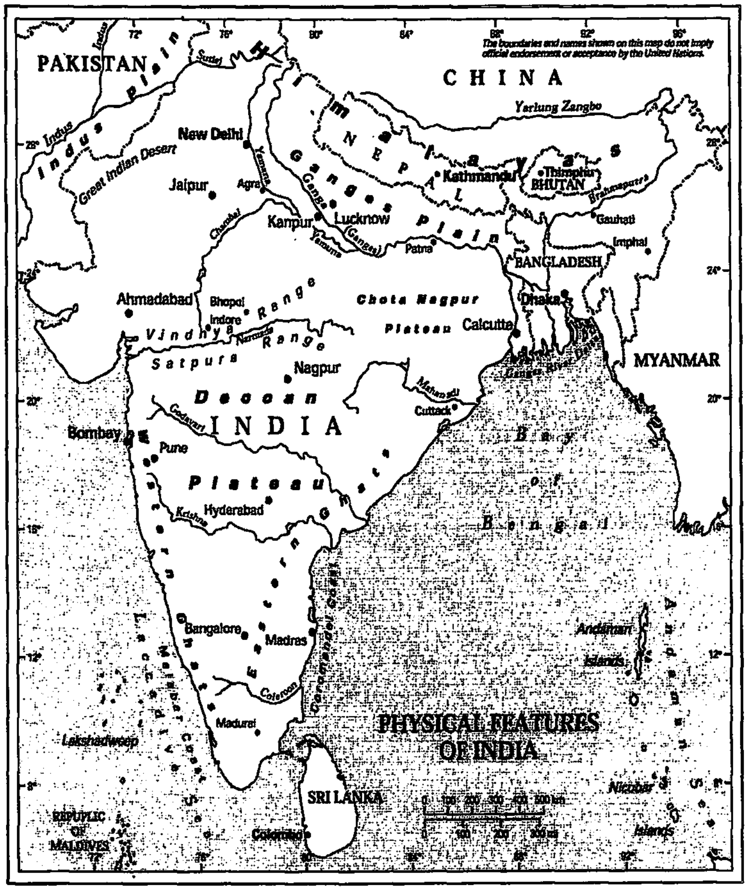
The storage of a sufficient amount of water in a reservoir like a tank, although crucial, is not enough for the successful cultivation of paddy. What is also required is the significant alteration of the landscape of the irrigated area for the easy movement and drainage of water. Every plot has to be levelled with respect to the surrounding plots and with respect to the direction of the flow of water in the irrigated area as a whole. Moreover, water has to be distributed among various users within the time period for which irrigation would be needed. Hence, in principle, building an irrigation facility for paddy cultivation implies creating a system for effective storage, distribution and drainage of water, which would mean altering the landscape by various methods. Tank irrigation is the means by which the landscape of south India[3] (figure 2.1) has been altered to facilitate paddy cultivation.

Historical and Spatial Expansion of Tank Irrigation

The practice of reservoir irrigation system started in the early centuries of the first millennium (Dikshit et al. 1993: 35; Srinivasan 1991: 10-42; Gurukkal 1986: 155-64).[4] However, the period 700 - 1000 A.D. in south India is identified with wider utilisation and effective management of hydraulic technology. It coincided with agricultural expansion (Gurukkal 1986: 155-64), especially with the spread of wet paddy cultivation (Ludden 1985: 16-17). The first organised forms of irrigation such as short channels, seasonal dams, cisterns, sluices and tanks began during Pandya rule in 700-800 A.D. in Tamil speaking south India for which procedures for social investment were established (Ludden 1985: 16-17). Before that, during the Sangam period (300 A.D. to 600 A.D.), paddy was cultivated in the low lands by inundation with water diverted from rivers by various means (Ludden 1985: 16).

The most significant technical development that made tanks a viable source of irrigation through gravity was string line sluice construction (Gurukkal 1986: 156). String line construction technique implies using a string to place the stones in a straight line. The method is still in use in construction engineering to ensure a straight vertical line of construction. Nandi (2000: 87-94) argues that the development of the sluice-weir technique during the sixth to eighth centuries was the most critical development that changed the course of irrigation technologies. Provision of sluices in a reservoir entails that stored water can be withdrawn for irrigation whenever needed. Excess water that may threaten the dam is discharged through weirs. According to Nandi the sluice-weir technique made it possible to divert water for irrigation under gravity in contrast to the earlier method of irrigation from ponds that chiefly used lifting devices such as baskets (Nandi 2000: 90). He calls this development a "shift from lift to drift irrigation". This shift allowed a considerable amount of human energy to be employed for more productive ends than lifting water with baskets. Thus, significant tank construction activities started in the wet region of the Tamil country between 700 and 1000 A.D., following an important technical breakthrough. Tank construction activity reached its zenith during Vijayanagara rule, between 1300-1750 A.D., when the tank irrigation method was expanded in upland regions across south India, more particularly in marginal[5] or mixed zones. A majority of the tanks in south and southeast Karnataka would be of the latter type. Tank construction in the wet region of western Karnataka began even before the Vijayanagara period.

FIGURE 2.1: Map showing South India as south of Krishna-Godavari watershed.



MAP NO. 3665 UNITED NATIONS
JANUARY 1992

Spatially, the density of tanks in Karnataka is related to paddy cultivation. Paddy remains the most important crop in tank-irrigated areas of the mixed and wet regions of western and southern Karnataka. But its importance declines as one moves from west to east and south to north, and correspondingly the density of tanks also reduces. The tanks in the mixed region of northeastern Karnataka support both paddy and irrigated dry crops. Further north, in the dry tracts of what is known as Bombay Karnataka or the Deccan plateau, only irrigated dry crops are grown in tank-irrigated areas. A majority of the tanks in southern and western Karnataka are more than three to four centuries old. But in Bombay Karnataka, tanks irrigating semi-dry crops were constructed only during the British period. Spatial variation of tank density in various parts of Karnataka is further discussed in chapter 4. Figure 4.1 shows different regions and table 4.1 gives district and region-wise distribution of tanks in Karnataka.

Tank irrigation technology essentially consists of the following physical structures: 1) a reservoir to store water (either diverted from the river or harvested from a seasonal drain), 2) an earthen embankment, 3) sluice/s to regulate outflow, 4) a waste weir to discharge excess water, 5) a network of field and main canals for the distribution of water in irrigated areas, and 6) well laid out fields. As discussed in chapter 1, these physical structures cannot come into existence or function without social arrangements to design and construct and to operate, manage and maintain them. In what follows, I attempt to explain certain design principles of tank technology and their link with paddy cultivation in the social and agrarian contexts of the pre-British period.

Paddy Cultivation and Tank Designs

Design principle one: embankment and sluice/s

Many observers have pointed out a common feature of tanks, namely expansive water spread areas and long embankments. Several tanks constructed during the pre-colonial era boast very long embankments, sometimes running into kilometres stretched out as if following a serpentine leisure stroll. A vast area was submerged as a result, creating an extensive stretch of reservoir, not necessarily with an equally massive storage capacity.[6]

A low ratio of water-spread area to length of the embankment goes against the logic of currently followed standards in civil engineering. According to current standards, a reservoir with the least length for the maximum depth of the embankment would provide maximum storage per unit length, would cause least submergence, and hence would be the most economical – costing the least per unit of water stored. Oppen and Rao (1987: 13) have also observed that the shape and length of the embankment largely determine the cost of the construction of a tank.[7]

FIGURE 2.2: A tank and its long embankment.

The length of an embankment is a direct function of the width of the valley that is being bridged and hence a function of site selection. In the delta region, the flat nature of the landscape would not have provided the option of deeper valleys with narrow openings – the ideal site as per the current engineering standards. However, in the pre-colonial historical context, the site selected for tank construction was primarily a function of political will to invest in that locality and the topographical features of the site played a secondary role. Development of irrigation during that period was part of building a local and supra local political order. The selection of tank location was largely decided on the basis of the ability of local and supra local elites to invest in developing the locality in order for them to claim higher political and ritual status.[8] The political importance of the location, and correspondingly political and ritual status of the investing agency, mattered the most while deciding the site for tank construction. Tanks in all probability were also constructed close to existing villages, at least during the early centuries of tank construction. However, during the Vijayanagara empire period investments were made to develop hitherto marginal habitats, in many instances, to settle migrant population (Breckenridge 1985: 50). Hence, one can argue that there was less control and emphasis on the dimensions of the reservoir, the embankment, the extent of water spread area and storage capacity.

Having argued that the commonly found feature of lengthy embankments was not an engineering choice but politically and socially determined, it can be further (speculatively) argued that lengthy embankments also provided opportunities for paddy cultivation. This is not to suggest that embankments were consciously designed to facilitate paddy cultivation, but to point out that the social and political order was inseparably intertwined with the functional rationality of technology that helped promote paddy.

The function of the embankment is to hold water for subsequent irrigation applications in order to reduce uncertainty of timing more commonly associated with rainfed cultivation. The quantity of water that can be stored is more important than the depth of the storage and the extent of the water-spread area.

Furthermore, a long embankment can possibly accommodate more sluices, which can provide the following opportunities. Firstly, more sluices, linked to a set of parallel canals, can potentially bring a larger area under cultivation. If the terrain is flat, the slope of the canals may not be sufficient for the water to travel a relatively long distance. This is because, for a given discharge in the canals with a relatively flat slope, losses would be high if water has to travel a long distance in sufficient quantity. In such a case, the longer embankments could accommodate several sluices and several canals, each feeding a relatively small number of fields located parallel to the embankment. This way the aggregate irrigated area would be larger than there were fewer sluices of larger capacities and longer canals.

Secondly, a number of sluices located at varied depths of storage provide a higher degree of manoeuvrability. Sluices may not only be progressively operated to suit the depth of storage in the reservoir but also to serve different parts of the atchakat with varied irrigation requirements. For instance, the tank discussed in chapter 6 has four sluices. The two located on the extreme edges are at a higher level and are operated when the tank is full. The other two are located at the deeper part of the embankment and are operated only if the water level in the tank depletes. This way, a certain amount of storage can always be preserved by not operating lower sluices, if needed. At the same time, each sluice connected with a specific canal can serve a specific patch of atchakat. As further discussed in chapters 5 to 7, water rights in paddy growing atchakats have been closely intertwined with social relations in the atchakat. More sluices provide an opportunity to technically negotiate a variety of water claims.

Thirdly, a longer embankment could present the possibility of installing a number of sluices and expanding their use by progressive extension of the irrigated area in the direction parallel to the embankment. Many scholars have argued that irrigation facilities were not built at one time in the pre-British period. New structures were progressively incorporated in the course of several centuries (Ludden 1985: 53). The mosaic of tanks that altered the landscape of peninsular India permanently was complete only by the Nayankara time of the late Vijayanagara period, around 1750 A.D., the process that had begun almost 1000 years ago (Mosse 2001). The same argument can also be applied in order to understand the engineering and agricultural history of an individual tank irrigation system at microscopic level, or even to comprehend the process of development of an individual paddy field.[9] For example, the different parts of irrigable area from one tank were progressively brought under cultivation, evidentially in the course of a few centuries.[10] Thus, both the physical structures and landscape of irrigable area from one tank were continuously transformed with expanding agricultural activities. Both expansion and intensification of cultivation within a limited spatial setting was an integral part of paddy cultivation. Importantly, the technical features of tank irrigation systems facilitated that process. It not only permitted progressive inclusion of more sluices at a later stage but also created a possibility of one or more already constructed sluices being brought into use at a later stage when more land was brought under cultivation.

Thus, although the length of the embankment was dependent upon the location of the tank, which was politically determined, it did not hinder, in fact facilitated, the requirements of paddy cultivation.

Design principle two: method of construction and labour requirement

I now return to an earlier point, namely that the length of an embankment determines the cost of construction of a tank. It could be argued that the length of the embankment was not a limiting criterion, despite the fact that cost increased with length of embankment, because labour – main input in embankment construction – was easily and cheaply available.

Several generations of engineers since the British time have wondered about the impeccably watertight nature of embankments to the extent that they have survived for centuries and have showed little signs of settlement. It has been speculated by puzzled engineers that embankments were consolidated with sheep or goat feet (the method is now adopted for consolidation of large earthen dams by a mechanically operated pestle made in the shape of a sheep foot). Alternatively, elephants probably consolidated not all but some of the large and important dams. The most likely possibility is that the embankments were allowed to weather for a few seasons after construction before the reservoir was allowed to fill up. This would have ensured natural consolidation. While these arguments might be important, I would argue that the labour intensive method of construction guaranteed maximum water-tightness and marginal post-construction settlement. Bligh (1907: 329-30), a British engineer in charge of embankment construction in Bombay presidency, described the customarily practiced method of embankment construction that he came across during his tenure as an engineer.

> The bottom 10 feet of the base of the bank should first be thrown up, and a temporary cut made in the solid ground or rock at a lower level to pass off waste water, or else the masonry outlet culverts can be first built and adapted for this purpose. The work should then lie in abeyance until water has collected in the basin behind the bank. The surface of the bank should then be divided into shallow basins about 12 inches deep by narrow partition walls of earth. Into these enclosures the water should be pumped or baled up from the reservoir. As soon as a series of these shallow basins are full of water, the earth is thrown in to fill them up level with the top of partition walls, after which another series of chequers are formed on top and again watered. While one part is being filled up, another is being watered or chequered, so that there is no intermission in the earth carrying. When the embankment is thus raised, the level of the bed of the escape cut can likewise be raised either by partially filling it up or cutting a new channel at a higher level, so as to allow the water to rise to a further height behind the bank. By means thus described each layer of earth is thoroughly soaked and clods dissolved, so that no ramming or clod breaking is requisite, and the new layer is further consolidated by having 6 to 9 inches of water laid over it, the result being that the whole bank is composed of wet earth devoid of air spaces, which are inseparable if dry earth is used,

> no matter how much it may be consolidated by rolling or ramming. Consequently when the tank fills, there can be no settlement whatever of the embankment (Bligh 1907: 329-30).

Bligh (1907: 330) has also described how it would be important to throw earth into the basins at an appropriate angle so that the earth would sink under water. That could be possible, according to him, only if the earth was carried in a basket on the head by, what he called, "coolie labour"[11].

Morrison's (1992: 87) observation, in her archaeological study of reservoir irrigation systems of Vijayanagara metropolitan regions, confirms this point. On the basis of her study of several tanks constructed during the Vijayanagara period, she reports that "the earthen embankment section consists of hundreds and thousands of soil lenses; presumably the result of innumerable head-loads of soil laid down by a large group of labourers." Further, Sewell (1900: 244-45) quoting from the account of Domingo Paes, a Portuguese traveller who visited the city of Vijayanagara between 1520- 1522 A.D., wrote, "in the tank I saw so many people at work that there must have been fifteen or twenty thousand men, looking like ants, so that you could not see the ground on which they walked." Paes's observation was presumably made while witnessing the construction of a large reservoir organised by king Krishnadevraya.

The precision with which the method was executed suggests that it must have been mastered after significant experimentation. The existence of several watertight embankments, surviving for at least three to four centuries, suggests that such a method is old. Though laborious, what is significant about the method Bligh described is that it needs no other form of material investment (for example, rollers of any type, animals or machines) except locally available earth, water and some simple instruments like pickaxes, racks, crowbars and baskets. The skill and labour of a number of human beings was the most costly investment, and that too did not cost much.

The importance of labour to this method raises the question as to how labour was organised during this historical era. Wittfogel's (1957: 43-53) oriental despotism theory of labour organisation in pre-British period is the most famous.[12] Several scholars, however, have largely refuted one of the main arguments of Wittfogel that the large-scale creation of irrigation infrastructure needed a centralised bureaucracy and a despotic state to control coerced labour.[13] Leach (1959: 13-14), based on his work on tank irrigation systems in Sri Lanka, countered Wittfogel's theory by arguing that existence of a large labour force under central government control can not be inferred based on the existence of large scale irrigation works. Leach (1959: 20) argues, what other south Indian historians have also argued (Ludden 1985; Morrison 1992), that "although irrigation works needed colossal investment of labour, their construction was haphazard and discontinuous and spread over many centuries. Moreover, the whole irrigation system was never intact at one point of time."

The debate that followed Wittfogel's hydraulic despotism thesis has significantly shifted its terms of reference from whole societies to communities, from water control to local agriculture and from a diachronic (measured against past conditions) to synchronic (measured against simultaneous conditions in the present) (Hunt and Hunt 1976: 390). As a result, the debate has led to a number of studies of local, community level resource management systems with a specific focus on water allocation and maintenance. Issues pertaining to the organisational efforts behind the construction of physical systems, on the other hand, have taken a back stage. As Hunt and Hunt (1976: 390) have said, "there has been little discussion on surplus generated through irrigation and more specifically on control of labour input for the construction." The scale, such an exploration may have to follow in time and space, may impose limits; nevertheless, it remains an important issue in order to conceptualise the role of irrigation in societal formation.

There are indications that since the early medieval time labour has been politically and ideologically controlled by elites. For this period, there is evidence to suggest that labour in general was extracted under coercion. Ludden (1985: 82-83) fleetingly mentions that "[coerced labour] was not unique to the nineteenth century, and perhaps was convenient during temple and tank construction over the centuries" although he does not provide any evidence for it. What little evidence exists suggests that the practice of extracting unpaid or coerced labour was not unknown to south India during the medieval times. What is still being debated is nature and form of forced labour, whether such form of labour extraction can be called compulsory labour, labour extracted in lieu of tax payment or forced or coerced labour (Rai 1976: 16-42)[14]. Yarlagadda (1993: 169-170), in her study of inscriptions of the western Deccan (delta region of Krishna and Godavari – a heartland of tank irrigation systems), suggests that the practice of *visti*, imposition of forced labour, began in 900 A.D. The practice signifies that the donee of the land grant was granted the right to impose forced labour and was provided immunity for extracting such labour. She further observed that the frequency of the term visti in inscriptions increased in the period between 900 and 1000 A.D., and then disappeared in the period between 1000 and 1300 A.D. (Yarlagadda 1993: 170). However, she argues, quoting other literature, that the disappearance of the term may be due to commutation of forced labour into money payment and not due to the disappearance of the practice altogether (Yarlagadda 1993: 170).

Based on the above discussion it would be fair to say that the practice of extraction of labour under coercion was known in south India in the medieval times. The practice might have been further institutionalised around the same time when agriculture expanded to new frontiers, when water management became highly organised and sophisticated, when hitherto communally held land increasingly became private property, and when the landless labourers were brought to servile position (Yarlagadda 1993: 169-170). During this time tank irrigation expanded to newer areas in an unprecedented manner. The political and ideological control of labour made it possible not only to expand tank irrigation into new areas but also to adopt labour intensive construction method. The labour intensive construction method was arguably responsible for embankments surviving for centuries.

Several folk stories and songs that I collected during my fieldwork also suggest that unpaid labour of the artisan caste of *vodda* was exploited for construction of tanks. The analysis of folk literature cannot be explored in this book due to lack of space.

To summarise, labour constituted the main input in construction of tanks. Since labour was cheaply available or coerced, it was not a limiting factor in choosing locations of tanks and designs factors such as length of embankments. The design of laboriously constructed, lengthy embankments thus is coded with an aspect of social relations of the historical time.

Design principle three: atchakat and field-to-field irrigation

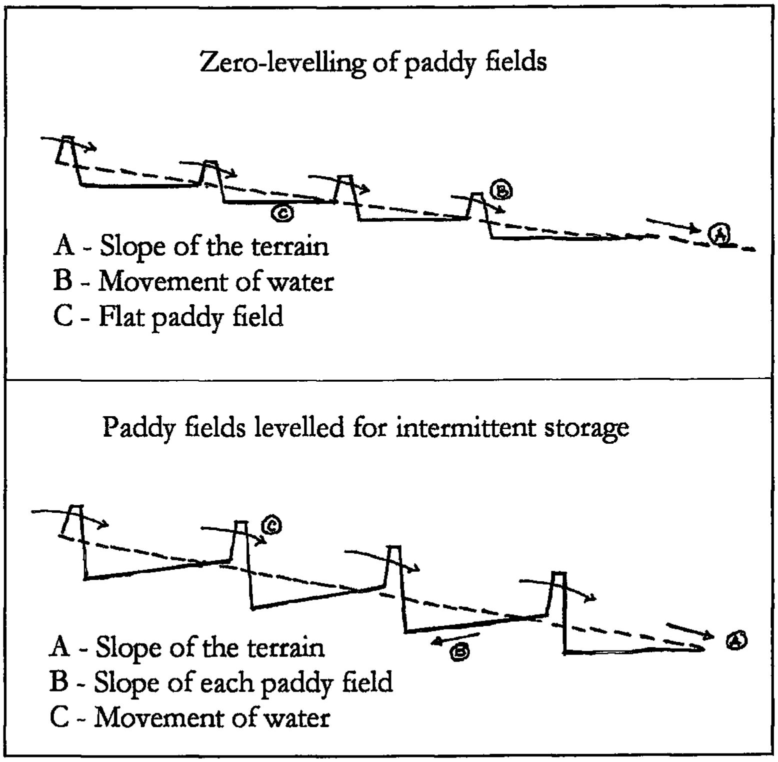
A relatively flat valley for tank construction provides a flat site for the atchakat, which is more suitable for paddy cultivation.[15] Although paddy is grown in varied environments and at various locations all over the world – in the plains, uplands, at high altitude, on hillsides, on the seashore – each individual plot of paddy has to be carved out in such a manner to change its shape and level for two reasons. Firstly, this is necessary so that the level of each plot fits with the other plots with which it shares irrigation. Secondly, it facilitates the accumulation and retention of water in the plot for the desired duration during the growth period of the paddy plant. Furthermore, when water has to be frequently applied and drained for paddy cultivation, irrigation from field to field may be an economical choice. And, when the nature of atchakat permits flow under gravity, having a separate connection to each field with the main canal and a separate drainage canal, would result in loss of a lot of land.

Tank-irrigated areas, hence, have peculiar topography. The atchakat as a whole slopes gently in order to facilitate irrigation water to flow under gravity from field to field. Each individual plot slopes corresponding to the slope of the atchakat as a whole and depending upon whether irrigation water flows continuously or is provided intermittently. Most commonly in case of transplanted paddy cultivation, especially in case of the modern high yielding varieties, each plot is made as flat as possible (See figure 2.3). The flow of water from the upstream to the downstream plot is ensured through a relative level difference between the successive plots. This method of levelling facilitates the continuous flow of water and also helps maintain a minimum depth of submergence in each paddy field.

However, traditionally, in parts of Karnataka, intermittent irrigation and drainage are more commonly provided for both transplanted and broadcasted cultivation.[16]

The water is stored in each field and not continuously supplied between the supply and drainage period. The field bunds are kept relatively high for this purpose as compared to a situation if water is continuously supplied. More importantly, for intermittent supply, the slope of each field is adjusted with respect to the overall slope of the atchakat. As shown in figure 2.3, each plot slopes in the reverse direction with respect to the general slope of the atchakat. Thus, each field behaves like a small reservoir with the maximum depth of storage near the upstream field bund. In addition to adjusting the slope of each plot with the slope of the upstream and downstream plots, the slope of the atchakat has to be modified in order to maintain the flow of water from field to field.[17]

FIGURE 2.3: Levelling of paddy fields



This type of arrangement of paddy fields that share an irrigation facility would have to be collectively built to an appropriate level of synchronisation. After such facilities are built, it may not be easy to convert them to an arrangement for growing other types of crops, especially dry crops, barring pulses. This is so also because continuous cultivation of paddy changes the nature of the soil. I will discuss this point more later.

Design principle four: type of sluice

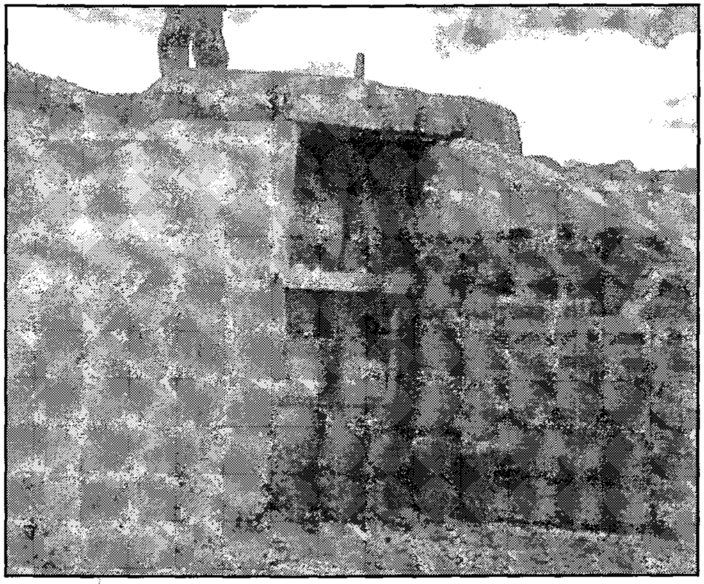
The pole and plug type of sluice, usually encountered in all tanks constructed before the colonial period, suits paddy cultivation.

Figure 2.5 is an engineering line diagram of a generally found plug and pole type of sluice. In its most rudimentary form, the plug and pole type of sluice is installed on the tunnel that cuts the embankment in a perpendicular direction to the main longitudinal axis. An opening is made in the tunnel on the side of the water-spread area from where the water is let in. The tunnel opens on the other side of the embankment from where the water is divided among one or more canals. The opening made in the tunnel is opened and closed by a plug connected with a rod or chain that can be ideally operated from above the full tank level. The plug, conical in shape, fits in the opening.

The design principle of the plug and pole type of sluice does not permit partial opening easily. The sluice aperture can only be kept opened or kept closed unlike a gated sluice[18], which can be partially opened. The only arrangement that permits adjustment of flow of water in the tunnel through the plug and pole type of sluice is multiple sluice openings (usually provided only in large tanks), which can be successively opened to ensure entry of water in the tunnel at varied depths of storage in the reservoir. Occasionally, in some of the very large tanks, the plug is provided with slots or tapered in such a way that it can be partially opened. However, the control over the flow of water in this case is marginal compared to a gated sluice.

This design principle is coded for its suitability for paddy cultivation. Unlike dry crops, paddy is neither damaged because of excess irrigation nor does it need a measured amount of water to be supplied at definite intervals, which would consequently have needed stringent control over the sluice operation. Water rotation among fields in the atchakat requires little control. Whatever control is required is provided by adjusting the timing of the sluice opening. In most of the tanks in southern and western Karnataka that predominantly irrigate paddy, the sluice is kept open for a large part of the cultivation cycle. Moreover, sluices do not have to be opened and closed frequently for paddy cultivation. In contrast, gated sluices (see figure 2.4) can be opened and closed frequently to deliver a precise amount of water. Gated sluices[19] have existed in south India since the British period mostly in newly constructed tanks that irrigated dry crops.

FIGURE 2.4: Shutter or gated type of sluice



Design principle five: social organisation and collective action

Field preparation and construction of irrigation facilities for paddy cultivation requires a relatively significant amount of organised labour. Water requirements for paddy cultivation are met by a common source of irrigation, which is largely facilitated by the engineered landscape and the construction of the atchakat in the fashion explained above. The level of each individual plot has to be correlated with the level of the upstream and downstream fields for effective water retention. Since the supply in one field is the drainage from the other, metaphorically, each field is tightly held in its irrigated topographical location by virtue of the others pressing against it. All the actions related to irrigation have to be collectively coordinated.

The collective that created and maintained the technical requirements of paddy cultivation rested on highly differentiated social relations in south India. As Ludden (1985: 89) specified, "although the villages were collective entities, they were anything but egalitarian". The same could be said about the production relations. In Tamil speaking south India, the higher, agricultural caste of Vellala and the ruling caste of Brahmins collectively promoted the irrigated agriculture. They collectively controlled land, labour and water because dominance over all the three productive forces was necessary for a successful production cycle (Ludden 1985: 85-86). The Tamil word for a particular measure of land, *kani*, also denotes the right over productive resources such as land, labour and water (Ludden 1985: 85-86). In the early medieval period, control over the productive forces of land, water and labour by the dominant section of the society was apparent not only in Tamil country but also in the coastal plains (the delta regions of Krishna and Godavari) and the western Deccan (Yarlagadda 1993: 158-181). Significantly, the nature of social stratification underwent considerable transformation during 800-1000 A.D., during the same time when extensive control over water and land was established, when the frontiers of agriculture were expanding and when the nature of organisation and management of water resources were fast changing, acquiring its sophistication. This process of change lasted for more than 1000 years.

The significant growth of productive activities during this period went hand in hand with the increasing concentration of surplus in the hands of the dominant sections and the subjugation of landless labourers to a servile position. The social stratification among various social groups was most pronounced in the wet, coastal plains of the Tamil country (and as Yarlagadda shows in the western Deccan) where "land owning became more and more detached from the agricultural labour". In other words, those who owned land rarely worked in the fields (Ludden 1985: 89-90; Yarlagadda 1993: 160).[20]

The much-eulogised institution of *neerganti* (or neerpanchi in Tamil and neerkatti in Telugu) meant for water distribution in tank-irrigated areas across south India was firmly embedded in this (stratified) web of social relations. Neergantis belong to the landless, lower caste of village servants. They are assigned the responsibility of distributing water among fields during the irrigation season, guarding the physical structures, and opening and closing the sluice/s under water. In return they were traditionally paid a share from the village income; these days farmers pay a part of their produce.

As Wade (1988: 79-80) has argued, the "common irrigators" save a great deal of labour time especially for the wealthy farmers.

Once the transplantation is done, irrigation is the only task that demands labour until weeding time. As the demands of irrigation are significant for paddy, landowners may be forced to employ household or hired labour especially for the relatively unskilled job of irrigation. This labour time may not be gainfully employed in case the upstream farmer has not completed his irrigation in time. The common irrigators (or neerganti) thus save a considerable amount of labour cost for landowners by handling water distribution in the irrigated area collectively. The institution of neerganti is thus embedded in the social practice of how labour is organised and gainfully employed.

The arguments presented in the chapter so far illustrate that the design characteristics of tank technology, in a historically specific way, relate to paddy cultivation. The discussion also shows how the designs embody productive and social relations of the time they belong to. For instance, the decision to construct a tank in a specific locality was a political one rather than a techno-economic one. As a result, there was less control over technical aspects such as the length of the embankment and the corresponding water spread area. The length of the embankment was not a significant constraint because labour was cheaply and easily accessible due to political and ideological control exerted over the artisan, labouring castes. The impeccably watertight embankments that have lasted centuries were constructed through a labour intensive method, which required only inexpensive and simple instruments and raw material. The design principle of this labour intensive construction method thus carries the imprint of a social order that was hierarchical and exercised a considerable degree of control over labour.

The other tank design elements such as topography of atchakat and method of water distribution were further shaped by the requirement of paddy cultivation. The design principle of field to field irrigation by synchronising the level of each field with other fields facilitates the movement of water in the atchakat and creates particular patterns of water distribution. This synchronisation entails that the process of irrigation for paddy cultivation is not only collective endeavour, but that each field is rigidly linked with the other. The collective of irrigation was thus held together as much by engineering the landscape of irrigated area as by means of institutions such as the neerganti. The labour of common irrigators reduced the overall requirement of labour needed for irrigating paddy fields. Control over labour thus emerges as a focal code that historically shaped the tank designs.

Wet against Mixed Cultivation

Having argued that the requirements of paddy cultivation played a crucial and influential role in determining the designs of the tank technology, we now examine how tanks supported the cultivation of other crops.

Tanks were increasingly constructed in marginal and mixed habitats away from fertile and rich, riverine areas to support paddy cultivation during the Vijayanagara period (1300 A.D. - 1665 A.D.) (Ludden 1985: 53). Many scholars have argued that socio-cultural history of different ecotype regions[21] followed a different course depending upon the different levels of moisture availability. The pattern of moisture availability is different in the mixed ecotype, as compared to the other two ecotypes. The other two ecotypes – in one case abundant availability of moisture and in the other scarce – would have one thing in common, certainty. Agricultural patterns can be planned and fairly routinised in both these settings, unlike in the mixed type of cultivation where each season would have to be weighed against the uncertain amount of water that finally might be available before planning the agricultural season (Stein 1980: 27-29). Tanks in the mixed zones were subjected to this uncertainty since they received an uncertain amount of water from the non-perennial rivulets, unlike river fed tanks in the wet zone. This uncertainty was accentuated when they were constructed to expand paddy cultivation in marginal hydrological terrains, which were otherwise not suitable for paddy cultivation.

This uncertainty about water availability in the tanks in mixed zones became a major worry for the British engineers. In one case it resulted in a fairly destructive response. Colonel Fife (1866: 12) expressed that he would like to demolish all existing tanks and build them afresh at favourable locations. The shift towards reservoirs constructed on assured catchments of perennial rivers became imminent during the early twentieth century. This was aptly voiced by Colonel Playfare (1866: 3) "that the small tank systems on tributary streams must fail: in the first place because the cost of storing the water is too great in comparison with the return to be expected; and secondly, that as the supply of such tributary streams is likely to fail in seasons of drought, the tanks would be dry at the very time they would be most wanted."

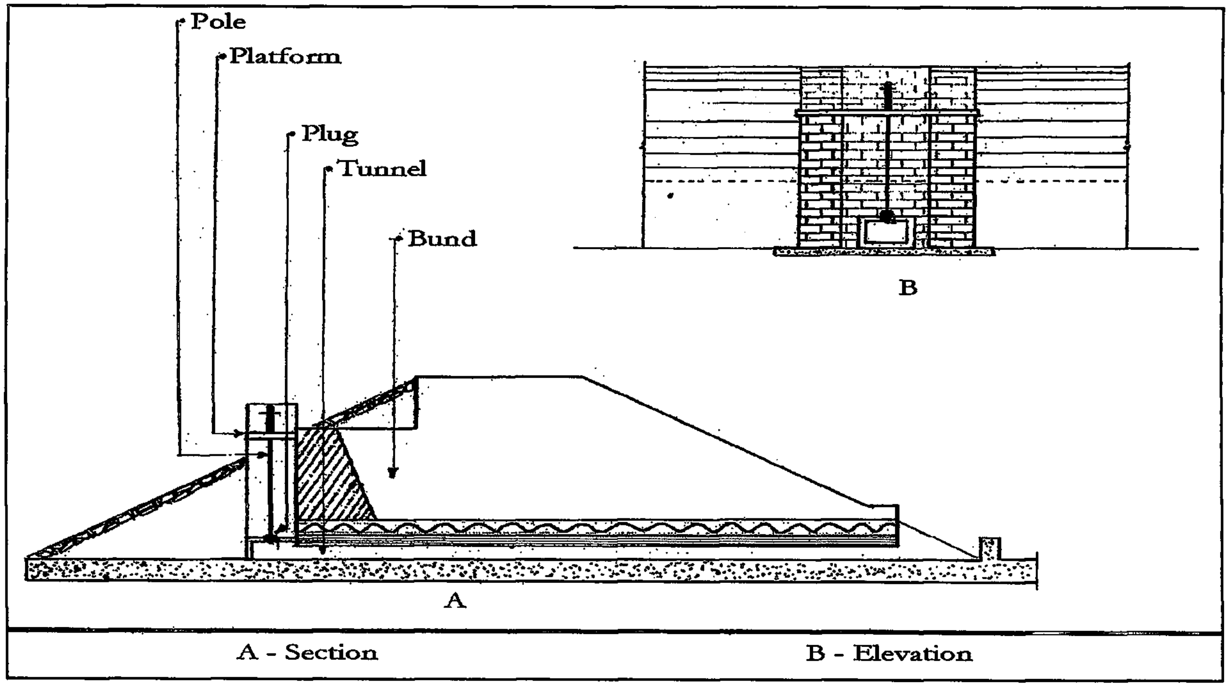
One more reason that contributed further to instability in the cropping regime of the tank-irrigated areas relates to the mixed cropping pattern followed in the tank-irrigated areas of mixed zones. In a good year paddy was grown, in a bad year either nothing was cultivated or rainfed crops were raised, and in an average year paddy was cultivated in part of the irrigated area and millets such as ragi, sorghum or pulses in the rest, or only millets were grown in the entire area (Ludden 1985: 53-54). It is likely that fields meant for paddy were never used for any other type of cultivation and that they were kept fallow in bad years. If millet were to be grown instead of paddy, the topography of the atchakat and slope of fields would have to be altered, the land would have to be ploughed and tilled differently and the logistics of irrigation would have to be changed.[22] These tilling practices would disturb the texture and structure of the paddy fields.

Repeated paddy cultivation changes the nature of the soil making it progressively more suitable. Mixed cropping, especially millet, potentially disturbs the landscape of paddy fields and the texture and structure of the soil. In the first half of the nineteenth century the wealthy and politically powerful landowners of Tambraparni valley of Tamil country could successfully convince the colonial Government to assess their lands at a lower revenue rate because they argued that the land was used for what was called *nanjah-mel-panjah*, i.e. dry cultivation on the wet land or cultivation of dry and wet crops alternatively on the same land. The land, if used for mixed cultivation, was believed to yield less than if cultivated exclusively with rice (Ludden 1985: 112-116).

Continuity of Paddy Cultivation needs Continuous Cultivation

Paddy cultivation thus comprises the alteration of the landscape in two ways – the creation of irrigation facilities and building of fields. However, this alteration of the landscape is just an initial condition for the requirements of paddy cultivation. For the longevity of paddy cultivation, paddy needs to be cultivated continuously because the process by which paddy fields acquire their stability and higher productivity is gradual, progressive and cumulative.

FIGURE 2.5: An engineering line diagram of plug and pole type of sluice (not to scale)



Several years of continuous paddy cultivation increases soil fertility, which is then maintained at a higher level almost indefinitely (Geertz 1963; Bray 1986: 28; Grist 1986: 21-24). It is no coincidence that some of the oldest human settlements are concentrated in the rice growing areas of south and Southeast Asia, China and Japan. In these areas some of the paddy fields have been under continuous cultivation for more than a millennium (Bray 1986).

Different types of paddy fields stabilise at various levels of yields depending upon the type of soil and nature of water control. This stabilisation occurs as a result of repeated cycles of instability created due to human activities involved in rice cultivation. Watanabe and Roger (1985: 229) describe a flooded rice field as an artificial ecosystem that is frequently disturbed, in fact manipulated by farming practices. All the activities connected with rice cultivation, such as cropping, fertilisation, weeding, irrigation and crop protection disturb and destroy environmental conditions in this artificial eco-system and cause extreme instability. In the absence of these human activities in paddy fields, a symbiotic relationship between the floodwater and the soil would have developed creating marsh-like conditions. In marshy land, certain types of grass and plants grow due to poor availability of oxygen, which further result in poor drainage and waterlogging. Frequent cycles of human activity inhibit growth of paddy fields into marshy lands, thus making monocropping of rice possible for centuries.

Hence, repeated cycles of cultivation that generate short-term instability are essential in creating long term stability in paddy fields. The repeated cycles of flooding also alter the chemical composition of the soil and contribute towards stability (Ponnamperuma 1985: 71). The alteration of the chemical composition of the soil due to continuous paddy cultivation is known as podzolisation.

> Soils used for paddy cultivation are kept for varying periods in an artificially flooded condition which brings about a movement of iron and manganese compounds from the upper layers and their subsequent reprecipitation at a lower depth. This reduction of the topsoil starts through the metabolism of anaerobic bacteria. The surface soil remains in an oxidised stage because of oxygen supplied from the irrigation water, but in the reduced zone iron and manganese compounds are carried down and, when they

> reprecipitate, form a layer 5 to 20 cm thick at a depth ranging from 20 to 60 cm. This 'hard pan' may occur in the upper layers of paddy soils as a consequence of the breakdown of aggregates by continuous flooding (Grist 1986: 21).

As a result of the process of podzolisation, the formerly well-drained upland soils lose their characteristics and much of the red iron compounds are dissolved and removed from the surface to the subsoil or into the river waters. The soils thus fade in colour until, after a long time, they are predominantly grey like the rice lands of the alluvial plains (Bray 1986: 28-29).

The creation of the hard pan reduces permeability of the soil and prevents leaching of important nutrients, and at the same time reduces water demand progressively. Water here performs two important functions. Firstly, it provides rich silt loaded with organic matter and hence acts as a fertilising agent. Secondly, continuous flooding entails conditions suitable for anaerobic bacteria which can process organic matter for plant growth, stabilise them and as a consequence also alter the chemical composition of the soil contributing to long term stability. Hence, for the soil to acquire the necessary qualities for stabilised and productive paddy cultivation, repeated cycles of flooding and human activities connected with rice cultivation are the most important aspects.

Tank Designs and Paddy Cultivation: Continuity and Discontinuity

Paddy cultivation, thus, entails labour investment first to alter the landscape for the construction of irrigation facilities and building of fields, and then for repeated growth cycles of paddy. Both forms of labour investment remain an integral part of the productive landscape, altering its nature irreversibly. As a result, land productivity is progressively increased per unit of labour invested (Bray 1986).

If continuity is a hallmark of the sustenance of paddy cultivation, and if the paddy-growing, tank-irrigated landscape has taken shape over centuries through carefully directed labour of generations, how would one conceptualise change? The issue of technological change in south Indian historiography has produced opposing views. Mosse contests the point that tank irrigation technology shows robustness just because some of the physical structures lasted for centuries. Referring Baker (1984) he states, "in purely physical terms tanks are not stable structures and require constant rebuilding" (Mosse 1999). Stein (1980: 29), on the other hand, argues that "agrarian technology – the techniques and devices with which south Indian peasants manipulated their environment remained unchanging over the course of thousand years". Mosse (1999) argues that "tank complexes" under social and political influence were "underpinned", "reproduced" and "extended" and hence changing and not simply decaying, whereas Stein observed that the forms of "agrarian technology" – the techniques and devices – were "unchanging". There is no contradiction between Mosse and Stein's positions if one accepts the distinction between tank complexes – that were extended and reproduced and hence changing – and technical principles of tank irrigation techniques and devices, which were not changing. Bandyopadhyay (1991: 98) substantiates upon this by saying that the crucial question of irrigation technology in Tamil history relates not to technological breakthrough but to continuance and maintenance of the technology. In Mosse and Bandyopadhyay's positions, thus, tanks were expanded, reproduced and continued with the expanding frontiers of production.

However, it is still an open-ended question whether agrarian technology did not change, or it changed but such change is difficult to grasp because of scant evidences. For instance, Champaklaxmi (1981) criticises Stein for basing his argument of "unchanging technology" on insufficient evidence. Champaklaxmi's contention suggest that south Indian historiography still has to significantly grapple with agrarian technological transformation in the pre-British historical context.

This chapter has not addressed the debate on technological change in south Indian historiography in any detail. Rather, my intent was to show that the designs of tank irrigation technology are coded with productive and social relations of the time they belonged to. The chapter argues that the requirements of paddy cultivation and control of labour for the construction of tanks and water management in the irrigated areas have largely shaped the design principles of tank technology.

In subsequent chapters I explore how these historically contingent designs create contradictions, described in the opening quotation of this chapter, and how they facilitate or constrain the process of change in the contemporary time. Chapter 4 to 8 explore the shift in tank designs on the interface of paddy and non-paddy cultivation.

Notes

[1] Others have made similar observations. Alary (1999: 1402) wonders whether risk aversion alone governs the farmers' choice in favour of paddy cultivation in the irrigated tracts (of large scale canals) of Telangana district, Andhra Pradesh. She concludes that in addition to farmers' concerns for food security, institutional, technical, social and political factors also influence crop choice. Mollinga (1998: 32-33), based on his study of a large scale canal irrigation system, has proposed that a shift from cultivating rice to irrigated dry crops is not just a change in the cropping pattern but also a change in technology, organisation of farming system and economics.

[2] The eco-typology of the mixed, wet and dry regions of Karnataka is discussed in chapter 4.

[3] The term peninsular India delineates the geographical area located south of Vindhya and Satpura hills. It includes both the Deccan plateau and what Stein (1980) describes as the "macro region of south India". South India generally refers to the entire peninsula; however, it is important to make a distinction between the Deccan and other parts of the peninsula owing to their distinct geomorphological and socio-cultural traits. South India here is understood, as described by Stein (1980), as being south of the upper watershed of Karnataka on the west and Krishna-Godavari delta on the east. The term peninsular India, therefore, includes the Deccan plateau which was ruled by various Muslim dynasties since the early centuries of the last millennium while south India refers to the region south of the Krishna-Godavari watershed. The mixed and wet regions of southern and western Karnataka fall in south India, whereas some arid parts of northern Karnataka fall in the Deccan. The historical and agro-ecological variation of different regions of Karnakata is further discussed in chapter 4. See figure 2.1 showing the Deccan plateau and South India as south of the Krishna-Godavari watershed.

[4] The earliest written records available on construction of tanks date from as early as 300 B.C., for example, the construction of the Sudarshan Lake in Junagadh, Gujarat. The earliest record of a tank in southern India refers to the tank that existed at Inamgoan near Pune in 1500 B.C. For a more detailed description see Dikshit et al. (1993).

[5] Breckenridge (1985: 44-72) describes it as a marginal habitat, less preferred for human settlement. Hence, agriculture was expanded here only later.

[6] Oppen and Rao (1987: 13, 21) calculated that the ratio of submerged area to command area for 45 tanks in Andhra Pradesh is 1.2 on an average. That means that irrigated area is only 20 percent more than the submerged area. They also pointed out that the ratio of submerged area to atchakat is inversely related to the size of the atchakat. In other words, with increasing size of the atchakat the area under submergence reduces. Similarly, Vaidyanathan (1998: 33), after studying 245 tanks in Tamilnadu, estimated that on an average the area submerged by storage is about 0.77 hectares (1.925 acres) for one hectare (2.5 acres) of atchakat. Further, the report on minor irrigation works in Mysore reports that the water-spread area in most of the tanks in the state is inordinately large compared with the corresponding atchakat. As per this survey, 863 tanks out of 7718 (11.87 percent) in the Krishna river basin have more water spread area than atchakat. Further southward the number increases; 2632 (27.32 percent) out of 9631 in the Kaveri basin, 1096 (55.63 percent) out of 1970 in the Pennar basin and 511 (39.61 percent) out of 1290 tanks in the south Pennar basin have a larger water spread area than atchakat (Committee on Plan Projects 1959: 40).

[7] Oppen and Rao (1987: 13, 21) have shown that the embankment constitutes 57 percent of the cost of the construction of a tank based on analysis of 45 new and old tanks in Anantapur district.

[8] Ludden (1979: 347-65) schematically explains how irrigation facilities like dams and tanks linked the interest of many investors, large and small, local and supra local. Rich peasants dug wells, chiefs built tanks, and kings built large dams, while local landowners dug channels, village distributaries, paddy fields and other relatively small works like small dams. For an overview of irrigation investment in Tamilnadu in the last 1000 years see, Ludden (1979). Stein (1980) has also explained how development of irrigation was part of building highly "decentralised" or a "segmentary" regional political order in which the locally dominant section of society invested in development of agriculture. Construction of tanks was an important means to develop agriculture through endowments and gifts to temples or through direct patronage in return for higher ritual status and political alliance. Investment in tank construction thus linked the local village with both the religious, symbolic order and political overlordship. The investment in tank construction thus was the backbone of the movement of resources from local to supra local levels and vice versa. See Ludden (1985) for a more detailed treatment of the role of irrigation development in the formation of the cultural

economy of south Indian society before 1800 A.D., and see Stein (1980) for investment in tank construction as a means to build a pyramidally and ritually organised segmentary political order. Both above-mentioned authors have studied the Tamil country. Since 1500 A.D., when agriculture expanded to marginal areas, the warrior chiefs competed to provide both investment in local tank systems and protection of cultivating communities in return for a direct share from the produce of the land. See Breckenridge (1985: 41-72) for an explanation.

[9] Geertz argues that labour needed for construction of a new irrigation facility for paddy cultivation had lower productivity than improving already existing facilities. The gradual perfection of the irrigation facility in such cases was the way to increase the productivity not only per hectare but also per person. Hence, Geertz argues that in Indonesia farmers preferred to work on the existing irrigation facility and paddy fields more intensely as opposed to opening up new irrigation facilities and fields (Geertz 1963: 28-37).

[10] Chattopadhyay (1990: 93-124) has reviewed the inscription records of an early medieval village in south Karnataka called Kalikatti. The first record appeared in 890 A.D. It has no mention of a tank existing around the village. The next inscription appeared after a lapse of two hundred and forty years, dated 1130 A.D. It mentions two grants gifted to the temple which consisted of dry and wetlands located close to the first ridge of the small sluice of a big tank called Hiriyakere. The third inscription, dated 1132 A.D., again recorded grants of dry and wet fields located close to a stone sluice. Chattopadhaya argues that the tank must have come into existence before the Hoysala period (beginning with around 1100 A.D.) In the course of thirteen years after 1130 A.D., four inscriptions appeared in the context of expansion of the agrarian space in Kalikatti. Most importantly the inscription of 1143 mentions the addition of one more sluice to convert dry land into wet, although it is not clear whether this was in the existing big tank or in other small tanks that came into existence in the same period. In the context of the expanding agricultural space of Kalikatti, the tank irrigation system may also physically have been transformed, either by acquiring new physical structures or by bringing previously dry land under wet cultivation. Accounts of gifts given to the temple may also indicate that a certain part of the irrigable area was brought under cultivation at a later date, i.e. after the tank was constructed.

[11] During the colonial period, manual labourers for construction activities were largely employed from the various factions of the artisan caste of *vodda*. Voddas are customarily known as tank builders. They were reduced to work as coolies or wage labourers during the British period.

[12] There is a chapter in Wittfogel's book entitled, "Developmental Aspects of Hydraulic Societies" which deals with the creation of irrigation structures and its connection to the nature of the state.

[13] See Hunt and Hunt (1976) for the most incisive discussion on the subject.

[14] Rai (1976: 18-19) clarifies that labour in lieu of tax was paid in the form of a service provision to ruling sections. This form of labour levied in the form of tax, in theory, was based on certain principles, for instance artisans worked for the king one day in a fortnight. But forced labour was extracted under some sort of threat for which money or any other form of payment was forbidden. Labourers were forced to work as long as they were fed.

[15] Bray explains that the rice field has to be carefully levelled to ensure uniform depth of submergence. In the absence of any mechanical equipment this requirement severely restricts the field size. A Chinese agronomist, writing after the process of collectivisation had begun, suggests that the optimum size of an irrigated paddy field is 0.1 hectare, while a Japanese expert sets it at 0.3 to 0.5 hectares if mechanical devices are used (Bray 1986: 29-30). Bray further points out that it is easier to construct level fields on land, which is fairly flat to begin with. She also observes that early rice growing settlers preferred river valleys and deltaic plains for easy access to moisture and flat land (Bray 1986: 30).

[16] Rice (1897: 131-43) highlights three conventional modes of sowing seeds of paddy in Mysore that follow three methods of cultivation. He also reports a great deal of regional diversity in following these cultivation methods but in general they follow the same principles as described here. In the first mode, known as *punaji bhatta*, the seeds are broadcasted dry on the fields which are ploughed at least six to eight times and watered before the sowing. Sowing is done in the month of May just before the commencement of the monsoon season. After the sowing, either the fields are inundated with a shallow depth of water or if there is rainfall no irrigation is provided until the forty-fifth day after which the fields are kept inundated. The second method, called *mde* bhatta, or broadcast sowing, seeds are sprouted and sown in the puddle fields after being kept under inundation for a month. For the first 24 days the fields are watered every other day and afterwards fields are kept under constant inundation until the crop is ripe. The third method of transplantation, called *nati* bhatta, the seeds are sown thick, raised for sixty days, then transplanted in the fields brought to puddle after being inundated for a month. The crop is then inundated until ripe.

[17] Chapter 4 further discusses why paddy (of high yielding varieties) is still grown broadcasted and not transplanted with intermittent supply of

irrigation in the wet region of western Karnataka.

[18] Gated sluices were not unknown to south India in pre-colonial times. What is called *madaga* (flood gate) used to be provided in the embankment directly, however, unlike the shutter type of sluice, the door of a madaga covered the entire depth of the embankment to control the flow of water.

[19] The gated sluice has a wooden plank that slides up and down in the iron guides provided on the side of the opening.

[20] Stein (1980) provides a similar explanation to the question: why did land ownership in the wet regions of the Tamil coastal plains become increasingly detached from labouring in the fields? He argues that certainty of availability of moisture and adequate storage facilities permitted cultivation practices to become fairly routine. Therefore, they could be left to low status labourers. The elites, without cultivating experience or skills, dominated local life. In contradistinction, the uncertainty about water availability kept the socially dominant groups bound to the land in the mixed zones. Cultivation decisions had to be weighed against moisture availability in each season and hence the landlords here retained the close management of cultivation operations.

[21]Historians have generally described three ecological settings in peninsular India, namely, wet, mixed and dry. Wet is the irrigated riverine tracts of major rivers such as Kaveri, Krishna and Godavari; mixed zones have rainfed tanks as a main source of water such as the major parts of Karnataka; and dry zones are wholly rainfed. See Stein (1980), Ludden (1985) and Morrison (1992) for the further discussion.

[22] These remarks are based on discussions with farmers. I will elaborate upon it in chapter 4.

3

Tank Irrigation Policy

New Agrarianism and the State

There is no difference between small and large farmers. The small farmer uses water for irrigation; so does the large one. The small farmer puts chemical fertilisers on his field; so does the bigger farmer. The small farmer has to plough his field; so does the large farmer. The only difference is that the small farmer has a small income and the large farmer a large one. Even if the small farmer does not sell his output, he still is a peasant.

— Ranbir, a supporter of Bhartiya Kisan Union, a farmers' organisation led by Tikait in UP; as quoted in Gupta (1998: 94).

The previous chapter has shown how tank designs carry an imprint of the historical time and space they belong to. It has also shown how tank designs in a historically contingent way are uniquely suited for paddy cultivation. These tank designs have both constrained and facilitated agricultural transformation in irrigated areas. The designs, scripted with agrarian and social requirements of an earlier historical era, in their modified form continue to facilitate cultivation of the most modern, high yielding varieties of paddy. However, the same designs constrain the shift from wet to lightly irrigated cultivation. The varied trajectories of tank designs (further discussed in the next chapter) are shaped by historical contingencies and by the opportunities provided by other agro-climatic parameters; but more importantly, they are formed in the larger context of agrarian transformation that is taking place under the influence of changing state-society relations.

This chapter charts the political economy of agrarian change after independence in India and specifically in Karnataka as a background to subsequent chapters.

Introduction

In recent times, many policy makers and academicians have shown concern about the state of tank irrigation resources (cf. Tippaiah 1997). The most common view expresses worry about the deterioration of tanks beyond a point of reclamation. Their declining status is said to have resulted in the reduction of irrigated area, disintegration of traditional water management institutions, siltation of the water spread area and deterioration and decay of the physical structures (cf. Janakarajan 1993: A-53-54; Shankari 1991: A116; MIDS 1983: 157-59). In fact, in the last two decades concerted efforts have been directed to rejuvenate and modernise tanks, specifically in Andhra Pradesh and Tamilnadu - two other south Indian states with a large number of tanks. In the state of Karnataka, only very recently such efforts have begun.

The apathy of the state - beginning with the colonial and later the postcolonial state - is held responsible for the declining status of tank resources. There is now a reasonable consensus in the academic literature that state intervention since the colonial period has generated an adverse impact on communities' participation and management of their own resources. This is argued in a variety of ways. Mukundan and Sengupta think that although the British brought local irrigation works under the management of revenue and civil engineering departments, their inexperience with these works (Sengupta 1985: 1923, 1997: 126) and inadequate financial allocations for management (Mukundan 1988: 10) led to their deterioration. Similarly, Sreedhar (1997: 2) in his study on tank irrigation in the semi-arid zones of Andhra Pradesh says that during the colonial period indigenous irrigation systems were subjected to gross negligence. Govindaiah (1994: 11), in his work on tank rehabilitation in Karnataka, remarking on tank decline says that the government after independence should have taken the responsibility of maintenance of tanks systems, but it did not.

In a similar vein, *Kudimaramat* practices in Tamilnadu and the British efforts to legalise and enforce these practices have generated a fair deal of debate. Kudimaramat refers to maintenance and repair of tank works voluntarily undertaken by a particular community. The British legalised voluntary labour contribution into a compulsory labour Act because they were worried about deterioration of tank irrigation systems and communities' apathy to maintain them (Janakarajan 1993: A-53). According to one argument Kudimaramat conventions declined with the change in land tenure brought about by the British (Vaidyanathan 1992). Mukundan (1988: 13) similarly comments that village communities lost their ability to maintain *Erys* (tanks) because British rule left cultivators impoverished and consequently broke down the traditional system of resource allocation for maintenance of tank structures. Agarwal and Narain (1997), Reddy (1991), and Reddy (1990), in different ways, align with the view that British intervention in local affairs and their negligence led to decline in tank systems.

The post-independent state has been criticised for neglecting indigenous irrigation resources in favour of medium, major and well irrigation schemes (Shankari 1991: A-124; Sengupta 1993: 14). Scholars have argued that lack of state investment for maintenance and management of indigenous water resources is responsible for their decline and deterioration. The Centre for Science and Environment (Agarwal and Narain 1997) has compiled excerpts from several articles published all over India on the subject in a volume. In this volume, several authors, including the editors, argue that the administrative and financial resources of the state have not been enough to take care of numerous small and dispersed structures and hence the state has failed to appropriately take care of these resources.

Ironically, there are two sides to the above-mentioned arguments; both ultimately lead to the same road. One viewpoint believes that the intervention of the British state led to the alienation of community participation. And the second holds that the apathy and negligence of the post-independent state was responsible for deterioration and decline of local resources. Although one viewpoint holds the state to be too interventionist and the other insufficiently interventionist, both viewpoint conclude that, "state intervention must reduce". Despite the contradictory claims, the conclusion has always been that the state has failed and hence its counterpart, the community should step in to maintain irrigation resources.

The state emerges in this argument as pervasively powerful. It can uni-directionally declare property rights over the structures and then let them decay because it cannot maintain them. On the contrary, the image of the community surfaces in these arguments without any agency. First the British suppressed community initiative and then communities were either coerced to provide labour for maintenance or left to fend for themselves.

This literature that disapproves state intervention, visualises the state at the centre of social and productive currents. Whether the state intervenes or not, it is pervasively powerful to drive society; it is a central institution that creates and moulds the patterns of domination (Migdal 1994: 8). Such a state-centred approach not only presupposes state and society to be two distinctly separate and undifferentiated spheres, but as a result also tends to visualise social change as unidirectional (Kohli 1994: 294-95). Furthermore, the state-centred approach strips the various components of society of their agency and oversimplifies struggles for domination spread through society's multiple arenas as struggle between an oversimplified version of community vs. an all-powerful state (Migdal 1994: 9).

This study intends to demonstrate the recursive, i.e. mutually transforming roles played by state - society interactions (Kohli 1994: 294). In this sense, the boundaries between state and society are considered blurred. Although those who control state power are in a position to take decisions with far reaching socio-economic consequences, and although these decisions may at times reflect the interests and pressures from other powerful actors – both at home and abroad, the choices made by the state are ultimately political choices. When state organisations come into contact with various social groups, they clash with and accommodate various moral orders (Migdal 1994: 12). This process of shaping the moral order, as a result of state-society interactions, is explored in this chapter with special reference to agriculture and irrigation.

National and International Food Regimes and New Agrarianism

The impact of the green revolution on the agrarian and political structure has been intensely debated in the literature on political and economic change in south Asia. The degree and nature of differentiation that green revolution caused among the peasantry has generated polarised viewpoints. The mode of production debate[1], in predominantly Marxist analytical framework, has examined to what extent the green revolution succeeded in converting Indian agriculture into a capitalist mode of production and how it further contributed towards proletarisation of the landless class to potentially be the vanguard of a red revolution. Overall, there has been a widespread consensus and concern among scholars that the introduction of green revolution technology brought about far reaching changes in the fabric of social and agrarian relations of rural society (cf. Frankel 1971; Farmer 1986; Griffin 1979). But while some scholars feared that the green revolution might result in small farmers losing control over their means of production and hence result in mass poverty and destitution, others believed that increased productivity would increase grain production and eradicate hunger. By now it has been sufficiently debated and concluded that perhaps the new technology increased the grain production, but failed to be revolutionary in production of both grains and agrarian unrest.

In stark contrast to what some scholars argued in the mode of production debate, the introduction of new agrarian technology became the forerunner of the "new agrarianism" – a movement of politically organised, especially rich and wealthy farmers, in India. New agrarianism was a major point of departure in terms of economic and political mobilisation beginning in the 1970s and acquiring its zenith in the 1980s (Rudolph and Rudolph 1987: 319-25). Following is a brief introduction of the global and national scenario of food politics that contributed towards the emergence of populist politics of landed farmers who benefited from green revolution technology.

Since independence until 1964, when India's first Prime Minister Jawaharlal Nehru died, agricultural interests and values were poorly represented in New Delhi (Rudolph and Rudolph 1987: 2). In the 1950s and 1960s, Nehru's version of an interventionist state, pursuing welfare and socialist objectives, gave prominence to the creation of basic and heavy industry. As a result, a major share of the state's resources was diverted to the industrial sector with little investment in agricultural production (Rudolph and Rudolph 1987: 68-74). The government relied upon Public Law 480 grain shipments from the USA.[2]

By the mid 1960s, four independent but incidentally connected events triggered a new era in Indian agriculture. These were: a) decline of the industrial era with the demise of Nehru in 1964; b) economic sanctions imposed by the USA following the 1965 India-Pakistan war; c) Indian opposition to the Vietnam war leading the

US government requiring food supply to India through P.L. 480 shipment to be renewed every month; and d) heightened food crisis due to two exceptionally and consecutively bad monsoons in 1965-66 and 1966-67. During this time, the pressure from the World Bank and the US government to enhance investment in agricultural programmes with the help of international aid along with other policy reforms such as the devaluation of the rupee, economic liberalisation and increased export drive mounted on the Indian government (Rudolph and Rudolph 1987: 319-25).

The "miracle seeds" arrived at this historical juncture when the Indian state was torn apart between international and domestic pressure related to the food crisis.[3] By the mid 1960s, the new varieties were introduced in different parts of India. The term green revolution was coined to cover "the new technology" that comprised high yielding varieties of cereals, especially dwarf wheat and rice varieties, accompanied with other inputs such as fertilisers, agro-chemicals and assured irrigation (Farmer 1986: 175).

During the 1950s and 1960s, Nehru had also initiated a series of legislative reforms to abolish the intermediary and landlords class and to ensure justice and equity for all agricultural producers. The first wave of land reforms began during his era, between 1947 and 1964 (Rudolph and Rudolph 1987: 314). The implementation of land reform received widely varied responses in different states due to the fact that agriculture was a federal state subject. At the national level, the first wave of land reforms was considered successful in significantly abolishing the intermediary and landlord class (Rudolph and Rudolph 1987: 49-54). However, these reforms largely failed in ensuring equitable distribution of land resources.

This combination of forces – abolition of the intermediary class, increasing domestic and international pressure that forced the Indian state to enhance investment in the development of agriculture, and the arrival of new technology – resulted in a new era. Agriculture not only became an important element in national politics, but several far-reaching changes were triggered at the local level in rural society over the period of the next two decades. Several agrarian movements are the feature of this era.

The phase, as described by Desai (1986), witnessed several agrarian struggles in different parts of India. Balgopal (1986: 1404) mentions, while reviewing Desai's book, that there are three reasons for agrarian upsurge in 1960s. The first reason is a conscious political decision by various revolutionary leftist political groups to organise the rural poor militantly. The second and third reasons were severe drought and the failure of land reform legislation. The important political consequences of these struggles were that the land ceiling was sharply lowered in many states. The political focus also shifted to poor peasants and to the landless (Balgopal 1986: 1405). However, both lowering of the land ceiling and pro-poor political populism did not achieve the goal of equity and distribution of resources all over India, including in Karnataka. Notwithstanding the militant agrarian struggles, and the state's hurried responses (on paper) to it, a hegemonic class of owner-operated landholders ultimately emerged. They became the torchbearers of the new agrarianism in India (Rudolph and Rudolph 1987: 2, 49-54).

A wave of "new agrarianism" swept national and regional politics beginning in the 1970s and continuing throughout the 1980s. Several agrarian minded regional parties emerged and acquired important positions in regional and national politics. Examples include Sharad Joshi's Shetkari Sanghthana of Maharashtra, Karnataka Rajya Raita Sangha, Tamilnadu Agriculturists Association, Bhartiya Kisan Union led by Mahendra Singh Tikait in north India and the Kisan Union led by the *kisan* (farmer) ideologue Charan Singh.

The main and consistent demand of the movement has been to increase the prices of agricultural outputs and reduce the costs of inputs. The fixing of a procurement price for agricultural outputs is a crucial concern of the movement. Other issues included the lowering of prices of agricultural inputs such as electricity and irrigation water, betterment levies and taxation of agriculture. Non-payment and waiving of government loans has also been a strong issue.[4]

The nature of the movement has been populist and oppositional, in the sense that the demands are made on behalf of all rural and farming communities irrespective of class, caste, religion, ethnicity and gender and the chief target of the demands has been the state government. The main manifesto of the movement is based on the premise that the state's policies with an urban bias have failed to deliver the development promise to rural farming communities (Gupta 1998: 80). Farmers' movement and its populism[5] insist that the interests of urban, industrial "India" have systematically undermined the well being of agrarian, rural "Bharat".

The movement succeeded, especially in the 1980s, in changing the agricultural policy, especially pricing policy, considerably in farmers' favour. In this context, many scholars are concerned about the question who from the differentiated peasantry benefit in the short and long run from participating in the movement. Ascertaining the class or economic character of the new farmers' movement has been a topic of debate among scholars.

Nadkarni (1987), Dhanagare (1995) and Gupta (1998) unequivocally call the new farmers' movement a rich/well-off/wealthy farmers' movement with a populist ideology. Brass (1991) argues to establish its capitalist class character. Similarly, Balgopal (1986) calls it a movement of the provincial propertied class. Omvedt (1995) is the most vociferous among those who argue that the movement benefited all sections of peasantry equally, although she does not deny internal differentiation among the peasantry. There are others (cf. Lindberg 1995) who take the middle position and argue that the middle peasants, like the rich farmers, are the principal constituency and beneficiary of the movement.[6] While Rudolph and Rudolph (1987) also talks about benefits to middle peasants, they define the middle peasant in a more classical Chayanovian way, namely those who rely entirely on family labour and who cultivate more for subsistence than for the market. The debate also intimately touches upon the wider question of the character of the peasantry and their political role in social change. See Brass (1991) for a critical review.

All agrarian minded organisations, whatever may be their class character, have heavily mobilised owner-cultivators for their core support (Gupta 1998: 80). Even if small farmers are an important constituency of the movement, it is still heavily biased towards the landed sections of the peasantry and even more towards those farmers who have a relatively large marketable surplus. The movement has rarely raised the concerns of landless labourers and more importantly never questioned the differential distribution of land resources within the landed peasantry.

In this way, the movement is not only biased towards the landed class, but it has a fundamental connection with the nature of the green revolution technology that tied the cultivators, especially those who grow food crops such as wheat, millet and rice, to the market in an unprecedented way. All landowners, including small farmers, have become sensitive to prices – both of inputs and outputs with the advent of the green revolution (Varshney 1998:

129).[7] The opening quotation of this chapter, spoken by a supporter of Bhartiya Kisan Union aptly represents how small farmers' fate is as tied with the market as that of big farmers. Notwithstanding differentiation in landholding patterns, a majority of food grain cultivators were petty producers who hardly ever placed more than 10 % of their produce in the market before the green revolution technology was introduced (Anderson et al. 1982: 5). Furthermore, key inputs of agriculture – seeds and manure – could only be produced on the farm. The key inputs of the new technology – seeds, chemical fertilisers and power for irrigation – are now purchased from local and global markets. Since purchase of inputs demands cash outlays, it has become necessary for food grain cultivators to sell at least part of their crops in order to get some revenue. All landed farmers, including small farmers, thus have become more strongly tied to the market with the advent of the green revolution.

To sum up, the emerging agrarian politics at the national and regional level beginning in the late 1970s and early 1980s, in the aftermath of the green revolution, divided the agrarian sector vertically on sectoral – urban vs. rural – lines rather than class lines, and generated a point of departure that culminated in a landed farmers' movement in many parts of India over the next two decades. This new phase has had far reaching implications for agricultural policies in India. The case of Karnataka is presented below.

New Agrarianism and Paddy Price Policy: Karnataka

The agrarian context of Karnataka presents a slightly different picture than that of the nation as a whole. The non-Brahmin agricultural castes of Vokkaligas and Lingayats together are the largest landholding and politically the most powerful groups in Karnataka. The socio-economic and political dominance of the Vokkaligas and Lingayats groups has consisted, among other things, of the control of a substantial proportion of better land around the village, possession of the village headmen's post and leadership of patron-client networks, often through money lending (Manor 1989: 332). No region-wide or imperial government could make its authority significantly penetrate the dominance of these castes at village level during the colonial regime (Manor 1989: 327).

As a result, the dominant forms of land control and local power structures continued without much disruption during the British period (Manor 1989: 328).[8] Even after independence, both the landowning castes have remained in a powerful position. They have competed for power and patronage at the state level, a factor that has influenced the very nature of the polity (Manor 1977).

However, it has been argued that Karnataka being a cohesive society, has a more equitable distribution of resources compared to other parts of India.[9] In terms of the land holding pattern, Karnataka has a higher percentage of owner-cultivators than the national average. Before the second wave of land reform began in 1974, the percentage of owner cultivators had increased from 70.2 percent in 1961 to 88.8 percent in 1971 (Manor 1989: 343); 92.8 % of the area cultivated in the state was wholly owned and self operated (Rajan 1981: 57). As per the 1971 agricultural census in Karnataka, the total area under tenancy was 7.4 percent (as against 8.5 of national average) (Rajan 1981: 57). This pattern of landholding has not significantly changed despite two stages of land reforms initiated at the state level. See Kohli (1987) and Pani (1997) for the discussion.

The owner cultivators, a majority of them Vokkaligas and Lingayats, thus have emerged as the most influential class of landowners in the social, economic and political history of Karnataka.

This dominance, which in the past manifested itself at mostly village level, has acquired a new face in the last two decades. The interests of the landed in Karnataka found new political alliances and articulations at the state level in line with their counterparts in other parts of India. Since the 1980s, beginning with the agitation for remunerative prices for agricultural outputs, rich and landed farmers in Karnataka have also organised into a regional political group – *Karnataka Rajya Raita Sangha* (KRRS) – arguably the state's most "powerful farm lobby" (Kripa 1992: 1182).[10]

The new farmers' movement not only has a base among sugarcane growers of Shimoga district, but also among paddy growers, especially from the surplus rice-growing areas of the same district (Nadkarni 1987; Assadi 1997). In fact, the abolition of the procurement levy on rice[11] and relaxation of the restriction on the movement of food grain[12], the main demands of the movement in the 1980s and 1990s, have been those of paddy-growers (Nadkarni 1987; Assadi 1997: 79).

The most tangible gains, especially for the paddy growers have been three fold. The first and the most immediate gain was that the collection point for the procurement levy was shifted from the growers to the millers in 1981 (Mooij 1998: 91). This meant that millers paid for the subsidised public distribution system and not the rice growers. Rice growers have indirectly benefited from the procurement policy, a point elaborated later in this section. The second gain came in 1983 when the intra-state restriction on the movement of paddy was relaxed. This benefited the paddy growers especially from the surplus rice producing districts like Shimoga (Nadkarni 1987: 125). Relaxation of inter state movement of food grains, though, has continued to be one of the demands of the movement (Assadi 1997: 90). The third and the most important gain, which began in the 1980s and has continued through the 1990s, is the penetration of the rice and wheat growing farmers' agendas in the policy food grain price fixing at both national and regional levels.[13]

There have been other means by which the input costs have been reduced for rice and wheat growing farmers in addition to the encouraging price policy. In Karnataka, several tax concessions have been granted in the post-new farmers' movement phase. In addition to the concessions on betterment levy, water rates and electricity charges, sales taxes on fertilisers and insecticides were reduced in 1983 and 1984-85 from 3 to 2 and from 4 to 3 percent respectively (Nadkarni 1987: 132).

This upward trend of favourable price policy of both output and input, coupled with the assured market due to government procurement, and an assured and stable trend of prices beginning in the early 1980s as a result of pressure put by farmers' lobby, has made paddy growing an attractive enterprise.[14]

Tank Irrigation Policy and New Agrarianism

The phase of new agrarianism has achieved a significant gain in terms of price and assured market for output and reduced prices for inputs for farmers, the relevant question for this study is, "what does this politics imply for the day to day management of other crucial resources – such as tank irrigation – at the local level?" The other related question is, "how has this new agrarian politics influenced tank irrigation policy at the state level?" Harring (1984:

199), while critically looking at the south Asian literature on concentration of political and economic power and its impact on growth and productivity, noted that concentration of power at local level permits reproduction of systems in which a large share of surplus from the producers is extracted by the dominant classes. Harring's work suggests that the question to focus on is how this surplus is deployed, over time, to reproduce economic and political dominance (Harring 1984: 199). Other scholars such as Kohli (1987: 308) have argued that the established patterns of authority at village level, that extracted the surplus and deployed it to reproduce the forms of domination, has been significantly undermined as a result of new economic activities and democratic politics. For Kohli (1994: 309), this shift has created a crisis in governability, making the old pattern of rule impossible to be reproduced, whereas the new pattern being "personalistic" and "populist" has failed to address many pressing problems at the village level.

Changing agrarian power equations at the regional, national and local level, the gist of which I have discussed in the previous pages, have generated a point of departure for management of tank irrigation resources during the last two decades. The rise of centrist politics with the rise of a politically ascendant class of owner-cultivators, who have acquired an influential position at both national and regional level, is one among many factors that has undermined old forms of authority at the village level. This shifting locus of power relations has produced a perceptible change with regard to tank irrigation policy at the state level and tank irrigation designs at the local level. I address the first issue in this chapter and the second in subsequent chapters.

Department of public works to minor irrigation department

In the early 1970s, administrative responsibility for the maintenance of tanks was transferred to the PWD from the Revenue Department. The management of tanks, the power to collect water and irrigation charges[15] and other judiciary powers to penalise the cultivators were retained by the Revenue Department. However, the village level revenue officers – *Patel* and *Shanbhoga* – remained in charge of tank management even after tanks were formally transferred to the PWD in the early 1970s.

During the subsequent decade, the PWD, as part of larger reforms being initiated on the agrarian front at the national and regional level, repaired several tanks. For the first time ever since independence, replacement and repair were taken up on this scale that attended to the distribution network, sluices, and damaged bunds. It is further discussed in subsequent chapters that the replacements and repairs accompanied a marked shift in the designs especially of the sluices and distribution networks.

In some parts of the state, these design changes preceded the introduction of green revolution varieties of rice in the 1970s. In other parts, these changes accompanied the shift in cropping pattern only in the 1980s. In this sense the repairs, which roughly accompanied the introduction of new seed varieties of the green revolution, provided new economic opportunities to the landed class in tank-irrigated areas. The choices made by this landed class have influenced the way tank resources have been managed and maintained in the last three decades. Not only did a major shift in cropping pattern occur during this time, but also a whole new techno-managerial system emerged especially in the atchakat of paddy irrigating tanks.

The magnitude of investments made for minor surface irrigation in Karnataka during the third plan period (1961-66) was 157.9 million up from 50.8 million in the second plan. The fifth plan had double the provision of the third plan but the greatest increase in the provision can be noticed during the sixth (1980-85) and seventh (1985-90) plans.

The increase in provision for investment during the 1980s suggests that this was a crucial time for the tank irrigation policy. The rise in the provision for planned investment on minor irrigation works was accompanied by a state of confusion with regard to which government department should be in charge of tanks. Since the early 1980s, the responsibility of tanks has been transferred several times between various government departments. A quick review of the history of the Minor Irrigation Department supports this point.

After the reorganisation of Karnataka in 1956, the Public Works Department was constituted with two wings: Communication and Buildings, and Irrigation and Public Health Engineering. Separate chief engineers were appointed for each branch, although the lower level of engineering staff remained common to both branches. This means that the lower level of engineering staff looked after all the public works although each branch had separate higher staff. In the history of PWD, this phase is known as undivided PWD. During the time of the undivided PWD, there were constant complaints from the staff and from the farmers that the public works of irrigation were neglected and prioritised last. It was only in the 1980s that a separate Irrigation Department was formed. It was further bifurcated into major and minor. At that time, the Department of Public Health Engineering was also separately constituted. Almost all tanks, barring a few big tanks defined as major or medium irrigation schemes, were handed over to the Minor Irrigation Department in 1980-81. In 1987, there was a further shift when Karnataka constituted Zilla Parishads (ZP)[16] with the aim of decentralising and devolving power to lower administrative levels at district and below, a point further discussed later in this chapter. After the formation of Zilla Parishads, tanks with an irrigated area of less than 200 hectares were handed over to the engineering section in the Zilla Parishad. As a result, the Minor Irrigation Department was left with only a few tanks to look after. However, within a couple of years, tanks with an irrigated area of more than 40 hectares were handed back to the Minor Irrigation Department. During this period, when the files shuttled between the PWD, MID and ZP, the Congress regime attempted to resolve this "crisis of identities" by again creating an undivided PWD in 1989. The impracticality of the idea became evident soon after it was coined and hence was dropped.

This confusion – which department is responsible for what, and the related question of which tank (based on size) rests with which department – suggests two things. Firstly, the decade of the 1980s was a period of crisis. The crisis was generated by expectations that the state would invest in the management and maintenance of tank irrigation resources more than had been done till then. The state bureaucracy had inherited from their British predecessors a large volume of technical data, such as detailed contour maps, supply statements of all important rivers and their tributaries, a census of tanks, several thousand detailed maps of the tank irrigated areas and so on. However, my discussions with several retired and serving officials of the MID suggests that the state bureaucracy inherited no institutional arrangements to manage the tanks on an ongoing basis. As I explained previously, the British did not interfere much with local forms of tank management dominated by local elites. After independence same social arrangement for the management of tanks continued, for which the village revenue officers (Patel and Shanbhoga) played an important role, although the Revenue and Public Works Departments were officially responsible for tanks. This point is elaborated in subsequent chapters. The main mandate of the PWD and MID remained the engineering aspects of repair and maintenance. There were no institutional structures created and finances allocated in these departments to manage tanks on a daily basis.

This point can be explained by the fact that the PWD and its successor the MID have mainly engineering staff trained mainly to handle civil engineering work. Each of the engineering staff is in charge of a few hundred tanks spread over a certain geographical area. Even visiting each of the tanks, once in a while, and attending to the major repair and maintenance tasks tax the time and energy of the engineering staff to the extent that expecting them to partake in day to day management of each tank is impractical. For some chosen tanks, someone is appointed to open and close sluices and watch physical structures. However, such staff is not appointed for all tanks. In fact only a few well-functioning and bigger tanks receive this assistance from the MID. Moreover, these persons are appointed mostly from the service castes from nearby villages and are not considered as regular staff of the MID. Chapter 5, 6 and 7 further show that farmers of irrigated areas themselves handle most of the crucial decisions about operation of physical structures and management of water distribution without the involvement of the MID. Furthermore, farmers themselves largely bear the financial cost for operation, management and maintenance of tanks except the occasional repair and maintenance done by the MID and previously the PWD. The managerial and financial involvement of the state bureaucracy in tank management on a daily, routine basis is thus limited.

Secondly, the crisis generated in the beginning of the 1980s was a new crisis. Since the beginning of the 1980s, with the rise of populist politics of farmers, the lack of state participation in the management of rural infrastructure began to be questioned seriously. The political process that began in the 1980s and culminated in the formation of Zilla Parishads expected state machinery to invest a sizeable amount of resources to build, manage and maintain rural infrastructure, including irrigation infrastructure. In the 1980s, thus, for the first time ever since the colonial period, state machinery was expected to invest – especially financial – resources for routine repair, maintenance and management of tank resources. Shifting small tanks from department to department is perhaps a symptom of the confusion these expectations have generated.

TABLE 3.1: Plan-wise provision (budgeted) of investment for surface water Minor Irrigation Schemes in Karnataka.

Five years Plan Period	*Annual Plan*	*Investment in Rs. Million*	*Real Rs.*[17]
I (1951-56)		41.5	601.44
II (1956-61)		50.8	747.05
III (1961-66)		157.9	1998.73
	Three years (1966-69)	131.8	1098.33
IV (1969-74)		230.3	1668.84
V (1974-78)		372.1	1653.77
	1978-79	138.9	546.85
	1979-80	169.2	577.51
VI (1980-85)		944.8	2889.29
VII (1985-90)		1674.6	3438.60
	1990-91	391.8	531.61
	1991-92	391.5	466.62
	1992-93	354.2	387.95
	1993-94	925.6	925.60

Source: GOK (1993).

The pressure on state machinery to invest in tank resources can be understood in two ways. Firstly, it can be interpreted that the rural elites want to shed the inherited responsibility of tank management, which had started to become a burden now that there were other means to expand political and economic gains. The next and subsequent chapters describe how, with an intensifying and diversifying cropping pattern, controlling tank management is not the only means by which rural elites gain their economic power. While intensification of paddy cultivation generated unprecedented gains for rural elites, diversification of cropping pattern also presented them with other opportunities to earn cash. At the same time, the investment in tank irrigation, which earlier reproduced their political and economic power over resources, has increasingly become non-remunerative with changing social relations. However, I need to clarify that this process of transformation is not uniform in all parts of Karnataka and for all rural elites. Chapters 5 and 7 demonstrate that although the dominant farmers want the state to share the financial cost of tank maintenance, they are wary of bureaucratic involvement in tank management. Variation in this process of change is mapped in the next and subsequent chapters.

Changing social arrangements for management and maintenance of tanks is the second reason for the increased pressure on the state. Whatever may be the process of decision making at the tank level, the actual tasks of operation and maintenance cannot be carried out without the labour input of non-landowning and service castes members. Conventional arrangements of both decision-making and actual carrying out of the management and maintenance tasks have been rooted in social relations of power at village and at tank levels. These arrangements have come under pressure more prominently in the last two to three decades with changing caste and economic relations. Not only have the decision-making processes regarding tank resources been significantly transformed, but more importantly the mobilisation of labour from non-landowning caste members has become increasingly difficult. For instance, lower caste tenants are refusing to partake in canal cleaning. Some of them have acquired their own lands and are questioning non-participation of higher caste farmers in maintenance of physical structures. Neergantis are employed somewhere else and hence water is not distributed field to field. Details are discussed in subsequent chapters.

So, the crisis faced by the state bureaucracy reflects a larger process of change. The political economy of agrarian change has created new opportunities for rural elites who now expect the state to invest, especially financially, in the management of tank resources. This demand is also buttressed by the fact that conventional social arrangements that ensured labour input for management and maintenance of tank resources cannot be reproduced in their entirety. The push and pull has culminated in an overall crisis in which the state is expected to invest but has no institutional arrangements to do so, when rural elites are exploring greener pastures and demanding the state to take over the financial responsibility of tanks, and in which the non-landowning peasantry is disrupting earlier arrangements of labour contribution. The Act on decentralisation and formation of ZPs were born out of this crisis-ridden situation.

Formation of Zilla Parishad

The formation of ZPs was an election promise of the Janata Dal government – the first non-Congress government in the state of Karnataka. The Janata Dal government came to power in 1982 after a landslide victory against Congress. The election slogan of the Janata Dal in Karnataka was " we want to rule not from Delhi but from the village". According to one of the senior cabinet ministers of the Janata Dal government, the landslide victory in 1982 came as a surprise to everyone, even to party members.

Many political observers attribute the failure of Janata Dal's predecessor, the Congress government headed by Gundu Rao, as an important contributing factor for the Janata's victory. As Srinivas and Panini (1984: 73) suggest, Gundu Rao paved the way for the launching of two strident movements – the farmers' movement and the Kannada movement – which ultimately caused his own downfall and that of Congress rule in Karnataka. It was during Gundu Rao's chief ministership that the relationship between the socio-economic constituency and the major parties of Karnataka was thrown into disarray (Manor 1984: 1624). Until 1972, the Congress enjoyed the unwavering support of the two locally dominant landed clusters – the Lingayats and the Vokkaligas. After 1972, Deveraj Urs' populist political programmes also cultivated the constituency of the less prosperous groups in the state (Manor 1984: 1624; Kohli 1987: 157). These political equations were changed during Gundu Rao's time when the Janata Dal started to gain considerable support from landed groups (Manor 1984: 1624). In the general political climate of the farmers' agitation all over India questioning the urban bias of state policy and administration, Gundu Rao irked landed farmers from Karnataka by giving false promises.[18] He also disregarded several of their demands (Manor 1984: 1626). He first promised to favourably revise the paddy procurement policy (Manor 1984: 1626), but instead Gundu Rao demanded all farmers to sell half of their produce at the lower rate fixed by the government. This revision hit the small and marginal farmers harder than rich farmers and created widespread resentment (Manor 1984: 1626). Gundu Rao also interpreted the low rate of recovery of loans from farmers as a sign of the administrative slackness and instructed the bureaucracy to be strict in recovering loans. When that did not produce the expected results, he sent in revenue officials with armed detachments of police to seize moveable property of defaulters. He even disregarded the High Court ruling that such actions were against the law. His actions not only resulted in the deepening alienation of Congress from rural constituencies but also intensified "rural" suspicion of the "urban" state machinery. There were over 80 police firings during this time and 120 people were killed (Manor 1984: 1627). The election of 1982 was a case of Congress losing rather than Janata Dal winning.

On winning the election, Janata Dal recognised that holding on to power would require a major concessions to rural constituencies especially the landed class. It was then time to fulfil the election pledge to "rule not from Delhi but from the *halli*" (*Naauu Hallienda Alutteve, Dilliendalla*). The promise of decentralisation and devolution of power to the district and lower levels was soon taken up in a big way. The bill[19] enabling this was introduced in the state assembly in 1983 but it received presidential assent only in 1985. The first round of the Zilla Parishad elections was held in 1987. In subsequent years, as per the stipulation of the Act, 27 departments were surrendered to the Zilla Parishads from the state government. It is important to note that this was not the first time that an attempt was made to decentralise power to lower levels.[20] The significance of the Act of 1985 was its context not so much its revolutionary character (Chandrashekar 1984: 683). As one of the senior cabinet ministers of the then Janata Dal government, who de-facto held the portfolio of Rural Development and Panchayati Raj put it, "we were on the winning side because the general political climate was in our favour". It was Janata Dal's successful appropriation of populist rhetoric that made it possible to make the bill on decentralisation become an Act.

However, the process of devolution of power was not without opposition. There was significant opposition from within the cabinet cadre of the party. Deve Gowda, one of the most important cabinet ministers of the Janata government, who held the Public Works portfolio, bitterly opposed the move to transfer 27 departments to the Zilla Parishads. He spearheaded dissent by arguing that the ZP lacked the necessary experience and an educated cadre, and might not be able to take up the colossal task of taking charge of all rural infrastructure. Heated arguments followed. The faction of the Janata Dal that championed the cause of decentralisation not only represented landed interests but also mastered the idiom and language spoken by their leaders. Gandhi's response to Churchill was invoked to disarm the opposition. In response to Churchill's provocation that Indians were incapable of providing a good government, Gandhi had said that "we do not want a *good* government, we want *our* government". The Zilla Parishad Bill was meant to create "our" government. In this discourse, "they" and "us" were clearly demarcated. "They" who opposed "our" government were compared to the colonisers.

The dual nature of the country's development, which has created two different countries of rural "Bharat" and urban "India", has been the central feature of the discourse of the influential leaders of the farmers' movement such as Sharad Joshi of Shetkari Sangathana in Maharashtra and Charan Singh of the Kisan Union of UP. This division between Bharat and India was intended to highlight the urban bias of development policies, which according to this view, resulted in a widening gap between urban dwellers who work for the state and industries and rural people who sustain on agriculture. Gupta (1998: 80) argues that this duality of Bharat and India, differently expressed as "they" versus "us", "collapses a variety of dissatisfactions experienced by different segments of the rural population into a unitary framework". The appropriation of this unitary framework by the ruling Janata Dal in 1983 was indicative of the fact that the landed farmers' agendas had deeply penetrated into the populist politics at the state level. The roots of decentralisation of power to ZPs during the Janata Dal regime, which resulted in the transfer of a significant number of tanks to ZPs, and also a significant rise in the finances provided for their planned development, grew in the soil of this populist politics of the landed class.

How easy it has become for the landed class to access the resources available at the lower levels of administration is an issue for future research. At a normative level, the intervention of the state bureaucracy to provide services has freed the dominant actors at the local level to a considerable degree from the need to reinvest the extracted surplus back into the system.

Back to where they belonged?

After shifting tanks between the government departments a few times in the 1980s, in the 1990s the state government seeks to hand them over to the community – back to where they belonged. A World Bank funded project recently initiated in the state seeks to develop an approach to community based management and improvement of tank resources. The project aims at transferring totally one third of the existing tanks to farmers. Management and operation of the tanks with an irrigated area of less than 40 hectares that are currently looked after by ZPs will be transferred to communities. And tanks with more than 40 hectares of irrigated area will be handed over to farmers' organisations. The project is conceptualised as a part of the globally initiated irrigation reform policy supported by multilateral funding agencies – in the case of Karnataka, the World Bank. The globally initiated irrigation reform policy forms part of other global initiatives that envisage a reduced role of the state in the affairs of civil society.

Tank policy in Karnataka faces an apparent contradiction with respect to initiatives to transfer tanks to communities. On the one hand, farmers are demanding a higher level of state intervention and participation in creating, managing and maintaining rural infrastructure including irrigation infrastructure, on the other hand the state machinery is developing an approach which will make communities responsible for tank management and maintenance. There is another side to this contradiction. That is, in spite of the state departments officially being in charge of tanks, in reality only communities have managed and maintained tanks, a point that even the state bureaucracy acknowledges. The state bureaucracy's failure to appropriately manage local resources is put forward as a justification to return tanks to communities. Tanks have been managed by communities all through and hence the state policy that advocates development of an approach to make communities manage and maintain tanks sounds a bit like a hoax.

The starting point in developing a community-based approach – to increase community participation in tank management – is in my opinion a non-issue. Subsequent chapters substantiate the central argument of this book that no technology can be designed and made to function without social arrangements made around it. Tank technology, like any other technology, is also socially organised. Subsequent chapters show that tank designs are shaped and reshaped in their agrarian and social context. This means that social organisation, one may differently call it community participation, is a pre-requisite for technology to exist and function.

The notion of community adopted by irrigation reform policies and backed by international agencies, however, is only remotely based on the realities of social arrangements around resource utilisation. Kakarala (2003), attempting to trace the "community" focus in the World Bank policies, observes that concepts like "community empowerment" emanated from a close and rigorous scrutiny of "cultures" in the social science literature in the 1980s. He further observes that in sharp contrast to the focus on the "local" in social science literature that emerged as a critique to the over centralising development framework of the "nation state" and its blindness to the needs of the local people, "the World Bank literature tends to refer to community and participation in either a loose way or in a reductionist way." Benda-Beckmann and Benda-Beckmann (1999) reviewing the notion of community as referred to in a variety of ways in the social science literature also contend that the highly differentiated rights to natural resources are not yet part of larger national and international debates and policy formation.

The discussion in the subsequent chapters show that in stark contrast to the World Bank's "community" as an abstract group, which has some kind of solidarity and interpersonal trust (Kakarala 2003), the social or community arrangements made around tank technology are embedded in hierarchical and discriminatory social relations. In other words, community arrangements around management and maintenance of tank resources are also expressions of power relations. The challenge, in front of those working towards productive and participatory management of tank resources, is to overcome the dichotomy of state and community and to work towards creating institutions both within community and state that ensure democratic utilisation of irrigation resources.

Diversification and Commercialisation of Agriculture

The closing decade of the twentieth century posed a challenge. The current trend of globalisation had begun imposing a food regime on third world countries through the General Agreement on Tariffs and Trade and later the World Trade Organisation,[21] an impact of which still needs to be fully deciphered.

This trend of globalisation, since the 1980s, has had a lasting impact on the food regime in third world countries. The most important element of this trend has been the diversification and commercialisation of agriculture on an unprecedented scale. Opinions in the academic world are divided on whether diversification and commercialisation of agriculture has provided more opportunities to especially the small and marginal farmers. Nadkarni (1996: A-67) argues that even small farmers have benefited in absolute terms from the increased opportunities due to commercialisation. He, following Bharadwaj, distinguishes between compulsive or forced commercialisation and genuine commercialisation, which is meant for realising a surplus (Nadkarni 1996: A-63). But Patnaik (1996a) is worried that the emerging inverse relationship between food production and exportable production,[22] sponsored by what she calls the Fund-Bank, has seriously undermined food security in developing countries.

The farmers' movement is also equally polarised. The Shetakari Sangathana led by Sharad Joshi has supported the liberalisation of the Indian economy, whereas the KRRS led by Nanjundaswamy in Karnataka and the Bhartiya Kisan Union have opposed it.[23] This split among the relatively wealthy farmers with marketable surplus signifies the dichotomous nature of the globalising agriculture. A sizeable number of wealthy farmers seem wary of the GATT negotiations because they fear that the ensuing liberalisation will produce the opposite results than their demands so far have been: calling off loans, non-payment of irrigation and electricity dues, increase in subsidy for agricultural inputs and steady and assured rise in support prices of output. The other section holds an optimistic belief that Indian farmers can profitably sell their products in the world market if the Indian government lifts trade restrictions. These polarised views, even among the privileged section of the peasantry, suggest that the current trend of globalisation may be Janus-faced.

My attempt here is to sketch the broad aspects of the process of diversification and commercialisation of agriculture in the 1980s and 1990s, because as the subsequent chapters will show, they have closely influenced the way tank resources are used, managed and maintained. First of all, it is more or less agreed among scholars that the cropping regime is changing. For instance, Nadkarni argues that non-foodgrain crops are fast replacing foodgrain crops in Karnataka.[24]

The reason could be the reduced market risk for these crops for even smaller farmers as Nadkarni (1996: A-67) argues. In the last decade, several processing companies have made direct contact with farmers to purchase their otherwise perishable products such as vegetables and fruits. In addition to assured purchase, these companies provide credit, technical know-how and seeds. Even small farmers have benefited in absolute terms from such contracts. This pattern has resulted in diversification of the cropping pattern (Nadkarni 1996: A-67).

Nadkarni also points out that rice was predominantly grown by small (1 to 2 hectares) and marginal (less than 1 hectare) landholders in the later half of the 1980s. Given the assured market and steady rise in support price for rice in the decade of 1980s, smaller holdings were also commercialised to a significant degree. Nadkarni (1996: A-70) suggests that this is the class of small landholders, along with the semi-medium landholders (2 to 4 hectares), is the most dynamic in the post-1980-81 phase of the farmers' movement.

However, Patnaik's concern is visible in Nadkarni's observations. His analysis of gross and net income and total cost per hectare of the principal crops in Karnataka shows that commercial crops not only have a higher net income but also require higher expenditure. Most of the non-foodgrain crops have a considerably higher net income per hectare than foodgrain crops, which goes in the negative for the main staple food of Karnataka – ragi (HYV). Even jowar and bajra (both HYV), the other two staple grains of north Karnataka, give marginal incomes per hectare.

This diversifying and commercialising cropping pattern has created a paddy dominated cropping pattern in tank-irrigated areas. It has replaced other staple crops such as ragi and jowar. Ragi, especially in south Karnataka, has been relegated to dry land as growing ragi in tank-irrigated areas proves economically unviable. Although hybrid jowar is still grown in tank-irrigated areas of the mixed agro-climatic zones[25] of eastern and northern Karnataka, they are cultivated only when paddy cannot be grown. In the mixed agro-climatic zones of Karnataka, cultivation of vegetables is gaining wide currency. As Nadkarni points out, processing companies that provide credit, seeds and know-how and provide assured purchase of produce, support the cultivation of vegetables. In some tank-irrigated areas of south Karnataka, vegetables have replaced paddy cultivation especially if ground water is accessible at a reasonable depth. Unlike paddy, cultivation of vegetables does not have to observe seasons. There can be several batches grown in one year depending upon the type of vegetables. In the neighbouring state of Andhra Pradesh, several experiments have been made to permanently cement the sluices to convert the tanks into percolation ponds so as to recharge wells. Further discussion on the changing cropping pattern in different regions of Karnataka and the corresponding transformation in tank designs follow in the next chapter.

There are instances when irrigation from tanks is completely abandoned in order to cultivate lightly irrigated crops such as cotton, potato and onion in the irrigated area. In rainfall assured areas of Dharwad district, rainfed cotton is grown in tank-irrigated areas and consequently distribution canals and sluices are found in disuse and disrepair. Those who can afford to have also shifted to dry land, growing lightly irrigated cash crops. They are either irrigated with borewells or rainfed if intensity and duration of rainfall permit. The detailed discussion on the tank designs in the subsequent chapters will show that the opportunity to grow dry crops is heavily circumscribed in tank-irrigated areas. The subsequent chapters further discuss the shift in tank designs in the context of this diversifying cropping regime.

This chapter thus argues that in the aftermath of the green revolution, a hegemonic class of owner-cultivators emerged at the all India level, including Karnataka, whose populist politics has triggered off a new era of agrarianism in the Indian polity. Their politics has influenced tank irrigation policy, which changed dramatically in the decade of the 1980s. The dramatic shift in tank policy in the decade of 1980s signifies a crisis period with increasing demands on the state to invest in management and maintenance of rural infrastructure, including irrigation.

The chapter shows how the roots of decentralisation policy in Karnataka, which resulted in the transfer of a sizeable number of tanks to the newly formed Zilla Parishad, has grown in the soil of the populist politics of the new agrarianism. The chapter further argues that the crisis period faced by tank policy entails that social arrangements that hitherto managed and maintained tanks are under pressure. On the one hand, rural elites seem no more willing to shoulder their inherited responsibility of managing tanks and are demanding instead that the state financially invest in the management of tanks now that they have found other means to expand their economic power. On the other hand, the social organisation that mobilised lower caste labour to manage and maintain tanks can no more be reproduced in its entirety, reinforcing demands on the state to invest in tank resources.

However, there is an apparent contradiction between internationally funded irrigation reform policy, recently implemented in Karnataka, that seeks to transfer tank resources back to the communities, thus envisaging the state to play a reduced role, and the demands of rural elites asking for enhanced state intervention.

Lastly, the chapter summarises the main trends of commercialisation and diversification of cropping pattern. Transformation in tank designs in the context of changing cropping pattern and shifting social relations is discussed in the next and subsequent chapters.

Notes

[1] Utsa Patnaik (1990), one of the most influential thinkers in the debate that was originally published in Economic and Political Weekly, has edited significant papers in a volume.

[2] Explaining the origins of Third World food dependence in the 1950s and 1960s, Friedmann (1990: 14) states that, "the international food regime includes a deep (and deeply destructive) relationship between the urban poor of the Third World and family farmers in the First World". This food regime was dominated by the USA's domestic policy, which supported agricultural prices through government loans that farmers paid off in grain, resulting in huge stocks of grain surpluses held by the American government. In the post World War II period, these surpluses were diverted to reconstruct Europe and Japan as food aid, later generalised to Public Law 480 aid to the Third World. Third World countries became dependent on wheat imports available at subsidised rates from the United States. For the newly industrialising countries this meant that the cheap availability of food kept the wage bill of the urban industrial population low and helped domestic industries flourish and integrated into, as Friedmann (1990: 16) argues, the capitalist sphere of the world economy. This food regime started to collapse in the 1960s with the decline in American food stocks, the rise of world wheat prices and the participation of other countries in foreign food aid (Friedmann 1990: 21-22).

[3] In 1964, the combined efforts of scientists supported by the Rockefeller

Foundation and the Indian Council of Agricultural Research resulted in a new variety of maize. Plant geneticists funded by the Rockefeller Foundation had developed a hybrid of Mexican wheat and Japanese dwarf wheat that could achieve double the output of Indian varieties (Rudolph and Rudolph 1987: 320). At the same time the newly founded, Rockefeller Foundation funded, International Rice Research Institute in the Philippines was reporting results with high yielding varieties of rice. At the international level, the whole programme was institutionalised in a massive way by the formation of a Consultative Group on International Agricultural Research (CGIAR) sponsored by the Food and Agricultural Organisation (FAO), the United Nations Development Programme (UNDP) and the World Bank (Gupta 1998: 58-59). In implementing this internationally initiated strategy, foreign exchange was a crucial bottleneck for the Indian government to overcome, for which aid from the World Bank and the US government was absolutely critical (Gupta 1998: 60).

[4] See Brass (1995), Gupta (1998), Varshney (1998) for an overview new farmers' movement, their politics and demands.

[5] Theories on populism are many. I summarise here the various strands of populism, heavily borrowing from Gupta (1998). Populism is usually understood to imply that the masses are manipulated by charismatic leaders. The populist coalition typically consists of vertical, multiclass alliances that are not aimed at linking lower classes to the ruling class through democratic processes, but rather at creating a unified, hegemonic ideological field in which "people" are pitted against the other historically privileged social groups. The ideology of populism is usually built by defining a common enemy. Some scholars believe that populism as a phenomenon characterises transitional societies and exemplifies an uneasy and unstable balance between modernisation and tradition. In this way populism signifies a general social crisis. It is also believed that populist politics arises during times of large scale urbanisation.

[6] Lindberg (1995) defines the middle peasants as those who have less than three hectares of land, but who nevertheless grow cash crops.

[7]Varshney (1998), based on rational choice method, has shown that the support of the marginal and small farmers to the movement may be based on personal interest, not on the misperception of caste, ethnic or religious identities or on coercion. He argues that small farmers can be expected to be more sensitive to post-harvest prices than bigger farmers who can hold onto their stocks until the prices increase in market. Small farmers do not have much holding power. At the same time they are more sensitive to the purchase of inputs as sowing of the next crop has to be completed in time. Since procurement prices are fixed in the post-harvest time, small farmers have a clear interest in having them raised (Varshney 1998: 129).

Varshney (1998: 130) further argues that the indebtedness of the net buyers of food – marginal or deficit farmers – may be increased with rising market prices of food grains; however, the other non-price benefits such as loan waivers and higher employment may have a counter effect on the increase of grain prices.

[8] Different governments administered different parts of Karnataka before Independence. They include the governments of Mysore Princely State, and the Bombay and Madras Presidencies. These governments in principle followed the ryotwari system of land settlement, but in reality mediated through village headmen and their allies who were from the dominant land owning groups (Manor 1989: 327-28). In Bombay and Madras Presidencies, the revenue officials were drawn from Marathi, Gujarati, Tamil and Telugu speaking communities, belonging to a different social group, mostly Brahmins, than the village level land owning dominant castes of Vokkaliga and Lingayat and hence could not penetrate the local power structures. The Mysore government too was reluctant to alienate locally dominant groups by interfering in village level matters especially after the revolts of land owning peasants in 1830 that led to imposition of British administration (Manor 1989: 330).

Others extend similar arguments. Hardiman contends that the colonial system rested on the complicity of the powerful forces within Indian society. These classes in many cases welcomed the advent of a system of colonial rule, which in so many novel and ingenious ways enhanced their ability to exploit the poor (Hardiman 1987: 45-50). Frykenberg (1963) also argued that colonial rule would not have found its roots in native soil without the active support of the ruling classes. This complicity of the ruling classes in the colonial system meant that in turn they were not alienated from their control over local resources.

[9] Manor (1989: 322), while discussing caste, class and dominance, put forward that Karnataka is a cohesive society in the sense that in its history there is not much evidence of any particular group feeling or demonstrating severe alienation from the social order. He further qualifies his argument by saying that this cohesiveness would not mean that the society is harmonious or without inequalities; they exist but not so severe to undermine the cohesive fabric of the social order. Neither does society remain so forever (Manor 1989: 322). Manor (1989: 324) traces his argument about cohesiveness to the Virsaiva devotional movement of the 12th century A.D. that covered much of western and northern Karnataka and integrated various artisan and service castes together as the members of the Lingayat sect (Manor 1989: 325-31). How this egalitarian base of the Lingayat sect acquired a place in the caste hierarchy requires further attention.

[10] If everything has to begin somewhere (in order to be narrated), the phase of new agrarianism had a triggering moment in the Malaprabha agitation of 1979. Farmers launched an agitation against the betterment levy imposed on the irrigated area of Malaprabha irrigation system. The agitation also targeted the corrupt practices followed by the revenue and irrigation department officials. Lasting many months, the agitation culminated in a violent attack on an irrigation department office in which files and furniture were burnt. In the tussle between the police and mob one boy and a sub-inspector got killed. The agitation later spread all over the state, adding demands such as opposition to rise in prices of essential commodities like jowar. The Malaprabha agitation, in contrast with the later dominant trajectory of the movement that demanded higher prices for agricultural produce, opposed the higher prices that would have affected the consumers more than the producers. The movement, without finding it contradictory, also demanded an increase in the minimum support price of food grains to farmers, which would have increased consumer prices.

The events that followed the Malaprabha agitation attracted massive participation in the form of meetings, *bandhs* (strikes) and processions, which at times turned violent. At least 20 people were reported to have lost their lives during the agitations. The government response, apart from the suspension of betterment levy and water rates, also included several other benefits to the farmers, for instance, a reduction in electricity price for operating pump-sets, the reduction in the purchase tax on sugarcane, and the reduction in the sales tax on fertilisers, the removal of the agricultural income tax on dry lands, and a waiver of penal interest on cooperative loans. For further discussion on the Malaprabha agitation, see Nadkarni (1987: 84-95) and Assadi (1997: 49-58).

Prior to the Malaprabha agitation there were efforts by the CPI, in 1979, to organise small and marginal farmers to demand minimum guaranteed prices, nationalisation of trade in grains and monopoly purchase by government. At the same time, the Farmers' Federation of India (FFI), in contrast to the CPI's political agenda, also attempted to create a mass base to oppose cooperative farming and to defend peasant proprietorship in addition to several other demands such as abolition of sales tax on agricultural goods and inputs, and reduction in electricity rates addressing the demands of well-off farmers (Nadkarni 1987: 82-84). Both these efforts, with antagonistic political agendas, failed to acquire a mass base until the spontaneous protests of farmers beginning with the Malaprabha agitation.

As Nadkarni (1987: 96) argues, the Malaprabha agitation set the pace and trend for the rich farmers' new agrarianism in Karnataka. The government by yielding to some of the crucial demands fuelled the agitation. In the post-Malaprabha period, farmers from several districts joined the movement with diverse demands, but soon the demands such as anti-price rise of essential commodities got dropped and more and more demands of the farmers from the irrigated areas were voiced (Nadkarni 1987: 96). Several *Raita Sanghas* (farmers' associations) were formed all over the state, but the initiative to form a political strategy was passed on to the secretary of the Sugarcane Growers Association of Shimoga. This culminated in the state level formation of the now famous Karnataka Rajya Raita Sangha (KRRS) in 1980-81 (Nadkarni 1987: 97).

[11] The procurement policy of 1966 was meant to procure food grains at a cheaper price than the open market price in order to support and subsidise the availability of cheap food grain to mainly the urban poor through the public distribution system. As part of this policy, paddy cultivators had to surrender part of their produce to the government. For further discussion on the public distribution system and procurement levy, see Mooij (1998).

[12] The government, along with the imposition of procurement levy on rice growers, also imposed a restriction on the movement of grains from the surplus producing areas to the deficient areas either within one federal state or between the states. The enforcement of procurement levy is easy in the surplus rice producing areas because if supply is larger the prices are lower and procurement easy (Mooij 1998: 93).

[13] The Agricultural Price Committee (APC) was constituted in 1964-65 to advise the government on price policy and to recommend a Minimum Support Price (MSP) after taking into consideration the cost of production. Its formation preceded the introduction of the new wheat and rice varieties. The policy of APC has been to advise remunerative prices in order to provide incentives for the producers. There has been significant gain for the farmers with respect to the procurement price as a result of the political pressure exerted by the agitating farmers in Karnataka. As Nadkarni has noted, time in the post-movement phase the Karnataka government fixed the procurement price mostly at a higher level than the Minimum Support Price (MSP) recommended by the ACP. In this way, the procurement price not only became remunerative, and acted as an insurance against the open market price to fall below the standard thus set by the government, but also induced the open market price to rise upward as a result of the policy (personal communication with Mooij 2002). The ACP was later replaced by the Committee on Agricultural Costs and Prices (CACP). The mandate of CACP was similar to that of the ACP – to examine the cost of production and advise the government on the level of remunerative price (Mooij 1998: 87). The

CACP was initially envisaged as a purely technical body consisting of economists, statisticians and agricultural administrators, but in the mid-1970s a farmers' representative was appointed as a member in the committee. Due to the pressure exerted by the farmers' movement in 1984, the committee was constituted with three technical members and three farmers' representatives (Mooij 1998: 87).

Even in the 1990s, the procurement prices have continued to experience a steep increase and are consistently set higher than that recommended by the CACP (Dev and Mooij 2002: 64). The procurement policy has also taken a full circle. In the 1970s and 1980s, the compulsory procurement either from the producers or from millers created wide spread irk (Mooij 1998) and the abolition of the procurement levy was one of the demands of the farmers' agitation (Nadkarni 1987), but in the 1990s the procurement price fixed by government has become so favourable that millers want the government to procure when the government has no space to stock (personal communication with Mooij 2002). This shows that over two decades the price policy has evolved favourably for the producers. According to Dev and Mooij (2002: 65), as per the current scenario, the real upward push on the prices begins once CACP sets the price level. There is direct pressure on the Prime Minister from the Chief Ministers of three wheat and rice producing states, namely, Haryana, Punjab and Andhra Pradesh to set the procuring price at a higher level. In all these states, the wealthy food grain-producing farmers are important political constituencies of the ruling governments (Dev and Mooij 2002: 64-65).

[14] How these concessions have translated into an increase in real income of different sections of the peasantry and how far they have achieved parity in terms of trade between industry and agriculture is a point of further debate. See Bharadwaj (1993: 291-346) for a review of the debate and critical discussion.

[15] A fixed rate per acre is collected as irrigation charge from all cultivators receiving irrigation, whereas the water charge is collected for every season depending upon the crop cultivated.

[16] Zilla Parishad is the district level (elected), political and administrative unit of the three-tier structure of local government.

[17] To convert costs from one year to another, I have used the ratio of GDP deflators for the respective years as specified by the Economic and Political Weekly Research Foundation.

[18] He promised 850 million rupees to the farmers lobby without a word to his revenue minister. However, this promise went wholly unfulfilled (Manor 1984: 1625).

[19] It is called the Karnataka Zilla Parishad, Taluk Panchayat Samitis,

Mandal Panchayats and Nyaya Panchayat Bill, 1983.

[20] The earlier Village Panchayat and Local Boards Act, 1959 was not amended by successive governments. A bill was introduced in 1964, following the report of the Kondaji Bassappa Committee in 1963, to establish a three-tier administrative structure. Incidentally the bill was referred to a joint select committee of the legislature headed by Ramakrishna Hegde who became the chief minister of the 1983 Janata Dal government. The select committee in 1964 recommended enhanced powers for the panchayati raj institutions but nothing came out of it because the ruling government and party were not prepared at that time for such an experiment (Chandrashekar 1984: 683).

[21] Agriculture has played the most crucial role in the GATT and WTO negotiations. The main objective of the GATT treaty is to reform world trade that is highly distorted because of direct and indirect subsidies that flow to various sectors of the economy in the different countries of the world. The underlying philosophy on which these reforms are proposed premises that the direct and indirect subsidies that flow to the agricultural sector manifest themselves into distorted world prices of agricultural commodities. These distorted world prices result into a situation of deceptive comparative advantage that leads to an inefficient use of world resources. The aim of the GATT treaty is to correct these distortions in world trade of agricultural commodities in order to promote efficient allocation of world resources (Gulati and Sharma 1994: 1857).

[22] Patnaik (1996a) argues that the policy regime of the advanced countries vis-à-vis third world agriculture is geared to sustain the import-based high living standards of advanced countries. The high degree of import dependence of developed countries on developing ones is rooted in the climate soil specificity of crops and the bio-diversity of tropical and subtropical areas. She shows that the sustenance of import dependent, high living standards of the Northern countries has been possible only at the expense of the decline of basic food grain production for local third world populations. She calls this trend the inverse relation between food production and exportable production, which is a pan-developing countries phenomenon.

[23] The 1990s began with the spurt of protests against the Dunkel draft and GATT provision. In March 1993 a rally organised in Delhi by Bhartiya Kisan Union, Karnataka Rajya Raita Sangha and Karnataka Farmers' Association was attended by approximately by 100,000 farmers from different parts of India. This rally was followed by another in Bangalore in Karnataka in October to protest against the Uruguay round proposals, claiming that GATT proposals would have devastating effects on farmers' livelihoods and their control of seeds in particular. The rally in Bangalore

was also attended by several thousands of farmers from India and abroad (Rane 1993: 2391). There were other incidents that preceded these rallies. In December 1992, the members of the Karnataka Farmers Association ransacked the Bangalore corporate office of Cargill Seeds India Private Limited, an Indian subsidiary of a USA multinational, broke the furniture and burnt papers. Nanjundaswamy, the leader of the Karnataka Farmers Association declared Cargill as the West India Company akin to the East India Company that colonised the country and looted its wealth. The Maharashtra-based Shetkari Sangathana, on the other hand, supported the Dunkel draft. They held a rally in Delhi in March 1993 to support the Dunkel draft and the liberalisation of the Indian economy (Gupta 1998: 321-26).

[24] The growth rate of area under non-foodgrain part of the agricultural production recorded higher than for foodgrains in the period of 1940-50 to 1993-94 in spite of the technological advance in favour of foodgrains (Nadkarni 1996: A-64). Nadkarni shows (1996: A-64) that the proportion of area under foodgrain declined from 1950-51 to 1980-81 by only 2.8 percent points but within the following decade by 5 percent points. Nadkarni (1996) further shows that between 1950-51 and 1991-92 there is a significant decline in percentage to total gross cropped area for coarse cereals (30 to 18.6), the proportion of area under rice has remained constant (23.6 to 23.3) and that under wheat has increased (7.6 to 12.8). Among non-foodgrains there is a rise in percentage to total gross cropped area for fruits (0.6 to 1.5), vegetables (1.2 to 4.7) and oil seeds (8.3 to 14.9) between 1950-51 and 1991-92.

[25] This is discussed in detail in the next chapter.

4

Paddy Cultivation and Tank Designs

Diverse Trajectories

Earlier some land in the atchakat used to be kept fallow; now every inch is cultivated with paddy.

-- A farmer from the wet region of Shimoga.

Farmers don't want to go into the slushy paddy fields anymore. They want to cultivate clean, white collar, dry crops, earn money and buy rice from the market.

-- A farmer from the mixed region of Dharwad.

The real farming activities have now shifted to hankalu (dry) land.

-- A farmer from the wet region of Hangal.

Paddy has emerged as the most important crop in tank irrigated areas, despite the fact that some farmers have indicated a preference for other crops as quoted above. Chapter 2 has discussed how the requirements of paddy cultivation have historically determined the nature of tank designs and chapter 3 has shown how paddy cultivation has been a lucrative option in the current political economy. In other words, paddy is still the most important crop cultivated in tank-irrigated areas as a result of the convergence between tank designs that are historically suited for paddy cultivation and favourable price policy in the current context.

Diverse ways in which paddy is cultivated in tank-irrigated areas is reflected in diverse patterns of tank designs. This chapter outlines the diversity of these tank designs corresponding to diverse ways in which paddy is cultivated in tank-irrigated areas. However, as the statements of farmers suggest, there has been also a shift from paddy to non-paddy cultivation. On the one hand, paddy cultivation has been intensified in tank-irrigated areas of the wet region due to favourable price policy, especially in the last two decades, on the other hand, lightly irrigated crops are replacing paddy in the mixed region of southern and northern Karnataka. The chapter also discusses transforming and adapting tank designs on the interface of intensification of paddy cultivation and diversification of the cropping pattern.

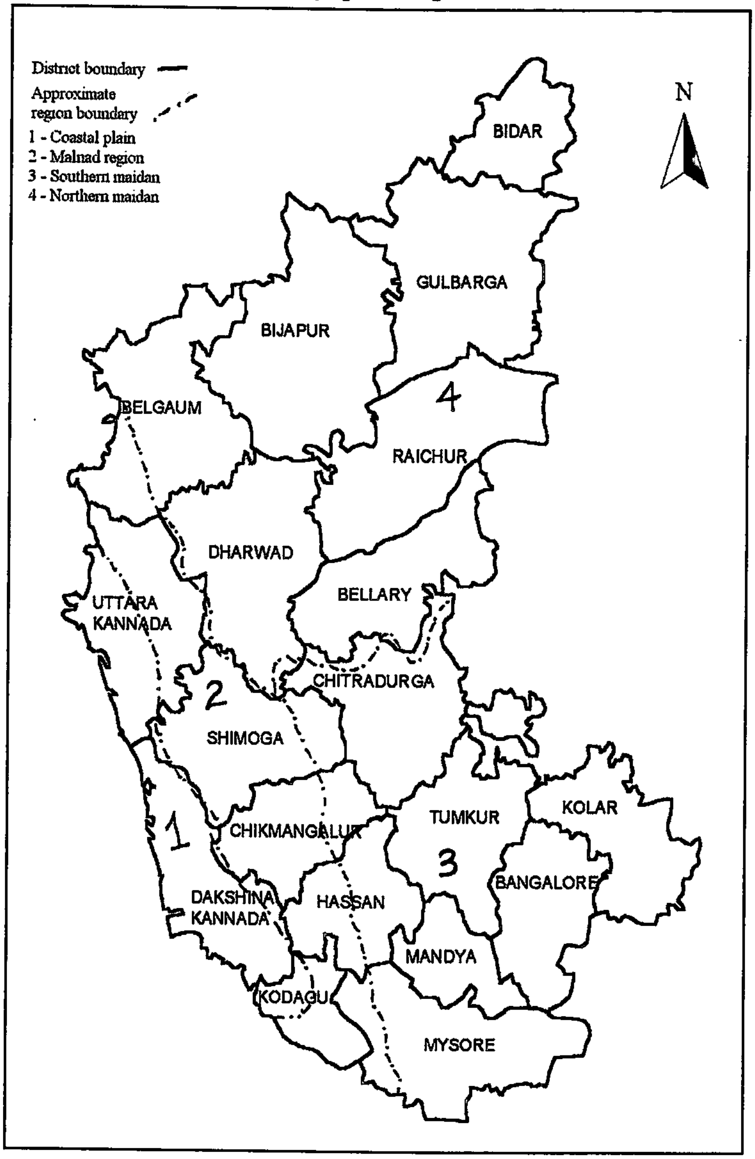
Geographical Regions of Karnataka

The historical literature on south India generally refers to three ecotypes. Stein (1980: 25) defines ecotype not as a natural system but as a socio-cultural and environmental subsystem. He (1980: 26-29) calls them "wet", "dry" and "garden" ecotypes, of which garden refers to semi-dry cultivation. Ludden (1985) also describes three ecological terrains which he calls wet, dry and mixed zones. Other historians working on Karnataka have more or less referred to these same ecotypes (cf. Morrison 1992: 75-81). Mosse (1997a), however, suggests that local variation cannot be understood based entirely on economic and ecological variations. He argues that variation has to be socialised into local cultural ecologies that have been shaped in historically distinctive ways. What all these historians argue is that different ecotypes follow a different course of socio-cultural history and that availability of moisture is a key determinant in shaping these ecotypes.

I have followed a similar eco-typology for the state of Karnataka. The state of Karnataka is usually divided into four geographical zones, namely, coastal, malnad, northern maidan and southern maidan (See figure 4.1). Roughly speaking, the coastal and malnad areas form the wet region, part of the southern and northern maidan constitute the mixed region and part of northern Karnataka form the dry region.

The coastal region lies between the edge of the Western Ghats and the Arabian Sea. The coastal region along with malnad is also popularly known as western Karnataka. It includes parts of the districts of Shimoga, Chikkmanglur, the western edge of Dharwad and parts of Uttara and Dakshina Kannada (Vasantha Madhava 1991:1). Irrigation in the heavy rainfall receiving coastal region is

FIGURE 4.1: Geographical regions of Karnataka



Source: Based on Saldanha (1987: 1).

done from rivers and small ponds. Tanks are not a significant source of irrigation in this part of the state.

The region of malnad that lies east of the coastal region is further divided into the malnad and semi malnad areas. Rainfall in malnad is in the range of 2000 to 2500 mm, whereas rainfall in the semi malnad area is in the range of 1500 to 2000 mm. Semi malnad is also known as a rainfall assurance region. Tank irrigation in the belt of the semi malnad is studied in this research.

The northern maidan includes the Deccan plateau. The Deccan plateau is hydrologically defined as the triangular tableland lying to the north of the Krishna and Tungabhadra rivers. The Deccan, in the state of Karnataka, consists of the districts of Belgaum, Bijapur and a part of Dharwad. This region is also popularly known as Bombay Karnataka because part of it was annexed to the Bombay Presidency during the British period.

Generally the scholarship on south Indian historiography distinguishes between peninsular India and south India. The Deccan – that was ruled by various Muslim dynasties for several centuries during the pre-British period – is included in peninsular India. The region south of the Krishna-Godavari watershed, which predominantly remained under the rule of Hindu dynasties, is considered as south India. Corresponding to the same distinction, the Deccan plateau is considered as lying north of the Krishna-Tungabhadra watershed.

The other part of the northern maidan consists of the districts of Bidar, Raichur, Bellary, and Gulbarga all of which were part of Nizami kingdom of Hyderabad during the British period and are now popularly known as Hyderabad Karnataka.

The region south of the Krishna-Tungabhadra watershed is known as the southern plateau or popularly known as south or Mysore Karnataka. The districts of Chitradurga, Tumkur, parts of Chikmanglur, Hassan, Kodagu, Mysore, Mandya, Bangalore and Kolar are located in this region.

These regions are termed in this research as wet (malnad and semi malnad), mixed (southern and part of northern maidan) and dry (Deccan plateau and the eastern part of northern maidan) corresponding to the scholarship on south Indian historiography.

A few tanks from districts in each of these regions were studied to map the diversity in tank designs and cropping pattern. They are as follows:

Wet region:	Shimoga district and Hangal taluk of Haveri district
Mixed region of southern maidan:	Kolar and Bangalore districts
Mixed region of northern maidan:	Bellary and parts of Dharwad
Dry region:	Bijapur district

As discussed below, distinct patterns of tanks designs and corresponding cropping regimes can be identified in the wet region of semi malnad, in the mixed zone of southern and northern maidan and in the dry region of the Deccan plateau of northern Karnataka. Before I describe these patterns in detail, I provide a brief overview of the variation in size and spatial distribution of tanks across different regions.

Size and Spatial Distribution

Tank irrigation becomes less significant if one traverses from south to north and from west to east in Karnataka. Tanks have been the most important source of irrigation in the wet region and the mixed region of south Karnataka where paddy is the main crop cultivated. Well irrigation replaces tanks in the Deccan region of northern Karnataka where non-paddy crops dominate agriculture. However, even in the paddy growing wet and mixed regions, the importance of tanks as a means of irrigation decreases from the wetter to the drier regions.

Figure 4.2 shows the district-wise distribution of net irrigated area by tanks to total net irrigated area in the state. In the district of Shimoga (wet region), tanks irrigate more than 40 percent of the net irrigated area. Kolar, in the mixed region of the southern maidan, figures in the middle range – 15 and 30 percent of the net irrigated area is irrigated by tanks. Dharwad, Bellary and Bijapur in the mixed region of northern maidan figure in the lowest range of less than 15 percent of the net irrigated area irrigated by tanks.

In the wet and mixed regions, where tanks are an important source of irrigation, the average size of atchakat increases inversely with the density of tanks. That means in the wet region, thickly populated with tanks, the average size of atchakat is small. As density reduces, the average size of atchakat increases. Figure 4.3 shows the distribution of tanks according to the average size of atchakat. Shimoga has an average size of atchakat of less than 15 hectares, Kolar and Dharwad between 15 and 30 hectares and Bellary and Bijapur more than 30 hectares. Table 4.1 shows the district-wise size distribution of minor irrigation works in Karnataka in the four regions.

Further, the detailed atlas prepared by the MID demonstrates the taluk wise spatial distribution of tanks in Karnataka. Figure 4.4 (a, b, c, d) shows the spatial distribution of tanks in one taluk each from the chosen districts of each region. It is not possible to reproduce all, approximately 60, maps here. Nevertheless, the spatial distribution of tanks in one taluk each from the chosen districts demonstrates the variation in density of tanks. Figure 4.4 (a, b, c, d) shows the highest number of dots (representing tanks) in Shimoga and Kolar respectively from the wet region and the mixed region of the southern maidan. Bijapur, from the dry region, has the least number of dots and Dharwad and Bellary from the mixed region of the northern maidan figure in the middle.

The variation in both size and spread of tanks across the state is usually explained in terms of topographical and hydrological differences (cf. Committee on Planned Projects 1959). However, historically specific reasons have also contributed to the variation in the spread of tanks. A brief description follows on the topographical, climatic and historical features, which have culminating in different size and spatial distribution of tanks across the state.

In the wet region with rainfall between 1500 to 2000 mm, the soil is laterite with average fertility. Due to the porous nature of the soil, irrigation is needed in this region even during the heavy rainfall receiving monsoon months. There are numerous small sized tanks located in this region. As per one estimate, about 25 percent of the total number of tanks in Karnataka is located in the wet region of malnad and semi malnad (Palanisami 2000: 12). Paddy and garden crops such as betel nut and coconut are cultivated in tank-irrigated areas.

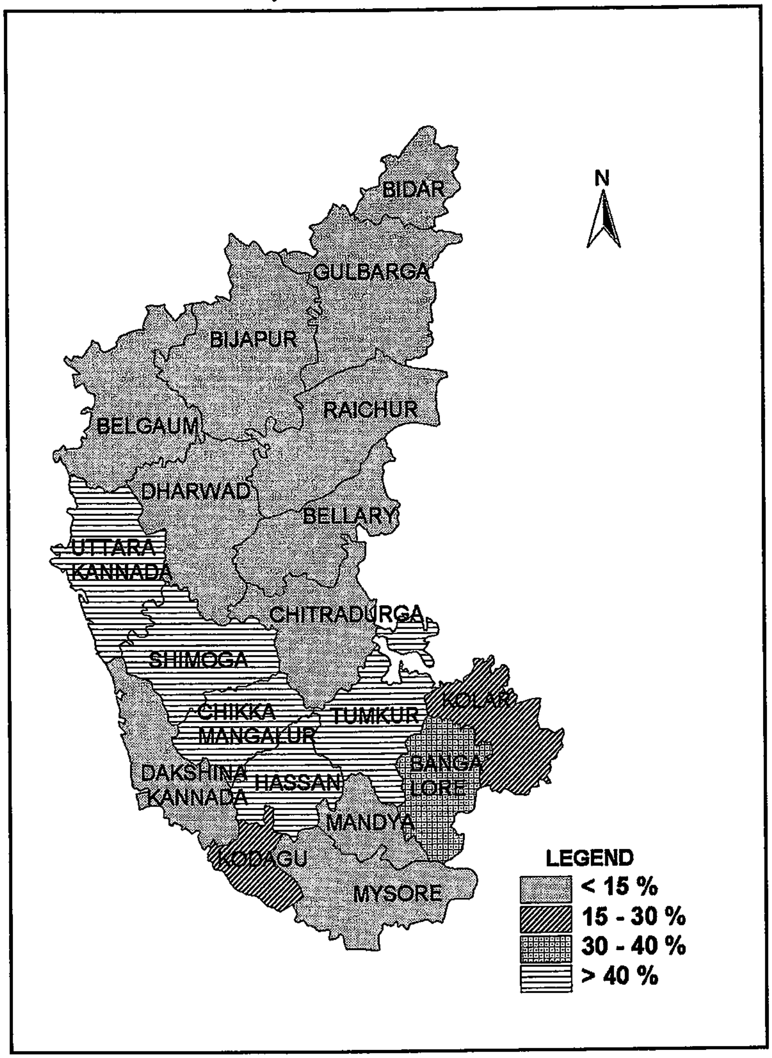
The malnad and semi-malnad areas of the wet region receive continuous rainfall during the months of June to September, during both the northeast and southwest monsoon seasons. The tanks must have been originally designed, i.e. at least 3 to 4 centuries ago, to supply water during the dry spells in between the monsoon showers, and during the dry months of October and November. Tanks in this region usually fill up several times in the monsoon season. In the present context, one application of irrigation to the entire atchakat practically empties the tank. The capacity of tanks is enough to supply water for one application of irrigation for the entire atchakat and before the next application they fill up again. Thus, the size of the atchakat below these tanks is relatively large in comparison to the capacity of the tank (Committee on Plan Projects 1959: 1-2). Tanks become bigger in size relative to the size of atchakat with the decrease in rainfall from the western to eastern and from the southern to northern side of the state. It is estimated that in the areas with around 1500 mm rainfall, the ratio of water spread to atchakat is 1:10 but in decreasing rainfall areas of the southern plateau it reduces to an average 1:2 (Committee on Plan Projects 1959: 1-2).

The southern maidan of the mixed region ranges from the eastern edge of the malnad towards the eastern boundary of the state. The soil is predominantly red and rainfall ranges from 600 to 900 mm. About 60 percent of the tanks in Karnataka are located in this region (Palanisami 2000: 12). Rivers like Kaveri, Pennar, and Palar traverse this region. Paddy is the main crop grown in tank-irrigated areas of this region.

In southern maidan, there are few perennial rivers. Most of the streams in this region flow only in the monsoon seasons. The region receives rainfall during both northeast and southwest monsoons. The rivers in this region usually flow from early August until October or November. The rivers have numerous major and minor tributaries, spread densely across the drainage area. Tanks in this region are constructed in chains on this dense network of numerous major and minor tributaries and also on non-perennial rivers or streams. Excess water from one tank is emptied in the next in the series (GOI 1968: 136-37), or one major or minor tributary feeds several tanks in a series.

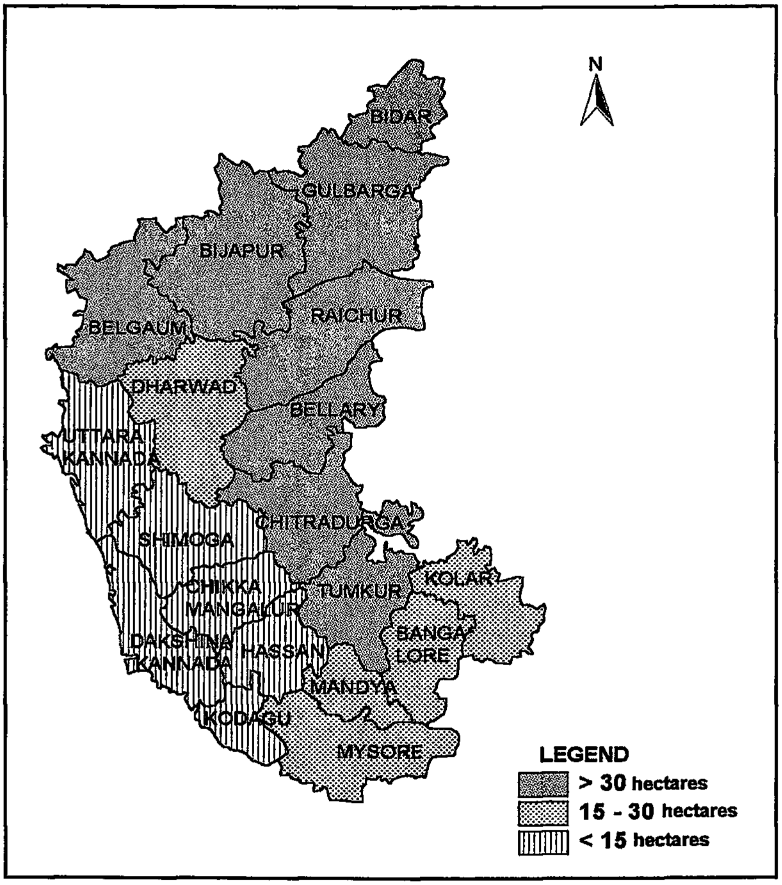
Unlike the rainfall pattern of malnad, rainfall in the southern maidan is highly erratic. Rainfall in this region is not only unevenly distributed but also the variation in the amount of rainfall from year to year is very large. As a result, water inflow in the tanks of the mixed region is subject to a much higher degree of uncertainty. It is common that tanks in the mixed region do not fill up for a few consecutive seasons, unlike tanks in malnad that fill up few times in one monsoon season. But when tanks in the southern maidan fill up, they fill up in just one heavy shower.

FIGURE 4.2: Spatial distribution of tank irrigation in Karnataka: NIA by tanks to total NIA in state



Source: Vaidyanathan (1998).

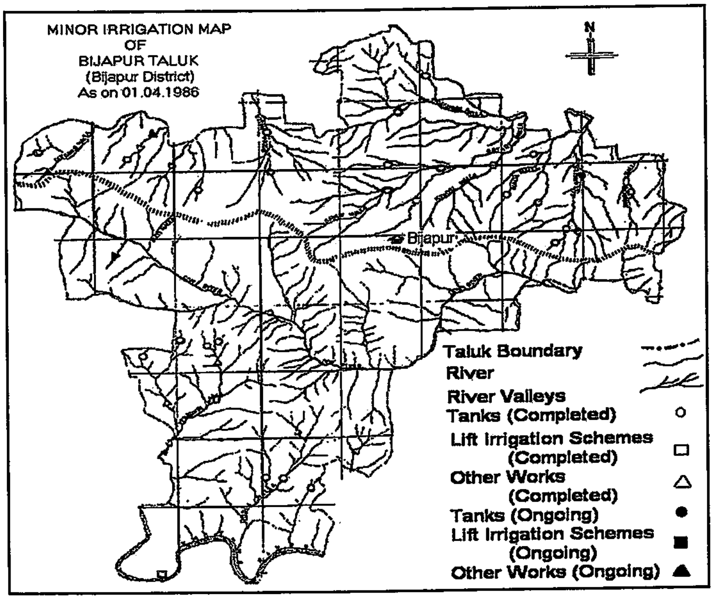
FIGURE 4.3: Spatial Distribution of tanks by average size of atchakat



Source: Vaidyanathan (1998).

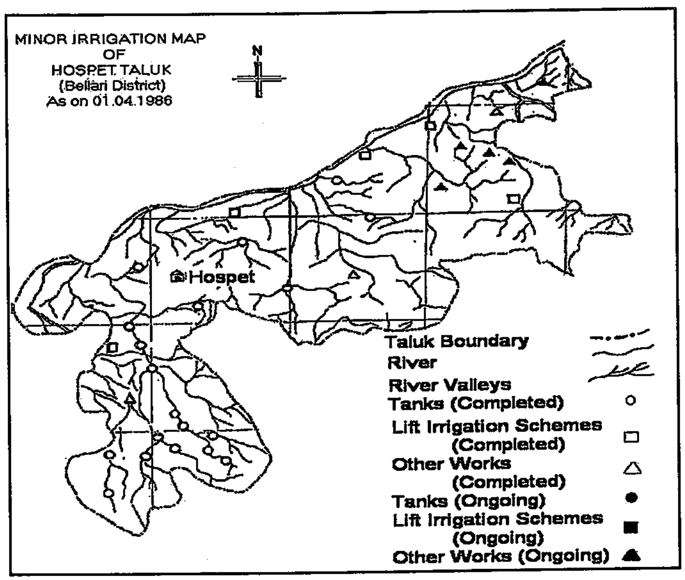
However, one heavy shower could in fact be all what tanks may receive during that particular season. Intense showers that can produce more runoff, therefore, may be more desirable than well-distributed rainfall across one season. Engineers from the MID of Kolar district pointed out that even if the region received good rainfall in a particular season, tanks may not fill up if none of the showers were intense enough to produce good runoff. Once tanks fill up, stored water has to irrigate the entire atchakat for one season. Hence, the atchakat size, corresponding to the capacity of a tank, is much less compared to its counterpart in the wet region.

FIGURE 4.4a: Spatial distribution of tanks: Bijapur taluk of Bijapur district



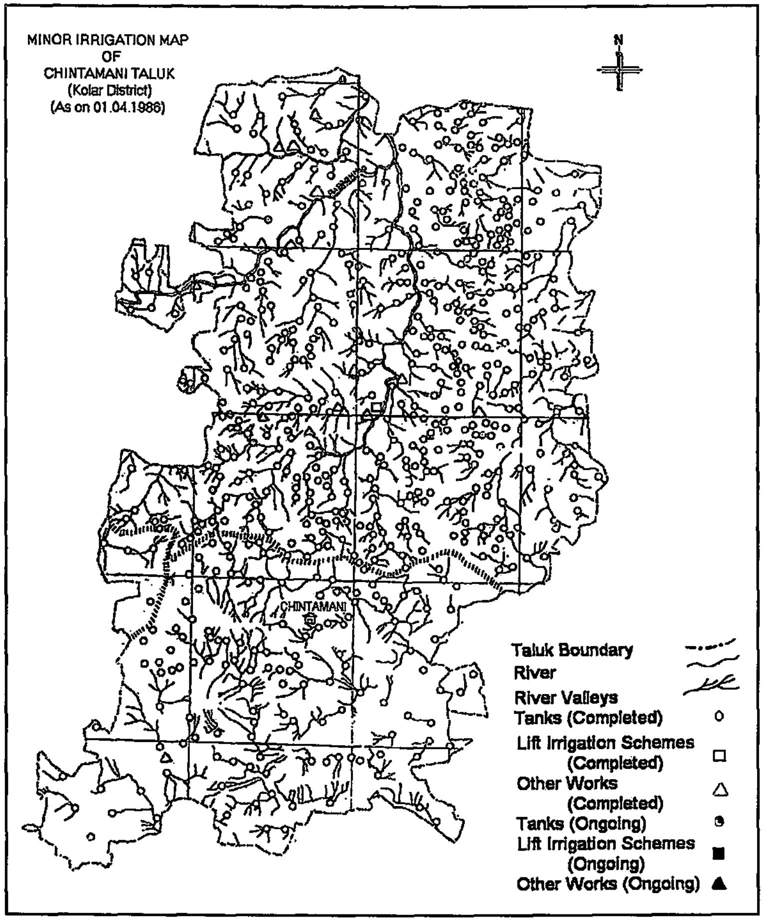
Source: GOK (1988).

FIGURE 4.4b: Spatial distribution of tanks: Hospet taluk of Bellary district



Source: GOK (1988).

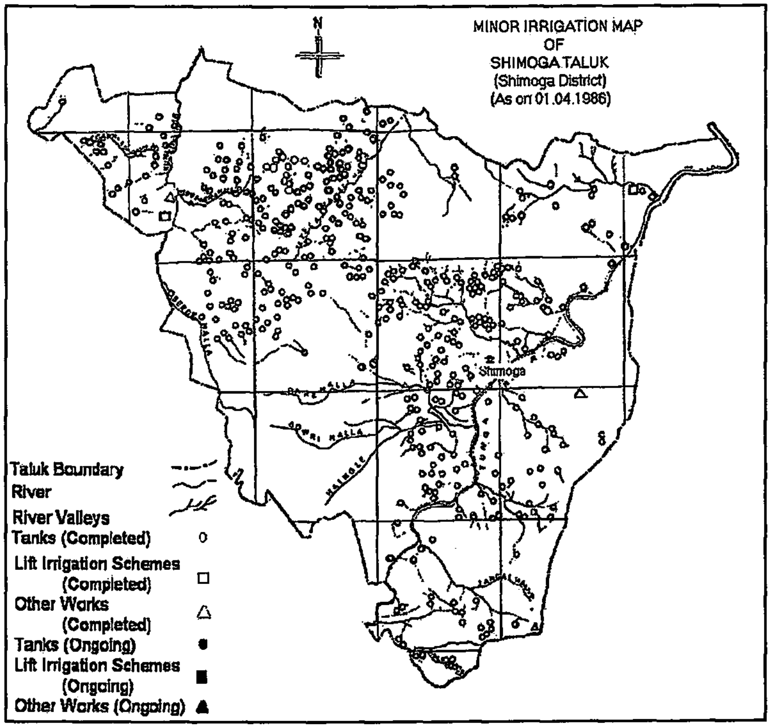
FIGURE 4.4c: Spatial distribution of tanks: Chintamani taluk of Kolar district



Source: GOK (1988).

There are also historical reasons for high density of tanks in malnad (wet region) and the southern maidan (mixed region). Various dynasties, from the tenth century until the mid-seventeenth century, built tanks in these regions as a part of the process of agricultural and political expansion. Although different dynasties gave unequal priority to various locations, tank and empire building activities for political reasons were primarily concentrated in eastern and southern Karnataka.[1]

FIGURE 4.4d: Spatial distribution of tanks: Shimoga taluk of Shimoga district



Source: GOK (1988).

In contradistinction, the northern maidan of the mixed region remained outside of the political overlordship of the macro region of south India between the eleventh and seventeenth centuries. Neither temples nor tanks were the backbone of the building of the political system of the Muslim dynasties of Bijapur.[2]

The northern maidan lies to the east of the semi-malnad and stretches to the northern and eastern boundaries of Karnataka to the north of Bellary district. This region has rich black cotton and moisture retentive soil in the river valleys. Rainfall ranges from 350 to 900 mm per annum. The districts of Belgaum, part of Dharwad, Bijapur, Raichur, Gulbarga and Bidar are located in this region. Around 15 percent of the total tanks are located in this region (Palanisami 2000: 12). The major crops grown in this area are jowar, wheat and cotton.

TABLE 4.1: District-wise distribution of tanks and potential irrigation created in Karnataka as on April 1992.

District	*Number of Tanks*	*Atchakat in Hectares*
South Kanara	679	5607
North Kanara	3277	24827
Coastal region Total	**3954**	**30434**
Shimoga	6331	74580
Chikkamangalur	2866	29121
Hassan	5609	53971
Wet Region Total	**14806**	**157672**
Kolar	4282	67059
Bangalore	2084	48302
Mandya	965	23312
Mysore	1371	34938
Tumkur	2004	64259
Chitradurga	371	28440
Southern Maidan Total	**11077**	**266310**
Bellary	268	16125
Dharwad	3160	69730
Raichur	671	20974
Gulbarga	514	25200
Bidar	93	17805
Northern Maidan Total	**4706**	**149834**
Bijapur	135	27480
Belgaum	813	29779
Deccan Total	**948**	**57259**
Total Tanks	**36639**	**673253**

Source: GOK (1993).

The hydrological and topographical features of this region are not very conducive to tank construction. The dry and arid tract of the Deccan plateau is an undulating plain and is furrowed extensively by streams. These streams have gentle gradients and well-formed valleys that are wide-open areas such as Dhone river basin. Some amount of running water is available throughout the year in the streams and the valleys that form the agricultural belt of the region. Krishna and its tributaries, Bhima, Dhone, Malaprapha and Ghataprabha drain the entire region.

As mentioned above, some of the unique hydrological and topographical features of this region constrain the spread of tanks. During rainy seasons, rivers and tributaries receive torrential floods, which overflow and spill over the normal channels to a wider area. The topography of the undulating plain and the poor infiltration capacity of black soil produce a much higher rate of runoff during rainy seasons that spreads across a vast area in the form of a thin sheet. Due to freshly deposited silt and soaking of flooding water, the surrounding areas of the streams with water retentive deep black soil, become the most prised agricultural lands in the region. Just one heavy shower can render enough moisture for a bumper harvest of crops like jowar, wheat and bajra (GOI 1968: 9-22). These features that fertilise the valleys, at the same time make them unsuitable for the construction of tanks. The torrential floods in the aftermath of rain are not conducive to storage in the relatively flat or shallow valleys, because if they are embanked, a vast area may be submerged.

Nevertheless, a few tanks were constructed before the British period mostly to provide drinking water or to serve as a summer leisure spot for rulers. Tanks exclusively constructed for irrigation were constructed in this region only during the British period. In 1881-82, 32 reservoirs in Bijapur district irrigated totally only 1372 acres of land (Campbell 1884: 312). Of this tanks, the most important ones such as Kumutgi and Mamadapur were recognised as constructed by Adil Shahi king of Bijapur and intended as a pleasure resort with water pavillions (Campbell 1884: 313; Cousens 1905: 14), although during the British time they watered the surrounding land as well. On the other hand, 6119 wells were identified in 1881-82 that watered the land around villages (Campbell 1884: 312). Due to the peculiar geology of the region, water in 1881-82 was available in the wells at a shallow depth of 20-30 ft (Campbell 1884: 312), which now has gone down to 40-60 ft. The pervious and layered, fractured stones that are located at shallow depth capture water from the underground slow flowing streams and yield water in the open wells at the rate of few inches of water collected each day. Even today, these shallow open wells are the principal means of irrigation in Bijapur district, although there are a few tanks constructed in the British and the post-independence period, which also continue to support semi-dry irrigated crops.

The type of soil available for embankment construction influences the size of tanks. In the upper watershed of the wet region, the embankments made of sandy soil tend to be weaker and hence tanks tend to be smaller, whereas in lower watershed or in areas with clayey soil, where there is less risk of breaching, tanks tend to be bigger (at least in terms of water spread area) and embankments tend to be longer and higher (Palanisami 2000: 15-16).[3]

Upper watershed areas with laterite soil produce high runoff and therefore the density of tanks is high in this region (Palanisami 2000: 15). Although embankments made of black soil in the northern maidan can be bigger and higher, the cross section of the earthen embankments made entirely of black soil tend to be of massive size. The angle of retention[4] of black soil, without enough clay content that can impart tenacity, is fairly flat. That means that the embankments made of black soil have flatter front and rear slopes as compared to embankments made with soil with enough cohesiveness. Besides, the flat nature of the country necessitates lengthy embankments to bridge flat and shallow valleys. This is one more structural reason why the northern maidan does not have a high density of tanks.

Cropping Regimes and Tank Designs

I studied a few tanks from each region in order to map the broad patterns of diversity of tank designs and cropping regimes. Table 4.2 summarises the agro-climatic and historical backgrounds of the selected districts.

Before I begin my discussion on the diverse patterns of tank designs, I need to clarify that identifying diversity per se is not the purpose of this study. There could be innumerable local differences and one may find every tank and every village different than the next. The purpose of illustrating diversity is not to emphasise the variation per se, but to point out differences in tank designs corresponding to their relationship with ecology, history and agricultural patterns. The central purpose is to demonstrate that the choice of cropping pattern significantly interacts with ecology and history and results in a variety of design outcomes. Or to put it the other way round, the purpose is to show how tank designs are contingent upon ecological and historical specificities and on the choice of a particular cropping pattern. Hence, I emphasise the need to identify certain key variables that represent specificities and generalities of time and place. Also, I emphasise the need to identify features pertaining to a cultivation regime, or agrarian

TABLE 4.2: Agro-climatic and historical background of selected districts

Districts	*Region*	*Agro-climatic zone*	*Rainfall and soil type*	*Historical Background*	*Density of tanks*
Kolar and Bangalore	Southern maidan	Mixed	800-900 mm, deep red and black soil	Ruled by Tamil speaking chieftains during Vijayanagara empire period, was part of Mysore Presidency in British time	High
Bellary and part of Dharwad	Northern maidan	Mixed	600-800 mm, red soil and geological formation of shallow basaltic granite rocks	Was part of Vijayanagara metropolitan region, annexed to Madras Presidency	Medium
Bijapur	Deccan plateau of northern maidan	Dry	500-600 mm, black cotton soil, geological formation with shallow, layered stones	Ruled by various Muslim dynasties of Adilshahi kings, annexed to Bombay Presidency	Low
Shimoga and Hangal taluk of Haveri	Semi-malnad	Wet	Above 1500 mm, laterite soil with average fertility	Ruled by Hoysala kings (famously known as tank builders), remained under Vijayanagara empire and was part of Mysore Presidency	High

system, which contribute to reproducing a particular type of social organisation which in turn reproduces a particular pattern of tank designs in one spatial and historical context. In nutshell, variation of designs entails a relationship between technology and its context.

I also need to clarify that further variation within what is considered as one region and one pattern in this study might well exist. In fact, there may be many more layers of differences if one asks questions from a different vantage point.

Furthermore, the pattern and trend of change in tank trajectories, as described in this chapter, is not absolute and complete. For instance, when it is mentioned that a sluice operating mechanism is quite often found missing in Shimoga, it does not mean that none of the tanks in Shimoga possesses a sluice operating mechanism. What I intend to indicate and explain is why the sluice operating mechanism has largely eroded in the paddy irrigating tanks of Shimoga district. While my argument does not claim cent percent empirical regularity, it is suggestive of a trend towards disappearance of sluice controlling mechanisms in tanks of Shimoga, more specifically, in certain political, agrarian and social contexts.

Table 4.3 summarises broad patterns of tank designs and corresponding cropping patterns in the studied tanks of the three regions. Based on the typology described in Table 4.3, three major trajectories of tank designs in wet, dry and mixed regions of Karnataka are discussed.

Tank Trajectory: Wet Region

Designs of water distribution infrastructure

It may not have been a sheer coincidence that water distribution infrastructure such as sluices and distribution canals in the tanks of Shimoga district began to either entirely disappear or were severely modified in the last couple of decades. The more serious modifications in the tanks I studied were undertaken in the last 10-15 years. Shimoga district produces the highest amount of rice and has the second largest area under rice in the state. High yielding varieties were first introduced in Shimoga district in 1966/67. According to one survey of two rice-growing areas of the district,

TABLE 4.3: Diversity of tank designs and cropping pattern in Karnataka.

Design Criteria	*Kolar (mixed region of southern maidan)*	*Bellary and Dharwad (mixed region of northern maidan)*	*Bijapur (dry region)*	*Hangal taluk of Haveri and Shimoga (wet region)*
Density	It has one of the highest number of (4282) tanks in Karnataka (GOK 1992). It has the longest history of tank construction.	There are 298 tanks in this district (GOK 1992). Dharwad has 3194 tanks. Tanks were constructed in these districts during the Vijayanagara empire period.	There are 135 tanks, out of which 12 were constructed before the British period (GOK 1992).	There is a dense network of tanks in this region. Hangal taluk has 1000 tanks and Shimoga district has 6656 tanks (GOK 1992). It has a long history of tank construction.
Main type of cropping pattern in tank irrigated area	One crop of transplanted paddy sown in December whenever tanks have enough water for entire atchakats. During rest of the years, paddy is grown in head reach and semi dry crops in tail end.	One crop of transplanted paddy sown in August-September in lower parts of atchakats. Groundnut, ragi and maize on higher parts of atchakats.	Tanks irrigate dry crops of wheat and white jowar in the main irrigation season of October – November and cotton, sunflower, onion and lemon are irrigated with well water in the summer.	One crop of broadcasted paddy sown in August-September every year. In Shimoga, second crop of paddy is grown in some lower lands if tanks have water. Tanks provide summer irrigation to garden crop of betel nut in Hangal.

Design Criteria	*Kolar (mixed region of southern maidan)*	*Bellary and Dharwad (mixed region of northern maidan)*	*Bijapur (dry region)*	*Hangal taluk of Haveri and Shimoga (wet region)*
Pattern of water availability in tanks	Tanks receive water up to full tank level once in three, four or more years.	Tanks receive some water every year but fill up only once in three to four years.	Tanks usually fill up every year.	Tanks fill up several times during one monsoon season.
Type of sluice preferred	Plug and pole is preferred in tanks irrigating paddy; shutter in tanks irrigating mixed crops.	Plug and pole is preferred.	Shutter type of sluice preferred for dry cropping.	Plug and pole preferred.
Sluice controlling mechanism	Usually plug and pole or shutter is found in place and in working order.	Plug is kept in good order. At some places plug is modified for partial opening.	Most irrigation tanks are fitted with shutter type of sluices and efficiently opened and closed for a measured amount of water to be released.	Sluice controlling mechanism is in considerable disorder and disrepair in Shimoga. There may be just a hole in the sluice-stone, which sometimes may be plugged with stones or sand bags at the end of the irrigation season. Plug is found relatively in better condition and in working order in Hangal.

Design Criteria	*Kolar (mixed region of southern maidan)*	*Bellary and Dharwad (mixed region of northern maidan)*	*Bijapur (dry region)*	*Hangal taluk of Haveri and Shimoga (wet region)*
Sluice opening timing	Seasonal opening. Once opened, kept open for the entire season. Day and night irrigation provided.	Opening and closing every day.	Opening and closing for stringent water control on daily and at times hourly basis.	Once opened, sluice is kept open for one season in Shimoga. Sluices are opened for three rounds of irrigation in Hangal, and closed at the end of each round. During each round sluices are kept opened day and night.
Main functions of neerganti	Neerganti irrigates each piece of land, maintains rotation schedule and opens and closes sluices.	Maintains the rotation schedule between dry and wet crops in atchakat and opens and closes sluices. Landholders themselves irrigate their plots.	None	None
Layout of fields in atchakat	Fields are terraced to facilitate field to field irrigation for paddy cultivation.	Part of atchakat meant for paddy cultivation is arranged to facilitate field to field irrigation. Atchakat meant for semi- dry cultivation has non-terraced fields.	Non-terraced atchakat.	Fields arranged to suit field to field irrigation.

Design Criteria	*Kolar (mixed region of southern maidan)*	*Bellary and Dharwad (mixed region of northern maidan)*	*Bijapur (dry region)*	*Hangal taluk of Haveri and Shimoga (wet region)*
Canal alignment and method of irrigation	Main canals run on the higher ground in the atchakat. Drainage canals run on lower ground. No other channels are found. Water is distributed field to field.	Each field, including paddy fields has separate access to main canals.	Each field has access to a main canal.	At present entire atchakat is irrigated from field to field, head to tail. In the past, main canals rotated water between head and tail end. At present main canals were found largely missing in Shimoga. In Hangal, they have started to disappear.
Rules for water distributio n and rotation	Water is supplied for irrigation only when enough is collected for the entire atchakat. Rotation may be observed among different patches irrigated by one canal.	Amount of land under paddy and non-paddy crops is adjusted depending upon water availability. Paddy receives assured water. Rotation is observed between paddy and non-paddy lands.	Rotation is observed among lands supplied water from one outlet.	Rotation between head and tail end used to be observed in the past, but is no more followed. Field to field irrigation in Shimoga. In Hangal 40 percent of water in tank is kept reserved for garden land.

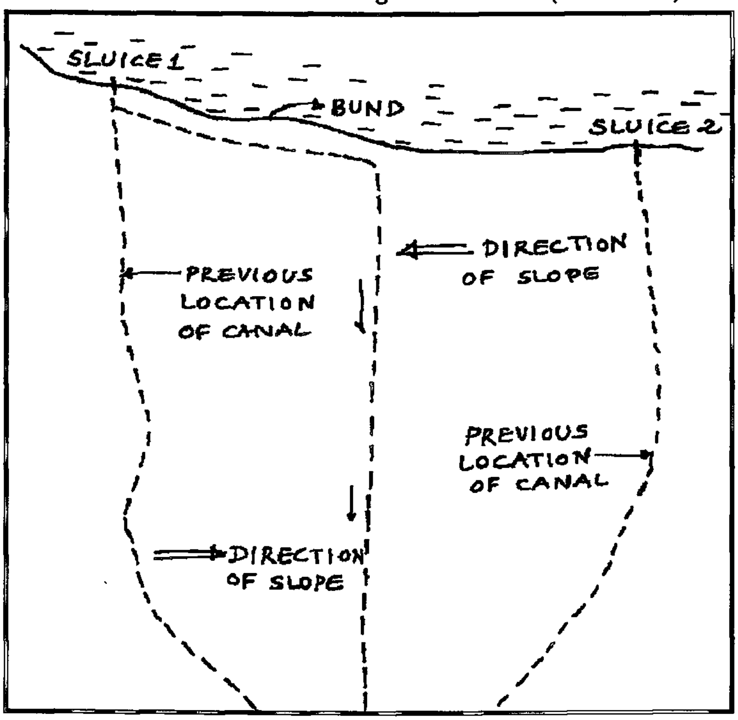
all farmers had adopted new varieties by 1972 (Krishna Murthy 1975: 121) much earlier than in other parts of Karnataka. A majority of the landowners of the study tanks adopted new varieties around 30 years ago. But the designs of irrigation infrastructure began to change only in the 1980s and in a striking manner in the last fifteen years.

The most apparent shift has been the disappearance of water distribution canals. A paddy growing atchakat is usually so designed that it facilitates the movement of water from field to field. Upstream and downstream fields are provided a relative level difference in such a way that they are irrigated in succession from head to tail. This design of fields, the position of canals and their slope thus facilitate movement of water in the atchakat but also favour some land in the atchakat more than the other. The direction of movement of water also produces grades of different types of lands in the atchakat. It assures repeated and assured supply to certain patches. Most often these patches are located in the head reach. The favoured patches acquire certain features, owing to their submergence under water for longer duration, which make them progressively more suitable for paddy cultivation (see chapter 2). These grades of lands relate to the land holding pattern in the atchakat. Almost always the best land in the atchakat belongs to the historically privileged groups of landowners. The position and slope of canals is crucial in determining the best patch of land in the atchakat. At the same time, the presence or absence of canals implies a correspondingly different water distribution pattern. The point is further discussed below.

Another major shift in tank designs in the last fifteen years has been the disappearance of the sluice operating mechanism. Conventionally, tanks irrigating paddy in Karnataka have the plug and pole type of sluice. Furthermore, tanks in the wet region, as already discussed in the previous section, are relatively small in size and have lower bunds compared to tanks in the mixed regions. The sluice apertures in the tanks of the wet region are located in embankments unlike in the case of bigger tanks in the mixed region where they are located in the water spread area away from the embankments. The sluice in the wet region has been conventionally operated from the platform provided over the opening in the embankment. In some of the tanks I studied in Shimoga district the sluice operating mechanism – plug and pole – was stolen or had disappeared all of a sudden in the 1980s. They were never replaced, barring in two tanks, where they went again missing.

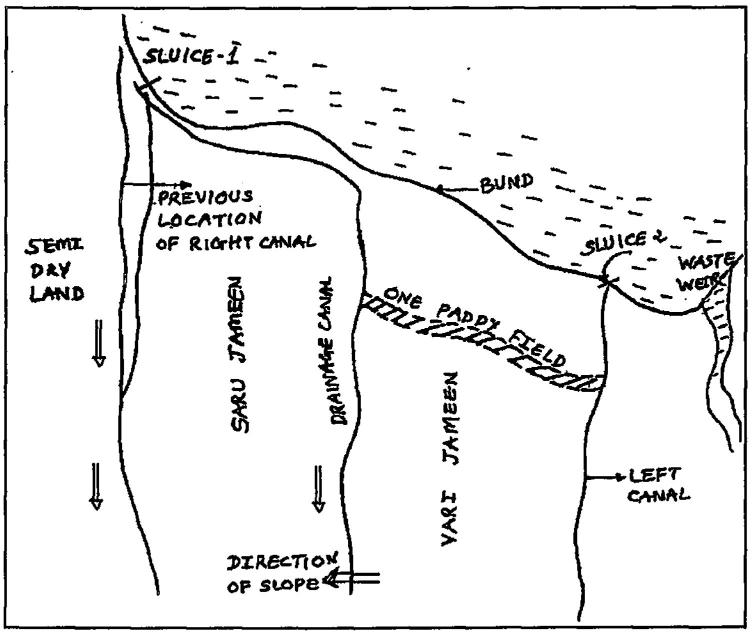
Take, for example, the case of Saulanga old tank in Shimoga district. Three canals - two distribution canals located on the extreme edges of the atchakat that are connected to two sluices and one drainage or seepage canal located in the middle - existed in the atchakat until a decade ago. (See figure 4.5). After the introduction of transplanted paddy in the atchakat, the section of the canal became narrower and finally disappeared completely in the last decade. The seepage canal used to collect drainage water from land on both sides. It also served as a carrier canal that supplied water to the tail end. Now irrigation in the atchakat is entirely done from field to field, from head to tail. Whereas earlier, water could reach the tail end in a few hours, it now takes at least 7 to 8 days. As a result not only has the amount of tail end land receiving irrigation has drastically reduced but also the choice of crops has been severely curtailed. Tail end farmers either plant semi-dry crops or plant early maturing paddy varieties broadcasted.

FIGURE 4.5: A sketch of Saulanga tank atchakat (not to scale).



In another tank called Chinnikatte Taverekere (figure 4.6), the LBC on the extreme edge still survives, but the seepage canal in the middle that earlier used to take water to the tail end has been heavily encroached upon and silted up. Tail end farmers say that its carrying capacity has been reduced to one fourth of the original. One more distribution canal, marked RBC in figure 4.6, has completely disappeared as a result of encroachment. Sluice 1 of this tank, which used to provide water to the RBC and which is located at a higher level than the rest of the atchakat, has gone out of use and now feeds only a narrow strip of land on the extreme left edge. The entire atchakat now receives water from the LBC. Water is first distributed to a part of the atchakat called *vari jameen* (upper land) from field to field. The drainage from vari jameen is collected in the seepage canal and then distributed to lower parts of the atchakat called *sara jameen* (lower or seepage land). The tail end now receives water once in eight days when it needs it every day. Although vari jameen practically forms the head reach in this tank due to its proximity to the canal, it is actually the higher end of the atchakat given its higher level than the sara jameen. And despite its proximity to the canal it is not sown with shorter duration varieties.

FIGURE 4.6: A sketch of Chinnikatte Taverekere atchakat (not to scale).



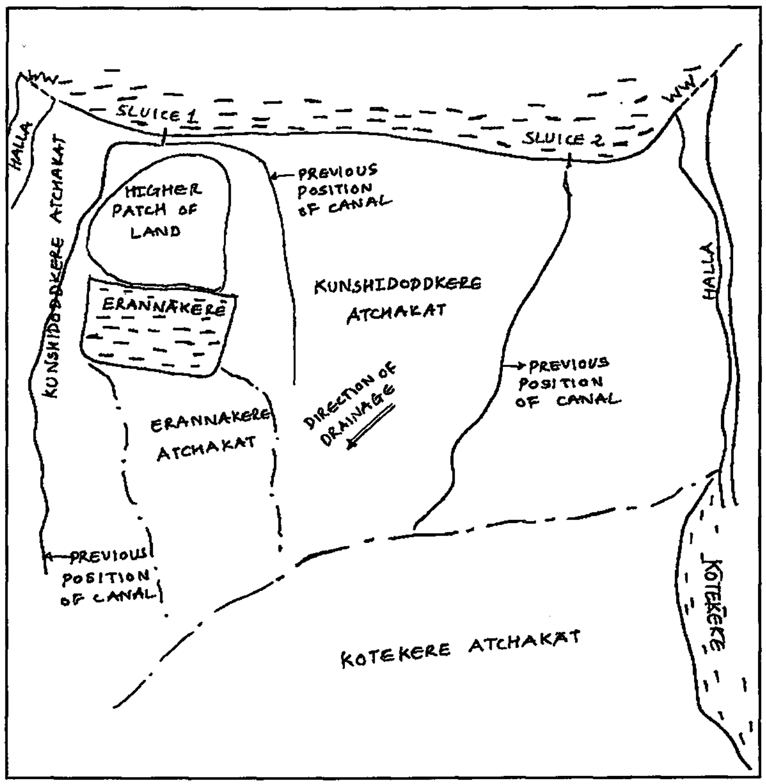
Similarly, the plug and pole arrangement of the sluice disappeared 20-25 years ago. Before that the sluice had a heavy plug, which used to be opened three to four times in the irrigation season after permission was granted by a Patel. Each time the sluice was opened, it was kept open for a few days until the entire atchakat was irrigated, and again closed until the next round of irrigation. The plug and pole of the sluice existed for a long time, until a couple of decades ago. The sluice is now stuffed with gunny bags and paddy stems before the rainy season, opened in July, kept open for the entire paddy season, again stuffed in October, opened in January, and closed before the rainy season.

Yet another tank, Kumsidoddakere, has neither distribution canals nor sluice operating infrastructure. The wooden plug and pole existed until the tank was managed by the village level revenue officers – Patel and Shanbhoga in 1971. In 1971, the tank was handed over to the PWD when officially the Patel and Shanbhoga stopped being responsible for the tank. This happened at almost the same time the new paddy varieties were introduced in the atchakat. The distribution canals existed at places shown in figure 4.7. Tail end farmers of this tank alleged that soon after the tank was taken over by the PWD the powerful farmers of the head reach, including the Patel and Shanbhoga, first encroached upon the canals and later even destroyed the remaining part. This happened after the introduction of transplanted paddy when the atchakat started to face water shortage. Destroying canals ensured that water is first supplied to the head reach and reached the tail end only if it is allowed to.

Another example is a tank called Sorturuhosakere. (See figure 4.8). It had 80 to 120 hectares of atchakat that has now come down to 12 hectares, all owned by one extended Lingayat family. There is an intense struggle going on between tail end, lower caste, Kuruba farmers and head reach, higher caste, Lingayat farmers. Tail end farmers are not only prevented from taking water from the tank but also prevented from acquiring land in the head reach. Even violent means were adopted to prevent one Kuruba farmer from purchasing a plot in the head reach. A Keladi Naika, two centuries ago, donated the whole of the atchakat to one Lingayat family whose descendents now own land in the head reach. One of the descendents, the most powerful farmer in the atchakat, is a civil contractor, who has also taken construction contracts from the

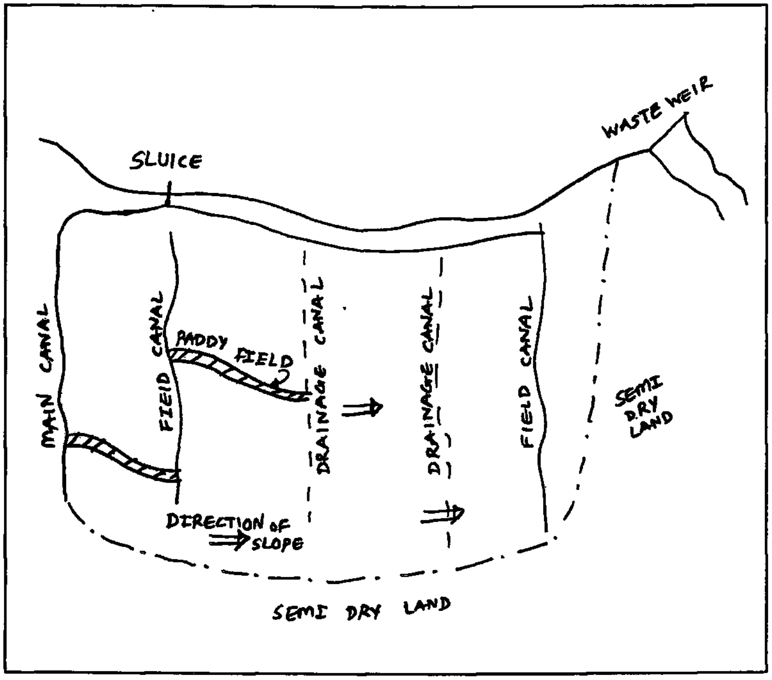
MID. It was due to his influence that the sluice was replaced and repaired and canals were extended and lined three decades ago. But even after the sluices and canals were repaired by the MID, only farmers related by caste and kinship, who own the 12 hectares of head reach land, have been allowed to take water from the tank. In case the tank receives more than three metres of water, the tail end farmers are allowed to irrigate semi-dry crops a couple of times but not allowed to take water for paddy cultivation.

FIGURE 4.7: A sketch of Kumsidoddakere atchakat (not to scale).



This shift in the state of the crucial water distribution infrastructure, in the tanks discussed above, does not seem to be a case of the deterioration of physical structures as a result of the lack of proper management or maintenance. Instead, in all tanks, the disappearance of the canals and the sluice operating mechanism was sudden. It is hard to comprehend why it would be difficult for farmers to replace this part of the tank infrastructure if needed. The plugs and poles are routinely replaced by farmers in other parts of the state, and once replaced, they can easily last for twenty years. Canal cleaning and mending does not require either sophisticated technical assistance or capital investment. Repair or reconstruction of any type of earthen or masonry work such as the embankment, the stone revetment, the sluice platform or the waste weir superstructure are difficult operations, hard for farmers to handle on their own. Desilting is another difficult operation, which may need an organised form of technical assistance. Farmers, however, routinely handle repairing and cleaning canals and replacing plugs and poles of sluices.

FIGURE 4.8: A sketch of Sorturuhosakere atchakat (not to scale).



The change in the state of irrigation infrastructure can be explained as an outcome of the shifting power dynamics at the local level in the context of the intensification of paddy cultivation. Nadkarni (1987: 3), while discussing the class character of the farmers' movement of the 1980s, noted that, "the landlords had a sense of security in the feudal order, which today's rich peasants do not necessarily have." The disappearance of crucial physical structures marks the breaking down of the old managerial order in which the ruling class seems no longer have a stake. Their earlier involvement with the management and maintenance of the physical structures earned them a right to be part of the decision-making authority, which in turn ensured that their interests were protected. Now, as long as they have land that is located in the privileged part of the atchakat that receives assured irrigation, they have not only been apathetic to the management and maintenance of the physical structures but, as the examples of tanks in Shimoga district show, have actually embarked into destroying some of the structures to remain in the privileged position.

The erosion of the local power structure has another side too. On the one hand, the rich farmers' movement of the 1980s rocked the corridors of power at the state level and gave fairly intense tremors to ruling governments in the early 1980s, on the other hand, it also resulted in the loss of external government authority to even nominally interfere and create a normative structure of order at the village level. This perhaps was the most evident in Shimoga district, the heartland of the new farmers' movement. One of the important strategies of the movement in the 1980s was to expose the corruption in public life and oppose the attachment of farmers' property by government officers in lieu of loan recovery. The latter culminated in government officials being prevented to enter the village (Assadi 1997: 58-62).[5]

The agitations were in response to the high handedness of government officers in power and their corrupt practices. The success of the agitations increased the power of well off farmers, especially sugarcane and paddy-growers, to new heights. This alliance, in my opinion, modified and suspended the normative structures of state authority at the local level. Irrigation infrastructure has been modified in other districts too, but not to the extent it has disappeared in Shimoga district.

The extreme case of Sorturuhosakere, where the atchakat is reduced to land owners related by caste and kinship, came to the notice of one MID officer. Due to his initiative, revenue officials visited the village and entered seven hectares of tail end land in their *pani* books (land registers) as wetland. After this event, some of the tail end land was allocated water for semi-dry cultivation. However, the tank is still monopolised by farmers from one extended family.

Designs and cropping pattern

These changes in the distribution infrastructure are as much a result of shifting power dynamics at the local level as an outcome of a changing cropping pattern. Most of the farmers narrated the change in terms of "before, when only broadcasted paddy was cultivated, and after, when all farmers began to grow transplanted paddy of new varieties". I maintain the same distinction to narrate the process of change over time.

As I have already discussed, tanks in the wet region of semi-malnad have a small capacity compared to the size of the atchakat because tanks here fill up several times during one monsoon season, which is also the irrigation season. Other than the monsoon showers, tanks receive irrigation return flow from the upstream tanks, i.e. the drainage from the cultivated area below one tank is captured in the tank located immediately below. Some scholars call a similar type of arrangement as a Small Tank Cascade System (Sakthivadivel et al. 1996). These two types of flow in the tank set a cycle of inflow and outflow of irrigation water.

Tanks in the wet region of semi malnad have sufficient capacity for irrigating the atchakat once. Earlier, paddy was usually sown in the last week of May by throwing dry seeds on the land that sprouted after the arrival of the first showers. The sluices were opened by a Talwar (a village servant) one and half months after sowing with the permission from Shanbhoga and that too was postponed if there was enough rain. Totally water was supplied three times during the whole season. Water thus was distributed intermittently and not continuously.

The local expression of this practice of intermittent irrigation is *Hodatha*. Hodatha, more precisely, refers to land and water management practice followed when water is provided first time to broadcasted paddy, 45 days after sowing. Only broadcasted paddy is grown nowadays in tanks of some parts of the wet region, for instance Hangal taluk of Haveri district. Hodatha involves providing a field with higher bunds, and altering the level of the field in such a way that each field slopes in the reverse direction than the movement of water from field to field (see figure 2 in chapter 2). The practice of hodatha consists of consolidating each piece of land with an instrument called *kunte* and subsequently applying irrigation water. Kunte is a long wooden plank or a blade that is used to consolidate lightly wet earth by pressing. It is tied to a pair of bullocks and then dragged through the field while a farmer stands on it. The blade has a gap in between in such a way that a row of young paddy plants can pass without being pressed, otherwise the movement of kunte breaks the stems of paddy plants from where new stems sprout. Only broadcasted paddy plants, which seem to have stronger roots than transplanted paddy, are not affected by the movement of kunte. This level of force would uproot transplanted paddy. Kunte uproots unwanted plants from fields in addition to consolidating fields and breaking the paddy stems and thus reduces labour requirements for weeding. Irrigation water is stored in fields with consolidated earth and higher bunds and then is allowed to seep gradually to provide continuous moisture to the paddy plants. The practice of hodatha thus makes intermittent irrigation possible for broadcasted paddy.

In the "before" phase, when broadcasted paddy was sown in tank atchakats of Shimoga district, the design of fields and the water distribution pattern in tanks suited the practice of intermittent irrigation. In the irrigation season, water was released totally three times; the first time for the hodatha, and supplied first to tail end in the next two rounds because early maturing varieties used to be sown in the tail end. Water was, therefore, rotated between the tail end and head reach and thus the presence of canal/s that would perform this rotation was absolutely crucial. Almost all tank-irrigated areas also had a seepage or drainage canal that carried excess water from the head reach to tail end, which rotated water between the head and tail and which carried irrigation return flow to the downstream tank. One round of irrigation would take 15 to 20 days depending upon the size of the atchakat. Sluices were operated during the irrigation round – opened in the morning and closed in the evening. For intermittent rounds of irrigation, the sluice operating mechanism was kept in order, as each round of irrigation would practically empty a tank. Sluice/s also had to be closed to store the next round of inflow till the next round of irrigation.

Irrigation now is provided as per the requirements of transplanted paddy. Sluice outlets are stuffed with gunny bags, paddy stems, stones and mud before the beginning of the rainy season. They are opened at the time of land preparation and transplantation when broadcasted paddy in the tail end would be one and half to two months old and would require water. After the completion of the first round of irrigation and depletion of water in the tank, sluices are again closed with gunny bags, stones and paddy straw until the second round of irrigation. This method of sluice control is fairly labour intensive, at times it even takes two days to entirely remove all the material stuffed inside the sluice openings. Only transplanted paddy farmers close and open the sluice outlets with the help of hired labour. The sluice is opened a second time after transplanted paddy has matured for one and half months. Once opened, sluice/s are kept open for the rest of the season because closing them under water is very difficult. Transplanted paddy needs continuous supply and drainage during the maturing season except in the first month. Hence sluice/s are again closed only at the end of the season. The disappearance of the canals and the sluice operating mechanism ensures that water is supplied to the tail end, field to field, only via the head reach and according to the requirements of transplanted paddy, completely negating the possibility of rotation between head reach and tail end.

In Kunshidoddkere, for example, water used to take three hours to reach the tail end, but now it takes four to five days and that also only if the head reach has received enough. Out of 40-48 hectares of atchakat, only 12-14 hectares are sown with transplanted paddy and the rest with broadcasted. Tail end farmers who grow broadcasted paddy stuff the sluices with gunny bags and paddy stems before the rainy season begins, which head reach farmers remove under water in June or July at the time of land preparation. Sluices are again stuffed in October or November after harvest and opened in January if some farmers cultivate another paddy crop in December or January.

Chinnikattetaverekere (figure 4.6) has a similar story. Transplanted paddy is grown in 12-16 hectares, out of 60 hectares of a total atchakat, of saru jameen in the rainy season. The saru land is sown with a second crop of transplanted paddy in December or January. Depending upon the amount of water in the tank in the rainy season, part of the vari jameen is planted with transplanted paddy, but the bulk is sown only with broadcasted paddy. In such a case, saru jameen receives water only from vari lands, although they have enough seepage for two crops of transplanted paddy due to lower position. In this tank, saru land is dependent upon vari land for supply of water, but the absence of the sluice operating mechanism ensures that the tank does not store enough water for vari lands to take transplanted paddy. When I asked farmers how difficult it would be to replace the plug and pole, the answer was, "it would be futile to do so as they will be stolen again". A fair deal of land in the tail end has been converted to semi dry cropping in both these tanks. Where transplanted paddy is not grown, semi dry crops such as maize, jowar or groundnut are alternated with broadcasted paddy. The sluice in this tank was repaired and replaced by the PWD two decades ago. The shutter type of sluice still survives, but absence of canals ensures that the tail end is dependent on the head reach. Out of 120 hectares of total atchakat, 40 hectares take transplanted paddy in the head reach and the rest broadcasted. Every year, some land in the tail end is converted into semi dry land in which jowar or maize are grown.

Thus, the disappearance of crucial water distribution structures ensures that water is supplied according to the requirements of transplanted paddy grown in the privileged patches in the atchakat. This shift in tank designs emerged along with the change in social relations in the context of intensification of paddy cultivation.

Institution of neerganti

It was surprising to know that the institution of neerganti – whose prevalence is associated with tank irrigation – does not exist in this region despite tanks being the dominant and historically the oldest mode of irrigation. Tanks may have manegara, or talwar or sowdi, some of whom are now employed by the MID to open and close sluices, but unlike neergantis of tank-irrigated areas of southern Karnataka, they do not distribute water among paddy fields, nor they make sure that the rotation between dry and wet land takes place like the neergantis in the northern maidan do.

There are three reasons for this. Firstly, when broadcasted paddy was grown earlier, there was much less water scarcity. The rotation between head reach and tail end was followed because paddy with different maturation times was grown in both areas. However, there used to be enough water in the system during the time of each rotation. The mediation of a neerganti, perhaps, was not needed to distribute available water.

Secondly, fields in tank-irrigated areas of this region are shaped in the form of long narrow strips which are flanked by a supply canal on the one side and a drainage canal on the other. As shown in figure 4.6, extremely thin strips of fields connect supply and drainage canals in such a way that water flows in the field from one side and excess water is drained on the other side. This arrangement is apparent in the case of Sorturu tank where the canals still survive. As shown in figure 4.8, there are three main canals and one drainage canal in the atchakat. Each field is not only connected with one of the main canals directly, but also drains into the seepage canal or into another main canal. Thus, field to field irrigation among the fields located in a particular patch was avoided. Water is always running in the supply canal during the time of one rotation and can be accessed by the farmers as per their requirement.

In contrast, supply canals in tank-irrigated areas of the mixed region do not carry water all the time. In the mixed region, canals irrigate land through rotation among different patches, and each patch of land is irrigated from field to field. Since water overflows to the downstream field only when the upstream field completes irrigation, an appointment of an individual who overlooks all patches of fields would save time and labour. Neerganti opens and closes the outlets in the supply canal to ensure rotation among different patches and also irrigates each field to ensure the economical spread of water. In fact, once water from the canal is taken out from the outlet, neerganti irrigates several fields simultaneously from field to field and saves a considerable deal of time and labour of the landholders. Without neerganti, in mixed region, owners, labourers, or tenants – those who are responsible for irrigation – would have to wait at their paddy fields for water to arrive.

The third reason pertains to the structure of agrarian relations in this region. Historically, Shimoga has had a much higher number of tenants than the rest of Karnataka, barring the coastal region.[6] Though nominally Shimoga was a ryotwari area during the British period, Gowdas were big landlords who not only controlled entire villages but also lands much beyond (Nadkarni 1987: 17). Their holdings were also larger than those of other landed groups in the rest of the state. The landlords here did not cultivate their lands under personal supervision but leased them out to tenants almost entirely (Nadkarni 1987: 17). So tenants cultivated the land in Shimoga district in contrast to other parts of the state where mostly owner cultivators cultivated their own lands. Given the fact that labour was cheaply available all the time, that there was no pressing problem of scarcity of water, that the rotation was observed only between head reach and tail end and not among the land cultivated from one canal, and when this arrangement was facilitated by the layout of paddy fields, there was no requirement for additional employment of services especially for water distribution.

Dry cultivation in the wet region

Paddy-growing farmers in Shimoga derive their economic power from land other than tank-irrigated land. The groundwater level in the region is comparatively high (available at 50 metres) and instances of bore well failure very rare. The tanks I studied are relatively barren of bore wells, one comes across one or two bore wells in roughly 120-160 hectares of land irrigated by a tank. However, the number of bore wells in the region is steadily going up.

The reason is that almost all landowners in the tank-irrigated area also have a piece of dry land, locally known as *hankalu*. Conventionally, subsistence crops such as ragi, jowar and horse gram were grown on hankalu land, but in the last decade or so, the cropping pattern on these lands has radically changed. Those, who could afford it have invested in bore wells on hankalu land to grow a variety of crops such as vegetables, cotton, maize, groundnut, betel nut, coconut and banana, in addition to conventional subsistence crops such as coarse ragi, jowar and horse gram. The process began almost 20 years ago when DCH 32 cotton first replaced subsistence crops. However, cotton at that time was rainfed, given the fact that this region has a well-distributed and high amount of rainfall. A more diversified cropping pattern based on extensive use of ground water has developed only in the last decade or so. Most of these new crops are grown for the market and as one landowner said, "the real farming activities now have shifted to hankalu land". A piece of land in the tank-irrigated area still fetches a much higher price than hankalu land because it assures at least one crop of paddy. Nevertheless, as my respondent said, the focus of agricultural activities has shifted to hankalu land as it provides more opportunities, especially after the arrival of Indo-American seed varieties of maize and vegetables. A favourable price structure – higher prices for output and lower prices for input – as a result of farmers' pressure at regional and national level has also made it possible for many – even small farmers – to invest in cash crops (Nadkarni 1996), at least in the wet region.

Those who could afford would install a bore well on hankalu land instead on atchakat land where only one or at the most two paddy crops could be grown. Consequently, two distinct cropping regimes have emerged in this region, one dependent on tank water and the other on rain and ground water. These two cropping regimes remain separate in terms of their agricultural activities and water utilisation patterns, unlike in other parts of Karnataka and south India where bore well irrigation and tank irrigation have clashed.

There is, nonetheless, a significant interrelationship between these cropping regimes, but of more economic nature. Income earned of cash crops grown on hankalu land is reinvested in tank-irrigated areas. More detailed research is needed to understand how the shift in cropping pattern on hankalu land has influenced tank irrigation practices, but prima facie, it looks as if tank-irrigated paddy land provides insurance of one crop for subsistence and for the market but that hankalu land provides new economic opportunities.

Broadcast or transplant?

The wet region has one more trajectory of tank designs – tanks irrigating paddy and garden crops. I studied some tanks in Hangal taluk of Haveri region, which is known as rain-assured region. Tanks in this region support paddy and a garden crop of betel nut. Almost all the studied tanks – Bommannahalli, Kalgudri, Yelvatti, Belgalpet, Annekere and Akkiaru – are more than 7 to 8 centuries old. Some were constructed during the time of Kalyani Chalukya dynasty in 1100 A.D.; others were constructed at least before the Vijayanagara period.

Similar to tanks in Shimoga district these tanks are also small in size vis-à-vis the size of atchakat they irrigate compared to tanks in the mixed region. Tanks in this region with long bunds and relatively shallower depth of 6-13 metres (compared to 15-30 metres average depth in the mixed region) have a capacity to irrigate the atchakat for one round at a time. Bigger tanks like Annekere and Belgalpet retain some storage but smaller tanks like Bommanahalli are practically empty after one round of irrigation.

Similar to tanks in Shimoga district, tanks here fill up at least three to four times during the monsoon season and hence provide at least three rounds of irrigation, but unlike tanks in Shimoga district, tanks in this region provide irrigation also to betel nut in the summer season. And further, only broadcasted paddy is grown in the tanks of this region unlike tanks in Shimoga that support both transplanted and broadcasted paddy. Finally, unlike tanks in Shimoga, tanks in Hangal have their sluices in place although the water distribution network has disappeared in some tanks.

The question is why farmers from the tank-irrigated areas of this region continue to grow broadcasted paddy while farmers elsewhere have predominantly shifted to transplanted paddy. For 15 to 20 years almost all farmers in these tank areas have been growing new high yielding varieties, broadcasted, and not transplanted except in the excessively wet patches in the atchakat. The wet patches, known as *jowgu* (seepage) land or saru land, sow their transplanted seedlings in the month of August. However, the amount of saru or jowgu land is much smaller than the rest of the atchakat, maybe only 5 hectares in an atchakat of 200 hectares. Besides, water requirement on saru lands more or less corresponds with the water need of broadcasted paddy as saru lands already receive a lot of seepage. Thus, no separate irrigation is provided to them.

A few design elements of tanks and the influence of the garden crop converge to constrain a shift from broadcasted to transplanted paddy. The most important factor is the limited capacity of tanks to support continuous irrigation for the entire duration of transplanted paddy, the characteristic that tanks here share with other – exclusively paddy supporting – tanks in the wet region. However, there is an additional reason: if grown in the entire atchakat, the irrigation requirements of betel nut would clash with the irrigation needs of transplanted paddy to an extent that the requirement of transplanted paddy may not leave any storage for garden crops. The norm of half capacity of tanks kept reserved for garden land is never compromised in this region.

Alternatively, the atchakat size would have to be substantially reduced to facilitate the shift from broadcasted to transplanted paddy, a process that has already commenced in a few tanks in this region. There are two reasons why the pace of such a shift has not been hastened. Firstly, the yield difference between broadcasted and transplanted paddy grown in the rainy season is five to seven bags per acre, but only three to four bags in a season of good rain. This is because transplanted paddy sown in winter gives good yield due to good sunlight but the rainy season yield is lower. At the same time transplanted paddy needs more capital and labour investments: transplanted paddy needs two bags of fertiliser, broadcasted paddy needs one; two rounds of pesticide application for transplanted paddy, none for broadcasted; two rounds of weeding for transplanted, only one for broadcasted and that also only in the rows of paddy because weeding in the surrounding land is done with a kunte. On the whole, broadcasted paddy is only a little less lucrative than transplanted paddy. Many farmers said that broadcasted cultivation is more economical in the tank-irrigated land, especially when water is scarce during the flowering time.

The second important reason that head reach farmers have not embarked on transplanted cultivation, as farmers in Shimoga have, is the fact that most of them have some amount of garden land. The choice for them would not be between transplanted and broadcasted cultivation but between transplanted paddy and betel nut cultivation. Sacrificing five to seven or in the worst situation even 10 bags of paddy per acre may not be too much given the much higher market value of betel nut.

Although a change to transplanted paddy has not occurred in the tanks of this region, there have been other changes due to intensification of paddy cultivation. The distribution canals have either entirely disappeared or have been heavily encroached upon in many tanks I studied. Hence, the conventionally observed practice that irrigation during the second irrigation round is first provided to tail end is no more followed in many tanks. In Yelvatti tank, canals have largely silted up and sections encroached upon; in Bommanahalli tank the head and middle reach irrigate field to field and water reaches the tail end only through fields; in Annekere tail end farmers do not receive enough irrigation because canals have largely disappeared. In these tanks, some of the tail end land is converted into hankalu land where crops such as maize and cotton are grown every year.

To sum up, the intensification of paddy cultivation, either broadcasted or transplanted, remains the dominant feature of the tank trajectory in the wet region. In the context of intensification, designs of tank structures have been opportunistically altered by the powerful farmers of Shimoga district, whereas tank designs in Hangal have constrained the transition from transplanted to broadcasted cultivation. Nevertheless, in both these areas paddy cultivation has been significantly intensified in the last two decades.

Tank Trajectory: Mixed Region

Designs at the interface of paddy and non-paddy cultivation

Intensification of paddy cultivation forms the core of changes in the wet region, whereas transition from paddy to non-paddy cultivation is at the centre of transformation in the mixed region of the southern and northern maidan. Uncertainty about water availability in tanks is one of the important causes for the struggle over tank water resources in the mixed region.

The spectrum of outcomes of the struggles can be described in relation to two extremes. One extreme is in the southern maidan where paddy remains the dominant crop in tank-irrigated areas. In the southern maidan, only paddy is grown in the tank atchakat. The other extreme is that of the northern maidan where paddy cultivation has been replaced completely by semi-dry cultivation, either irrigated with groundwater or rainfed. In such cases, water from tanks is no more used and canals and sluices are predictably in considerable disrepair. In between these two extremes lies a vast middle ground where the battle between paddy and non-paddy crops takes place in a variety of ways. What follows is a discussion on transforming tank designs between the two extremes of paddy and non-paddy cultivation in the mixed region.

In the tanks of the southern maidan, the battle at this moment is tilting in favour of paddy. The timing of irrigation, whether irrigation is provided or not and water distribution methods still revolve predominantly around paddy cultivation. However, the preference for paddy cultivation combined with the uncertainty about water availability in tanks creates a major dilemma. Tanks in this region do not receive enough water every year for the entire atchakat to grow paddy. This problem is circumvented in each tank by either adjusting the frequency of paddy cultivation or by limiting the size of the atchakat that can receive irrigation for paddy. Farmers from tank-irrigated areas are faced with a choice: whether to adjust the area of atchakat that can be sown with paddy every year or to reduce the number of years for which paddy can be grown in the entire atchakat. In case of the former possibility, only a part of the atchakat receives irrigation for paddy and the rest is sown with semi dry crops during the years when tanks do not receive enough water for the entire atchakat to cultivate paddy. In case of the latter choice, irrigation is provided for paddy cultivation only when enough water is collected for the entire atchakat. In the remaining years, when irrigation is not provided, either nothing is grown in the atchakat or rainfed crops such as ragi or groundnut are cultivated to some extent. Those who have bore wells grow a variety of crops.

Making this choice is not a collective and straightforward selection of one of the options but is a process, often intensely fought out between different sections of farmers. The political economy of agrarian change influences the choice of crops; however, at the tank level a particular configuration of power relations finally determines the choice of cropping regime and the designs. More detailed research is needed to comprehend the nuances of this process of selection of a cropping regime in a particular tank area. I have made an attempt to comprehend the nuances of social processes that finally converge into a choice of a cropping regime and tank designs in one of the tanks of southern maidan. This is discussed in chapter 6. However, the focus of this chapter is to outline overarching parameters within the limits of which the final choice at each tank level is made. Accordingly, in this section, I intend to chart the parameters of the relationship between cropping regime and tank designs in the mixed region through understanding the process of change.

Water availability

Tanks in the southern maidan fill up any time between August and October. Only if a tank receives enough water to cultivate paddy in part or in the entire atchakat are seedlings raised in October and transplantation begins in December or January. Sowing in December or January means that the crop is not only entirely raised on irrigation provided from tanks but also that the peak demand, during the flowering and pre-harvest times, occurs during the summer months. The size of atchakat in the mixed region is small compared to the size of atchakat in the wet region for a similar tank storage capacity. Actual area irrigated each year is further circumscribed according to the amount of water received by tanks.

Since the amount of water received by a tributary or a natural drainage in the mixed region is uncertain, a series of tanks fed by one tributary is subjected to a high degree of uncertainty about quantity and frequency of water supply. In addition, because a tributary is not a human-made canal, its gradient and course constrains the number and location of tanks that can be supplied water. This means that not only the amount of water received by each tank fed by a tributary is uncertain but also that a relatively less technical control can be exerted on water distribution from one tributary.

Most of the tanks I studied in the districts of Kolar and Bangalore in the southern maidan and Bellary and Dharwad in the northern maidan fill up to full tank level once in three years, in some cases once in five or even once in seven or eight years.[7] Water availability in tanks of Dharwad and Bellary districts is even more irregular than that of tanks in Kolar. Uncertainty of water inflow has in general increased in addition to overall reduction in availability, but in Dharwad, I studied a few tanks which have altogether stopped providing irrigation.[8] The intensification of water use in the catchment area, due to proliferation of bore wells and other forms of water use, may be one reason for overall reduction in availability. However, in Dharwad several tanks have gone out of use due to the gradual process of siltation and resulting reduction in water holding capacity, but there are also some other tanks which have been dysfunctional due to the modifications in the structures that brought water to them.[9]

Tanks in Bellary and Dharwad that have not been ruined have a pattern of water availability similar to the tanks in the southern maidan. Bannikal tank in Bellary district was constructed in 1967 but has by now considerably silted up. It fills up to full capacity once in two to three years; in the last 30 years the tank has filled up 19-20 times. Another old tank called Hargnur located in Bellary district has filled up to full capacity only 9-10 times in the last 40 years; in the last 10 years the waste weir has discharged only once. The tank on an average fills once in four years but receives water half full every year. Two crops of paddy are grown in some parts of the atchakat of these two tanks and semi dry crops are cultivated in the rest of the atchakat.

Having given a rather depressive account of water availability in the mixed region, I would like to point out that the current state of water availability in tanks in the mixed region has perhaps only a degree of difference compared to what was there historically. The mixed region seems to have been facing uncertainty about water availability for a long time, perhaps since the time tanks were first constructed. During my visits to several tanks in Kolar, Bellary and parts of Dharwad, Bangalore (and also Chitradurga) districts, I came across several folk stories and songs about sacrifice of men and, more specifically, of women in tanks. These stories and songs describe how a particular woman – young or adult, married or virgin, pregnant or mother of a newly born child, childless or mother of a male child, daughter or daughter in law of the village Gowda – was sacrificed in the tank. These sacrificial songs are variously known as Kenchemma, Hunnamma, Vennamma, Kennivirramma (and a few more names) songs. In fact the Kenchamma song is the most famous in Karnataka; it is considered as the finest piece of poetry in the Kannada language. Whatever may be the social setting, background and name of these women who in a certain historical context were perhaps considered disposable, what is common in all these stories and songs is the cause behind the sacrifice. The respective tank in which, according to the story or song, the sacrifice was made had not received water for a long time. The sacrifice was made to alleviate a long-standing drought. In certain parts of Kolar and Bellary districts almost every other tank has a story of sacrifice. A small shrine may also exist on the embankment in the name of the woman sacrificed in the tank; in rare cases even a temple may exist on the embankment or in the village. Based on the stories about nayakas, kings and gowdas in these narratives, it can be said that the historical setting of these stories and songs is the Vijayanagara empire period – between approximately 1200 and 1600 A.D., the time when many tanks in this region were constructed.

On entering the dry region of Bijapur in the north and the wet – semi malnad – region of Shimoga in the east, the shrines, temples and sacrifice stories disappear as uncertainty about water availability in tanks also significantly disappears. The historical validity of these aspects of the collective memory may be debated; nevertheless, the stories and songs do hint at the hydrological and ecological setting of the region. An uncertain amount of water availability in tanks of the mixed region may not entirely be a current problem, and may in fact partially be a trait the tanks in this region were born with. In other words, the intensification of cropping pattern in general and increase in water demand due to a number of reasons may have accentuated the problem of reduction of water availability, rather than cause it entirely.

Water availability and cropping regime

The ecological and hydrological settings circumscribe water availability and consequently the choice of crop in irrigated areas. Uncertain availability and reduced amount of inflow in case of some tanks have curtailed the possibility of growing water intensive crops. However, the view that the water availability pattern determines the cropping pattern would amount to looking at the relationship of water availability in tanks and choice of cropping pattern from one direction only. The choice of cropping pattern also influences how tanks perform.

For instance, Navloor, Guttalhalekere and Savnur tanks of Dharwad district still receive some amount of water every year. They do not regularly fill up to their capacity to support the cropping pattern of paddy and once famous garden crops; nevertheless, they do receive water to half their capacity, if not regularly, occasionally. Navloor tank still fills up to its full capacity as often as tanks in Kolar do. Farmers from Guttalhalekere said that thanks to the water inflow in the tank their bore wells yield a good amount of water. The local equation is that if the tank receives half of its capacity once, bore wells yield good water for five years.

In the case of some tanks in the mixed region, evidence is sufficient to suggest that a choice of a certain cropping regime results in farmers choosing well irrigation in place of tank irrigation, although further research may be needed to draw definite conclusions. Bore well irrigation is not entirely chosen due to a lack of water in a tank, but also because tank designs support certain types of cropping pattern and bore well irrigation different one. In Kolar and Dharwad, where uncertainty about water availability has always been there, borewell irrigation and diversifying cropping pattern have emerged together, more prominently in the last decade. Bore wells have mushroomed in tank-irrigated areas of the mixed region along with a non-paddy, semi dry, market oriented cropping regime. A number of bore wells have come up in the last decade and half in the atchakat of Navloor, Guttalhalekere, Hattimattur and Savnur tanks of

Dharwad, Bannikal tank of Bellary and almost all tanks I studied in Kolar. A variety of crops such as potato, tomato, chili, beetroot, eggplant, onion and other vegetables, maize, groundnut, mulberry, sunflower, cotton, green gram (and more) are now grown with bore well irrigation in tank irrigated areas. Particularly, a variety of vegetables, after the introduction of Indo-American seeds, top this list. Earlier, along with paddy, subsistence crops such as ragi, jowar and maize used to be grown in tank atchakats, irrigated once or twice with tank water; now the list of crops grown in tank irrigated areas along with paddy has grown longer.

The cases of Haraganur, Oblapura and Dannayakankere tanks of Bellary provide counter examples. These tanks are located in hard rock regions and hence bore wells cannot be installed in their atchakat. In a normal year, paddy is predominantly cultivated in these atchakats; when paddy cannot be grown because tanks do not receive enough water, the list of semi dry crops grown is short – maize, ragi and groundnut. The case of Hanshikere of Bellary is also a counter example. Although this tank is not located in the hard rock region, bore wells need double casing because the upper soil layer in this tank atchakat has a tendency to cave in at the time of drilling the well. Double casing is not expensive but risky, the well may not survive and hence farmers are not venturing to install them in a large number. Farmers of this tank have collectively decided to grow sunflower and maize when the tank does not receive water at full capacity. Head reach farmers are allowed to grow groundnut. And the list ends there.

It is my impression, based on observations of some tanks in the mixed region, that farmers in Dharwad district may be setting a trend towards choosing bore well irrigation in place of tank irrigation and thus choosing a bore well supported cropping regime in place of the tank irrigated one.

There could be a related reason why farmers from some tanks in Dharwad are setting a trend towards non-paddy cultivation and why one does not find such trend in Kolar and Bellary. Firstly, Dharwad has largely black soil, not considered suitable for irrigation. There are cases of tanks abandoned a generation ago because irrigated land became saline. Magadi tank was constructed during Shivaji's reign in the 17th century but around 100 years ago it was abandoned. Secondly, black soil is not considered suitable for paddy cultivation and more so for transplanted paddy. In Navloor tank, broadcasted paddy is grown in some 20 hectares of land (out of 60 hectares of atchakat) located close to and irrigated by the waste weir halla. Farmers of this tank began growing transplanted paddy a couple of decades ago but stopped soon after because land became exceptionally hard and less suitable for any other type of cultivation. Out of three sluices, two on the extreme edges have silted up (only in the last decade).[10] The third and the deepest sluice was desilted by the MID a decade ago and is still in usable condition, but the fear of making the soil unsuitable for any other cultivation drives the farmers not to cultivate tank-irrigated transplanted paddy. And growing one crop of broadcasted paddy per year is not as lucrative as cultivating three to four crops of vegetables. In this tank atchakat, broadcasted paddy is grown in the patch that is close to the halla that receives enough seepage. Other crops do not yield much here.

The transition from broadcasted paddy to transplanted paddy never happened in the other studied tanks in Dharwad that have largely silted up and gone out of use. Hattimattur went out of use 20 years ago, Savnur 30 years ago, Navloor only in the last decade. In none of these tanks was transplanted paddy ever seriously grown.

The type of soil may be a limiting factor for the cultivation of transplanted paddy in Dharwad, but it may have also proven a blessing in disguise in the last decade and a half. Farmers of these tanks are presented with more opportunities after the introduction of irrigated varieties of dry crops. As one of the farmers of Navloor tank put it, "farmers no more want to go into the slushy paddy fields. They want to cultivate clean, white collar, dry crops, earn money and buy rice from the market." On this side of the spectrum, the battle between paddy and non-paddy seems to be tilting in favour of non-paddy crops.

Method of water distribution

Usually only two or three main canals exist in the atchakat of tanks irrigating paddy. Main canals follow the highest contour of the atchakat and are generally located on the edges. Schematic sketches of Kurgepalli (figure 4.9), Venketeshsagara (figure 4.10) and Kodipalli (figure 4.11) tanks show such examples. In these cases, the land lying in the middle of the left and right bank canals is irrigated, while the area lying on the other side of the canals is higher than the canal level and hence not irrigated. However, as in the case of Vottadahosahalli tank, as shown in figure 4.12, main canals may pass through the middle of the atchakat. Other than the main canals, the atchakat may also have drainage canals following the lowest contours in the atchakat. The drainage canals may also overlap with the original drainage course through which the halla would have passed (in the absence of the tank) or is passing (as the case of Venkeshsagara tank, figure 4.10). Tank atchakats conventionally do not have any other canals or field channels. Water in the rest of the atchakat is distributed from field to field. Each field receives water from the field located at immediately above it. That means when paddy is irrigated the whole atchakat is reeling through streams of water. Especially after the introduction of high yielding varieties that are transplanted, fields are irrigated more frequently compared to the fields sown with broadcasted paddy. If paddy is sown in a considerable part of the atchakat, cultivation of lightly irrigated crops is not impossible but difficult. Some farmers, for example of Dandiganhalli tank of Kolar, make deep channels around their fields to keep water out in order to grow lightly irrigated crops when paddy is irrigated in the atchakat. Some other farmers have brought soil from outside the atchakat to raise the level of their fields in order to keep them free of seepage. These examples illustrate that some modifications in the designs of fields and water distribution methods are needed to facilitate the transition from paddy to non-paddy cultivation.

This transition in tank designs to facilitate the shift from paddy to non-paddy cultivation is apparent in some tanks of Bellary district of the northern maidan. Both paddy and lightly irrigated crops are grown, in one irrigation season, side-by-side. However, the major difference between the atchakat layout of tanks irrigating paddy in the southern maidan and of tanks irrigating paddy and semi-dry crops in the northern maidan is that in case of the latter the lands cultivating paddy and non-paddy crops are apart (or separate) in the atchakat. More often, the part cultivated with paddy forms the head reach of the atchakat which may also be the oldest part of the atchakat where paddy has been grown for many centuries. The part cultivated with non-paddy crops may be the newly expanded part of the atchakat. Chapter 5 discusses in more detail the case of a tank, located in the northern maidan, irrigating paddy and semi dry crops. Water is rotated between the paddy and non-paddy parts of the atchakat in the case of this tank. The separation of the atchakat into paddy and non-paddy parts while facilitating the transition from paddy to the mixed – paddy and non-paddy – cultivation, but also results in the discrepant water distribution between paddy and non-paddy parts. See chapter 5 for more details.

FIGURE 4.9: A sketch of Kurgepalli atchakat (not to scale).

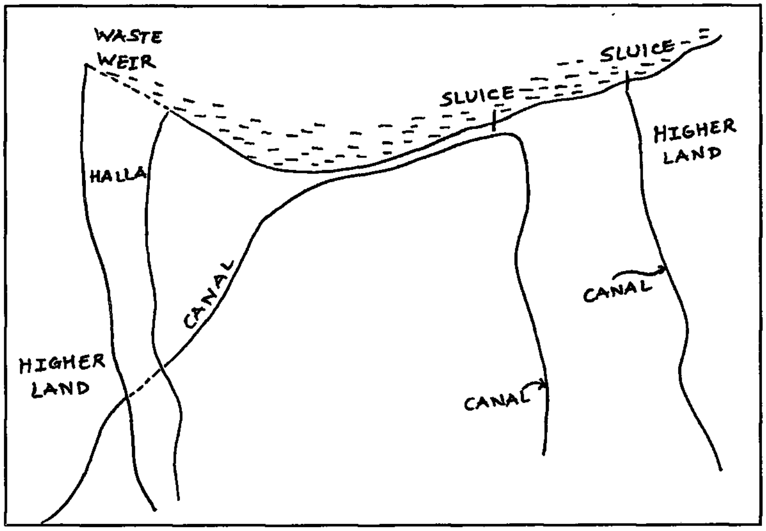
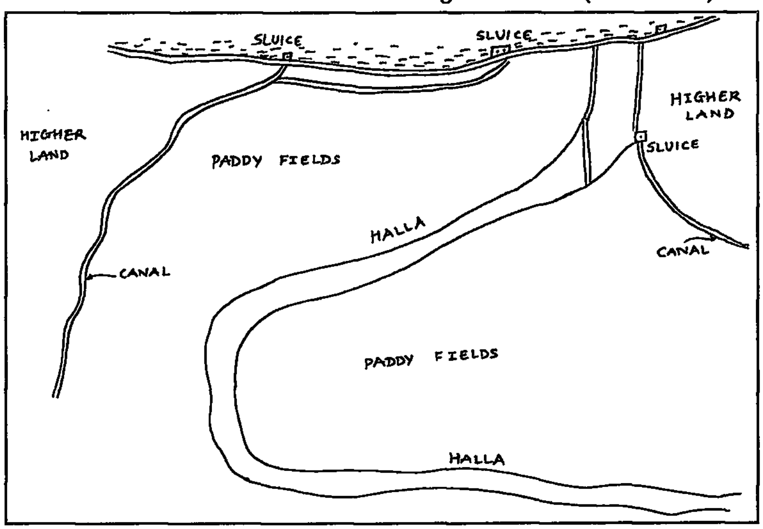
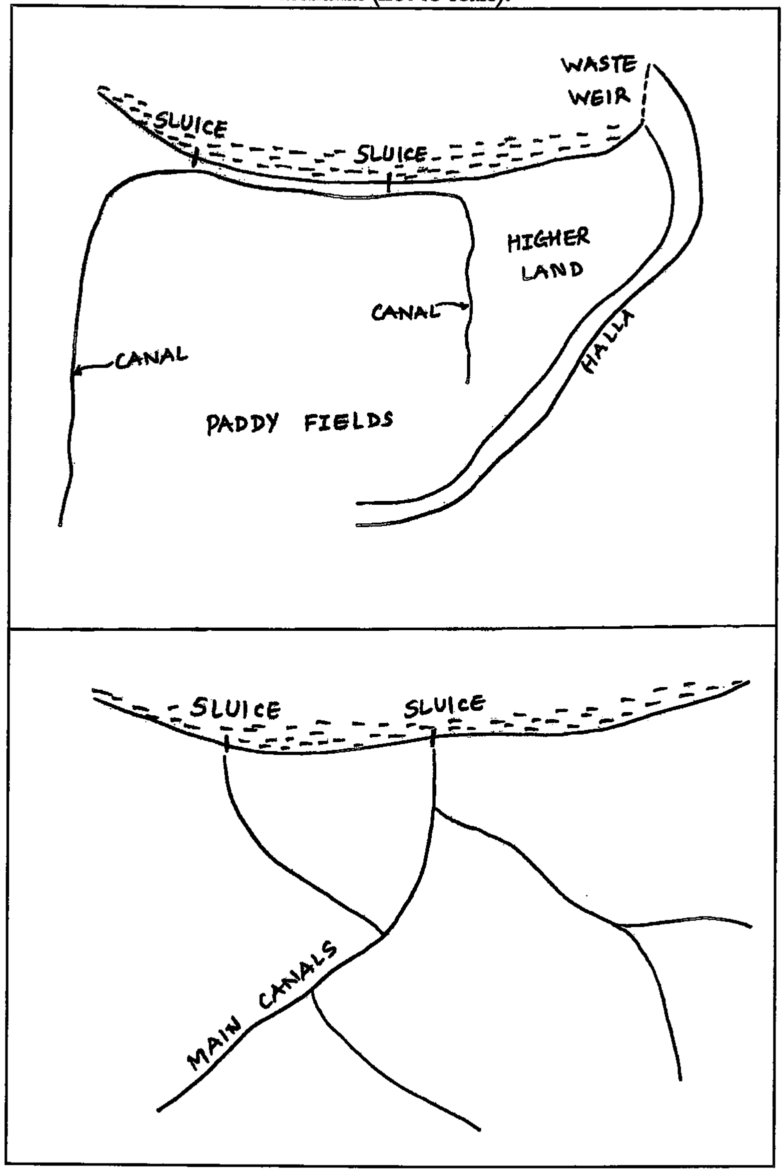


FIGURE 4.10: A sketch of Venketeshsagara atchakat (not to scale).



FIGURES 4.11 and 4.12: Sketches of Kodipalli and Vottadahosahalli atchakat (not to scale).



Another transition in designs pertains to the method of field-to-field irrigation. The provision of separate field channels connecting each plot with the main canals seems to be an emerging trend in the district of Kolar. Some examples are those of Ramasagara, Bairesagara and Vottadahosahalli tanks. The PWD lined the main canals of Ramsagara tank and provided piped outlets a couple of decades ago. Now each plot is separately connected with the main canal. It may be coincidental that in this tank area neerganti's services to distribute water from field to field are not utilised anymore. The trajectory of the transition from field to field irrigation to irrigation based on field channels may have a connection with the changing cropping regime in these tank areas. Bairesagara and Vottadahosahalli tanks of Kolar district are similar examples. In the atchakat of these tanks, semi dry crops are cultivated in the monsoon season for which, depending upon the water availability in the tanks, irrigation is provided at least two times. From December to May, during the main paddy-growing season in the region, groundnut is grown in more than 50 to 60 percent of the atchakat of both these tanks depending upon the water availability. Each field is connected with the main canal in both these tanks.

The transition in cropping regime has repercussions for other design elements such as the type of sluice-operating mechanism, sluice opening and closing timings and the institution of neerganti. There have been marked changes in designs in some tanks of Kolar district, although several tanks have also retained a great deal of affinity with paddy cultivation and paddy supporting tank designs. The case of one such tank is discussed in chapter 6. Tanks in Bellary and Dharwad districts have, however, largely acquired mixed cropping and undergone a transition to designs that sustain mixed cropping.

Type of sluice

The plug and pole type of sluice is conventionally provided in tanks all over Karnataka. Farmers consider this type of sluice leakage proof especially when the tank is full. As the plug vertically fits into the hole provided at the mouth of the tunnel at the base of the embankment, the water pressure further presses the plug down, not allowing, as some farmers described it, "even a drop of water to escape." However, operating the plug and pole type of sluice is not easy, especially when the sluice-operating platform is located in the water spread areas, as is the case in the mixed region. (See figure 4.13 and 4.14).

In southern maidan the sluice platform is conventionally provided, not in the embankment, but in the water-spread areas, especially for the bigger tanks. Tanks with more than a depth of five metres may be described as bigger tanks, although it would be difficult to prescribe any rule when the platform is provided in the water spread area and when directly in the embankment. Except for Budikote tank, which was constructed in 1942 and designed by the famous Vishweshwaraiya, old tanks with an atchakat of roughly 320 hectares and more usually have sluice-operating platforms provided in the water-spread areas. In many of these tanks, the operating platforms were relocated in the embankments (see figure 4.15) after sluices were repaired and replaced by the PWD in the 1970s and 1980s.

The sluice operating platforms, at the time of construction of tanks a few centuries ago, were perhaps not provided in the embankments to avoid a weak structural point. A stone structure provided in the middle of the earthen embankment may prove a foreign structure if proper adhesion between the stone and earthen structure is not ensured. Tanks especially with taller bunds, when they fill up after one torrential and heavy shower, were perhaps considered at greater risk of breach and hence all weak structural points were avoided in the embankments. However, this explanation is purely an engineering explanation; there must have been other, historically specific, reasons why sluice platforms were not provided in the embankments.

Whatever may be the reasons, someone has to swim to the location of the sluice at the time of the opening of the sluice if the platform is located away from the embankment. Lifting the plug under water when the tank is full needs skillful handling. Usually the plug has expanded under water and has to be skillfully lifted. It may not prove easy to carry out this operation frequently, certainly not every day. After the introduction of high yielding varieties, sluices of tanks irrigating transplanted paddy in the southern maidan have been kept open for the entire irrigation season, and irrigation is provided day and night in different parts of the atchakat according to the rotation schedule fixed. Even when broadcasted paddy was grown two to three decades ago, sluices were opened only three times during the irrigation season. At that time, one round of irrigation took at least 15 to 20 days to complete in an atchakat of roughly 320 hectares. During this time, sluices were kept open day and night.

FIGURE 4.13: Sluice operating platform located in water spread area.

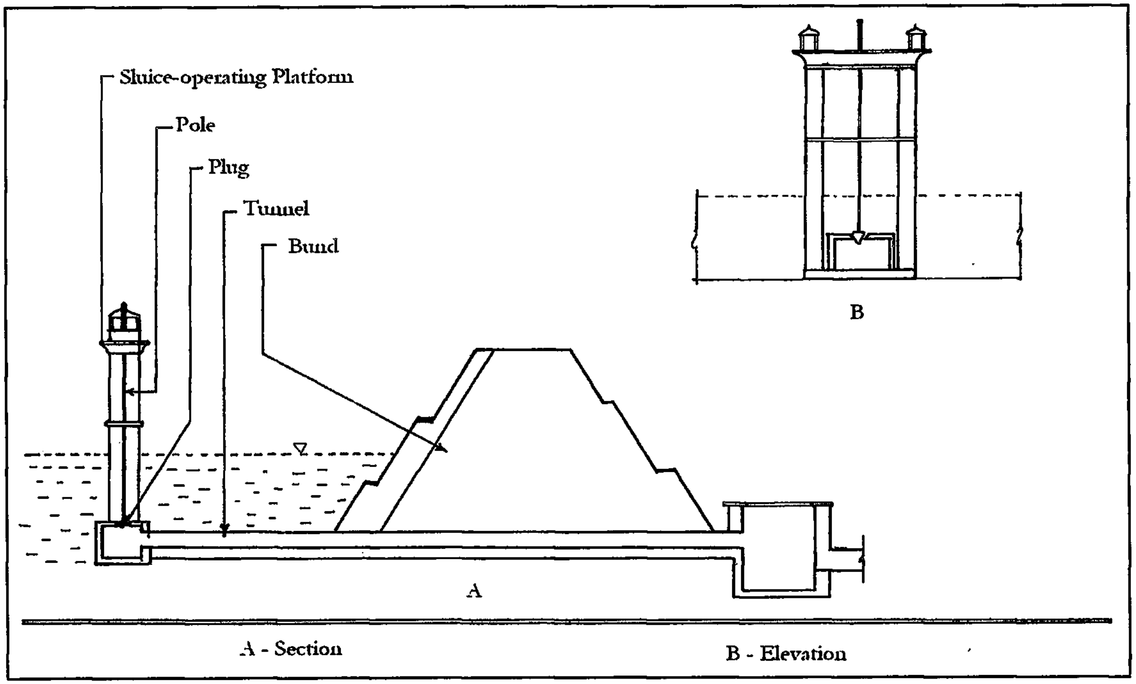
In the last couple of decades, especially after the introduction of high yielding varieties, and the context that tanks in the southern maidan do not fill up every year, semi dry crops are increasingly cultivated in tank-irrigated areas in the monsoon season. Even during the main paddy-growing season that begins in December-January, if the tank has not received enough water, semi dry crops such as groundnut are cultivated in part of the atchakat. For instance, in Vottadahosahalli tank at least three metres of water needs to be collected in the tank to grow paddy in 60-80 hectares. Six metres of water collected supports roughly 160 hectares and 10 metres permits paddy to be watered in 240 to 280 hectares. Only if the tank fills up to 12-13 metres is paddy sown in the entire atchakat of 800 hectares. Groundnut is sown in 50 to 60 percent of the atchakat in one out of four years. The Bairesagara tank located immediately upstream of Vottadahosahalli tank is a similar case. Much of the atchakat is sown with semi dry crops during the paddy growing season beginning in December.

In both these tanks, the PWD replaced the plug and pole with shutter sluices almost three decades ago. At that time, the cultivation of new varieties of paddy was not introduced in the atchakat. The cropping regime at that time was that of a mixed cultivation of broadcasted paddy and ragi or jowar in the monsoon season followed by a crop of pulses. The replacement of the plug and pole with a shutter was, therefore, not intended to match a shifting cropping pattern; rather, it was perhaps the result of the preference of PWD engineers of the British period. However, the shift in cropping pattern in the last two decades has been facilitated by the shutter type of sluice. (See figure 2.5 for shutter type of sluice).

It may be interesting here to mention that farmers of two newly constructed tanks, namely Dandiganhalli tank with World Bank assistance and Chikkhosahalli tank with NABARD assistance in Kolar district, prefer the plug and pole type of sluice to the shutter type, which was provided at the time of the construction. Farmers of Chikkhosahalli have in fact already replaced the shutter with the plug and pole. Dandiganhalli farmers also greatly complained that the shutter is largely rusted and not sliding in the guides properly, causing a considerable degree of leakage. Leakage is so much that three crops of paddy are cultivated in four hectares located next to the canal and close to the sluice simply by using leakage water. Both these tanks are located at the upstream of a series of tanks. Chikkhosahalli tank is located in Gauribindur taluk of Kolar district, which has assured rainfall. Tanks in this taluk enjoy a relatively assured supply of water. Dandinganhalli is a new tank constructed in the upstream of a series of tanks, hence has assured water supply. Farmers of both these tanks grow at least one crop of paddy. Their preference for the plug and pole type of sluice may be understood in the context of their choice of crop.

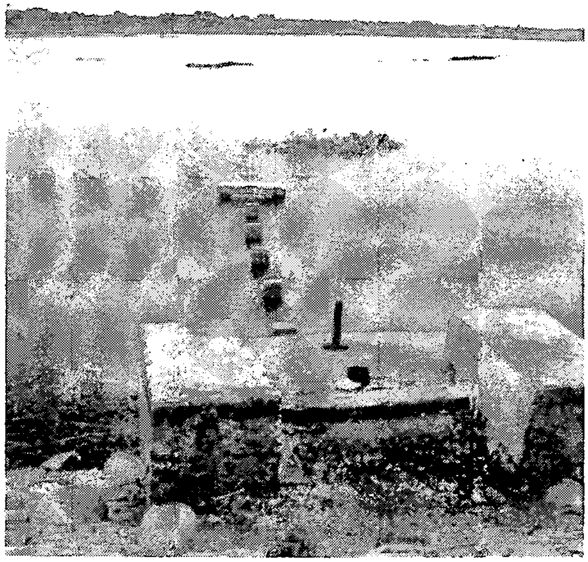
There is another side to the sluice preference. Farmers of Bairesagara and Vottadahosahalli tanks have been using the shutter type of sluice to its optimum. According to them, the shutter type of sluice provides the flexibility of partial opening. Once opened, the sluices in these tanks are kept open for the entire season like other tanks irrigating paddy in the region, but yet with a difference: sluices in these tanks are gradually opened. Especially in the paddy-growing season from December to May, when the atchakat has a mixed cropping pattern, the sluice of Vottadahosahalli tank is opened a little more than half for the first month for land preparation and transplantation of paddy. Later the sluice opening

FIGURE 4.14: An engineering line drawing of a sluice operating platform located in a water spread area (not to scale)



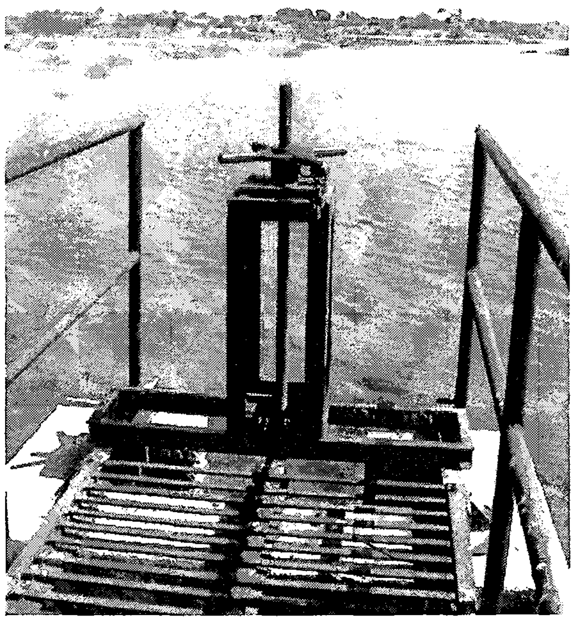
is reduced to two to two and half inches to adjust to the demands of mixed cropping. In Bairesagara tank, four inches of opening is adjusted to the demands. Opening of two to two and half inches is needed for the first month when paddy is grown in half of the atchakat and groundnut in the other half. But during low demand, after the transplantation is done, sluices are lowered a ring or two (on the threaded rod) and lifted again during the flowering time. Farmers usually follow the thumb rule to partially and precisely open the sluice to adjust the expected demand in the atchakat of mixed cropping, an opportunity that the shutter type of sluice provides.

FIGURE 4.15: Sluice operating platform relocated in embankment.



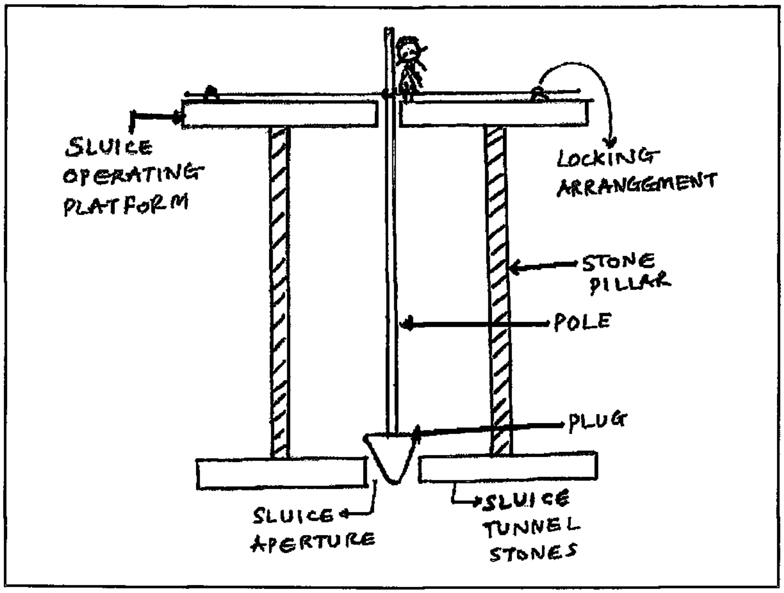
The plug and pole type of sluice can either be kept open to its full discharging capacity or closed. Theoretically, it can be opened and closed every day. However, as the apertures are located in the water spread area and lifting a plug needs skilled handling, it cannot be frequently done. This problem has been largely circumvented in some tanks after the PWD relocated sluice-operating platforms in the embankments and equipped sluices with threaded rods and gearboxes. (See figure 4.16). Theoretically, these sluices can also be opened and closed with measured precision but for the fact that such a precise lifting of the rod would not result in an equivalently precise opening of the sluice aperture because the conical plug lowered or raised does not ensure precise opening of the aperture. This is so because the plug and pole does not provide opportunity for the sluice to be opened or closed for a narrower difference in the amount of water discharged like the shutter type of sluice provides.

FIGURE 4.16: Threaded sluice rod.



Farmers of some tanks in Bellary and Dharwad have solved the problem of partial opening of the plug and pole type of sluice in different way and at different time. For instance, Savnur tank of Dharwad district from which irrigation is no more done now had the plug connected with an iron rod instead of a wooden pole. The iron rod had a few holes at intervals of a few inches. In order to keep the plug partially open, a wooden stick was horizontally inserted through one of the holes in the iron rod, rested on the sluice-operating platform and locked with iron rings provided in the platform. This way the iron rod was locked at a particular height to keep the plug partially open. Plug and pole sluices were similarly modified in other tanks in the region. If the iron rod had no holes, a stick was tied with the rod (or a wooden pole) with a piece of rope and rested on top of the sluice-operating platform, as schematically shown in figure 4.17.

FIGURE 4.17: A schematic diagram of partial opening of plug and pole type of sluice (not to scale).



I did not see any such arrangements because such an arrangements were made 20 to 30 years ago when sugarcane was popularly cultivated in tank-irrigated areas. Unlike paddy, sugarcane does not need irrigation every day. If the atchakat is partially sown with sugarcane and partially with paddy and much of the tail end with jowar, there is a gap in the timing for which irrigation would have been needed in different parts of the atchakat. The sluice in such a case need not be open to its full discharging capacity for the entire duration of the irrigation season. Farmers, of the tanks I studied, also informed me that even after sugarcane cultivation was stopped, since the early 1980s, this arrangement continued in some tanks. Most of the properly functioning tanks that I studied were attended by the PWD in the 1970s and plug and pole sluices were either replaced with the shutter type of sluice or fitted with threaded rods and gearboxes.

However, unlike farmers of Bairesagara and Vottadahosahalli tanks of Kolar district, farmers from Haraganur and Oblapura of Bellary district prefer the plug and pole type of sluice for two important reasons. Firstly, they think that the plug and pole type of sluice prevents leakage, although they agree that the plug and pole sluice cannot be opened for a precise amount of water to be delivered. But for a different reason they think the shutter type of sluice may become unavoidable. Usually the wooden plug is made from the wood of old tamarind trees because it expands only a little under water and is, therefore, less prone to cracking due to repeated cycles of expansion and shrinkage. Wood of a tree at least 30-40 years old is preferred to make the plug that is increasingly becoming difficult to find.

This may partially explain why PWD engineers preferred the shutter type of sluice even when they were most likely not aware of farmers' choices. Making a plug and pole type of sluice does not need much capital, more important is locally available skill and the right type of material, which may not always be available.

Institution of neerganti

Although the principle behind the institution of neerganti is embedded in the requirements of paddy cultivation, there is a difference in the way it functions across Karnataka. In the north, where only dry crops are grown in tank-irrigated areas, the institution more or less loses its substance. The prevalence of paddy cultivation alone does not determine its existence either. As explained in the previous section, the institution does not seem to have existed in tanks irrigating paddy in the wet region of Shimoga in the same way as it does in the southern maidan. In addition to the requirements of paddy cultivation, other tank designs (water availability pattern, method of water rotation and distribution, and atchakat layout) influence the nature of the institution.

The degree to which neergantis are involved in water distribution and the tasks they perform differ significantly in the northern and southern maidan of the mixed region. In Kolar and Bangalore, neergantis irrigate every paddy field as per the rotation schedule socially determined among irrigators in addition to the opening and closing of sluice/s. In Bellary and Dharwad, they open and close sluice/s, inform the water rotation schedule to farmers during each irrigation season and also ensure that water is taken as per the rotation schedule, but they do not irrigate every field. This difference is manifested in the number of neerganti persons needed to complete the task of irrigation in the entire atchakat. For instance, there are a number of neerganti families in the villages served by Hoskote and Budikote tanks from Bangalore district in the southern maidan. Guttahalli village of Hoskote tank and Unkunda village of Budikote tank have a whole colony of neerganti, namely 24 and 15 families respectively. Out of 24 neerganti families in Guttahalli village, three to four persons perform the task of neerganti each time paddy is grown in the entire atchakat. Each neerganti covers roughly 80 to 120 hectares of land. Hence for 800 hectares of total atchakat, 10 to 15 neergantis are employed as irrigators.

Amongst them, neergantis have a custom called *Bhagstru*. Bhagstru means that the right to do neerganti work is divided, sold and transferred among them. A great deal of internal negotiations take place in every village once the tank fills up and before the paddy-growing season begins to decide which family gets the turn to do the job. Furthermore, whether the rightful family will take the turn, sell it, transfer it or will divide it has a complicated genealogy. In both these tanks, irrigation is done during the day and night in the paddy-growing season once the sluices are opened. Depending upon the rotation schedule, fixed among the farmers from different parts of the atchakat and from different villages, water is rotated among different lands between day and night. A neerganti has to ensure that every field receives its share as per the rotation schedule.

The neerganti in these tanks also help in opening and closing the sluice/s at the beginning of the irrigation season. However, as the sluice/s are relocated in the embankment and closed and opened by persons appointed by the MID, opening and closing of the sluice/s is no more one of the important tasks of neerganti. Opening of sluice/s at the beginning of the irrigation season used to be a task performed by neerganti before the introduction of transplanted paddy in Kolar and Bangalore and when the sluice operating-platform was located in the middle of the water spread area.

There are two to three neerganti families in tanks of Bellary. Chitrampalli tank (100 hectares of atchakat) has three neergantis, whereas 280 hectares of atchakat of Hanshikere has one neerganti.

Haraganur with 200 hectares, Oblapura with 60 hectares and Chornur with 240 hectares of atchakat have one neerganti each. One of the main tasks of the neerganti in tanks from Bellary is to open the sluice/s in the morning and close them in the evening every day during the irrigation season. Neergantis in these tanks do not irrigate each field. All fields sown with paddy or with semi dry crops are irrigated by their owners or tenants. The main job of neerganti is to ensure rotation between paddy and non-paddy parts of the atchakat, although rotation between paddy and non-paddy crops is also largely maintained through atchakat layout. Semi dry crops are usually grown in the expanded part of the atchakat where paddy is not grown. Atchakat layout therefore largely sustains a differential pattern of cropping and water distribution in the atchakat of the mixed region. (This point is discussed in more detail in the next chapter). Neergantis, therefore, play a limited role in water distribution in the tanks of Bellary of the northern maidan compared to their role in tanks in Kolar and Bangalore in the southern maidan.

Accordingly there are also different norms of payment to neerganti in tanks from Kolar and Bellary. Neergantis conventionally are paid only a share from the produce of paddy in the mixed region, whereas there are no norms for the payment from produce of semi dry crops. However, the institution seems to have adapted to an extent to the changing cropping pattern in the atchakats of Bellary district; the new norms of payment from semi dry crops are emerging here. Even when sugarcane was grown in some tank atchakat a couple of decades ago, a share of jaggery was paid. Nowadays, farmers of Chornur and Haraganur tanks pay part of the semi dry crops but there are no norms for the payment, all depends upon farmers' will what they give or do not give.

The institution has been under great pressure in the tanks in Kolar district. The institution is not functioning anymore in a number of tanks, for instance in Ramasagara, Bairesagara and Vottadahosahalli tanks. In almost all tanks where it is still functioning, the neerganti services are called for only when the tank receives water up to the full capacity and when the entire atchakat is sown with paddy, which happens only once in three to four or even more years.

In tanks of Bellary, differential distribution of water between paddy and non-paddy crops is maintained by segregating paddy and non-paddy in different parts of the atchakat, whereas unequal rules of water distribution are sustained through the institution of neerganti in tanks of Kolar and Bangalore districts in the southern maidan. This may be because tanks in Bellary rarely have enough water for the entire atchakat to grow paddy, so only a small part of the atchakat is sown with paddy. Even when tanks fill up to full capacity, water is enough to grow paddy only in a part of the atchakat and semi dry crops are grown in the rest. As discussed in the previous section, other tank design elements such as the water distribution network and sluice operation are adjusted a great deal to mixed cultivation in the tanks in Bellary district. In contradistinction, in Kolar tank designs still revolve around the cultivation of paddy, which happens only once in three to four years. When paddy is grown, the institution of neerganti is instrumental in ensuring that (differential) water distribution rules are followed in the entire atchakat.

To sum up, the tank trajectory in the mixed region is interfaced between paddy and non-paddy cultivation. The transition from paddy to non-paddy cultivation is uneven in the mixed region, oscillating between the two extremes. On the one extreme, paddy cultivation and in the same guise even tank irrigation methods are completely abandoned, and on the other extreme, paddy cultivation remains pivotal in determining tank designs. In the vast middle ground, the battle is still on.

Tank Trajectory: Dry Region

The Deccan plateau of the northern maidan is representative of the dry region. The uniqueness of this region with respect to tank irrigation lies in the fact that there are not many tanks in this region owing to its historical and hydrological specificities, already discussed in the beginning of this chapter. Furthermore, tank designs in this region have not been subjected to the tussle between intensification of paddy cultivation and diversification of the cropping pattern. Paddy was never a main crop in this region, which may also be a reason for a lower number of tanks constructed before the British time. In some respects, tanks as a significant source of irrigation in this region emerged along with the opportunities of cultivating irrigated varieties of dry crops.

Three types of tanks can be identified in this region. The first type are the tanks that were constructed before the British period, such as Mamdapur, Kumutgi and Shirur tanks. It looks that tanks in the pre-British period were constructed either as leisure spots for the kings and his troupes (for example Kumutgi and Mamadapur) or to provide drinking water (such as Shirur tank). These tanks have now been provided with sluices to supply irrigation. Mamadapur small and big tanks were converted into irrigation tanks by the British, but Kumutgi and Shirur were provided with sluices by the PWD only in the last three decades. The second type of tanks in this region were constructed by the British, for example Muchkundi and Nandargi tanks. The third type is the tanks constructed in the last three decades, some of them are percolation tanks such as Aliyabad and Devanhippargi tanks.

Notwithstanding the total contrast in choice of crop between the wet and dry region, one thing that tanks in the dry region share with the wet region is the certainty of water availability. Only old tanks that have been converted into irrigation tanks face uncertain water availability. However, the choice of cropping pattern in irrigated areas more than the actual inflow of water in the tanks liberate farmers from facing a dilemma of whether there will be irrigation or not. Usually two cropping seasons are followed in irrigated areas: wheat and white jowar are sown in the kharif season for which irrigation from tanks is provided from October or November. Both these crops are sown before the tank receives water up to full capacity. In the summer, whether groundnut and cotton are grown or not depends upon how much water is collected in the tank. They are grown only if tanks have enough water. This means that the main irrigation season of kharif is not entirely tank dependent.

Tanks are relatively a new entrant on the irrigation front of this region. There are several other, conventionally followed means of land and water management that sustain agriculture in which tanks are not yet fully integrated. A fair deal of agricultural activities are organised around use of ground water tapped from shallow open wells and other land and water management practices that are discussed in more detail in chapter 8. In fact *bavis* (shallow and open wells), like their more recent counterparts of bore wells and tube wells in other parts of Karnataka, provide more opportunities in this region. Tanks in the dry region, to some extent like tanks in the wet region of Shimoga and Hangal, provide irrigation for the subsistence crops of white jowar and wheat, but other cash crops are irrigated with bavi water such as banana, onion, sunflower, mulberry and cotton. Unlike Shimoga and Hangal, where bore well irrigated crops are grown on dry land and not in tank-irrigated areas, bavis in the atchakat of this region, recharged by tank water, provide more opportunities than bavis outside the atchakat. However, a bavi supported cropping regime does not conflict with the tank irrigated one unlike in the case of the tank trajectory in the mixed region. This is so because tanks also recharge bavis, and thus in the dry region perform both as irrigation and percolation tanks.

The struggle in the tank irrigated area takes place around water distribution from outlets in the main canals. Most of the newly constructed tanks in this region do not have village-based authority, like the tanks in the mixed and wet region have. Thus, management and maintenance of the tanks are not effectively looked after. Neither do these tanks have socially and conventionally determined rules for distribution of water. In the absence of well structured, locally emerged social arrangements of water management, which in the wet and mixed region is highly hierarchical and discriminating for certain groups of farmers (further discussed in the following chapters), water management practices are less discriminating here but at times chaotic and conflict ridden. While in other parts of Karnataka, the MID's intervention in local affairs is considered a nuisance, farmers here, for example of Nandargi and Muchkundi tanks, have time and again contacted the MID to resolve their conflicts.

In my opinion, development of social arrangements for the distribution of water in tank irrigated areas and integration of tank irrigation in conventional methods of land and water management are the challenges tanks in this region face.

Conclusion

This chapter has outlined the diversity of tank designs in relation with the cropping regime followed in the irrigated areas. The intensification of paddy cultivation is a hallmark of struggle around tank infrastructure in the wet region. Farmers from the mixed region face a dilemma of "to be" or "not to be" – to cultivate paddy or to switch to semi dry crops – every season. In the chapter, I have attempted to map transforming and adapting designs on the face of intensification of paddy cultivation in the wet region and on the interface of paddy and non-paddy cultivation in the mixed region. Tanks in the dry region are a new entrant in the conventionally followed land and water management and agricultural practices. The dry region faces the challenge of integrating tanks into the local agricultural practices.

What I have not explored in this chapter is how within the limits of differences, social relations shape tank designs and how designs in turn shape a certain form of social arrangement. This remains a theme for the next four chapters.

The next four chapters focus on designs of four types of tanks. The tank irrigating paddy and dry crops in the northern maidan of the mixed region is the subject of chapter 5. Chapter 6 deals with a tank irrigating paddy from the southern maidan of the mixed region. Chapter 7 looks at a tank watering paddy and garden crop in the wet region. And chapter 8 discusses a new tank constructed in the dry region.

Notes

[1] In this historical era most of the tanks were constructed in what Stein (1980: 30-62) calls south India or south Indian macro region - south of the upper watershed of Karnataka on the west and Krishna-Godavari delta on the east - which excludes the Deccan plateau of northern maidan. Stein has further showed that there was a fundamental continuity between the eleventh and seventeenth centuries with respect to several important aspects of society and culture within the macro region. This continuing political system, he described as "pyramidal" or "segmentary" (Stein 1980: 367).

As discussed in chapter 2, tank irrigation played an important role in the formation of the cultural economy of the south Indian state in the macro region. Breckenridge (1985: 41-42) extends a similar argument for the Vijayanagara era (1350 to 1750 A.D.). This was a period of uncertainty marked by warfare, long distance migration and the expansion of settled agriculture in dry zone. This was the period when temples and tanks were linked together for creating, what she calls, social storage.

[2] Vijayanagara rulers were at constant war with Bahamani and later Adil Shahi dynasties of Bijapur until the fall of its royal seat in Hampi in 1565 A.D. When the tank construction activities were at their zenith in the south Indian macro region, the different localities were tied differently together in the regional polity in the medieval Deccan. Contrary to Stein's pyramidal, segmentary and decentralised political, religious and symbolic

order that linked localities with the central authority in the macro region, Eaton (1978: 85-89) described the Adil Shahi administration of the sixteenth century as a large and rationally organised civil bureaucracy on the principle of cultural syncretism. His kingdom was divided into several administrative divisions, either directly governed by the officer appointed by the King's office or hereditary tax officers appointed at the village level. In both the types of administrative divisions the tax was directly collected from the tenants (Fukazawa 1998: 1-10). The secular order of the polity, derived its economic power by sustaining military control over agriculturally rich river valleys such as the Richur doab and Dhone valley (Eaton 1978: 84).

[3] Although Palanisami refers to the lower watershed areas of Tamilnadu, the explanation is equally relevant for the upper watershed of Karnataka.

[4] The angle of retention is the side slope or gradient a heap of soil acquires in the natural form. For structural stability the embankment should not exceed the angle of retention for its front and rear slopes.

[5] The local bureaucrats, especially from the Irrigation and Revenue Departments, have been targets of the farmers' fury during these agitations. Their officers and files were burnt at times as part of the agitation, for instance in the Malaprabha agitation (Nadkarni 1987: 92). The government officers who came to attach the farmers' property to recover the due loans were hackled routinely, and were at times locked up following the strategies adopted by Punjab farmers. Many villages were declared as no-entry zones for the government officers (Assadi 1997: 58-63). Pitched battled were fought between the KRRS squad and government officers. At times some officers refused to enter certain villages (Assadi 1997: 62).

[6] In Shimoga district particularly, only 49.7 percent of the plots were held by owner-cultivators in 1961 (Manor 1989: 343). See Rajan (1981: 57) for further detail.

[7] The Hoskote tank of Bangalore district has received water up to FTL ten times in the last three decades according to what farmers from the atchakat told me. The tank needs six to eight metres of water to irrigate paddy in 200 hectares of the atchakat. Irrigation from the tank was provided for two years in 1998 and 1999, but prior to that no irrigation was provided from the tank for seven years. Similarly, paddy was cultivated in roughly 320 hectares out of a total 800 hectares of the atchakat of Budikote tank of Kolar district for five years before 1999, but prior to that water was not released for irrigation for eight years. The waste weirs of Vottadahosahalli tank of Kolar district overflowed four to five times in the last two decades. The tank needs at least six metres of water to irrigate paddy in 120 - 200 of the total 800 hectares of atchakat.

The tank has received 16 metres of water only four times in the last two decades that could be enough for the entire atchakat to irrigate paddy. Every third year, on an average, paddy is cultivated in roughly 200 hectares of Vottadahosahalli tank whereas the entire atchakat is irrigated only once in five to seven years. Some other tanks have a similar water availability pattern. Venkeshsagara, Korlaparti, Balareddykere, Kotekalluru and Kurgepalli tanks of Kolar district, all share a similar fate of having water available to full capacity once in three to four years.

[8] Once famous Hattimattur, Savnur and Navloor tanks of Dharwad district do not provide irrigation anymore. Irrigation from Hattimattur tank stopped around 20 years ago and from Navloor in the last decade. I was also asked to visit Guttalhalekere tank where irrigation stopped 60-70 years ago. Savnur stopped receiving adequate water around 30 years ago. Hattimattur and Savnur were once famous for betel nut and betel leaf grown in their irrigated areas.

[9] Farmers gave many reasons why irrigation had stopped from Savnur tank of Dharwad district. The halla that brought water to Savnur changed its course three to four decades ago; it has also silted and dried up. What finally rang the death bells, however, for this tank was the construction of several check dams by the Forest Department on the halla to reduce soil erosion. In addition, bore wells in the surrounding region have proliferated in the last two decades reducing overall water availability in all water bodies.

There are similar examples of dramatic change in water inflow in tanks from Bellary district. Chitrampalli tank stopped receiving enough water after eight check dams were constructed upstream on one of the hallas that brought water to the tank. There were 15 check dams constructed on one more halla that also fed the tank. The check dams were constructed under the watershed programme funded by the NABARD and the World Bank and implemented through the Agriculture Department and Panchayat officials of Karnataka. Although the check dams have reduced soil erosion and recharged the ground water, the tank is more or less ruined. Similarly, Hanshikere in Bellary has an uneven pattern of water availability. The British repaired the check dam on the upstream on the halla to divert water to this tank. It was further repaired by the PWD a decade ago. The PWD also cleaned the canal that brought water to this tank and increased water availability but some land in the catchment was submerged as a result. Subsequently, those farmers whose lands were submerged destroyed part of the check dam reducing water availability in the tank considerably. Farmers from this tank repaired the check dam once again to improve the water availability.

[10] It is a pure engineering question: if water in a tank is not used for

irrigation, would it not increase the rate of siltation? Silt would inflow with water but would have nowhere to go other than to pile up in front of the embankment if there is no outflow. Water would evaporate or disappear in the ground but silt would accumulate. If not used for irrigation, a tank may be ruined faster.

5

"Are All Farmers Equal?"

A Tank Irrigating Paddy and Semi-dry Crops in the Mixed Region

"... he (neerganti) dare say us no, if we ask for water!"
— A paddy-growing farmer.

Collective action theories of natural resource management, pertaining especially to south Asia, have paid attention to modes of collective action and sustainability issues but not so much to questions of equity among resource users (Lele 2002). Agrawal (2001: 1651) put is slightly differently. He points out that studies on the commons have focused on institutions around the management of common pool resources and external parameters that condition this management while actual use practices have received scant attention.

This chapter discusses how technology conditions the way the resource can be utilised. The chapter intends to show that the question of equity, who receives how much water and when, is not simply an issue of rule making and rule following that can be achieved by creating appropriate institutions. Rather, it is intimately related to the way technological designs create and sustain the patterns of (unequal) resource allocation and distribution.[1]

The Tank

The tank discussed in this chapter is around 600 years old according to a local legend. It is one of the important tanks in the region. The tank is located in the mixed region of northern maidan with an average annual rainfall of 600-650 mm. The tank supports mixed cropping of paddy and lightly irrigated crops. (See figure 5.1 for the approximate location of the tank).

According to local legend, a popular folk hero, who also constructed a few more tanks in the region, built this tank. It has acquired a unique place in folk literature. Farmers have retained much of the rich folk history as essential part of tank's identity.

The tank offers an attractive case study for the following reasons. Firstly, the tank has fairly robust physical structures that according to the villagers were innovatively built several centuries ago with a technique that would surprise modern engineers. (Refer to the following box for the details on the embankment). Apparently, the physical structures have not been seriously modified or reconstructed in the course of a few centuries. The tank has a fairly complicated mechanism to control water storage. It operates automatically based on the relative difference of the levels of the several discharging structures. (Refer the following box for details on the sluices and weirs). Secondly, at present, the tank provides irrigation to at least 560 to 600 hectares in a semi arid climatic region where there is no other form of irrigation available. Located on a hard rock area, the tank atchakat has no bore wells and hence no access to other forms of irrigation. Hence, the tank is a fine and working example of the ingenuity of traditional technical expertise, is small scale and can be considered ecologically and culturally well adapted owing to its local origin and long history. Finally, the most important reason for making this tank an attractive case to study is that farmers here have formed an Irrigation Organisation (IO) around 24 years ago entirely on their own initiative. The Irrigation Committee (IC) appointed by the Irrigation Organisation is in charge of, what members of the IC claimed, conflict free, equitable and efficient water management. Thus, what we have for the study is a traditional, culturally and ecologically suitable, community managed example of tank irrigation technology.

Cropping Regime

The tank supports mixed cropping of paddy, sugarcane and

Embankment

The embankment of the tank is 2625 metres long with a maximum height of 7.96 metres. The water-spread area is 404 hectares. The tank receives water from a combined catchment of roughly 120 square kilometres. The embankment apparently has experienced very little settlement even after loaded trucks have regularly passed over it. Villagers claim that the embankment has an internal wall made of a locally made binding material called *gachchu*. Gachchu is made by mixing sand, water, jaggery, lime and sap (which is extracted from a local tree) in a grinding mill. This may be understood as a pre-modern substitute for concrete. The wall inside the embankment – according to the villagers – has prevented undue settlement. Modern civil engineering, though, may not support such a claim. A near-concrete wall cased in earthen outer sides without a proper structural adhesion may behave like a foreign structure and instead of imparting strength to the embankment may become a reason for generating weak points, especially under pressure. However, the middle portion of the cross section of the embankment had no signs of settlement while the sides were relatively depressed. Villagers further claim that they have seen a similar wall inside the embankment of other tanks located nearby, constructed during the same historical period, which had breached.

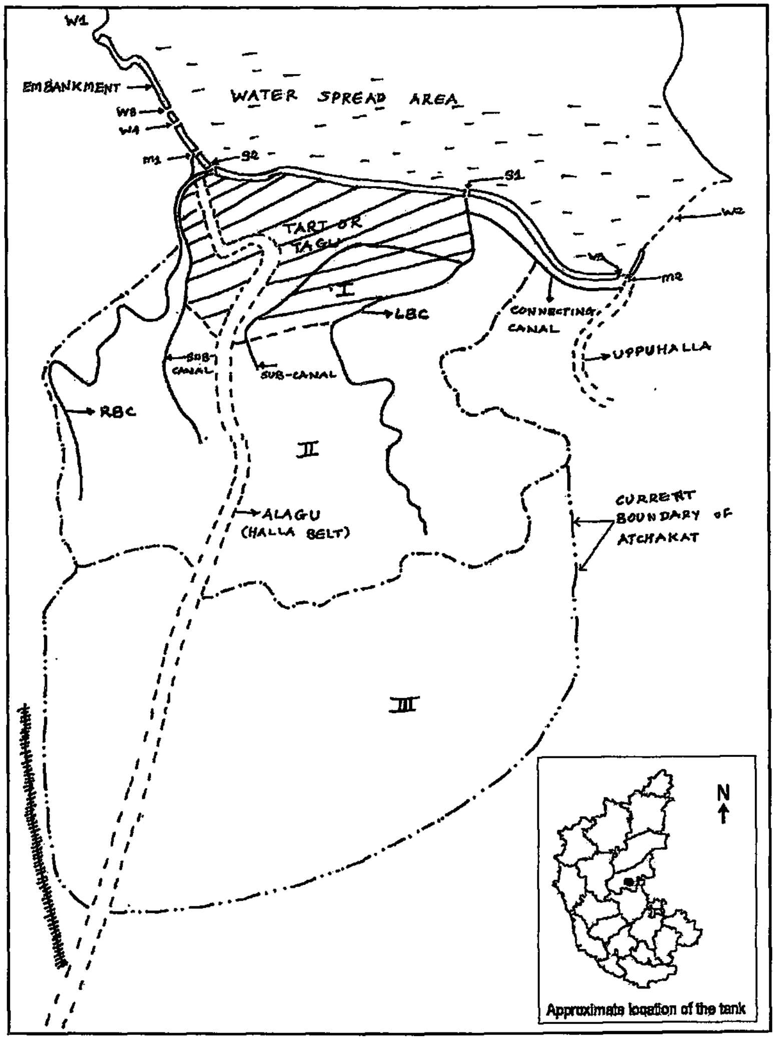
Sluices and waste weirs

The tank has five waste weirs and two sluices; they are shown as W1-5 and S1 & 2 respectively in figure 5.1. When the tank overflow, two waste weirs on the extreme edges – W1 & 2 – function at the same time; two others – W3 & 4 – function together if the tank collects more water than can be discharged by the waste weirs located on the edges of the embankment (W1 and W2). The fifth waste weir (W5) has a floodgate, known as madaga in the local language, which is connected with the LBC. There is one more floodgate or madaga (M1) on the other side of the embankment connected to the RBC. When the tank is full but none of the waste weirs is discharging water, i.e. at the full tank level, both sluices are submerged. At that time the madagas supply water to the RB and the LB canals. Both sluices are operated after the madagas stop discharging water.

Neerganti

There are two neergantis appointed on hereditary basis. One of each looks after water distribution in the land irrigated by one of the two main canals. They are paid a fixed share from the produce by the farmers.

FIGURE 5.1: A schematic diagram of the atchakat and approximate location of the tank.



I (Probable) size of the original atchakat when the tank was constructed. This patch is prime paddy land.

II Probable) size of the atchakat during the colonial period.

III Approximate boundaries of the present atchakat. Expanded alignment of canals is not yet plotted on the map by the MID, hence are not shown in this map.

groundnut during the main irrigation season that begins in November or December. Mixed cropping implies a discrepant need of quantity and timing of irrigation water and hence is more likely to create conflicting situations. The crucial question is: if the tank has water enough only for some to cultivate paddy or sugarcane, then who are permitted to cultivate these crops. The Irrigation Organisation (IO) and Irrigation Committee (IC) have a crucial role to play here.

The tank generally receives water up to full tank level between early July and mid October or latest by November and December. According to farmers, the tank overflows once in three, four or even seven years. The cropping pattern in the atchakat is adjusted according to three possible scenarios of water availability in the tank: 1) If the tank fills up to a level which results in waste weirs and madagas overflowing, irrigation is invariably provided. 2) If the tank fills up only up to the full tank level, water is enough for cultivation of partial wet and semi dry crops for a period of nine months. The IO then becomes active and irrigation is provided as per the rules laid down for mixed cropping of paddy and non-paddy crops in the atchakat. The IO becomes active only when the tank receives water up to the full tank level. 3) If the tank receives less water than that of the full tank level, water is not released for irrigation. The tank usually receives water every year for the mixed cropping for the period of three to six months.

Water availability in the tank is measured against the level of the step up to which water reaches during the irrigation season. There are 27 steps in front of the small temple on the embankment used for approaching the water-spread area for *puja* (worship) and other ritual performances. Farmers had slightly discrepant views with regard to measurement of water availability in the tank vis-à-vis the step at which water should have reached. Some head reach farmers and members of the IC told me that when water reaches the 20th-22nd steps (counted starting from the bottom), the waste weirs on the extreme edges start overflowing. The tank continues overflowing until water reaches the 18th step when two of the madagas start operating and when both sluices are still submerged. At that time, both canals are connected with the madagas and land is irrigated for a short while with water discharged from the madagas. Water up to the 16-17th steps is stored in the tank once all the waste weirs and madagas stop discharging. Sluices then become operational. This is considered as full tank level. However, curiously, when water is at around the 16th step, farmers call it *aregere*, which means tank half full. But actually this is the maximum level at which water can be stored in the tank and hence it is also called full tank level.

In what follows, I give a broad account of the pattern of water availability in the tank based on my fieldwork during late February and early March, 2000 during the main irrigation season when water was supplied from the tank. The tank usually carries a part of the storage of one season forward to the next. Therefore, I also discuss the water availability pattern in the tank for the three years preceding my fieldwork.

In 1998, the tank had received more water than full tank level and irrigation was provided for one season that ended in April 1999. At that time, the tank had water available for three months to support hybrid jowar and some paddy in the monsoon season. The tank again received water up to full tank level in 1999 so irrigation began in December, the season during which I did my fieldwork. By the end of February 2000, the tank had water for four months when there was need for only three months. That means the tank had bright prospects to support paddy and semi dry crops for the next season too. In 1996, the tank received water a little less than full tank level; irrigation was nonetheless provided. But at the end of the cropping season in April 1997, the tank had only one month of water left for hybrid jowar. In the following monsoon the tank did not receive enough water and hence only semi dry crops were grown in the entire atchakat in the main irrigation season beginning in November-December, 1997. Typically, if the tank fills up to full tank level, water is available for six months (November-December to April-May) of mixed cropping and for hybrid jowar and some paddy for the next three months. But if semi dry crops are grown in the entire atchakat after the tank fills up to FTL water is available for three seasons.

During one of the initial discussions I had with members of the Irrigation Committee, they informed me that if by the second week of December the tank has received water up to 15-16 steps, a meeting of all farmers is called and as per the rules each farmer is given instructions about the cropping pattern and rotation schedule. They also informed me that there was a high degree of rule adherence in the atchakat and that conflict free water distribution was achieved in the last two decades because of the management by the IC and IO. Members of the IC also informed me that rules about water distribution and cropping pattern were even written down.

On hearing this, I requested them to show me the written rules. I was hoping to read at least a couple of pages of written rules. It was an anti-climax when after a couple of days of searching, the members showed me one line written in the Irrigation Organisation's minute book of 1992. The sheer length and simplicity of the rule was a disappointment given the fact that I had expected a labyrinth of rules dotted by a complex combination of "ifs" and "buts".

The magic line in the minute book read, "all farmers are allowed to grow whatever they want, but paddy would be given water once in 8 days, sugarcane once in 15 days and groundnut once in 15-20 days." Later, several farmers told us that there was nothing new about this rule except that it was penned down. The elderly farmers recalled that the rule had been in operation for at least two generations and many surmised that it must have been applied for many more generations.

The written rule does not provide much insight into how the atchakat can support mixed cropping when the tank does not receive enough water for all farmers to grow wet crops. Since the rule allows all farmers to grow whatever they want, all farmers simply may plant paddy and demand irrigation once in eight days for which the tank would not have enough water. The rule, therefore, looks insufficiently framed to cover all possibilities of cultivation in the atchakat. Nevertheless, it eventually proved a key to understand how one line can make everything (look) fall in place. The rules of water allocation between paddy and semi dry crops and accordingly water distribution among all the landholders in the atchakat are imprinted on the landscape of the atchakat, not written on paper. A particular social and historical context has shaped the atchakat layout in such a fashion that a one-line rule is enough for an orderly water distribution pattern in the atchakat.

Does soil/land have a history?

Various parts of the atchakat are known by different names; each refers to a distinct type and nature of soil and level of fields. As shown in figure 5.1, the middle patch in the atchakat is called *alagu*, which is the original path of the seasonal rivulet or halla that supplies water to the tank. Around 20-24 hectares is alagu land. This part remains under water when the waste weir(s) are discharging. The entire atchakat drains into the alagu. Hence, it always has seepage cum drainage water when the atchakat is irrigated. Even when the tank has not overflowed for several years, this part may still have enough moisture to cultivate sugarcane by lifting water manually from small dug out ponds. Farmers, with land in this part of the atchakat, invariably cultivate two or three crops of paddy when irrigation is provided for one season and sugarcane when irrigation is not provided. Practically no other crop can grow here. During the irrigation season, the lands in this part do not need irrigation as drainage from both sides of the atchakat would be more than necessary. Hence, these lands are not part of the rotation schedule imposed by the IO. Nor do the landowners here pay any irrigation charges collected by the Irrigation Committee.

The land situated at higher level than the alagu land is called *tagu*, which means (paradoxically) lower level land. This land receives sufficient seepage from the canals when irrigation is being provided in the atchakat and during the time of heavy rain. Many farmers told me that when the tank has water at full tank level, this part stays wet; i.e. it receives subsurface moisture. Otherwise, it receives irrigation once in eight days as per the rules, but in reality more often than once in eight days (as discussed later). The landowners of this type of land pay Rs. 10 per year per acre (0.4 hectare) to the IC. The type of soil here is sticky clay, which is considered especially suitable for paddy. The nature of the soil in this part - upper crust fine, black and clayey - compared to red and mixed sandy soil in the other parts of the atchakat suggests that paddy must have been cultivated here for a long period, perhaps for several centuries.[2] This type of land is also called *tari* or paddy land. For the last 20 years, rain-fed hybrid jowar has also been grown here in the rainy season, but many farmers uproot the jowar and plant paddy if there are heavy rains. Much of this land is located close to the embankment, although some patches exist all over the atchakat. There is around 100 hectares of tagu or tari land.

A small chunk of tagu or tari land exists in the tail end of the LBC. The land here slopes away from the LBC towards the edge of the atchakat whereas the rest of the atchakat slopes from the sides towards the middle. LBC and RBC run on the higher contour at the edges of the (perhaps original) atchakat. The land in the tail end of the LBC was brought under cultivation about four decades ago. A group of farmers, displaced by a dam constructed nearby, mostly Lambanis (a lower caste) and Muslims, extended the then existing LB and RB canals, cleared the land and started cultivating it. A part of this newly expanded land on the LBC side is at a lower level and hence receives enough seepage to grow paddy. However, the Minor Irrigation Department and the Irrigation Organisation call this land as *khushgi* land and charge them at a higher rate than for the tagu land, i.e. Rs. 50 per year per acre (0.4 hectare).

The land type called khushgi is actually a mode of classifying land rather than a descriptive category. It has multiple meanings; each invokes a different history. To start with, it is not a Kannada word, but an Urdu word meaning dry land. According to the farmers whose ancestors served as village servants, the colonial officers first coined this term to classify land in the atchakat that was meant for non-irrigated crops. There were three types of land in the atchakat during the time of the colonial administration. The first type was the land where two crops of paddy were allowed to be grown, which was around 15 hectares. This type of land belonged to Shanbhoga, Patel and Brahmins. The second type was the single crop land on which sugarcane or groundnut were grown, which was around 80 hectares. The remaining 120 hectares was khushgi land, which was not permitted to have tank water.

Some farmers who owned land at a higher level on the RBC side told me that some patches of land in the atchakat might have been at a higher level at the time of the construction of the tank – almost six centuries ago. This land was known as *valadi* or *bagadi* land in the local language, and subsequently came to be known as khushgi land. During the course of six centuries, this land has been levelled and now much of it can effectively take water from the canals, but owing to its historical status, the land is still considered khushgi and charged at a higher rate than other land. Finally, as per the official position of the Irrigation Organisation, khushgi land is the land for which no payment of water cess to the Revenue Department is made. The Irrigation Organisation charges a higher rate for this land because the MID does not recognise is as localised atchakat.[3]

So, all the land that is not recognised by the MID as localised atchakat – the land that is newly cultivated by new settlers, the higher patches that exist in the middle of the otherwise localised atchakat and the land that was not allowed to have water from the tank during the colonial period – are termed khushgi land. It is difficult to say how much khushgi land exists but the Irrigation Committee once argued that the tank had 750 to 800 hectares of actual atchakat of which, as per the official MID records, only 203 hectares was localised/registered atchakat. If one accepts the Irrigation Committee's figures, then at least 550- 600 hectares is khushgi land.

The fourth type of land, namely valadi or bagadi land, some of which is classified as khushgi land, is at a higher level than tagu or tari land. This type of land has red sandy soil. Water cannot stand for more than a day on this land and hence this land is considered suitable only for groundnut, hybrid jowar and sometimes sugarcane. Irrigated paddy is rarely grown on it because it would need water almost every day.

The riddle of how mixed cropping is managed in the atchakat with the help of a one-line rule can be partially solved now. The tagu land, which is part of the localised atchakat, is the most favoured land historically, is the finest quality of paddy land in the atchakat, is located close to the embankment in the head reach or in the alagu and receives considerable seepage and irrigation (officially) once in eight days. This land has become suitable for paddy cultivation because it was favoured for irrigation during all the previous historical regimes. This land can cultivate paddy with less frequent irrigation compared to other land in the atchakat.

Paddy cannot be grown on valadi or bagadi land if irrigation is not provided every day. Sugarcane and groundnut are grown on this land, which receive irrigation once in 15-20 days. But khushgi land is prone to a serious identity crisis. Lower level tari land belonging to the khushgi category exists in the tail end of both RBC and LBC. Although this land should, according to the rules, receive irrigation once in eight days, tail end farmers on the LBC side have to go through several rounds of negotiation among themselves and with the neerganti in order to receive adequate supply of water during the peak season, unlike their head reach, paddy-growing counterparts. The farmers on the RBC side are in a relatively better position compared to the LBC side. They can grow one crop of paddy if the tank has received water for six months, while farmers in the head reach can grow two paddy crops a year.

I tried to find out the caste wise land holding pattern vis-à-vis their location in the atchakat. There are 543 registered (localised) landowners as per the water cess demand list of 1992-93.[4] With the help of one of the IC members, whose family has been living in the village for three generations, I found out that out of 543 landowners 71 are Lingayat or Shettars – the higher castes after Brahmins. There are no Brahmin landholders in the atchakat. The Lingayats are a politically powerful, landowning caste in Karnataka, whereas Shettars are a money-lending caste who undercut Lingayat dominance at the local level (Manor 1989: 334). Together they hold 42 hectares of localised atchakat as per the water cess demand list. The challenge was to identify in which part of the atchakat their land is located. On the basis of the survey numbers mentioned in the water cess demand list and with the help of the Irrigation Committee member, who roughly gave me an idea in which part of the atchakat the land may exist, I located a majority of the plots on the survey map prepared by the Revenue Department. But, it wasn't easy; survey numbers looked more like mustard seeds than numbers on a barely readable ammonia map. Hence I could not locate all the survey numbers, nonetheless the picture is relatively clear.

Out of the 71 higher caste farmers holding totally 42 hectares in the localised atchakat of 203 hectares, 58 (82 percent) hold 26 (62 percent) hectares of prime paddy land located either in alagu or in tagu. That means that the majority of higher caste farmers hold prime paddy land. It may even be possible, if I had successfully located positions of all lands on the map, I would have found that all higher caste farmers hold prime paddy land. However, the other side of coin is that the lower and backward castes not only possess, in aggregate, a higher amount of land in the localised atchakat than higher castes, but they also posses a higher amount of land in even tagu and alagu. (See table 5.1). That means that numerically they dominate the landholding in the tagu, tari and alagu – the prime paddy land in the atchakat.

What impact could such a landholding pattern have on the nature of irrigation organisation? Janakarajan (1997: 256) found, in his sample tanks of Tamilnadu, that a large-scale land transfer to lower castes and a change in technical, institutional and physical factors have resulted in the disruption of traditional irrigation institutions. In his study of the Kaveripakkam tank in Tamilnadu, the lower castes of Harijans and Pillais have acquired land in the tail end while land in the head reach belongs to higher caste of Naickers (Janakarajan 1997: 258). The conflict is, therefore, as much between the higher castes and the lower castes, as it is between the farmers who occupy favourable lands in the atchakat and those who do not. Although in his case both categories largely overlap.

TABLE 5.1. Landholding pattern in the localised atchakat of the tank

Landholders	*Own localised atchakat (total 203 hectares)*	*Own alagu/tari – paddy land (total 124 hectares)*
Lingayat and Shettars	42 hectares	26 and more hectares
Lower and Backward castes	161 hectares	98 or less hectares

In my case study tank, most of the favourable patch belongs to lower and backward castes. The non-favourable, non-paddy patch is also largely owned by lower and backward castes. Whose agendas then influence the formation and functioning of the IO and IC? Actually, the paddy growing farmers, historically from the upper castes, but now also from lower and backward castes, are favoured by technology and by water distribution practices. Paddy-growers priorities dominate the formation and functioning of the Irrigation Committee and Irrigation Organisation, a point elaborated below. Even the rotation schedule during irrigation seasons is implemented by keeping the need of paddy growers at the forefront. Paddy growers from various caste and class backgrounds share the best part of the atchakat, are benefited from the water distribution rules, and shape agendas of the IO and IC. Paddy growers emerge as an independent category cutting across traditional caste and class boundaries. Technology has thus dissolved traditional boundaries that determined resource distribution and has created its own. Creating institutions with higher representation of marginal groups, though necessary, may prove insufficient to ensure democratic utilisation of the resources. Discriminatory distribution practices are also mediated and institutionalised through technology. A fair and just distribution of the resource can hardly be achieved unless the designs of the technology are decoded to disentangle the bias.

Formation of the Irrigation Organisation and Irrigation Committee

Another question follows from the above discussion is why would there be a need to have a formal IO if the nature and type of land

and design of distribution structures can effectively control differential water distribution practices? Rules to restrict and control water allocation between paddy and non-paddy crops in time of scarcity have existed after all for at least two generations without a formal organisation. The formal irrigation organisation came into existence only about two decades ago. The answer to the above question is probably that farmers did not organise primarily for regulating water distribution. In fact, water distribution was already fairly regulated and sustained for a long time. A mixed cropping pattern was and is followed in the atchakat of many tanks in this region and equally stringent rules for water distribution also exist. However, an active farmers' organisation does not necessarily exist in all tank-irrigated areas.

Unlike what Wade has argued[5], farmers of this tank did not organise to manage scarcity alone, although it played a role. I was told that in 1977 the tank overflowed after almost seven years of relative drought and many farmers planted paddy. As paddy was planted that year after a long dry spell, a large part of the irrigation water was lost through deep percolation because the soil had acquired a relatively high level of permeability when semi-dry, lightly irrigated crops were grown in the previous years. In spite of the strict water distribution rules, the tank was emptied in less than six months. As a result many farmers lost their paddy entirely. This experience prompted the influential farmers to find a more permanent solution to unreliable water availability in the tank.

Many influential farmers who became members of the first IC in fact organised to get an abundant supply of water rather than to manage scarcity. They were motivated by the experience of farmers of the irrigated area of a nearby dam. As some members of the Irrigation Committees described it, farmers from the dam area take "paddy after paddy after paddy", possess 2-4 hectares of land and can afford to own a tractor, whereas all farmers from this tank atchakat are small and marginal.[6] The first president of the Irrigation Committee told me that when the Irrigation Organisation was first formed in 1977, eleven wealthy and influential farmers from the Lingayat and Shettar castes were chosen deliberately (in fact they chose each other) to form the first IC because they could afford to travel to the nearby city and to the capital of Karnataka in order to lobby politicians and interact with relevant government officers. Thus, the first Irrigation Committee was formed with a clear purpose: to lobby for a scheme to lift water from the nearby dam to this tank.[7]

What is the level of water shortage the lobbying farmers have been trying to compensate? The water scarcity in this tank atchakat is more a result of enhanced use than hydrological. Although at present the tank receives water up to full tank level only once in three years on average, the expansion of irrigated area in the last four decades and more importantly the differential cropping pattern – the mixed cropping of paddy and semi dry crops – have made scarcity more a function of the water utilisation pattern than the result of reduced water availability due to ecological or hydrological changes in the catchment. Many elderly farmers remembered that the tank used to retain water for seven years once it was filled when they were young. However, at that time the atchakat was possibly limited to only the paddy growing area, and much smaller in size than the present paddy growing area. The extent of paddy growing area at that time was perhaps was linked to the hydrological limits of water availability in the tank. During the colonial period too, the extent of water availability seems to have corresponded with the social limits the colonial government exerted on the size of the irrigated area, which perhaps also corresponded with the limits exerted by local elites in earlier times.

It is necessary, therefore, to ask how scarcity is first generated and how it is compensated. In the following sections I explore who may benefit from the Irrigation Committee's efforts to receive water from the dam reservoir.

Over the span of two and half decades, the Irrigation Committee's domain of legitimacy has grown much beyond lobbying for the lift irrigation scheme. The Irrigation Committee has succeeded in formalising water allocation and distribution rules. The rules for differential water allocation to different types of lands in the atchakat have existed for a couple of generations if not more, but the Irrigation Committee gave them formal legitimacy and further institutionalised them. It formalised the rule that the sluices are opened in the morning at 7.30 a.m. and closed at 3 p.m. in the afternoon during the irrigation season. Further, it formalised the rule that the neerganti had to take permission from the president in case night irrigation was provided during the peak season. Mondays and Thursdays are observed as irrigation holidays. The key-spanners to open both sluices, which were earlier with the MID, are now kept at the president's house. The Irrigation Committee also set the procedure to identify and impose penalties on defaulters. Collection of irrigation charges and managing accounts is one of the important activities of the Irrigation Committee. Although the posts of neergantis are still hereditary, and although farmers directly pay them in the form of part of the produce, neergantis remain accountable to the president of the IC.

The Irrigation Committee has been reconstituted only once after its formation. As already stated, influential farmers deliberately chose each other as members of the first Irrigation Committee, even before the IO existed. At the time of the reconstitution, a representative number of influential farmers from each of the three villages that benefit from the tank were selected as members.

Everyday Forms of Rule Adherence

Although the Irrigation Organisation and Irrigation Committee institutionalised and formalised water management practices, a large part of the unequal water distribution in the atchakat is also supported and sustained through designs of atchakat and distribution structures. Technology, in other words, not only organises rule adherence but also creates conditions for conflict free environment. One can hardly quarrel with the physical structures for being partial. And if the legacy is inherited through generations, it is even more difficult to do so. This sustains the discourse that the village is like a family and all farmers are equal. There were no conflicts about water distribution and if there were any differences they were settled through mutual adjustment. The discourse further generates the belief that once water from the near by dam is lifted to this tank, all problems regarding water management in the atchakat will be solved. The discourse on equality thus has always maintained that all problems with regard to water management were entirely and only due to the lack of water. The following discussion further details the argument that much of rule adherence to the differential distribution of water in the atchakat is a direct function of the tank designs.

Lack of conflicts

The only incident of conflict that the farmers repeatedly mentioned was a prolonged tussle between the first president of the Irrigation

Committee and the then panchayat president on the issue of extra charges collected from the khushgi land. The IC president was from a higher caste and from what is described as the most influential family in the village while the then panchayat president was from a lower caste but relatively influential and wealthy family. The then panchayat president along with a couple of supporters opposed the unequal collection of irrigation charges and as a sign of protest disobeyed the irrigation water distribution rules a few times in spite of repeated warnings from the neerganti. He was then asked to pay a penalty, which he refused. The dispute was not resolved and at one point MID officials were invited to intervene. They apparently instructed the defaulters to pay the penalty and advised them to adhere to the rules, which they did not. Finally, a general body meeting of the irrigation organisation was called in which the panchayat president agreed to pay the penalty on the condition that the president of the IC would resign and a new IC formed. The general body agreed; the then IC was dissolved and a new committee was formed.

Non-paddy growers, more specifically the khushgi landholders, had a varied response to this tussle about higher charges paid by them. I spoke to a group of landholders at the tail end of RBC and LBC who grow semi dry crops and pay higher charges to the IC. Farmers from both groups felt that the disputing farmers actually were not fighting about the higher charges. A group of six farmers, all from lower castes, either sharecropping tari land of influential farmers or having khushgi land in the tail end of LBC, told me that none of them had attended the controversial general body meeting. The sharecropping farmers had no choice as the landowners attended the meeting. Others said they had something else to do and a couple of them did not say anything. When I asked whether they knew that higher irrigation charges collected from the khushgi land was the main agenda of the meeting, they disagreed and said it was all about the power struggle between the big farmers.

The discussion later focused on the routine water rotation operations. The group of tail end farmers first took the official position of the IC that usually a meeting for all the farmers is called to fix the cropping pattern and rotation schedule before the main irrigation season starts in November or December. When I asked them whether they regularly attend these meetings, they said, "no, some farmers do." They said they do not attend because they would have already sown their seeds (groundnut or maize for khushgi landowners and paddy for the sharecroppers) if the tank had collected water for more than six months, i.e. at the level of 16-17 steps, before such meeting actually would take place. When I asked them about the fixation of the rotation schedule, they said that after each farmer is given water first time in an irrigation season, the neerganti would write down his name in his little notebook against the date and exactly after a minimum of 15 days his next turn would be allocated. I then asked whether they usually received water exactly after 15 days. They answered that water generally did not reach their lands as per the rotation fixed in this way. Later they contradicted their earlier account by saying that meetings were rarely organised at the start of the irrigation season. The neerganti might discuss the rules with some farmers but there were no proper meetings. The question then was how the rotation schedule is fixed then. Last year one farmer lost a substantial part of maize in his land because he received only one wetting a month when his land would have needed more. He got only eight bags per acre instead of 20 if there was good irrigation. This year in spite of the tank having water for more than six months he decided to keep his land fallow. One of the farmers' lands is adversely sloping towards alagu, like part of the tail end of LBC does. As water quickly drains, his land with groundnut needs water once a week when he got it only once a month. Despite these problems, there were no conflicts about water management, they said. It was all mutual adjustments and sometimes if needed night irrigation was done, they concluded.

The discussion with the group of tail end farmers suggests that there is more to conflict free water management than what one encounters in the first instance. It is my interpretation that this group of tail end landholders by refusing to acknowledge that the controversial general body meeting and the dispute between the influential and leading farmers in the village were about the unequal charges collected from the khushgi land, also denied to acknowledge that the leadership was seriously concerned about their problems. Furthermore, tail end farmers, by calling the disputing farmers as big farmers, were indirectly challenging the rhetoric of equality actively promoted by the leadership. Although tail end farmers did not directly criticise the role of the leadership in water management, nor declare their grievances about water distribution practices openly, their responses were suggestive that a conflict free environment may not be the same as fair and equal water distribution practices.

Many farmers confirmed that meetings hardly took place before the beginning of the irrigation season. Location and level of the land would be the main determinants of the cropping pattern. A major decision regarding whether irrigation would be provided or not needs to be taken every season depending upon water availability in the tank. If the tank has received water to the level of the 16th step, farmers planted their seeds before any meeting is called to inform them of the cropping or rotation pattern. There could be defectors who in spite of having khushgi land may sow paddy, although I was told that that rarely happens.

A number of meetings do take place, however, during the peak irrigation season but only amongst khushgi and tail end farmers and the neerganti. A great deal of negotiation usually takes place on the rotation schedule in these meetings. Given the discharge capacity of the canals and different needs of irrigation for different crops, water is rotated among different patches in the atchakat. According to the modified rule, the farmers who have land in patches need to be irrigated on a particular day are asked to remain present on the embankment at the sluice opening time – between 7 and 7.30 in the morning. Only when a number of farmers gather on the bund is water diverted in the main canal towards their lands. Once it is decided which patch in the tail end would receive water, the whole group travels with the neerganti through the atchakat, some watch, others help the neerganti and his assistant close the other outlets. Another bunch of farmers might be waiting at the place from where water would finally be diverted to one of the tail end patches. Once the decision has been made with regard to which patch would be watered that day, the neerganti then convenes a meeting under the tree near a temple in the middle of the atchakat for further negotiation. When there is scarce water and too many contenders, the neerganti's job as a negotiator becomes crucial. He cajoles those who demand assurance about their turn, promises night irrigation to others, convinces some farmers not to leave the outlets open after completing the irrigation, apologises to those who complain about the delayed rotation, and explains to yet others why rotation is delayed. I witnessed that during one such meetings, a khushgi farmer persuasively questioned the neerganti why his groundnut had not received water for more than two weeks and demanded to know when his turn would arrive. The neerganti answered, "can't you see that paddy is drying; can't you wait for a couple of more days? Paddy will die if not irrigated but nothing will happen to your groundnut." The neerganti's negotiations include justifying the decisions and preferences he does not make.

FIGURE 5.2: Tail end farmers negotiating with the neerganti (and posing for the photograph).

Apart from the negotiations between the neerganti and the group of tail end farmers, there were also parallel negotiations among paddy growing farmers on the LBC tail end. As already stated, these farmers are mostly Lambanis and Muslims from the same village, who were displaced by the nearby dam. This group of farmers face serious water shortage unlike paddy growing farmers of the head reach. These farmers negotiate among themselves about the timing of irrigation during the peak irrigation season when night irrigation has to be provided. Some farmers, who had a turn during the day, preferred night irrigation. They exchanged their turns and informed the neerganti. In another case, the whole patch decided to postpone their turn to the next day and allowed farmers of the other patch to irrigate on that day. Some of these negotiations had a complicated trajectory of give and take, of interdependence and sometimes of conflict too.

The rotation schedule had been considerably delayed when I did my fieldwork at the peak of the irrigation season. The neerganti explained that there was higher percolation through some patches and that some lands were sown with crops that needed more water. When I did my fieldwork, irrigation was provided from the tank for the third consecutive season. Paddy was grown in the atchakat in the previous two years too and hence there was no reason for the higher percolation than usual. There was nothing special about these negotiations and delay in rotation. The tail end and khushgi farmers have to struggle to receive water in their lands every season irrigation is provided from the tank.

The neerganti, on the other hand, need not meet head reach, paddy-growing farmers at all. A paddy-growing farmer typically makes a cut in the main or the sub-main canal with which his/her plot is connected and irrigates his/her land once in four to eight days. Although officially paddy land is supposed to be irrigated once in eight days, many farmers contended that all paddy land in the atchakat is irrigated once in three to four days. Accounts are not kept about how often and when paddy-growing farmers received water, but usually paddy-growers face no shortage of water for other reason that they often take water out of turn. For instance, once when I was walking with the neerganti through the atchakat, he found that one of the members of one of the influential families of the village was taking water out of turn to the paddy field. That day water was diverted to one of the tail end patches. The neerganti instructed the person to stop taking water, closed the cut made in the canal and put his seal on the mud surface (more on the neerganti's seal follows). Later, when I met the concerned family member independently, I was told that the neerganti stopped the water flow due to my presence. "He dare not say no if we ask for water!" was the statement that followed. There may be some paddy farmers who take water even when it is the tail end turn for irrigation. The neerganti usually does not stop them unless an outsider inquiring about rules for rotation is walking along with him.

Thus, not only does the atchakat topography support unequal water distribution in favour of certain lands and crops, but the rotation rules also favour paddy land. The lack of conflict with regard to water management does not imply that all is well with water distribution. The atchakat topography permits the cultivation of paddy only in some parts; the rest is cultivated with less remunerative crops, implying a layer of discrimination. One may argue that this layer of inequality is unavoidable given the mismatch between the size of the atchakat and the tank capacity and the erratic pattern of water availability. The second layer of discrimination is with regard to higher charges paid by khushgi and tail end farmers. Despite paying more, khushgi and tail end farmers have to go through rounds of negotiation among themselves and with the neerganti every time water flows in their lands. Paddy farmers, on the other hand, get assured irrigation. The discourse on the high degree of rule adherence and conflict free water management camouflages the fact that for some getting water to their lands involves lengthy negotiations while for others it simply requires making a cut in the canal.

A lift irrigation scheme will solve all problems

A general opinion that has found wide currency among the farmers is that once a lift irrigation scheme is sanctioned by the government, water availability in the entire atchakat will uniformly increase. Farmers also believe that once the lift irrigation scheme is sanctioned, they will be free of the demanding process of negotiations for water. The design of the distribution structures, however, suggests that the benefits of enhanced water availability in the tank may not be equal.

The main canals in the atchakat do not irrigate all fields simultaneously; they irrigate only a patch of fields at a time. Meaning, the supply (at full carrying capacity) is rotated among different parts of the atchakat. Discharge capacity of canals hence needs to be enough to rotate the supply and irrigate a certain patch of the atchakat at a time. Canals cannot provide simultaneous irrigation to all land as this would require a higher carrying capacity.

The limited capacity of the canals is why rotation among different patches in the atchakat is unavoidable. The limited design capacity of the canals is further reduced for to two reasons, both of which make rotation further inevitable. First, in this tank atchakat, only the first km of LBC and half a km of RBC are lined. There is a heavy loss of water from canals because they are silted up and there is vegetation grown inside them.[8] Secondly, the canal sections have been heavily encroached upon as a result of the intensification of cultivation in the atchakat. This has reduced the thickness of the canal walls, which causes a high level of seepage. The neerganti also told us that the sluices could not be opened entirely even if the water is available in the tank because the canals might overflow. Even during peak demand the neerganti does not fully open the sluice.

Given the current capacity, the RBC irrigates around 5-6 hectares and the LBC around 10-12 hectares in a day according to the neerganti's calculations. At present, the RBC irrigates approximately 200 hectares and the LBC irrigates 240 hectares (according to farmers and the neerganti's account), although the atchakat size, as projected by the IC at the time of lobbying for the lift irrigation scheme, is 800 hectares.[9] Let us assume that the IC inflated the size of the atchakat to justify sanctioning of the lift irrigation scheme and let us assume that the RBC and LBC irrigate only 440 hectares as accounted by the neerganti. Accounting Mondays and Thursdays as irrigation holidays, at present it takes close to a month for one rotation to be complete for all the 240 hectares irrigated by the LBC and more than a month for the 200 hectares by the RBC.

It can be hypothetically argued, based on available evidence, that even if the lift irrigation scheme is sanctioned and the water availability in the tank is improved, paddy cannot be grown in the non-paddy growing part of the atchakat unless the capacity of the water distribution network is considerably enhanced. At present, 124 hectares out of 440 hectares is prime paddy land, which given the soil type and slope (ideally) needs irrigation once in eight days, although in reality these lands are irrigated more often as discussed above. The rest of the land, approximately 315 hectares, is non-paddy/khushgi land. If sown with paddy, this land would need irrigation almost every other day or even every day given the type of soil and slope. That means both canals together would have to irrigate roughly 160 hectares of khushgi land each day (minus the irrigation demand of 124 hectares of paddy land), while they at present these canals irrigate only 18 hectares a day. The sheer magnitude of the gap between the present and expected future suggests that the entire atchakat may not be equally benefited if the lift irrigation scheme is sanctioned even if we assume that the atchakat size remains 440 hectares and is not 800 hectares as projected by the IC, that canals are desilted and cleaned of all vegetation growth to substantially reduce the conveyance losses and enhance the capacity, and that irrigation is provided seven days a week.

The same argument can be put forward in a different way. At present, water for three months remains in the tank after the conclusion of the main irrigation season if the tank has received water to its full capacity. That means that the tank already has extra water for the current cropping pattern if it has filled up to its capacity and yet the tail end khushgi land suffers from not enough irrigation. Even if one argues that the current problem of insufficient irrigation for the khushgi land can be partly remedied by increasing irrigation hours every day and by cancelling irrigation holidays, the gap between the demand and supply for the current cropping pattern – some khushgi land requiring water once a week and getting once a month – is sufficiently large to tentatively argue that the carrying capacity of the canals play a decisive role in determining cropping pattern.

The gross storage available in the tank is not the only factor that influences the choice of crop. Two other elements – the atchakat type and design of distribution network – crucially influence the choice of crops. The whole of the discharging network would have to be considerably overhauled if paddy is to be grown on khushgi land. This may prove difficult, because even the thickness of the canal walls have been halved because of the encroachment.

Hence, it is very likely that the prime paddy land located in alagu and tagu would corner most of the benefits from the lift irrigation scheme. Instead of one crop of paddy grown once in two to three years, these farmers would be blessed with two to three crops every year.

Key-spanner and night irrigation

The IC usually gives permission to provide night irrigation during the peak irrigation season. However, farmers did not openly speak about night irrigation, there was something clandestine about it. At present, both keys of the sluices are returned to the president of the IC at the end of the irrigation day but the neerganti collects them again if night irrigation has to be provided during the peak season.

The operating mechanism of the sluice was reconstructed around 30 years ago by the PWD. The plug and pole type of sluice, at that time, was replaced with an operating mechanism fitted with a gearbox and, instead of a pole connected to the plug, a threaded iron rod for precise opening was provided. Prior to that the sluice was opened only with the permission of the influential farmers of the village after puja and other rituals were performed. During the irrigation season, at that time, the technology did not permit easy lifting of the sluice. The neerganti and other farmers had to skillfully lift the plug under considerable water pressure when the tank was full. At that time, the operating mechanism of the sluice had a social lock and key. Some farmers told me, however, that technically it was possible to open the sluice even when it was socially not permitted. Apparently, two people can lift the handle of the pole from one side and insert a stone in the plughole to partially open the plug. But this operation was fairly tricky and risky.

Opening the sluice has become as easy as turning the spanner, i.e. the key, in order to lift the rod and the plug after the provision of gearbox and rod. This iron artefact, now, embodies power. There have been disputes about where it should be kept at the end of the irrigation day. The key used to be returned to the Assistant Engineer every evening after the tank was handed over to the PWD from the Revenue Department in the early 1970s. But some farmers from the village argued that it was too much of work for the neerganti at the end of a tiring day to travel a few kilometres to hand over the key and fetch the same the next morning. They wanted the key to be kept in the village itself. For some time, it was kept with the erstwhile Shanbhoga but other (influential) farmers challenged Shanbhoga's special position and argued that all farmers were equal. Hence, for some time the key was circulated among different farmers. Since the formation of the IC in 1977, the key has been kept at the house of the president, who is considered as the most influential farmer in the village. Later, the key was rotated among other paddy growing high caste farmers in the village. Now, there are more contenders for the position of influential and important farmers other than Patel and Shanbhoga.

The balance of recognition of power in the village has to some extent been inverted with the entry of key-spanner. Earlier the sluice was never opened without the permission of the most powerful farmer in the village. Now, whoever acquires the possession of the key-spanner could attain a recognisable status in the village. This elevation of status may not stop only at a membership in the IC; it may possibly result in acquiring a party ticket for the panchayat election too. For instance, one of the

Lingayat farmers who does not hail from Patel or Shanbhoga lineage, who has been active in the IC and is considered by other farmers as an important farmer, who has held the sluice key in his (night) possession for a while, contested the panchayat election on the Congress ticket the year I did my fieldwork. The nightly possession of the key spanner has thus indirectly earned him a position of an important local actor.

It has become common in academics to argue that penetration of electoral or state politics has significantly disrupted locally managed affairs.[10] What remains unexplored is the manner in which this happens. In my opinion, as much as there is external intervention; the capillary action from the local area creates and sustains channels for (external) non-local elements to enter into the local sphere. Channels created by the local elites, who derive their power from the most local level of resource management are central to ensuring the exchange between local and non-local arenas.

Returning back to local level politics, the change in recognition of power is not the only change the key-spanner has brought. Many farmers fleetingly mentioned water theft, night irrigation and bribing the neerganti to get out of turn irrigation, although no one was ready to talk about it openly. Direct questions resulted in denial that such practices existed and resulted in answers such as, "such practices did exist five years ago, but no more." I think that the spanner-key made it possible to open the sluice and receive out of turn water relatively easily. Although the key was usually returned to the president's or some other IC member's house at the end of the irrigation day, sometimes it remained with the neerganti under some or other pretext. An influential farmer told me that (a while ago) the neerganti used to keep the key and give it to his friends and sometimes the sluice was opened in the night even if only two farmers needed water. Later it was decided in the IC that unless all the farmers with irrigation turn on a particular day gathered on the bund in the morning at the sluice opening time, water would not be diverted to their lands.

This observation raises a different question: "Who needs to bribe the neerganti to get extra water?" It has been already discussed how the rotation schedule as per the rules and in practice favours the paddy growers. As such much of this land is located near the bund and receives a considerable amount of seepage from the canals when irrigation is on. I also already mentioned how paddy-growing farmers indirectly stated that neerganti should bend the rules in favour of the paddy-growing farmers. Hence, paddy-growing farmers would rarely be desperate enough to bribe the neerganti to get water out of turn. They have various other socially approved, perfectly legitimate means to resort to receive water out of turn. Although there is no direct evidence to prove that non-paddy growing farmers bribed the neerganti and took water out of turn, I suggest that the provision of the gearbox and rod type of sluice-operating mechanism with a key-spanner theoretically made it possible and provided the opportunity for any one to open the sluice easily. The possibility that the sluice can be easily opened presented an opportunity to those who are at the receiving end and are not favoured by the rules.

My argument is meant to illustrate how designs and artefacts of tank irrigation technology change and perform within the web of tension generated by relations of power, authority and discrimination. The above discussion further shows that when a particular, historically specific form of rule formation supports and perpetuates unequal distribution of power and resources, its moral authority is not without contestation. Interestingly, in the dominant discourse, if technology is used in a way that approves the dominant mode of moral authority, the process is called rule adherence, and the contestation of such domination is branded as a disruption of collective action based on customary practices.

Canal cleaning and rotation rules

The IC's authority with regard to canal cleaning would appear in doubt given the conditions of the canals. The main canals, sub-canals as well as the field channels in the atchakat are heavily silted up. There are patches where water barely flows unless the downstream farmers clear a mound of silt. One has to search under the thickly grown vegetation to find the watercourse at some other patches. Some IC members claim that all farmers gather once in three months for a day to clean the canals. The IC fixes the day for cleaning and all the farmers are informed in advance though an announcement made in the village by beating of a *tomtom* (a drum). But the condition of the canals does not indicate that the cleaning is done regularly. Neither do sharecroppers' accounts suggest so.

The influential and wealthy landowners, especially in the head reach, have stopped working their lands for at least a couple of generations. The sharecroppers – almost all of them from the lower castes – provide all the labour in the fields. Irrigation is the most labour demanding activity in the paddy fields after weeding. A group of sharecroppers in the head reach grumbled that the landowners are invited for the meeting of the irrigation organisation, while they often are not even informed about the meetings. They would in fact be specially invited for canal cleaning. The sharecroppers therefore assert themselves by not easily providing their labour for the canal cleaning. If a sufficient number of them do not show up on the day fixed for the cleaning, the operation is postponed until the next time. Several postponements without any action add up to the dismal state of canals.

The state of canals even has an impact on the IC's authority to impose a penalty on defaulters who take water out of turn. There is a unique system in this tank to prevent out of turn water intake that perhaps dates back a few generations. The earthen canals here do not have pucca outlets and water generally is given to each piece of land by making a small gap in the canal or field channel which is again filled in with mud once the irrigation is complete. The neerganti has a wooden punch or seal on which the letters "Rani Sarkara" (queen's government) are inscribed. In case someone defaults, the neerganti presses this seal on top of the mud surface of the makeshift outlet in such a way that the letters would be inscribed on the mud. If the defaulter disobeys the "Rani Sarkara" and breaks the outlet and again takes water, thus making the letters disappear, thereby provides evidential proof for his/her act. No one usually dares to open an outlet with the inscribed mud top-surfaces; second time defaulters are liable to pay a penalty.

Given the thickly spread mosaic of canals and field channels and a complicated rotation schedule, one would expect that the neerganti would be busy punching "Rani Sarkara" on many mud top surfaces. Yet, it is only rarely that the neerganti has to punch the queenly seal on top of the mud surface. This may be partially so because the incidents of default are rare. However, it is also possible that in the middle and tail end where the canal walls have thickly grown vegetation, the top of the mud surface is hardly visible and the seal cannot be inscribed. Many fields also have permanent gaps made in the canals. That means that as long as the canal has a certain depth of water, it would flow into the field until the field acquires the same level of water as the canal. The neerganti's authority to prevent default with his seal is more nominal than actual.

This further confirms that the IC's authority is not entirely responsible for the high degree of rule adherence in the atchakat. Much of the rule adherence in the atchakat is more a direct function of the designs of the distribution network and atchakat layout than a function of institutional parameters.

Collective Action and Role of the MID

The members of the IC think that the cleaning of canals is primarily the MID's responsibility given the tussle on the issue of canal cleaning. There is a contradiction in this demand. The IC has waged a low intensity struggle with the MID on the question of proprietary rights of the tank. At one point of time the MID declared that this tank, like other tanks in the state, is government property and hence the MID has a right to interfere with the IO and IC's management. The MID has refused to legally recognise the authority of the IO, until a responsible MID officer is made either a member or preferably the president of the Irrigation Organisation. The MID officials contend that the IO's registration under the Cooperatives Act is not enough for them to recognise its legal status. This means that the IO does not have a right over the produce from the tank. It also cannot hire a contractor on its own to perform maintenance tasks and claim financial assistance and concessions from the MID, as stipulated in the Irrigation Act.

The MID claims the ownership of the tank and declares that "the tank cannot be handed over to the farmers". This is what annoys the IC members. They do not want a MID official to become part of their organisation because they fear that the MID's intervention will unnecessarily politicise their tank environment and may bring factional party politics right in the centre of water management practices and may disrupt what they feel is a congenial environment.

There is also another side to the non-acceptance of MID officials as member of the IO. The MID's entry into the IO could result in a normative model of equal distribution of water and equal right for all farmers to participate in the management of the resource. The MID may also interfere with the cropping pattern by disallowing cultivation of paddy and sugarcane. The Levy of the

Water Rates Rule 1965, which was amended in 1987 (and also in 2000), states that the farmers in this region are allowed to grow only semi dry crops in tank-irrigated areas.[11] Paddy and sugarcane are officially not allowed. The penalty for defaulters is five to ten times higher than the water rates for dry crops. Although the rate of collection of fines is very low, both Revenue and Minor Irrigation Departments can create nuisance for paddy and sugarcane-growers. Paddy cultivation is still tolerated because some land in the atchakat is considered unfit to grow anything else, but sugarcane is strongly disapproved.

For example, around twenty years ago, when the tank did not receive enough water for a few consecutive seasons, many paddy-growers grew sugarcane. When the Revenue Department objected, the sugarcane-growing farmers submitted a written petition defending that sugarcane was grown in the tank atchakat since the nineteenth century after British introduced it and since then it had become part of their customary practice which they had a right to continue.

The members of IC face a major contradiction here. On the one hand, they are asserting their right to independence and autonomy from the MID, but on the other, they are asking the MID to invest in the cleaning of canals, maintaining the physical infrastructure and also providing the lift irrigation scheme. This contradiction parallels the crisis tank irrigation policy is going through at the state level, as discussed in chapter 3. The local elites at one level do not want to financially invest in tank management because they are no longer able to reproduce social arrangements that sustained the institutional mechanism for tank management in the past. This disruption results in the demand for the MID to step in and replace earlier practices. However, the invitation to the MID is partial. The MID is expected to provide financial assistance for the maintenance and management and leave the rest to customary practice and collective action, which, as discussed at length in this chapter, are largely unfair and discriminatory.

To sum up, the success of irrigation organisation in achieving a high degree of rule adherence is intimately connected with the design aspects of the tank technology that sustain differential water distribution practices. The atchakat landscape is shaped in a particular manner by historically specific land use patterns. There are four types of land each with a different soil type and level, and correspondingly a differential pattern of irrigation needs. This is the first constraint on the cropping pattern followed in the atchakat. The designs of the distribution structures exert further limits on the amount of water that can be made available to different parts of the atchakat.

A one-line rule, applied and mediated through designs of technology scripted with social arrangements, can achieve an impressively high degree of adherence.

The discussion suggests that an institutional mechanism alone may not be enough to ensure democratic utilisation of the resource unless the forms of technology that create and sustain the patterns of discrimination are understood and challenged.

Notes

[1] In irrigation literature, the notion of allocation and distribution are defined in various ways. Basu and Shirahatti (1991: 94-95) extend a definition, which is useful for my case study. They refer to water allocation as a division of a scarce amount of water between seasons and crops in a single command area. In south India, this notion may be more relevant where allocation of scarce water is generally achieved by prescribing or allowing a certain cropping pattern in a particular season. Farmers accordingly are entitled to receive irrigation water for a prescribed cropping pattern.

Water distribution generally refers to the division of an available amount of water among different contenders in one irrigation season, depending upon the size and location of the land, for the prescribed cropping pattern. In tank-irrigated areas, distribution is usually achieved by rotation of water among different contenders for a prescribed cropping pattern. See Basu and Shirahatti (1991: 94-95) for further discussion. Water available in this tank is allocated between paddy and non-paddy cultivation, which forms the basis for water distribution among different farmers in one irrigation season.

[2] For detailed discussion on paddy cultivation and the corresponding change in the nature of soil, see chapter 2.

[3] The localised atchakat is that part of the actual atchakat that is officially recognised by the Revenue and Minor Irrigation Departments. The landowners of the localised atchakat are registered with the Revenue Department and are supposed to pay water cess. In theory, they can also claim compensation (if the prescribed cropping pattern is followed) from the MID in case the tank fails to deliver water after the MID has

sanctioned irrigation for that season. The Revenue Department last surveyed the extent of the atchakat in 1920. In order to include newly expanded atchakat in the localised atchakat the Minor Irrigation and Revenue Departments will have to survey the atchakat together during the single irrigation season. In figure 5.1, the part of the atchakat marked I and II is localised atchakat.

[4] After every irrigation season, the MID prepares a list of water cess demand for every registered irrigator based on his/her crop choice. This list is then passed on to the Revenue Department for collection purposes. The water cess demand list records the extent of land owned by each irrigator, the extent of land cultivated by each irrigator in a particular irrigation season, and the crop irrigated.

[5] Wade (1988) argues that the presence of water scarcity and the corresponding presence of the risk play the determining roles for the presence of collective action.

[6] Only two farmers hold 4 hectares of land each and the rest own anywhere between 0.4 and 2 hectares.

[7] This tank falls in the upper watershed of the dam under reference and hence unlike many other tanks that have been regularly recharged by the canals from the dam reservoir, this tank technically cannot receive water under gravity from the reservoir. The water has to be pumped up through several stages of pump houses in order to bring it to this tank.

[8] Siltation reduces the cross section of the canal and even the slope if the pattern of silt deposit is not uniform throughout the canal. The resulting unevenness of the canal cross section is likely to reduce the velocity of water and increase losses. The growth of vegetation in the canals increases water losses for two reasons. Firstly, the growth reduces the velocity of water by increasing friction and thereby increasing losses. But more importantly, vegetation consumes water for its evapotranspiration and at the same time increases losses by increasing the infiltration capacity of the soil.

[9] The reason for the IC to project the atchakat size as big as possible is to counter one of the MID's rules. The estimated cost of the lift irrigation scheme works out to be around Rs. 40 millions. The MID has a rule that the lift irrigation scheme can be sanctioned at the rate of Rs. 10,000 per acre (0.4 hectare) of the area likely to be benefited. According to this rule, the lift scheme proposed by the IC cannot be justified even for the highest possible (projected) size of the atchakat.

[10] See Rudolph (2000: 1764-65) for a recent discussion. She quotes many studies on local initiatives for natural resource management to show how external interference has torn apart the fabric of traditionally legitimated equilibrium and created conflicts over the use of natural resources and

how the competition generated due to the entry of party politics has devastated older forms of collaboration and solidarity.

[11] Public Works and Electricity Secretariat, Notification No. PWD 89, Bangalore dated 4 November 1987.

6

"Either all or None?"

A Tank Irrigating Transplanted Paddy in the Mixed Region

"Society is like a web which touched at any point shivers through the whole."
— Thomas Hardy as quoted in Jeffery (2001: 217)

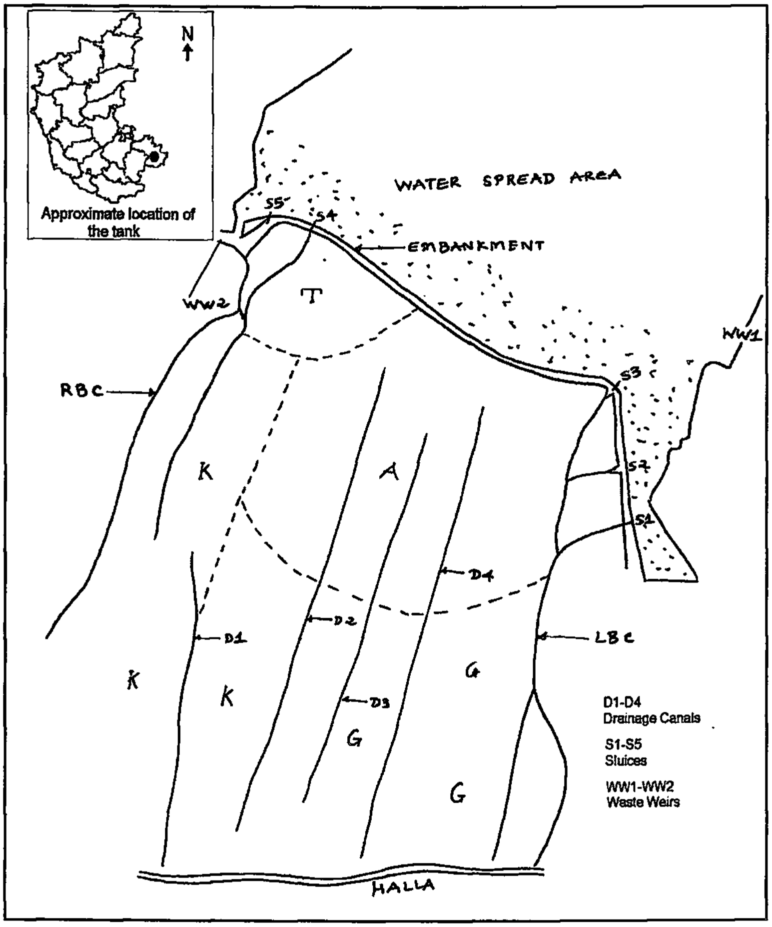
In chapter 3, I argued that tank irrigation policy at the state level faced a crisis during the 1980s, which resulted in demands on the state to invest significantly in the management and maintenance of tank resources. This crisis signifies a shift in authority with respect to tank management.

This chapter discusses the case of a tank, irrigating paddy, located in the outskirts of a medium size town in the mixed agro-climatic region of south Karnataka. It explores how the shift in authority – the MID partially replacing village level local elites – has co-evolved with the shift in the patterns of water utilisation, tank designs, cultivation practices and also the introduction of the new irrigation technology and new crops.

MID's normative model of equality among all irrigators is located in the wider context of agrarian change. The chapter is an attempt to understand how the norm of equality among all irrigators translates in multiple arenas of tussles between tail-enders and head-reach landholders, small landholders and economically powerful bore-well owners, paddy and non-paddy growing farmers and service castes members and small landholders in the atchakat.

The tank is around 500 years old and was mostly constructed during the Nayankara period of the Vijayanagara empire (after 1365 A.D.).

FIGURE 6.1: A schematic map of the atchakat and approximate location of the tank



The Tank

As per present calculations, the live storage capacity of the tank is 120 mcft, but according to the tank registers of the British period, the tank had a storage capacity of 659 units. One unit is 0.2614 mcft and irrigates one acre of paddy in the monsoon and 0.84 acres (0.339 hectares) in the summer, as per the PWD manual. So, during the British period the atchakat size effectively was 659 acres (263 hectares) for the monsoon paddy. At present, the atchakat size in the MID records is 763 acres (305 hectares), but according to the farmers', the sowdi's and the neerganti's accounts, the tanks irrigates 800 to 900 acres (320 to 360 hectares). The annual average rainfall in the region is around 700 mm. The tank receives water from a gross catchment area of 51.24 sq. kilometres of which the intercepted catchment area is 19.62 sq. kilometres and the free catchment area is 31.62 sq. kilometres. The tank has five sluices: three shutter type and two plug and pole type. There are two waste weirs, both of the overflow type.

The Contour Lines of Change

In the early 1970s, the tank was handed over to the PWD from the Revenue Department. Until then, the Patel of one of the villages managed it. This Patel's family had served as village officer for several generations and continued to serve in spite of the abolition of hereditary posts as per the Inam Abolition Act of 1955.[1] After 1963, when the Inam Abolition Act was implemented in Karnataka, the Revenue Department successively appointed members of the Patel's extended family as village officers in the absence of any other experienced person until the time the tank was handed over to the PWD in the early 1970s. There was a marked shift in the tank management practices after the tank was handed over to the PWD.

In the early 1970s, the PWD repaired and replaced some of the crucial physical structures of the tank. Three of the five plug and pole sluices were converted into shutter sluices; all the sluices were fixed with threaded iron rods and gearboxes for easy operation; two main canals located on the extreme edge of the atchakat were partially lined; the feeder channel that brought water to the tank was cleaned and provided with wooden shutters to control water inflow into the tank; and the embankment was strengthened at some places. A *sowdi* (waterman) was appointed who was paid entirely by the PWD to watch this tank, along with 39 other nearby tanks, and to operate the sluices of this tank during the irrigation season. These changes, which preceded significant changes in the cropping pattern by almost a decade, gave a new life to the tank.

The landholders of this atchakat have different views about when high yielding varieties of paddy were introduced in the atchakat. One view is that the then District Commissioner introduced new varieties in 1963, which were cultivated by a Japanese method. Given the unlikely possibility that green revolution seeds arrived in this village three years earlier than in the rest of the world, it may be that the then DC introduced improved varieties developed by one of several local agricultural stations. The erstwhile Patel recalls that the high yielding varieties of the green revolution first arrived in 1973, but most of the landholders we interviewed said that it was only in the 1980s that they completely shifted to the cultivation of new varieties. This shift signifies not so much the adoption of new varieties but the extent of cultivation of high yielding transplanted paddy in the atchakat. As one of the elderly farmers remarked, "earlier our needs were limited, farmers cultivated ragi, or broadcasted paddy and occasionally grew transplanted paddy and were satisfied. Now in the last 10 years or so, all farmers in the atchakat sow paddy without fail, if the tank has water."

Change in Authority and Tank Designs

Sluice opening

Two cropping seasons used to be observed before all the landholders in the atchakat began to grow one crop of tank-irrigated transplanted paddy. One crop of paddy (sown by the method called *punaji bhatta*[2]) used to be broadcasted in the rainy season along with ragi or jowar and three or four irrigations used to be provided for all the crops. The second crop of paddy, of either old or improved varieties, used to be transplanted in October or November and fully irrigated with tank water. Farmers told us that previously if the tank filled up once, water was enough for two crops of paddy and still two months of water remained even after the harvest of the second paddy crop. It should be mentioned that the talk about abundance of water in the tank is based usually on the tacit understanding that only head reach landholders have the privilege of cultivating two crops of paddy. The season of the second crop of paddy was the main cropping and irrigation season for which neergantis used to be hired and paid. Neergantis were sometimes hired for the first paddy crop, but there were no socially prescribed norms for payment. Farmers opened the sluices themselves for the first paddy and jowar or ragi crops, but elaborate social arrangements were in place for the opening of the sluice for the second paddy crop.

All the sluices were plug and pole type before the PWD repaired them. The opening of sluices used to be an important social and ritual event. The festival of *Dipotsava* (festival of lights) was celebrated with fanfare if the waste weir had discharged water that year. A candle weighing 6-7 kgs made of rice flour mixed with jaggery would be placed on a raft on which the elite of the village – generally the Patel and Shanbhoga – would also sit. The raft would be taken to the *Gangamma* (water goddess) temple, which was located in the water spread area. As part of the same festival, neergantis would sacrifice a buffalo in the Durgamma temple. Although this would be funded by the elite of the village, the meat would go to the service castes members. The sluices were opened only after the festival was celebrated, puja performed, and buffalo sacrificed. This social event that marked the tank's filling up, in which the elites financially invested, ensured social locking of the sluice. Most importantly, it signified that the sluice could not be opened unless the big men sponsored the ritual, performed the puja and granted permission to lift the plug at the end of the celebration.

The ritual thus reproduced the authority and power of the elites and played a decisive role in the deployment of economic resources. Genovese (1965) has argued that in order for economic power to be socially reproduced and legitimated, it often needs clientelist distributive expenditures, lavish consumption and funding of collective rituals. The elites maintained control over the deployment of economic resources by means of funding this lavish ritual, which otherwise could be considered a non-productive form of investment. Thus, the ritual performance was a means by which economic power was reproduced and legitimated.

This ritual has now taken a curious turn. The ritualistic celebrations did not stop when the tank was handed over to the PWD and when the power to sanction permission to open the sluice was also transferred to the PWD. The ritual is still performed with all festivities, but the money for the performance of the ritual and for the sacrifice of a buffalo is collected from all the landholders, or raised by service caste members, because the elites now resist bearing the whole financial burden. In other tanks of the southern maidan, only service castes members raise money for ritual celebrations by collecting small donations or contributing poultry. The elites of the village sometimes supplement their collection. Some of the ex-village officers, now placed economically in a comfortable position with family members located close to urban centres, also advocated that such ritualistic celebrations were blinded by superstition. Some even expressed agony over the animal sacrifice, interpreted these events as a waste of money and stigmatised them as signs of backwardness and lack of education. The hesitation of elites to invest in the ritual celebrations that earlier reproduced their economic power implies a significant shift in the authority with respect to tank management.

The way the ritual is performed now, the parameters of the recognition of power have remained unchanged; rather those who embody positions of power have simply been replaced. Instead of the Patel and Shanbhoga, nowadays the Executive Engineer of the MID and the Tahsildar of the Revenue Department are made to sit on the raft and taken to Gangemma. What does this suggest? Is this practice just a residue of old forms of power relations or is it indicative of the expectations the service castes members continue to have from those who occupy positions of power?

This shift in the established patterns of authority vis-à-vis sluice opening has been facilitated by the shift in the sluice design. I have discussed the hydrological specifics of tank designs in the mixed region of south Karnataka in chapter 4. To remind readers, I again briefly discuss one particularity here. The size of tanks (in terms of ratio of water spread area to atchakat) in the southern maidan is relatively high compared to other parts of Karnataka. In tanks of the southern maidan, one filling suffices for one irrigation season, unlike in the wet region of western Karnataka where a few fillings are common. The overall capacity of tanks in the southern maidan is usually higher per unit of atchakat irrigated compared to its malnad counterparts. Correspondingly the embankments are also bigger and longer as compared to those in the wet region. The sluice openings and consequently the sluice-operating platform are not located directly in the embankment in this region possibly in order to avoid a structurally weak point in the embankment.[3] They are located instead in the water spread area away from the embankment. Earlier when all the sluices were of the plug and pole type and when the opening was located in the water spread area, one or two neergantis trained in carrying out this operation, had to go under water to lift the plug before the irrigation season began. Often the wooden rod had come out of the plug or the wooden plug would have expanded under water requiring skillful application of pressure to open the sluice. Furthermore, the water column above the sluice aperture would apply downward pressure, requiring at least two men to dive under water to lift the plug. The operation could prove dangerous. Once the plug was lifted, the gushing water could even drag a person into the tunnel. This difficult sluice opening process, especially when the tank was full, was an additional form of social locking. The sluice could not be opened unless the neerganti with the permission from the Patel and Shanbhoga carried out the difficult operation.

Once the PWD fitted the sluices with iron rods, gearboxes and operating platforms in the embankment, the sluice opening became easy. All the five sluices can be opened with the help of key-spanners standing on the platform above water level. The act of sluice opening has been transformed from a ritualistic, socially organised event into an operation that is carried out by a person appointed by the MID. The shift in authority and sluice design emerged together, rather than one leading to the other.

Water distribution rules

The MID constituted several taluk level Irrigation Consultative Committees (ICCs) in the district after the tanks with more than 200 hectares of irrigated area were taken over by the MID from the PWD in the early 1980s. The Assistant Commissioner, Tahsildar, Agriculture Department officials, Executive Engineer and Assistant Executive Engineer of the MID are ex-officio members of these committees. In addition, representatives of landholders, whom some MID officers described as "politically and economically strong farmers" or as "small time politicians", and whom some landholders from the atchakat described as "powerful farmers", are also appointed as members of these committees. The only condition these farmers have to comply with to become a member of an ICC is to own land in the atchakat of any of the tanks under the jurisdiction of the MID in the district. The ICCs meet usually once a year primarily to decide irrigation timings for the tanks. These committees have institutionalised a general rule, apparently in the interests of the tail end farmers, that unless the tanks receive sufficient water for the entire atchakat to grow one crop of transplanted paddy, sluices will not be opened. Sluices were not opened for a couple of years even when the tanks received 75 percent of capacity and even when head reach landholders of some tanks had staged a *dharana* (picketing) in front of the MID office.

These events have alternated positions of those who usually received their share of water without petitioning with those who usually have to. The events also suggest that like the elites of the tank described in the previous chapter, the elites of this tank also face a contradiction with regard to MID's role in tank management. On the one hand, the MID is expected to invest in the management and maintenance of tanks, on the other hand, this investment result in the unintended consequence of a normative model of equity among all irrigators being introduced, which threatens established forms of power dynamics at the local level.

However, events like head reach farmers staging a dharana in front of the MID office do not imply that the requirements of tail end farmers receive prominence in tank management. Although in this case the head reach landholders may be losing their traditional control over the resource. The emerging new forms of economic interests are in the background of this loss. The interests of those who fish in the tank and borewell owners who have newly entered on the scene of tank management seem to have superseded the interests of the traditionally powerful, paddy-growing, head reach farmers. Decisions are taken in the interests of tail end farmers because their interests coincide with other newly emerged powerful interests. This can be understood better once I map the change in cropping pattern in the atchakat.

Changing Cropping Pattern and Tank Designs

Paddy

High yielding paddy varieties have dominated in the atchakat only in the last 10 to 15 years. These non-photoperiod sensitive dwarf varieties can survive and provide maximum yield during the dry, sunny rabi season which extends from the end of January to April and May. In the conventional cropping pattern, the growth cycle of both paddy crops was adapted to the onset and departure of the northeast and southwest monsoon cycles. Local varieties, especially, were adapted to monsoon patterns. The photoperiod sensitive varieties flowered and went into their reproductive phase of growth when day length reached a certain critical duration. In contrast, the non-photoperiod sensitive HYVs would flower and mature within a fixed duration of about 107 to 115 days (Frankel 1971: 52-53). That means, if non-photoperiod sensitive HYVs were planted after the onset of the monsoon, they would be ready for harvesting during the monsoon season and thus harvesting might have to take place during the time of heavy showers. To avoid this, HYVs are planted at beginning of December or January when both northeast and southwest monsoon seasons are over.

There is one more reason to plant paddy at the end of the monsoon season. This has to do with tank designs. Given the rainfall pattern of the region, the amount of precipitation and number of rainy days differ from year to year. Earlier, both paddy crops largely survived on rainfall. Only during rain deficient days would irrigation from the tanks be provided. Nowadays, however, it is important to check the level of the storage in the tank at the end of the monsoon season before the planting takes place because the continuous water demand of HYVs makes them entirely dependent upon tank storage.

The new varieties have thus brought about a shift in the cropping season in the atchakat. The adoption of the new varieties for tank irrigation means that if the tank fills up, which it does latest by October, water has to be stored, while it is subjected to evaporation and percolation, for at least two to three months before irrigation begins. Besides, there is no other form of moisture available during the cropping season except what can be provided through irrigation. Furthermore, the atchakat size has increased from roughly 260 to 320 hectares since the time the tank was handed over to the PWD in the early 1970s. It is not surprising that the discourse on scarcity dominates farmers' conversations on tank irrigation.

However, the intensification of paddy cultivation has accentuated the scarcity induced by hydrology. As discussed in chapter 4, the tanks in this region are constructed on a dense network of non-perennial rivulets or on tributaries. These streams flow only during the monsoon months. Rainfall as such is highly erratic. On top of that, if there are no intense showers to produce enough runoff, even if there is well distributed, normal rainfall during the monsoon season, the tanks may not fill up. According to the collective memory of farmers, the tank has always received water once in three to five or sometimes seven years. Elderly farmers recalled that waste weirs discharged water only once in a few years even when they were young. They also added that in the past when the tank filled up, water used to be enough for two to three years. Most of the farmers said that they had had five to seven paddy crops in the last 20 years, a reflection of water availability or lack of it in the current times.

I will return to the irrigation practices for tank-irrigated paddy cultivation later in this section, but will first outline the major changes in the cropping pattern.

Paddy versus non-paddy crops

Landholders in the atchakat can be divided into two groups in order to understand cropping pattern when paddy is not cultivated: those who have bore-wells and those who do not. According to farmers, there are 50-60 bore-wells in the atchakat; most have come up in the last 10 years, a good number only in the last six to seven years. This proliferation of borewells in the last decade has coincided with the introduction of Indo-American seeds of vegetables such as beetroot, carrot, radish, tomato, potato, cabbage and cauliflower. Some landholders cultivate maize or ragi irrigated with bore well water. They take bore-well water from their neighbours at the exchange rate of 25 percent of the produce of maize and ragi. There is no season as such for the cultivation of vegetables; several crops are grown one after the other as long as the bore-wells have enough water. Roughly 60 to 80 hectares are cultivated with non-paddy crops, all grown entirely with bore-well water when tank-irrigated paddy is not being cultivated.

Paddy is seldom irrigated with bore-well water. Farmers gave three reasons for that. Firstly, it is not economical to grow paddy during the non-paddy growing seasons because labour charges are high. Labour as such is costly due to other employment opportunities for labouring classes in the proximate urban area. However, the higher cost of labour during the off paddy season may have to do with the non-collective nature of such cultivation.

As discussed in chapter 2, paddy cultivation has historically been a collective activity for three reasons: firstly, it needs common access to the irrigation source and involves common decision-making; secondly, collective growing reduces the amount of overall labour investment (Wade 1988: 79-80); and thirdly and most importantly, labour availability for collective cultivation has been organised, for a long time, through the social control of labouring castes. This aspect of reduced control over labour for irrigating and mending paddy fields implies that the essential part of productive power relations in rice growing areas could no longer be reproduced in their entirety. For instance, the hereditary posts of village officers and posts of service castes, including the post of neerganti have been abolished under the Inam Abolition Act. Abolition of these posts not only demoralised neergantis but also had direct economic consequences for some of them, as they lost a tiny piece of Inamati land they possessed. The loss of control over an economic resource, in addition to the loss of employment due to reduction in paddy cultivation irrigated with tank water for which they have been conventionally employed, have compelled them to look for other forms of employment. The proximity of an urban centre in this case has generated other employment opportunities for the labouring castes, further loosening the landholders control over their labour for paddy cultivation.

The cost of hiring labour is high for bore well-cultivated paddy due to the non-collective nature of cultivation. For instance, a manual labourer can earn Rs. 70 to 100 per day in the nearby town whereas work in the paddy fields can fetch him maximum Rs. 55 to 60 per day, and that too only for a few days during the weeding and transplantation time. In the atchakat, therefore, labour hiring charges need to compete with the urban rates for the bore well irrigated paddy. In contrast, when tank irrigated paddy is cultivated in the entire atchakat, there is a higher availability of labour for tasks like weeding and transplantation. These labourers usually work in a group and if paddy is cultivated in the entire atchakat there is enough work for them in the season to leave odd manual jobs (availability of which is also seasonal and irregular) in the urban area and work instead as agricultural labourers; some of them may even have a small piece of land of their own in the atchakat. This reduces the overall labour hiring charges farmers have to incur. Furthermore, at least in the part of the atchakat owned by economically powerful landholders, the services of neerganti are utilised, which further reduces the overall cost of labour for tank-irrigated paddy.

There are, as mentioned above, two other reasons for not growing paddy with bore well water. Firstly, the landholders believe that bore-well water does not have as much *takat* (nutrition) as tank water with sediments has, and hence does not give a good yield. And secondly, bore well owners prefer to break away from paddy cultivation. As already discussed in chapter 2, the long-term submergence of land for continuous cultivation of paddy changes the nature of soil to the extent that land may be rendered unfit for the cultivation of vegetables and dry crops. Those landholders who grow vegetables with tube wells said that the vegetables need smooth soil; seeds may not survive in the soil that is converted into hard lumps after consecutive cultivation of a couple of paddy crops. Although it is rare, I came across at least three to four landholders in the atchakat who have dug deep ditches all around their plots and who grow only vegetables and occasionally ragi or maize irrigated with bore water even when the whole of the atchakat is reeling under streams of water for the cultivation of tank-irrigated paddy. Furthermore, I found that at least one landholder whose land is located in the head-reach, has kept two pieces of land strictly separate. On one plot he cultivates tank-irrigated paddy and on the other only vegetables. The level of the second plot is raised by spreading soil brought from outside of the atchakat. The cropping pattern supported by tube well irrigation, therefore, clashes with paddy cultivation supported by tank irrigation.

The bore well irrigated cultivation regime clashes with the tank-irrigated regime for one more reason: well holders prefer that the water be stocked in the tank so that their wells will yield water for a longer duration. In the nearby tank, an experiment was undertaken by farmers who collectively decided to block the sluices, i.e. stop the surface irrigation completely and instead allow the tank water to recharge the aquifer to be used through bore wells. The tank was completely emptied in five months when otherwise that much of water would have lasted for a six months crop of paddy and would have left two more months of water. As a result, the landholders in this tank abandoned the idea of permanently blocking the sluices. Yet, such experiments are widespread in the neighbouring state of Andhra-Pradesh. It is in the context of this clash of bore well irrigation with tank irrigation that the bore well owners support the rule that water be released only when sufficiently available for the entire atchakat to grow paddy. The longer time of storage in the tank increases the time for which water is available in bore wells.

The Fisheries Department, it is worth mentioning, also prefers water to be stored in the tank and not used. The fisheries department contracts out fishing rights to several big tanks in the district to a private agency. Tanks need to be at least half full for fingerlings, which are released in the tank in the rainy season, to survive for nine months. However, at the time of removing the fish, i.e. in March and April, the tank should only be quarter full for effective removal of fish. Fishing in tanks has become a highly profitable enterprise; powerful interests vie for getting contracts, although a contract in principle is given to any private agency through auction. Thus, for those who are involved in fisheries it is also good if water is not removed for irrigation unless it is enough to take care of the multiple – and conflicting – stakes.

The intensification and diversification of agriculture have generated conflicting interests. The major loss as a result of shifting cropping pattern is that subsistence crops are not more cultivated in the atchakat. Ten years ago, if the tank received water less than full capacity, landholders would collectively decide to grow only irrigated ragi; that practice has now stopped. Only smallholders who do not have a piece of dry land grow ragi in the atchakat for which they buy water from bore-well owners. Cultivation of jowar has likewise also stopped in the atchakat after the arrival of new paddy varieties. Lands, other than the 60-80 hectares irrigated by bore-wells, remain fallow for three to four years before the tank fill up and paddy is grown. This implies that most of the land in the atchakat is cultivated only once in three to seven years except for those 60 to 80 hectares watered from bore wells. Further research is required to find out who gained and who lost due to this change in cropping pattern.

Water distribution for paddy

Not all irrigation practices have been transformed with the shift in management practices and cropping pattern. Discriminatory rules for water distribution for tank-irrigated paddy still remain the basis of practices followed in the atchakat, but not without contestation. I will first delineate how certain designs, especially the atchakat layout and the canal alignment, facilitated the pattern of rule adherence. In the next section, I discuss how the same designs have generated barriers for change.

Resistance to the established pattern of water distribution has come from small landholders with land in all parts of the atchakat;

many belong to the erstwhile service castes and historically non-landowning castes. The atchakat at the tail end of the RBC and LBC has largely expanded due to the acquisition of land by Kuruba and service castes members, who in the last decade and a half have raised capital to buy land through casual employment in urban areas. Farmers from historically non-landowning castes are increasing in number in the atchakat. A majority of the new landholders may also be small landholders. Much of the land in the atchakat is small and marginal in size. Landholdings of the magnitude of 20 to 30 *gunta* (100 gunta is 1 hectare) are the most common and half a hectare may be considered on the higher side. Non-landowning castes acquiring land in the atchakat has been a main catalyst for change in water distribution rules. But, as I explain later, for these changes to culminate in democratic water distribution practices, the tank designs would also have to be transformed, as they are presently playing a crucial role in sustaining established, iniquitous patterns of water distribution.

The tank has five sluices. Three sluices - S1 and S5 on the extreme sides of the bund and S2 - are at a higher level than the middle sluices - S3 and S4 (see figure 6.1). The RBC and LBC run across opposite edges of the atchakat. Sluices S1 and S5 are smaller in size, located at a higher level and are kept open day and night during the irrigation season. The LBC is supplied water first from sluices S1 and S2 and once the water level in the tank reduces, S3 is opened. Similarly, the RBC is first fed by sluice S5. Once the water level in the tank declines S4 is opened. According to the map, prepared during the British rule, four sub-canals passed through the middle of the atchakat (marked D1 to D4 in the figure 6.1). Traces of these canals are still there but a large part of them have been lost.

The water rotation rules are contingent upon the landholding pattern in the atchakat. Many rules that have remained unchanged for a long time are as follow.

The atchakat is divided into four parts (see figure 6.1) depending upon which villages have land in different parts. Each part has landholders from one or more villages out of the seven villages that benefit from the tank, although some farmers from other villages own land in the atchakat as well. Each village benefiting from the tank is predominantly inhabited by one caste. Village T, inhabited by the historically privileged, landowning caste of Vokkaligas, has 21 hectares in the head reach of the RBC (marked T in figure 6.1).

The Patel, who earlier managed the tank, came from this village. In the middle parts of the head reach between the RBC and LBC, around 100 hectares is owned by the money lending castes such as Shettars and Muslims[4] from the nearby town and in a lesser number from some other villages nearby (marked A in figure 6.1). Lower caste of Kurubas own 40 hectares of tail end land of the RBC. The RBC, therefore, irrigates land of the historically privileged groups of Vokkaligas, Muslims and Shettars in the head reach and lower caste land of Kuruba in the tail end. The LBC irrigates lands belonging to Shettars and Muslims from the nearby town in the head reach, and lands belonging to the lower and service castes of village G in the tail end. The LBC irrigates a total of 160 hectares of land.

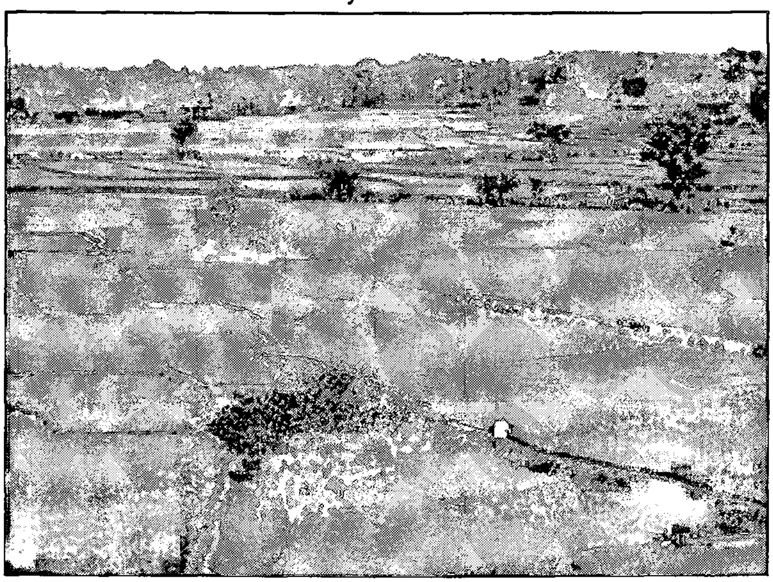
The rotation rules are as follows. Water is supplied to Muslim and Shettar lands during the day and is rotated between Vokkaliga and Kuruba lands in the night. The irrigation turn from the RBC alternates between 21 hectares of Vokkaliga land and 40 hectares of Kuruba land in the night. Vokkaliga lands are irrigated one night and Kuruba lands the next night. In one night, however, only around 20 hectares can be effectively irrigated from the RBC. Hence although Vokkaliga land receives water every alternate night, the Kuruba land is irrigated once in four nights only. Due to this imbalance, the Kuruba landholders sometimes divert water to their lands before the prescribed time, which has been a source of tension between the Vokkaliga and the Kuruba villages. The RBC also irrigates Shettar and Muslim lands during the day. These lands are largely are at the lowest level in the atchakat and known as tagu land. As they receive subsurface moisture from the tank and gain from the drainage from both sides, they do not need irrigation every day. In addition, they are irrigated by the RBC once in three to four days.

The LBC totally irrigates 160 hectares of which 100 hectares are tail end lands belonging to service castes and 60 hectares belonging to Muslims and Shettars in the head reach. Although the LBC can irrigate only 8-12 hectares a day, lands located in the tagu area of the head reach receive enough seepage and hence receive water almost every day. There are no set rotation rules for the 160 hectares of land irrigated by the LBC. Water in the head reach is usually rotated by a neerganti. The landholders in the tail end of the LBC, most of them owning a small amount of land, at times have refused to utilise neerganti services. (This point is further discussed below). Water from the LBC in the tail end is rotated without any definite rules and without the help of a neerganti. On the other hand, water rotation from the RBC is not only discriminatory but involves the neerganti who ensures that the rotation rules are followed and minimises conflicts and tensions. A tabular summary of the landholding pattern and rotation rules is given in table 6.1.

TABLE 6.1. Landholding pattern and rotation rules for paddy cultivation in the atchakat

Canal	*Head reach lands*	*Tail end lands*	*Rotation rules*
RBC	21 hectares Vokkaligas, 100 hectares Shettars and Muslims	40 hectares Kurubas	Rotation between Vokkaligas and Kurubas land alternate nights, Shettars and Muslims lands in the day.
LBC	60 hectares of Muslim and Shettar land	100 hectares of lower and service caste land	No set rules in tail end. Water is rotated in head reach by neerganti.

FIGURE 6.2: Paddy fields in a tank atchakat.



The discussion thus far illustrates that the best land in the atchakat not only belongs to the historically privileged social groups but that these lands also receive assured irrigation as per the rules. The requirements of field to field irrigation create and sustain this landholding pattern in the atchakat. To facilitate field to field irrigation, fields in the atchakat are constructed in a stepped fashion sloping from the head to tail and from the sides to the middle. However, it is the absence of any canals other than the two main canals on the opposite edges and (now almost non-existent) drainage canals in the middle that makes the head reach the most favourable location in the atchakat. The arrangement of fields and field to field irrigation ensures that the head reach not only receives water first but that the tail end cannot be irrigated before the head reach completes its irrigation.

The method of field to field irrigation inscribed on the atchakat is at the heart of the head reach first rule and the reason behind why head reach lands are owned by powerful farmers.

Institution of neerganti

As I have already discussed at length in chapter 2 and also hinted at in this chapter, the institution of neerganti has been firmly embedded in power relations in particular local and historical contexts. The institution of neerganti was perhaps never meant to institutionalise equitable water distribution. The institution, in its structural and normative forms, hardly has the power and agency to determine or modify water distribution rules. As I have explained in this chapter and elsewhere in the book, rules for water distribution are the outcome of negotiations among different sections of landholders in the atchakat, and determined and sustained by the designs of the atchakat topography and distribution structures. The institutionalised practice of neerganti carries out water distribution according to the rules shaped in a specific social context which leave little room for manoeuvre.

In my study, I found at least three conflicting, at times openly antagonistic, forces that have shaped the current form of the institution of neerganti. Many small landholders in the atchakat are refusing to make use of the neerganti's services and consequently refusing to pay them. Secondly, the irregular nature of paddy cultivation has forced neergantis to take up other forms of employment. And finally, although on the one hand there is intense competition among twenty odd neerganti families to acquire the right to undertake the job of water distribution, on the other hand, the norms about neerganti duties have changed significantly and affected the continuity of the institution.

Only two to three people are employed from the twenty odd neerganti families in the village T each time the tank-irrigated paddy is cultivated in the atchakat. Likewise every village has several neerganti families from which only a few persons are employed for one irrigation season. On the whole 10-12 neergantis may be hired for the entire atchakat, each of them irrigating around 100 acres. In the village T, for example, each neerganti family approximately gets a turn to be employed once in twenty years. This turn may be further delayed because neergantis are employed only when tank-irrigated paddy is cultivated which is only once in three years. Moreover, the work of neerganti no longer gets a regular and reliable income because of the insufficient amount of payment made to them. Neergantis after one season of paddy receive totally 12 to 15 bags of paddy from the land they are assigned to irrigate, which is insufficient until the next turn arrives. As a result, all of them have sought other employment. Almost all of them work as casual labourers in the nearby town. Although this work is also seasonal and irregular, this income is critical in terms of their sustenance. Those who take up the job of neerganti cannot afford to leave these means of employment entirely when the tank fills up and tank-irrigated paddy is cultivated. As a result, the institutionalised role of neerganti to distribute water as per the established rules has been heavily circumscribed.

During the irrigation season, many neergantis perform water distribution only during the night as they are employed elsewhere during the day. They only have time to open and close the canal outlets; the landholders on their own distribute water from field-to-field; though the Vokkaligas, Muslims and Shettars partly have their land irrigated by neergantis. By irrigating paddy fields the common irrigators save a great deal of labour and time of wealthy landholders, but small landholders who till their own land are not equally benefited.

Small landholders also work as casual labourers in the lean season to raise additional income. While they may contract harvesting and weeding out to outside labour, they also hire themselves out for similar operations on other farmers' lands. It is this group of landholders who have been resisting and refusing the services of neerganti. For them, payment of even 50 kgs of paddy per acre (0.4 hectare) to a neerganti is not agreeable. In the absence of the neerganti to mediate and ensure that water is distributed among all lands as per the established (and discriminatory) rules, the rules have become less stringent thus tilting the balance of power towards those not preferred by the rules.

The slackening of rules, however, is not greatly facilitated by the design of the atchakat. The atchakat is roughly square in shape with a four km length and breadth. The RBC runs only up to a part of its full length. As the LBC receives sewage water from village G located on the edge of the atchakat, its course is maintained, although water from the canal is unusable for irrigation after a point. Field to field irrigation, in the absence of field channels, except for two main canals on the edges and two drainage canals in the middle, is the main reason that the head reach first rule is sustained. Irrigation water is supplied in the atchakat from field to field, from head to tail in such a way that unless the head reach completes the irrigation, water cannot arrive in the tail end.

Once irrigation begins, it usually takes 8-10 days for water to reach the tail end travelling from field-to-field. The supply in the tail end also stops much earlier than the head reach. Most of the farmers in the tail end cultivate early maturing paddy varieties barring some portions that receive enough seepage. The only way tail end farmers can escape the bottleneck of head reach first would be to make a canal that can directly bring water to their fields. At times they do create a make shift canal by defying all conventions. In the peak irrigation season, a group of tail end landholders often block water inflow in one narrow strip from head to tail and divert this water to the tail end, thus converting a narrow strip of fields into a temporary canal. This practice is considered water inefficient, is tricky, and also requires a lot of coordination while water travels four kilometres from head to tail. Landholders in the head reach do not always allow this makeshift canal to be operated.

The sowdi, who earlier worked as a neerganti, told me that Kuruba landholders nowadays take water out of turn. Head reach farmers, in fact, complained that in some parts of the atchakat no rules are practically followed. In the same breath, they also complained about the wasteful use of water during the irrigation season. All practices that challenge the established pattern are wasteful because they go against the laws of gravity, against what is considered as the "natural", "unassisted" flow of water from field to field, from head to tail, inscribed on the atchakat.

Acts of resistance to norms have proven counterproductive to the institution of neerganti. While refusing to employ the services of the neerganti, many smallholders argue that the government has now appointed a sowdi to open and close the sluices and they can handle the rest of the water distribution on their own. Refusing to accept the neerganti's mediation translates indirectly into the non-acceptance of the established rules of water distribution in the atchakat. Only head reach landholders, who largely are non-cultivators, want neerganti services.

It is a point of speculation whether the institution will transform itself to accommodate emerging defiance of smallholders. What should be the basis for institution's legitimacy as a mediating agency for water distribution among all landholders? When defiance to unequal distribution of water is one of the aspects that results into delegitimising the institution, the possible answer may be that the social arrangements for water distribution are democratised before the institution adapts itself.

However, the preceding discussion indicates that the democratisation of water distribution rules would touch upon all aspects of water management, tank designs and agricultural practices in the atchakat.

To sum up, the shift in authority of tank management has coincided with a shift in the cropping pattern and corresponding water utilisation methods in the atchakat. The intensification of paddy cultivation in the atchakat has accentuated water scarcity induced by the hydrology of the region. As a result, paddy cultivation in the entire atchakat is possible only if the tank completely fills up. The increased involvement of the MID in tank management has brought in a normative rule that water from the tank will not be released unless is enough for the entire atchakat. This normative notion of equality between head reach and tail end farmers does not imply that the interests of tail enders are given prominence in tank management. New interests have emerged with the diversifying cropping pattern and with the introduction of bore well irrigation in the atchakat, which also have a stake in tank water. These new interests seem to have coincided with tail end interests and have superseded the traditionally powerful, head reach stake in the tank.

Shifting tank designs have been located in the context of a tussle over water resources between conflicting and often directly antagonistic actors. The chapter, thus, shows that the change in designs and cropping regimes not only emerged together, but that designs have been transformed and are transforming as a result of a challenge to and defiance of the "naturalised" norms that inscribe these designs.

Notes

[1] In the state of Mysore, the first of such abolition laws was passed in 1955. Inams, including the hereditary posts for any type of village services, stood abolished by the date prescribed in the Act. See Rajan (1981: Annexure 3) for further reference.

[2] There were two ways of sowing punaji bhatta. In one method, the seeds were thrown dry and then the land was ploughed; seeds would sprout after the arrival of first rain. The seeds can survive without sprouting for 15 days to one month waiting for the first rain to arrive. Irrigation from the tank was provided two months after sprouting. Those who were late in sowing followed the second method. The seeds were first sprouted separately and then thrown on the land that is reduced to slush. Both methods needed the same amount of water and gave the same yield.

[3] The strength of earthen embankments depends upon homogeneity. If structural non-homogeneities or foreign entities – in this case the sluice opening and the platform to operate it – are located in the middle of the earthen mass, and if the structural connection between the foreign body and the earthen mass in the embankment is not sufficiently adhesive, there could be sliding between the different structural materials. It would be a weak point for the stability of the embankment.

[4] Although Muslims are a minority group in Karnataka and largely socio-economically disadvantaged, some of them have acquired wealth and power. Muslims in the business of money lending figure in the latter category.

7

"Tail-Enders First"

A Tank Irrigating Paddy and Garden Crops in the Wet Region

In order to explain, why water cannot be supplied first to the tail-enders, a head reach farmer (of some other tank-irrigated area) asked me a question, "how could you expect water to flow from toe towards head if you pour it on top of your head?"

It is natural that water flows from a higher to a lower level under the force of gravity. Therefore, it may be logical or even self evident that water is first supplied to the land through which it passes first. My respondent's agitated answer to my query (as quoted above) was perfectly understandable as he was trying to explain to me what is natural and hence logical.

This chapter discusses the case of a tank irrigating paddy and garden crops located in the wet region of western Karnataka. Tail end farmers of this tank have reversed the customary norm of "water is first supplied to the head reach" practiced in other tanks in the region. The tail end challenge to the "head reach first" norm is based on an uncommon interpretation of patterns of supply and seepage from the earthen canals. The chapter further explores how struggle over water involves interpretation of tradition, rights, rules and physical dimensions of the irrigation infrastructure. Rules and rights are entangled with the physical dimensions of irrigation structures. The chapter further shows how challenge to and change in traditions involving rules, rights and physical structures are related to changes in cropping pattern and social relations.

The Tank

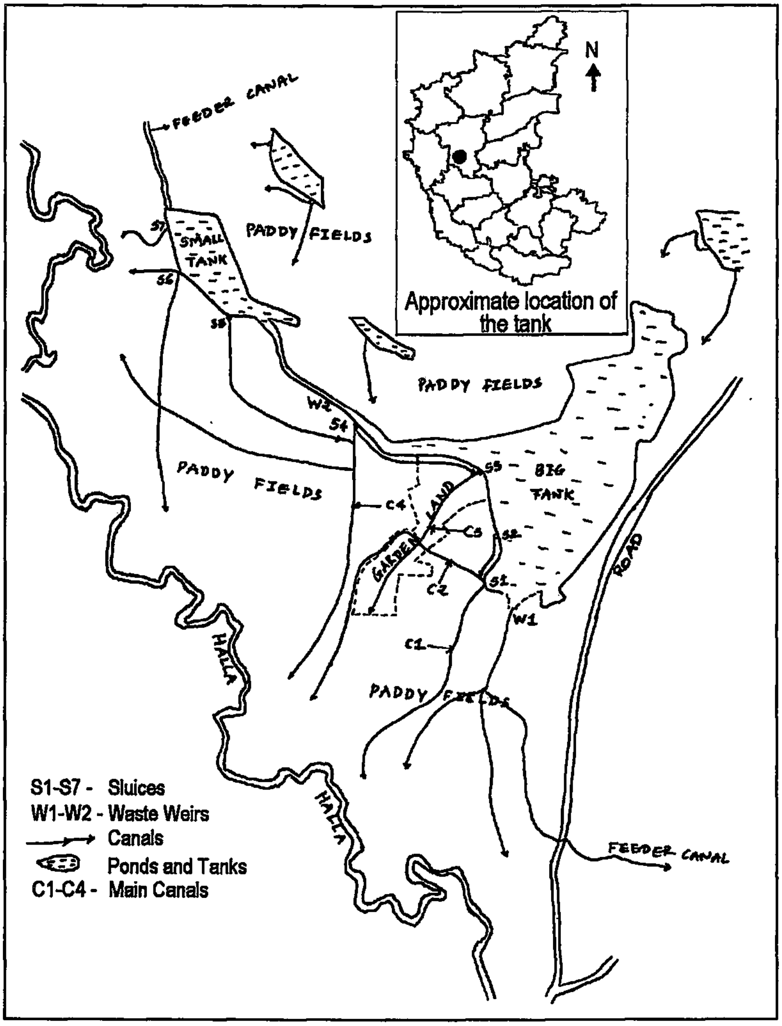
The tank is located in the wet region of western Karnataka, a rain-assured region also known as the semi-malnad region. The average annual rainfall is above 1500 mm. Tanks in this region provide irrigation to paddy in the rainy season and to the garden crop of betel nut in the summer season.

The tank under study has a somewhat unique arrangement. As shown in figure 7.1, there are actually two reservoirs that are located next to each other and connected in the middle by a common waste weir (W2). That means the halla that feeds both tanks flows from one reservoir to the other. The embankments of both reservoirs meet up in the middle where the waste weir is situated. As the embankment is more or less continuous, the two reservoirs can in fact be considered as one tank. However, I call them two separate tanks not only because farmers consider them as two separate tanks with separate names but also because they have distinct irrigation and cropping patterns. This chapter focuses on the bigger tank.

The tanks in this region were constructed during the Kalyani Chalukya dynasty between 900 and 1100 A.D. Both tanks are at least ten generations old. The hydrology of the tanks is as follows. The earthen feeder canal that brings water to both the tanks passes from the small to the big tank past the waste weir named W2 in figure 7.1. Looked differently, one of the banks of the feeder canal is dammed to create both reservoirs and hence the embankment of both tanks run parallel to the course of the feeder canal. After feeding the big tank, the feeder canal passes over one more waste weir, named W1 in the figure 7.1, and splits into three; two meet up with the halla downstream after irrigating several paddy fields and the third resumes the role of the feeder canal to the downstream series of tanks.

Both tanks together irrigate roughly 240 hectares of land, of which 16-20 hectares is garden land and the rest paddy land. One crop of broadcasted paddy is grown in rainy seasons, followed by pulses. The farmers claim that a part of the garden crop of betel nut is more than 5 generations old. The garden crop of betel nut is considered precious and is prioritised for irrigation. Half the capacity of the tank is hence always kept reserved for the garden crop.

FIGURE 7.1: A schematic diagram of the atchakat and the approximate location of the tank



The sluices

The bigger tank has a 2.5 kilometres long bund and the smaller one 2 kilometres. The two tanks have 4 and 3 sluices respectively, marked as S1 to S7 in figure 7.1. All the sluices are of the plug and pole type. Sluices S2, S3 and S6 are the deepest sluices and are operated for summer irrigation. Sluices S2 and S3 have two apertures, vertically located above each other. Usually the plug is removed in the vertical direction in almost all the plug and pole type of sluices in Karnataka. But the tanks in this region, perhaps the oldest tanks presently in working condition in Karnataka, have some sluices with their lowest (deepest) apertures opening horizontally. Removal of the plug in the horizontal direction cannot be performed by standing on the platform on the embankment and someone has to manually perform the task. See figure 7.2 for the engineering line drawing of such a sluice.

Usually the deepest sluice of the big tank is operated only during summer seasons to irrigate garden land. The tank has now silted up to the sill level of the lowest sluice, hence during summer when there is a few feet of water in the tank, it is not difficult to remove the plug horizontally. However, it is a puzzle why horizontally-opening sluices were provided when vertically-opening one would be more convenient to operate. The reason perhaps is that the lowest sluice would require the vertical tunnel to operate the pole to pierce through the entire depth of the embankment. In this region, the embankments are made of sandy soils and face a higher risk of breaching due to heavy torrential showers common during rainy seasons. In order to avoid weak points in the embankment, the vertical tunnel through which the sluice pole operates was only provided up to half the depth of the embankment for the vertically opening sluice while the deepest sluice was operated horizontally. Sluices S1 and S4 are at 5 ft depth (from the top of the embankment) and the middle sluice in the bigger tank is at 20 ft depth.

The plug actually is a hollow cap made of *bidu* (an alloy) through which the pole passes up to the bottom of the cap. This type of plug is known to survive under water at least for one generation without rusting and swelling, unlike wooden plugs.

Water availability

As explained in chapter 4, the capacity of tanks is usually smaller in this region corresponding to the size of the atchakat. Like other tanks in this region, this tank also empties after one round of irrigation provided to the entire atchakat. At the same time, it fills up at least three times during the rainy and paddy-growing season.

It is very rare that the tanks in this region do not fill up during the rainy season at all. That has happened only 3-4 times in the lifetime of elderly farmers. The tank fills up in July or August and waste weirs usually discharge water until the end of October. November showers are stored in the tanks for the summer irrigation.

There is also a hereditary post of neerganti which in this region is known as *manegara*. Neerganti or manegara's job is to watch the embankment, open the sluices and ensure that the atchakat land is irrigated as per the rotation schedule. At present a person known as Patkeri is appointed by the MID to open and close the sluices and watch the structures. Farmers themselves distribute water.

Tail-Enders First

In the atchakat of the big tank there is a customary rule, applied more stringently in the last two decades, that whenever water is released for irrigation, it is supplied first to the tail end. The rule is not entirely new; it is also not peculiar to the atchakat of this tank only. In the irrigated areas of some other tanks in this region such a rule has been followed for at least two generations. The rule is no more followed in other tanks I studied. According to the longstanding rule, water was first supplied to the tail end when irrigation was given the second time – during hodatha – to the paddy crop. (See chapter 4 for the description of hodatha).

In this region, paddy is cultivated broadcasted in the rainy season in the atchakat of tanks irrigating paddy and garden crops. The reasons why farmers continue to grow broadcasted paddy in this region, while farmers in other parts of Karnataka have shifted to transplanted paddy, are discussed in chapter 4. Here I briefly summarise the main reasons. First, tank capacity in this region is enough only to supply water for one round of irrigation for the entire atchakat. This is the main constraint why transplanted paddy, which needs more water, cannot be grown easily. The second important reason is that if grown, the season of transplanted paddy beginning in December or January would clash with summer irrigation for betel nut. Even if early maturing varieties are chosen, the irrigation requirement for crucial flowering stage would clash with the summer irrigation demands of garden crop. The last showers of November are stored for the summer irrigation of garden crop.

Water for broadcasted paddy is supplied totally two times, first during the hodatha time and second during the flowering time. As early maturing varieties have been conventionally sown in the tail end they flower earlier than in the head reach and require the second irrigation before the head reach. Hence, water is conventionally supplied first to the tail end in the second round of irrigation. However, the rule is no more in practice in other tanks I studied in the region.

Any arrangement for water distribution necessitates appropriate design of physical structures. But a set of rules and roles are needed to operate physical structures in order to accomplish the intended outcome. The rule that irrigation is first supplied to the tail end during flowering time can be implemented only if main canals are in good shape. Put another way, main canals exist in the atchakat to rotate water between the head reach and tail end according to the rule. In the other tanks I studied in this region, main canals have largely disappeared and hence the rule has also become dysfunctional. Furthermore, tail end farmers justify the tail end first rule by referring to the manner in which the earthen main canals in the atchakat function. Thus, the rule that irrigation is supplied first to the tail end is constitutive of the way water distribution structures are designed.

The tail-enders first rule in the atchakat of the big tank, however, has a slightly different trajectory than the earlier rule in other tanks. Any time water is supplied to broadcasted paddy, it is first supplied to the tail end, also during the hodatha time. The tail end farmers argue that such a rule is justified not only because it is the most efficient way of distributing water but also the only way water can be supplied to the entire atchakat.

There are four main canals (marked C1 to C4 in figure 7.1) in the atchakat of the big tank. Three canals irrigate paddy land. The middle canal C3, supplied by the deepest sluice S3, exclusively irrigates garden land. Each of the main canals irrigating paddy land is connected with two sluices. Sluices S1 and S2 supply the canals C1 and C2 and sluices S3 and S4 supply canal C4. Out of roughly 160 hectares irrigated by the big tank C1 and C2 irrigate around 120 hectares and C4 the rest. Around 80 hectares take water from the main canals directly while the rest is irrigated field to field starting with the fields adjacent to the canals. All canals are earthen canals.

The canals in the atchakat of the big tank are also in a bad state like is the case of main canals in other tanks that I studied in this region. There is heavy seepage from the main canals because canal bunds have been thinned down due to encroachments. Rodents have also heavily burrowed through them. As a result, in the words of one of the elderly farmers, "if the canals irrigate 4 hectares, they waste water for another 4 hectares." This is what exactly tail end farmers are arguing. The water distribution method should take advantage of seepage which otherwise would be wasted. They argue that when the canals supply water to the tail end, they automatically and simultaneously irrigate the head and middle reaches due to heavy seepage. Hence, the canals should always supply water first to the tail end.

It usually takes two days for water to reach the tail end after the sluices are opened. Meanwhile head and middle reach farmers irrigate their lands with seepage water but they are not allowed to cut the main canals to take water to their lands. If water is first supplied to the head reach, in one day four hectares in the head reach, two hectares in the middle reach and 0.4 hectares in the tail end can be irrigated. In such a case, by the time water arrives in the tail end it is merely a trickle. This is the reason why in some other tanks of this region, tail end land is converted into hankalu land and land earlier planted with paddy is now cultivated with maize and jowar. In case water is first supplied to the tail end, the seepage water can irrigate around five to ten gunta (100 gunta = 1 hectare) in the head and middle reaches in one day. Once opened the sluices are kept open for 20 to 25 days, including during the nights, until one round of irrigation is complete. Hence, by the time it is turn of the head reach, a large part of the lands adjacent to the canals have already been irrigated. Nonetheless, farmers with land away from the canals in the head and middle reaches have to wait until they are allowed to make a cut in the canals and take water field to field to their plots.

Tail end farmers justify "tail end first" rule also for a second reason. Both farmers and engineers would agree that there is a need of higher pressure (as farmers formulate it) and discharge (in the engineers' discourse) at the beginning of the canal in order for water to travel a longer distance. That is why tail enders argue that in the beginning of the irrigation round when the tank has "depth" (larger amount of water for the engineers) water can travel unto the tail end easily. Once the water level in the tank depletes, the "pressure" and "discharge" reduce, and the result is a trickle at the tail end. So it is logical that water should first be supplied to the tail end to utilise the higher "pressure" and "discharge" available in the beginning of the irrigation round when the tank has more water. Such a system is also efficient because it prevents wastage of seepage water. This is how tail-end farmers have interpreted the functioning of earthen canals for the efficient and also equitable distribution of water.

The question is why in the case of the big tank tail-enders have been able to contest the head reach first norm, but not so in other tanks where tail end land is being converted into hankalu land due to shortage of water. The change in landholding patterns and a shift in cropping pattern may be one explanation.

Tail End versus Head Reach: Land Holding in the Atchakat

There are two dominant landholding castes/communities in the atchakat – Jainas and Muslims – of which Muslims are traditionally the largest landholding group in the tail end. In the last couple of decades, Muslims have acquired more garden land in the head reach and hankalu land outside the atchakat. A few of them acquired property rights to their tenancy land as a result of the tenancy act implemented in the 1970s, though this number is very small. Migration of one family member, especially to the coffee growing areas of Mangalore and Coorg or to Goa doing odd jobs, seems to have enabled many Muslim families not only to keep the ownership of their lands in the atchakat but also to expand their economic assets. During the same period the other dominant landholding caste Jainas have lost part of their lands because some of them sold their lands in order to settle in urban areas or to shift to more profitable economic activities. At present, the village has 90 percent Muslim population.

The landholding pattern in the atchakat of both big and small tanks highlights the fact that Muslims own a substantial chunk of land not just in the tail end but also in the garden land. According to water demand list of 1998, there are totally 358 landholders in the atchakat of both tanks, of which 173 are Muslims (48 percent), 130 Jainas (36 percent) and the rest 55 (15 percent) SC, ST and Lingayat according to the water demand list of 1998. Table 7.1 gives a rough break up of Muslims and Jaina landholders in the tail end, middle and head reaches based on the water demand list.

TABLE 7.1: Number of landholders in the tail end, middle and head reach of the tank

	Paddy-Tail	*Paddy-Middle*	*Paddy-Head*	*Garden*	*Total*
Muslims	43	42	35	53	173
Jainas	13	55	39	23	130
Total	56	97	74	76	303

Out of total number of landholders 76 percent in the tail end, 44 percent in the middle and 47 percent in the head reach are Muslims. The landholding pattern first of all shows that while the number of paddy landholders in the head and middle reach is largely balanced between Muslims and Jainas, Muslims are the largest landholders in the tail end. Secondly, except one Lingayat landholder, Muslims and Jainas own all the garden land. Out of the total number of garden landholders 70 percent are Muslims. The break up on the basis of the number of landholders does not give a clear picture of how much land is owned by each community. However, the average size of paddy land in the atchakat is one hectare per landholder. The size of garden landholding is even smaller. A majority of landholders own less than 0.2 hectare; none of them own more than 0.3 hectares. Assuming that the amount of land owned is not drastically skewed between Muslim and Jaina landholders, the numerical strength of landholders is roughly indicative of the amount of land owned by each community.

In addition, almost all farmers in the village have hankalu land. The cropping pattern on hankalu land has significantly diversified in the last couple of decades. After the introduction of irrigated varieties of dry crops, a number of crops such as DCH cotton, hybrid jowar, maize, sunflower, mulberry, groundnut, various vegetables and even paddy and garden crops like betel nut, betel leaf and coconut are grown on hankalu land. The economic power earned by Muslims from their garden land and diversification of agriculture on dry land is visible in the form of their collective assertion in the public sphere of the village. One manifestation of this assertion is the demand of water first to the tail end. Collective assertions of Muslims have also challenged many conventionally/traditionally accepted norms of management and maintenance of the tank.

Traditions: Challenge and Change

Jainas, in this region, are historically a ruling caste. Village officers in the British period were appointed from Jainas that continued after independence until 1964 when the post was officially abolished. Unofficially, they continued to play an important role in the management of tank resources even after 1964. Until the 1970s, usually one "powerful" (in the words of the ex-Patel) farmer each from the head, middle reach and the tail end were selected to form a farmers' committee to take decisions on irrigation matters. This committee and some other influential farmers usually met in the panchayat office especially before the sluices were opened and the canals cleaned. The committee decided how much land could be cultivated with a second paddy crop in the summer, how much water should be kept reserved for garden land, how water should be distributed in case the tank filled up less than half and also how irrigation turn should be rotated for paddy land. Although the committee had no official mandate before or after 1964, it enjoyed a social mandate and legitimacy. After the tank was taken over by the PWD in the 1970s, a similar system continued for another decade or so until the tank was handed over to the MID in the early 1980s. Around 15 years ago (around 1985 or so), the MID asked landholders to form an Irrigation Committee separate from the influential farmers' committee. This committee was formed and the list of the members was given to the MID. This newly formed Irrigation Committee, however, barely functioned because by then the conventional norm that only a few influential and powerful farmers gathered to decide on behalf of all the farmers was being challenged.

The canal cleaning and rotation schedule were first contested. Traditionally, the main canals had to be cleaned before every irrigation season began otherwise almost all water would be lost through seepage. Conventionally, the influential farmers' committee decided the day to open the sluices for hodatha after assessing the rainfall and irrigation needs. An announcement was made in the village one or two days in advance of the scheduled day of canal cleaning. All landholders were expected to contribute their labour. However, around 15 to 20 years ago, some farmers started to object to the fact that the rich farmers sent their labourers. Those who contributed their own labour began to ask questions such as, "if I have one acre (0.4 hectare) of land and if I contribute my labour and if you have 5 acres (2 hectares) of land, how come you send only one labourer." For a couple of years, the canals were not cleaned because such disputes could not be resolved.

This was also the time when many other conventionally accepted norms came under close scrutiny. If the tank filled up more than half during the month of November, the influential farmers' committee usually gave permission for 16 to 20 hectares of land located next to the garden land to be cultivated with a second crop of transplanted paddy. Water was supplied to the second paddy crop around six times. The tail end farmers started to question this practice on the ground that if irrigation was supplied to grow a second crop of transplanted paddy on some land in the head reach, the tank would be empty by the end of the summer. In case rain arrived late in the next season, the tank would barely have water during the most crucial phase of hodatha for the next paddy crop in the atchakat.

The contestation to conventions was possible as some farmers had their economic power increased, also this challenge emerged in the context of escalating tensions due to the intensification of paddy cultivation in the atchakat. Although the size of the atchakat has not been significantly increased, over the last couple of decades every inch of land in the atchakat has been cultivated. One of the elderly farmers remembered that when he was young, "the field bunds were so large that cattle could graze on them, but now they have all been thinned down to half their size." As already mentioned, even the canal bunds have been thinned down to half their previous width. The elderly farmers also said that earlier at least a quarter of the total land in the atchakat was kept fallow for a variety of reasons, whereas now every inch of land is sown with paddy. As one of them put it, "if the owner of the land cannot afford to cultivate it, he would find someone else who could." Some other farmers also said that just a decade ago farmers in the atchakat rarely planted pulses after the harvest of paddy. In the last 10 years, however, this has changed and almost all farmers cultivate pulses. As a result even when the atchakat size has not significantly changed, the water demand has increased.

The intensification of cultivation also takes other forms. When previously farmers cultivated a crop of pulses using only residual moisture available in the fields after paddy was harvested, now farmers demand irrigation even for pulses. With the availability of chemical fertilisers, farmers in the atchakat – like other farmers elsewhere – discovered that if they "sow" (in their own words) fertiliser along with the seeds of pulses the yield would be much higher than otherwise. But for the "sowing" of fertiliser one round of irrigation would be required otherwise the fertiliser would not dissolve, remain concentrated and adversely affect plants. The farmers who grew pulses started to demand one round of irrigation for the entire atchakat instead of water supplied to a few head reach farmers for the second crop of transplanted paddy.

The challenge to the conventionally followed practice of canal cleaning and the demand of one round of irrigation for pulses heralded the change that in the last ten years all farmers are gathering for the crucial decisions. Canal cleaning is now contracted out. All farmers pay a certain amount per hectare as fixed in the farmers' meeting before the irrigation season starts. A contractor from outside the village is given the task of cleaning and repairing the canals. The issue of how much land can be grows with a second crop of paddy is still fiercely debated in the meeting, but one round of irrigation is provided to the entire atchakat at the time of planting pulses. In case the tank fills up more than 75 percent during November, some farmers in the head reach start land preparation for transplanted paddy even before the farmers' meeting is called. To contest this, other farmers from the tail end plant semi dry crops and ask for water just to prevent the head reach farmers getting water for the second crop. Farmers from the head reach in such case argue that water for the second paddy crop is their customary right. During a heated discussion, when the head reach farmers attempted to remind the pulse-growing farmers that, "your fathers and their fathers never asked for water to grow pulses", the retort from the tail end farmers, contesting tradition as sacrosanct, was, "our fathers and their fathers were mad, we are not."

The clash of interests of – the tail end and head reach farmers, Muslims and Jainas, pulse-growing farmers and second paddy crop growing farmers, tradition and change – extends to other issues. The head reach farmers increasingly argue for a more active role to be given to the MID in the farmers' committee, a demand the tail end farmers are strictly opposing. The head reach farmers argue that with increasing conflicts and tension over the demand of water in the atchakat, the impartial mediation of the MID and enforcement of legally valid rules is essential. They also advocate the formation of a registered farmers' committee with membership for MID officials. The tail end farmers in response point out that an external agency such as the MID may not remain neutral in the matters of conflict. They also fear that the MID's involvement may result in new power dynamics. Tail end farmers point out with regard to the legal enforceability of rules that if a matter goes to the court in case of disagreement it may take several years before the solution is found. If courts are not involved, there is no difference whether the MID or farmers make and enforce the rules. For similar reasons, tail end farmers are also not ready to register the farmers' organisation because then some farmers would have more power than others. And the arguments continue.

However, not all water management practices are contested; neither are all traditions rejected. One more outcome of the tail end challenge to the norms is that one traditional practice of water distribution is strictly implemented. If the tank does not fill up fully in the months of July and August, i.e. before the hodatha time, then water collected in the tank is distributed proportionally among the landholders.

The tank is considered full if all the seven sluices submerge and when the distance between the edge of the water spread area and the waste weir - W1 - is roughly five feet. The mark on the *basavanna* (bull) statue existing on sluice 2 is referred in order to estimate other scenarios of water availability. There is a stone mark close to the feet of basavanna that indicates quarter full. Water collected to a level of one foot above the stone mark is considered half full.

In case the tank fills up less than half, no farmers' meeting is called, water is not released for hodatha and whatever water is collected is stored for the summer irrigation of the garden crop. If the tank fills up to full capacity, no farmers' meeting is called and irrigation is supplied according to the rules. Only if the tank fills up between half full and full when the farmers' meeting is called. This meeting usually results in intense discussions about whether water should be released or not. In case it is decided in the meeting to release water, it is distributed proportionally. That means only a part of the land of each landholder is watered or water is supplied only to each field for a fixed duration. If only a part of the land is provided irrigation, only part of the paddy in each field survives. If water is supplied on a time basis, each field is allowed to take water for a fixed duration only, and it is up to the landholder how the water is distributed in his/her land. Water is released after estimating the level of water storage in the tank and correspondingly it is calculated how much land or what quantity of water can be supplied. After the discussions, when irrigation actually begins, many farmers go around with the Patkeri to ensure that all farmers take only the prescribed share of water.

The elderly farmers remember that in their lifetime water was proportionally distributed only on three to four occasions, but in the last 20 years such incidents have become more frequent. The simplest reason for the increased incidence of proportional division of water could be the more stringent following of rules. The more important reason, however, is that the tank almost empties at the end of the summer season after water is supplied to the garden land, to pulses and to possibly a few acres of second crop of paddy. Hence, it takes longer to fill up in the next season. Also, at times it fills up only close to the hodatha time. It has now become more common that the tank is less than full during the hodatha time. However, the tail end challenge to norms and the participation of all farmers in the decision making process has resulted in a more stringent following of the rule of proportional distribution when alternatively in such situations water could have been supplied only to the head reach.

There is another conventional rule that is never questioned. After November, water in the tank is reserved for the garden land. This is because the loss of betel nut due to water scarcity is considered too costly a loss. It takes not only several years of careful gardening for a betel nut tree to bear fruits but farmers also boast that some of the garden crop is at least five hundred years old. The betel nut crop is known as a *shashwat* (immortal) crop in this region. Garden farmers often tell to paddy farmers, "if your paddy fails, it's just few months of work, but if areca (betel nut) fails, generations of hard work would go waste." The "immortality" of betel nut makes the tradition of reserving half the tank capacity for betel but pious, sacred, too costly to be challenged.

Thus, the irrigation requirement of betel nut is given primacy over the irrigation needs of the second crop of paddy. The clash of seasons for transplanted paddy and the summer irrigation for the garden crop is one reason that constrains cultivation of transplanted paddy in the atchakat. If farmers shift to the cultivation of transplanted paddy, the water demand would increase to the extent that much of the tail end would not receive irrigation.

Hence, in this sense the interests of garden farmers and paddy-growing tail end farmers converge. There is also the related point that garden land is owned by farmers from the atchakat only. Numerically Muslims are the dominant landholders both in the tail end and in the garden land. In this sense, the interests of tail end and garden land farmers converge. In other words, it is in the interest of the tail end not to question the tradition of keeping half the tank water reserved for the garden land. And, it is in the interests of the garden farmers that transplanted paddy is not grown in the atchakat.

Downstream vs. Upstream Water Demand: Engineering Negotiations with Hydrology

The increasing magnitude of water demand is associated with larger changes in the highly contested hydrology of the region. Several new structures and consequent claims on water have come up on the halla that feeds these tanks. Not only do these fresh claims clash with the customarily recognised right to water, but also the magnitude of the claim over customary rights has gone up due to the intensification of agriculture. The resulting mosaic of various (claimed) rights to water is based on multiple interpretations of tradition and custom. Also, the mosaic is intricately connected with the engineering designs of the irrigation infrastructure. As I explain below, the engineering designs are the principal arenas of struggle.

As explained in chapter 4, the density of tanks in this region is high unlike in the mixed region of southern and northern Karnataka. Tanks are also hydrologically more closely interconnected with each other. Although in the mixed region of southern and northern Karnataka water inflow in the downstream tank depends upon the outflow from the upstream tank, usually the amount of water that can be negotiated between the downstream and the upstream tanks is not a simple function of the dimensions (level and width) of the upstream waste weir. In the mixed region, there are other engineering and hydrological constraints such as the size of the intermittent catchment of the halla, the size and shape of the valley that is bridged to build tanks and the level and size of the waste weirs in the upstream tanks that influence the amount of inflow in one particular tank. This means that the width and height of the overflow from the upstream waste weir is just one among many factors that influence the water availability in one particular tank. Several tanks in the mixed region, constructed a few centuries ago, have flush escape type of waste weirs, i.e. a mere escape is provided where the embankment meets with higher ground. Hence, there is not much scope to negotiate the dimensions of the waste weir in such a way that more water is received downstream. In such a case, once a series of tanks are constructed there is little scope to negotiate water inflow between downstream and upstream tanks.

In contradistinction, hydrology is a contested arena in the wet region where the tanks under study are located. The engineering negotiations of the hydrology in this region are as follows. A series of tanks is fed by a feeder canal (and not by a halla as in the mixed region). The feeder canal usually originates from a check dam constructed on a halla. At several places on the feeder canal, gates are installed to control the inflow and outflow of water to and from a series of tanks. The water flowing over the waste weir of an upstream tank either enters the halla or it flows into the feeder canal to be fed to the downstream tanks.

There also exists a complex network of customarily recognised rights over water along with a variety of engineering infrastructure. Various engineering structures are constructed and operated according to customarily recognised rights and rules. A particular right to a certain amount of water is based on the design of an engineering infrastructure and a rule. For instance, the sill of a check dam and the size of a gate on the feeder canal determines how much water can flow out of it, but the rule that unless one series of tanks are filled, water is not diverted to the other series is ultimately what makes the technology function with the intended outcome.

However, the dimensions of engineering infrastructure prominently define the right to water. Customarily, the downstream tank has a right to water that flows over the waste weir of the upstream tank. In this sense, the right to water of the downstream tank is imprinted on the dimensions (width and height of the crest) of the waste weir of the upstream tank. Consequently, the size of the gates on the feeder canals and the sill levels of the check dams on the halla, the sill levels and width of waste weirs are the sites of struggle between downstream and upstream users.

There are other claims to run off water other than what collects in a series of tanks. Impounding water supplied from a feeder canal into a tank is just one way of utilising it. On the way from one tank to the other the feeder canals also feed large chunks of paddy land. At several places the bunds of the feeder canals are further embanked and mostly piped outlets and occasionally gates are provided to irrigate paddy lands below. Farmers who own these lands, irrigated directly by the feeder canals, do not pay water cess to the Revenue Department because their right to water is not recognised officially, at times also not customarily. For instance, according to the customary rules, water from the upstream tanks has to be compulsorily released for the downstream tanks, but no such right to water is recognised for the lands irrigated directly by the feeder canal.

There are other means by which water is impounded for paddy cultivation in this region. Small check dams across small streams that show up only during the rainy season are very common. A small check dam with 5 to 6 gunta (100 gunta = 1 hectare) of water-spread can irrigate 2 to 2.4 hectares of paddy land. Many times during the rainy season such check dams are washed away and are reconstructed in the next season.

In my case study tank, water is received from a feeder canal that originates from a check dam constructed several kilometres upstream on the halla. According to local understanding, the feeder canal, both these tanks and the check dam on the halla from which the feeder canal takes off must have been constructed at the same time, i.e. at least nine centuries ago. According to farmers' popular understanding, the sill level of the check dam from where the feeder canal takes off and the sills of both the waste weirs of the big and the small tanks are at the same level. That means water is automatically diverted from the check dam on the halla towards these tanks until both the waste weirs start discharging. These sill levels are zealously guarded (in the peak irrigation season, farmers from these tanks take turns to physically guard the check dam) because only after both these tanks fill up will water from the check dam be diverted towards the other series of tanks fed by another feeder canal taking off from the same check dam.

The struggle to secure water is heightened especially during the hodatha and flowering time. The farmers of one particular tank have to guard both the downstream and upstream diversions that may reduce their access to water. During the hodatha time, farmers from the tanks fed by the second feeder canal originating from the same check dam routinely stake soil against the feeder canal that brings water to the tanks under study. Thus, farmers from the other series of tanks raise the water level behind the check dam to divert it to their tanks, which farmers from the tanks under study have to keep watch on and correct in time. The struggle reached its zenith when the politically powerful farmers from the tanks of the second feeder canal, with the help of the local MLA, got the check dam converted from earthen to solid masonry and also raised the sill level of the feeder canal that brings water to the tanks under study in order to increase water flow towards their tanks. After years of lobbying with the PWD and also fighting a court case farmers from the tanks under study finally got their customary right endorsed. Both the PWD and the court upheld their argument that the original sill level of the feeder canal and sill levels of both the waste weirs of these tanks were at the same level, had a historical, customary connection and hence should be honoured. So are the contested arenas of history, traditions and customs; some are challenged and others zealously guarded. This point is further discussed in chapter 9.

The New Entrant: Borewell Irrigation

Where does the bore well irrigation figure in this jigsaw puzzle? Like the old technology the new technology is neither wholly accepted nor rejected. The farmers from the tank-irrigated areas think that tube wells hold a promise for the future. By contrast, farmers whose lands are directly irrigated by the feeder canals prefer the security provided by tank irrigation.

This is because the farmers from tank-irrigated areas have a customary right to water while farmers whose lands are directly irrigated by the feeder canal do not have such rights. A leading farmer said that much of the feeder canal irrigated land has been sown with paddy only in the last couple of decades and hence these farmers do not have any customary rights. For instance, the waste weir canal of this tank, which resumes the function of feeder canal, irrigates 200 hectares of paddy land on its way to the downstream tank. This feeder canal receives water only once the waste weir W1 (see figure 7.1) discharges, i.e. after August. The supply into the feeder canal over the waste weir is highly erratic, thus making the life difficult for farmers of 200 hectares fed by the feeder canal. This is because these farmers cannot store water like farmers of tank-irrigated areas can. Rather, they have to depend only on the flowing water.

There are 100 bore wells in the 200 hectares irrigated by the feeder canal downstream of W1, whereas the atchakat of the big tank does not have any bore wells. The output from bore wells is not reliable because of frequent cuts in electricity supply. With frequent cuts in electricity, the bore wells can irrigate 0.8 hectares of land per day during the rainy season without canal water. Farmers having land in this patch of 200 hectares argue, however, that they prefer their lands irrigated by canal water even if the electricity were supplied round the clock. They explained that when their lands are irrigated with canal water, the whole patch has flowing water and enough seepage and hence their lands can retain a higher amount of water. In contrast, when they irrigate their land with bore wells, there is a much higher rate of percolation, especially if the neighbour's land is water starved. They also pointed out that having land in a tank atchakat has other advantages than just the higher yield. They further pointed out that their lands give the same yield as lands in the atchakat but bringing water to their lands poses a serious challenge every day in the cropping season. The security of supply, therefore, is the reason why farmers rarely install bore wells on tank atchakat lands.

However, farmers from the atchakat gave contradictory opinions than farmers of the feeder canal. Many of them said that the focus of farming has significantly shifted to hankalu or *megatti* (dry land converted to paddy land) from the tank land. If there is heavy rainfall during the paddy season, the megatti land, which is upland compared to tank-irrigated land, gives a higher yield than the atchakat land - 25 to 30 bags on megatti land against 20-25 bags in the atchakat. But if there is a moderate to normal rain the tank irrigated land gives a moderate yield - 22-25 bags and megatti land a lower yield than land in the atchakat. In general, the well-drained megatti land is considered superior to the overused - by now for centuries - and prone to water logging land in the atchakat. The farmers of the atchakat own roughly 200 to 240 hectares of hankalu and megatti land on which there are 70-80 bore wells. The attraction of having a bore well on hankalu and megatti lands is twofold: commercial crops like DCH cotton and garden crops can be grown, and a good yield of paddy can be reaped in good rainfall years. I was told that the megatti land (for paddy and garden crop) has a higher number of tube wells than the hankalu land owned by farmers of this atchakat. DCH cotton can survive if there is irregular rainfall but paddy is very sensitive to moisture stress and hence tube wells are more a necessity on megatti land. A couple of farmers from the atchakat of the big tank expectantly said that, if the problem of electricity supply is solved the struggle of sharing water in the tank atchakat would also be solved. According to them this would be the case because farmers would then prefer to grow paddy on megatti land, which is better quality land and gives a higher yield than the atchakat land.

Farmers from the canal irrigated area, therefore, vouch for the security of the atchakat land whereas the farmers from the atchakat are looking forward to the resolution of the electricity problem so that they get higher yields of paddy irrigated with tube wells.

The shift from tank to tube well irrigation in this region may not be entirely due to diversification of the cropping pattern as is the case in the mixed region because many farmers grow only paddy on megatti land. Rather, the shift entails the spatial dislocation of paddy from the atchakat to megatti land and from tank irrigated paddy to tube well- irrigated paddy. What such a choice means for the future of tank irrigation is a question for further research.

Thus, to sum up, the chapter narrates how tail end farmers have challenged the head first norm in their tank area. Tail end contestation, based on an uncommon interpretation of supply and seepage from the earthen canals, has challenged and reversed the dominant norm of "head reach first" and shown that technology can be scripted and made to function with an alternative value framework.

The chapter further explores how certain traditions are challenged when others are steadfastly guarded. In the context of heightened struggle over water due to the intensification of cultivation in the region, several customarily recognised rights and dimensions of physical structures have become arenas of contestation.

Shifts in water management practices and corresponding changes in designs of physical structures are understood in the context of struggle between – tail-enders and head reach farmers, paddy and garden crop growers, broadcasted and transplanted paddy growers, atchakat and hankalu land owners, Muslim and Jaina farmers, upstream and downstream farmers and kharif and rabi crop growers – against the backdrop of intensification and commercialisation of agriculture in the region.

8

"Tale of Two Paradoxes"

A Tank Irrigating Dry Crops in the Dry Region

"Of course, this is government's water!"

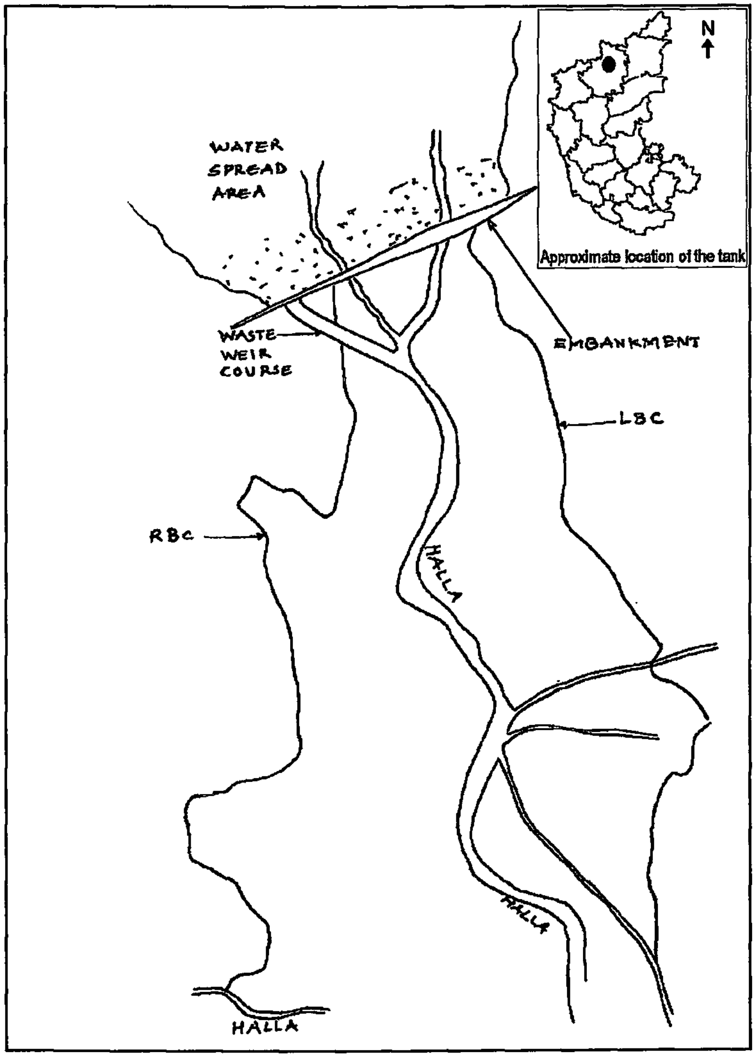
— A group of farmers from the atchakat discussing tank water.

This chapter discusses the case of a tank located in the dry region of northern Karnataka. The tank stands apart from the case study tanks of the previous chapters in three important respects. Firstly, in contrast to the old tanks discussed in the previous chapters, the tank discussed in this chapter is only a decade old. Secondly, this tank irrigates semi dry crops not paddy as is the case in the other three tanks. And thirdly, in contrast to the hierarchically managed, orderly, rule making and rule abiding social culture found in the previous case studies, there is an absence of recognisable form of hierarchy and at the same time chaos and conflicts in social environment of this tank.

The happenings in the irrigated area of this tank not only presented surprises during the fieldwork, but considerably baffled me at the time of conceptualising and analysing them. To me, this tank raises more questions than it answers. In this chapter, I have attempted to raise these questions in the form of two major paradoxes pertaining to the farmers' relationship with their irrigated infrastructure

The first paradox highlights the uneasy relationship between the MID and farmers. While the MID attempted to form a water users'

FIGURE 8.1: A schematic map of the atchakat and approximate location



association in the tank area, the farmers refused to organise into an association by claiming (as quoted above) that water stored in the tank belongs to the government and hence only the MID should manage and maintain it. The second paradox – the under-utilisation of tank water in this water parched region – points to the mismatch between culturally and locally specific land and water management practices and tank designs.

The Tank

The tank is located in the dry region of Bombay Karnataka. It was constructed with World Bank assistance. The work was started in 1986 and completed in 1989, except for the canal work. Irrigation in the head reach started in 1991 and in the tail end around 1994. The designed atchakat is 330 hectares, but only 220 hectares is irrigated. The bund is 1062 metres long and a maximum 10 metres high. The RBC is 4.32 kilometres and the LBC 4.92 kilometres long. Each canal is designed to irrigate 165 hectares. The canals run on the opposite edges of the atchakat. The tank is constructed at the meeting point of two seasonally flowing streams that converge into one on the downstream side of the dam. The converged stream, passing through the middle of the atchakat, is dry much of the year but flows during May to October. The water-spread area of the tank at full tank level is 69 hectares and collects water from 38.34 sq. miles of catchment area. The average annual rainfall in the region is 600-700 mm. Both the sluices are fitted with a shutter attached to a threaded rod and operated with a gearbox and a key spanner. The gross storage capacity of the tank is 1.7 million cubic metres of which 1.5 million cubic metres is live storage capacity.

"Of Course, This is Government's Water!"

The tank was constructed as a part of the Karnataka Tank Irrigation Project with financial and technical assistance from the World Bank. The contract for the project was signed with the World Bank in 1981. Originally the construction of 120 - 160 new tanks was proposed but eventually only 65 new tanks were constructed. The Staff Appraisal Report of the World Bank declared that, "the reason for constructing new tanks is to experiment with new planning and design criteria, the effect of which would be carefully monitored and evaluated. Lessons learned would subsequently be applied to the modernisation of existing tanks" (World Bank 1981: 20). Increasing farmers' participation in the operation of tank irrigation systems was one of the objectives of the project. And the study of possible approaches to the formation of water users' associations was declared as one of the important project components (World Bank 1981: 20-21). The staff appraisal report proposed the formation of a Tank Irrigation

Committee (TIC) immediately after construction of a tank was sanctioned in consultation with the Irrigation Department "before finalising the design of the Tank Irrigation Project" (World Bank 1981: 26). As regards TIC's role in water management, it was mentioned in the report that after the construction, at least twice a year before each irrigation season, local staff of the irrigation department would consult and agree with the committee on scheduling water delivery for the coming season (World Bank 1981: 35). The TIC was also envisaged to take part in design and planning of a tank before the construction, in addition to the operation and management of the infrastructure and water delivery after the construction, although the Minor Irrigation Department would retain the charge of physical structures. The report cautions that "experiences with farmers' organisations for irrigation, however, has generally not been encouraging in India or in most of Asia" (World Bank 1981: 86). The Karnataka Tank Irrigation Project was among the first experiments with farmers' organisations.

Despite the rhetoric about farmers' participation, no channels were created even on paper for farmers to participate in the design process. The design of crucial tank aspects remained the domain of technical experts trained in irrigation science. The experts appointed by the World Bank actively participated in the design process and several uneasy encounters occurred between the MID staff in charge of the designs and those appointed by the World Bank. (See Reddy (n.d.) for further discussion). Reddy (n.d.) argues that negotiations about design norms between the World Bank appointed experts and the staff of the newly created design department in the MID escalated the overall cost of the project and delayed the implementation. The evaluation and review of the design process that involved national and international technical experts and needs a different and detailed treatment, which is not dealt with in this chapter and book. It may be enough to point out here that despite the declared aim of the project to ensure farmers' participation, the design in reality remained a domain of technical experts.

I was presented with a surprise on my arrival in the village. This was my second visit to the tank after I selected it for detailed study. In the case of paddy tanks, the moment I stepped in the village and declared my intention to do research I was invariably taken to the "important/leading/powerful" farmer of the village/atchakat. The important farmer, may have been an ex-Patel, a president of the Irrigation Organisation or the economically and politically most powerful farmer of the village, would brief me on some basic facts and issues about the tank, would ask questions about my intentions of research and about myself. Only after he (in all cases a man) would tacitly approve my responses, would I then be taken to other farmers and allowed to approach the irrigated area on my own.

In contrast, when I declared my intention to do detailed research about this tank to a group of farmers at the teashop, they proposed that I make a presentation in a general meeting of all farmers in the afternoon. I should declare my intention of research in the meeting and only if the group agrees, could I continue. Around 20 to 25 farmers (all men) gathered in the meeting. The number grew to around 35 by the time the meeting ended. The discussion went on for one and a half hours in which all farmers participated. During the meeting, I was asked many pointed questions, some funny, some personal and others professional, some came up again and again. One of the serious questions that repeatedly propped up was my connection with the government.[1] Once farmers were satisfied that I was not sent by the government, a lively and general discussion on the tank, its history, water distribution issues and cropping pattern followed. Some farmers spoke more than others but the overall environment in the meeting was participatory. This was a surprise as I had grown accustomed to deal with social hierarchy in paddy tanks.

The social environment in this tank continued to pose surprises. In the next few days of my fieldwork, I was flooded with a long list of complaints, mutually contradictory story lines about water distribution in the atchakat, about disputes among farmers and stories about the MID and its officials. The whole experience was different than my usual experience in the tanks irrigating paddy. It also became clear that there was an absence of hierarchy and an absence of a locally recognisable authority in charge of tank management.

The landholding pattern in the atchakat also suggests a degree of horizontality in terms of the socio-economic profile of the farmers. While historically privileged groups usually own lands in the head reaches of tanks irrigating paddy, in this tank a substantial number of Lingayat farmers own land in the lower reaches of the canal and even in the tail end. The RBC irrigates lands belonging to 86 farmers out of which 33 are Lingayat and the rest OBC and lower castes. Out of 33 Lingayat landholders, only two farmers own land irrigated by the second outlet. Outlet numbers three and four irrigate no Lingayat land. Outlet numbers five to nine irrigate lands belonging to 15 Lingayat landholders. The rest of the lands belonging to 16 Lingayat farmers are either irrigated by outlet number 10 or are located in the tail end. The pattern is similar on the LBC side. The LBC runs seven feet below ground level in the head reach, a point discussed further later in the chapter. Hence, a part of the lands in the head reach cannot take water from the canal. The tail end benefits more from the LBC. Twelve Lingayat landholders, out of a total 65 farmers on the LBC side, have their lands irrigated by either outlet number one or two. The size of landholdings is also not significantly skewed between higher and lower caste landholders. All farmers on the RBC side own less than two hectares, except three Lingayat farmers who own between three and four hectares. I must also clarify that the pattern of landholdings may not remain constant over time. Right now the tank is only a decade old. The landholding pattern in the atchakat is the way it was before the construction of the tank. Once the benefits of having land in the head reach are fully realised, it is very likely that even here the historically privileged groups may gradually take over the head reach land.

However, at this point of time, the landholding pattern and absence of hierarchical social arrangements to manage irrigation suggests that the landholders in the atchakat share a degree of socio-economic similarity although they may be from different caste backgrounds. This is certainly not to suggest that all farmers equally participate in irrigation matters or that all farmers are equal. There are some farmers in the atchakat more powerful than others. But this difference in power and status has not (yet) manifested itself in an overarching structure of authority which institutionalise (usually discriminatory) rules of water distribution. It is a matter of speculation whether differences in power and status will result into hierarchical (and discriminatory) water management institutions or not once the tank is older. However, despite a degree of socio-economic horizontality among the irrigators, a democratically organised farmers' collective has not emerged in the irrigated area in the last decade despite the MID's efforts (largely on paper) to create one.

In the absence of a recognisable authority, either hierarchically organised or democratically formed, there is an absence of order in the irrigated area. The irrigated environment is marked by conflict and chaos. Farmers presented elaborate stories about internal disputes, the destruction of physical structures, fights among farmers and disputes with MID officers.

What forms the background of the first paradox is the absence of authority, either hierarchical or collective. It is paradoxical that while the MID has attempted to form a water users' organisation, farmers have refused to organise into an association despite a degree of socio-economic horizontality among them and have instead declared that the water stored in the tank belongs to the government and hence the government should manage the water distribution. The discussion on this paradox and its consequences for water distribution practices and collective action in the atchakat follows.

Outlet Stories

Almost all outlets on the RBC have been destroyed and several new pipe or open outlets have replaced them. Each new outlet has been installed to bring water exclusively to one piece of land in place of the designed arrangement that a few farmers would have shared water from one outlet via a common field channel. Farmers from all castes and economic backgrounds have participated in this process, although the method adopted for installing a new outlet has varied depending upon the status and power of the person, and correspondingly the degree to which the new outlet is concealed. The higher caste, influential farmer has simply destroyed the outlet and let the water flow into his land through an open channel (see figure 8.2), while the small landholder has installed a pipe outlet, nicely concealed in the canal bed or canal wall. The former has not even bothered to install any mechanism to control the water flow. As long as the main sluice in the bund is open, water would continue to flow into the newly made field-channel.

There were several contradictory accounts about "who has destroyed the outlets and why". Many farmers told us that all the new outlets were made with MID permission. MID officials denied making new outlets, or giving permissions for making new outlets or even modifying the existing ones. According to one farmer's version of what happened, the MID asked the contractor to make the canal and all the outlets that were marked on the map.

However, because some farmers did not agree to the proposed locations, the outlets were not made at the time of making the canals. The contractor installed them later by breaking the canal walls, but did not repair them. MID officials discard this story as bizarre. The last and most novel explanation was that women who regularly come to wash clothes and utensils broke the canal walls (presumably only where outlets were existing) and even the outlets.

The purpose here is not to determine what actually happened but to find out what generates this discrepancy between the actual design on paper and practice, between what is conceptualised and what is actualised. The design of water distribution structures that assumes the existence of farmers' organisation contributes to both paradoxes discussed in this chapter.

In case of the RBC and LBC, the cross sectional area of the canal decreases as one proceeds down the length of the canal from head to tail. In other words, the RBC and LBC have the highest width and depth in the head reach and lowest in the tail end. As the size of the cross section reduces and the amount of discharges remains the same, the depth (or head in engineering discourse) of the water available in the canal remains constant. With the uniform availability of head throughout the canal, water can be diverted to field channels with relative ease. Theoretically, the advantage of the canal with a decreasing size cross section compared to a uniform size canal is that, if the tank has enough water several outlets in the canal can simultaneously irrigate. This means that even when some outlets in the head and middle reaches are opened, water still reaches the tail end. In contrast, the tail end can effectively irrigate only if the outlets in the head reach are closed in case of a canal with an uniform cross section. A canal with a varying cross section also reduces losses and construction and maintenance costs. Thus, it promotes both efficiency and equity.

Furthermore, controlling the size and number of outlets and restricting the capacity of field channels can reduce diversion of water more than the allocated share for the prescribed cropping pattern. The size of the outlet and field channel can be restricted corresponding to the size of the irrigated area in two ways. The first way is to provide a bigger pipe and field channel and reduce the number of days for which the field channel would run. The second way is to provide water for all seven days and restrict the outlet size for daily supply. In case of the latter option, field channels are designed to run at their full discharge capacity every day. The full discharge capacity in this scenario would be the summation of daily irrigation needs of all land to be irrigated by that field channel. Hence, no rotation in the command of one outlet is needed. This option would be more appropriate for paddy cultivation where water, as per the preferred practices of farmers, is applied more frequently. The former option, namely to provide a bigger size outlet to supply water once in few days implies that the outlet is operated and the field channel is run only a few days a week to provide the irrigation needs for the whole week. In this case, again no rotation is observed among the land irrigated from one outlet.

FIGURE 8.2: An open channel taking off from the main canal.

The outlet is designed for a capacity somewhere in between the two options discussed above because irrigation is not needed every day for dry crops. In fact, for wheat and white jowar irrigation is effectively needed only once a week. In this tank area, each outlet is designed in such a way that rotation within the command area of the outlet is unavoidable. It requires collective management of an outlet, which farmers seem to be resisting.

Collective Action

Many farmers and even MID officials said that farmers settle scores by not cooperating in sharing the common irrigation resource. Some other farmers described the gist of farmers' lack of cooperation in a metaphorical way. Other farmers explained the lack of cooperation by saying that in their tank the rule "*jiski lathi usaki bhains*"[2] prevails. Even in the language of some farmers the orderly, collective management of the water resource is being arbitrarily opposed. Let us examine a couple of cases in which the cooperation is resisted.

1. One farmer owning land on the downstream side of a field channel, through which he was supposed to receive water from the common outlet, complained that the upstream farmer stopped tank water to flow through the field channel passing through his land. This, he claimed, was because he refused to give the upstream farmer water from his bavi (shallow open well). The downstream farmer approached MID officials and when even the officials could not resolve the conflict, he was given the permission to dig a separate channel to his field from the main canal. While talking to me, the tail end farmer gave a number of contradictory explanations about how the upstream farmer stopped water flow through field channel ranging from "he broke the field channel" to "he broke the diversion chamber" and finally to "he blocked the diversion chamber". We found that the diversion chamber and the field channel were both intact and that neither was blocked nor broken.

   The upstream farmer confirmed our hunch that the downstream farmer simply wanted a separate outlet channel for himself and had invented the whole story. But the MID official had a different story to tell. According to him, there was a conflict between both farmers over the issue of halla water. The upstream farmer wanted to lift halla water (which is flowing one plot below the land of the downstream farmer) with a diesel pump and wanted the downstream farmer to give permission to pass the pipeline through his land, which the downstream farmer refused, because he was worried about how it would affect his land. The upstream farmer then approached the MID to intervene. The MID also refused to give permission to lift water from the halla. I later found out that all farmers having land close to the halla have been lifting water from it, but the MID officials denied this was happening. The MID official told me that farmers have to take permission to lift water from the halla and those who were lifting water have been doing so since the time before the tank was constructed as no new permissions had been granted. This was a different story than what the MID officials told the upstream farmer when they refused to give him the permission in spite of the upstream farmer producing a recommendation letter from the local MLA. The MID official explained to me that the permission could not be granted because the upstream farmer's land was within a distance of 300 metres from the tank embankment and any digging in this area can potentially endanger the structure. The MID official also told me that the downstream farmer cannot in principle refuse to give permission to let the pipeline pass through his land as long as the pipeline was kept 3 ft below the surface. When I spoke to the upstream farmer he was not aware of the MID rule that no digging can be allowed within the distance of 300 metres of the dam structure despite the fact that the dispute had been going on for two years. The MID official also said that it all depended upon the discretion of the officer in charge who interpreted the rules and even if the actual distance was less than 300 metres, the official could refuse to give the permission on the ground that the digging could be potentially dangerous to the embankment.

2. Another farmer refused to allow a field channel that would have irrigated 80 acres of land on the downstream pass through his land. The farmer's reason was that the channel would have passed through his land but five feet (1.6 metres) below the ground level. As a result, he could not take water from the channel and also would lose part of his land. He tried to negotiate with the MID that if he were allowed to lift the water by pump he would allow the field channel to pass through his land, which the MID refused. Consequently, the farmer refused to give permission to let the field channel pass through his land depriving the downstream 80 acres of irrigation.

In my opinion, an attempt to dismiss these conflicts as simply personal problems between disputing farmers would be seriously misleading. The attitude of MID officials is a major reason that such conflicts have not been resolved and in fact are getting worse.

The upstream farmer could have easily been informed about the rule that no digging was allowed within a distance of 300 metres from the dam. MID's rule making, which does not seem to be very participatory in nature, is generating a fair deal of frustration among farmers. In another context, a farmer described the MID officials in derogatory terms and said, "they make rules and laws for others and they themselves never follow them." Stories were afloat with fairly detailed speculation about how much money MID officials swindled during the time of the construction of the tank. Several examples of poor quality construction were shown to me such as leakages from the cross drainage structures, canal lining made with inferior stones, canal lining made with stones directly fixed on the soil instead on a layer of jelly, heavy seepage from the earthen embankment, inferior quality of stone revetment on the embankment. Farmers also exchanged stories about how engineers fought among themselves when they could not amicably share the bounty given by the contractor. Even a couple of MID officials themselves, in one occasion said, "thank goodness, farmers just use harsh words and do not beat us up as it happens in (large) dam areas". In my opinion, by circulating stories about money swindled by the MID officers, and questioning their moral standing, farmers keep MID's authority of rule making, interpreting and enforcing in perspective.

However, what raises a major contradiction in farmers' attitude towards the MID is that in spite of MID officers are part of the problem, farmers still expect the MID to play a crucial role in problem solving. Ultimately, it is the MID which is the only recognisable authority in the irrigated area. When I asked the disputing downstream and upstream farmers about how the dispute on halla water between them could be resolved, they said that only the MID could resolve it, because only the MID has power to "make or break". At the peak of their dispute, which even came to blows, the upstream and downstream farmers even went to the police station, but the police refused to register a case. Both of them refused to recognise the authority of the panchayat that did try to intervene. Apart from hinting at the powerlessness of the panchayat, this incident also suggests the nature of farmers' expectations from state institutions. Notwithstanding the MID officers' high handedness, farmers continue to have latent expectations from impersonal state institutions to create rules, to create structures that can potentially prevent arbitrariness and ensure justice.

The upstream farmer's argument was that if the halla water belonged to the government and if he could not access it through the downstream farmer's land, then by the same token the downstream farmer could not have tank water passing through his land which also belonged to the government. The opinion that water stored in the tank belongs to the government was echoed in different ways and not only in the specific context of this dispute.

During a casual conversation at a teashop with a group of farmers, I was asked to tell them something about other tanks I had visited. I described some of the tanks I had visited but told them in detail about the tank discussed in chapter 5, especially how the farmers' organisation managed water distribution. Some were impressed, some surprised, but most sceptical. The discussion drifted to why farmers in this tank area do not organise and manage water distribution on their own, make their own rules, settle their disputes and prevent interference of MID officers. A couple of them laughed saying, "if government withdraws from managing this tank, the tank would be empty in two days and all infrastructure would disappear."

The paradox of the MID and farmers both wishing the other to manage water distribution remains at the heart of farmers' collectivity (or absence of). This paradox brings me to the second paradox this chapter is dealing with – the mismatch between the designed method of water distribution and farmers' agricultural practices. I also examine the consequences of this mismatch for the water utilisation practices, ultimately resulting in unused water in a tank located in a water scarce region.

To me, destroying outlet structures and not following water distribution rotation marks the rejection of the manner in which the resource utilisation is mediated through the MID's policy as well as a rejection of technological designs.

This pattern of destroying and/or radically modifying the irrigation infrastructure is not new in this region. In the famine years of 1898 and 1899, peasants of Bijapur filled up a newly constructed tank with sand and stones saying that it would breed mosquitoes (Irrigation Commission 1901-02). The tank had no productive value for them. A second newly constructed tank remained unused during the same period. Farmers' lack of acceptance of newly constructed tanks in the dry tracts of Bombay Karnataka became an important issue of inquiry for the Irrigation

Commission (Irrigation Commission 1901-02). A special inquiry, after a lengthy interrogation of Anglo-Indian officers, revealed that the farmers did not consider black cotton soils fit for irrigation, and hence feared that their lands might be damaged, and hence rejected tank irrigation.

Although destroying a tank and destroying outlet structures to modify and alter them are not the same, the underlying thrust of non-acceptance of a certain form of irrigation method is the same. In the following pages, I show how "designed" water management mismatches with culturally and materially specific farming practices, which as I will argue, have been primarily organised to avert risk and generate security by diversification. In the following section, I discuss how farmers use various sources of water and how they rotate different crops on different types of land. Stringently designed water rotation rules, which in fact have been designed for two important purposes - to solicit farmer's cooperation in collective management of the tank resource, and to mitigate water scarcity that is endemic in the region - generate a serious discrepancy between the cropping pattern that the designs can support and the pattern that farmers have been following for long. The making and breaking of rules and farmers' attitudes towards collective management have to be evaluated in the context of the productive practices followed by the farmers and the functional purpose for which irrigation is provided.

Productive Base of Water Management Practices

Land and labour

Farmers also use other water sources for irrigation besides tank water. Farmers tap shallow ground water which slowly seeps through the pervious geological formation through open shallow wells. In the local language, such wells are known as bavi. Bavi water has been the main source of irrigation in this region for centuries. As described in chapter 4, reservoir or tank irrigation historically is not as popular in this region as in other parts of Karnataka. The landowner has proprietary rights of water from the bavi existing in his land. Sharing bavi water with surrounding landowners is not unknown but the main method of bavi irrigation is individual land property oriented.

The risk of cultivation in this water-parched, dry region is significant. Failure of rain for several consecutive seasons is not infrequent and makes the threat of famine real. Memories of famines are an integral part of this region's cultural and social landscape (Vasavi 1996). Farmers follow intricate methods of cultivating various types of lands located at different places, with a variety of soil characteristics, endowed with varied water retention capacities and irrigation facilities as a means of risk aversion.

For example, a farmer who has land in the middle reach of the LBC may own as much as four different types of land with varied productive capacities within and outside the atchakat. Two types of dry/unirrigated land plots (called *melatto* in local language) are located outside the atchakat, probably several kilometres away from the village. Melatto land is of two (or more) types. The most inferior type is generally not invested with scarce labour to level and only rain-fed crops such as *navane* (a millet) or groundnut are planted there during the rainy season. The productivity of this land may be as low as 1:2 seed to grain ratio even during times of good rain. The other type of melatto land with a slightly higher amount of black soil, if levelled, could have a higher water retention capacity. Here, either rain-fed wheat or white jowar are planted with fewer seeds per row or with single row during the rainy season. Some other farmers, have a third type of melatto land with a bavi, which they may have partly levelled and which is planted with wheat or white jowar in the rainy season with double row planting or with double the number of seeds per row as compared to the inferior melatto land. The unlevelled land of the same piece is planted with a low planting density of wheat or white jowar or navane or groundnut. The same farmer may have two different types of irrigated lands, one located in the atchakat, and the other just outside the atchakat with a bavi. These two types of lands are usually planted with wheat or white jowar in the rainy season with single or double row planting, and cotton in summer depending upon the reliability of the water source – either a tank or a bavi. In addition to managing all these different types of land, he may even occasionally be sharecropping some other farmer's land.

Sharecropping in this region has a reverse economic connotation than in paddy growing areas. Generally, economically stronger farmers take weaker farmers' lands for sharecropping. Those who cannot afford to invest enough labour and capital in their lands because of the absence of a male member in the family, or illness or some other social or economic problem, give their land out for sharecropping. The sharecropper, in return, gives them half the produce.

One more example follows. A farmer with land in the middle reach of the LBC has totally 2.8 hectares of melatto land spread over three locations. He has totally two hectares of atchakat land at two locations and he sharecrops four hectares of melatto land. On one type of melatto land, he grows groundnut in the rainy season. This land is ploughed after harvest and allowed to weather until the next rainy season. On the second type of melatto, he plants wheat or white jowar in September-October. After harvesting wheat or white jowar, he grows cotton on this land. On the third type, he plants sunflower or maize in June and harvests them in October; wheat or white jowar are planted on this land in October. The family of two brothers manages these lands in such a way that the peak demand of labour is spread over the year. In fact the decision about crop choice and which land to cultivate depends largely upon the availability of labour.

Land in this region is relatively abundant, but labour and water are scarce resources. Although moisture availability plays a decisive role in dry or semi dry cropping, the productivity of this land is not so sensitive to water inputs as paddy land. Labour, on the other hand, is the most important and reliable productive force; it needs to be invested in the most effective and productive way to avert the risk of grain scarcity. A small piece of paddy field can respond considerably (compared to lightly irrigated crops) to water and labour inputs and hence a paddy-growing farmer can afford to patiently sit on the edge of his field waiting for water to arrive. On the contrary, the time and labour of farmers in this region need to be invested in dispersed geographical locations, with varied intensities during different seasons, including the irrigation season.

Furthermore, tank irrigation is not a question of life and death for farmers in the atchakat in the same way it is for a paddy-growing farmer of a paddy irrigating tank. Tank irrigation certainly is an important resource and can assure higher output if reliably available but even without tank irrigation the crop can survive 40-60 percent of its planting intensity and those with a bavi can even reap more. Without irrigation, paddy farmers would have nothing to plant. Farmers in this tank atchakat do not wait for the tank to receive enough water before sowing their crops. Both white jowar and wheat are unfailingly sown before a particular date called jowar *tithi* (a specific date as per the local agricultural calendar). In no case is the sowing delayed beyond this date. Those farmers who do not plant their crops on this date forego cultivation of white jowar that year. The tank generally has received some water by this date; however, it usually receives water up to full tank level only after the sowing is complete. Farmers' decisions about cropping pattern, especially choice of the crop and cropping intensity, are therefore independent of the timing of water availability in the tank, although the output of the produce will be finally affected by it.

Agricultural practices in this region have gone through transformation and so have farmers' attitudes. However, certain elements of socially and culturally organised farming practices aimed at averting risk still remain unchanged. They continue to remain in the backdrop of productively organised agriculture upon which transformation or change may manifest. One such risk averting strategy is to save and invest labour in the most effective way. And the second such strategy is to diversify agriculture to lands with diverse water retention capacities and fertility. Farmers manage several types of lands on which different types of crops, including those cultivated entirely for the market, are rotated and irrigated with diverse sources of water driven by similar style of farming in the tank atchakat.

Water

Land in this region appeared to be water starved. Especially after walking kilometres through a parched, dry landscape when mercury used to shoot up to 45^{0} C, I had presumed that water input in any form must be welcome. But, it was not so simple. Farmers use different water sources for different crops for pest control and higher yield.

Farmers consider tank water cold compared to bavi water. They believe that if white jowar and wheat are irrigated entirely with tank water, the yield will be less than if irrigated intermittently at least four times with bavi water. Only those farmers who have a bavi grow cotton in the summer, even if the tank has enough water. Onion is irrigated with bavi water only and fruit orchards such as lemon will not be irrigated with tank water at all, otherwise the fruit may fall prematurely. During the time of my fieldwork in February 2000, farmers were quite worried about the incidents of pest attack on wheat and white jowar. They felt that pest attacks had dramatically increased in recent years. When I visited the tank again in December 2000, farmers were in panic because wheat and white jowar were massively attacked by pest during flowering time. There was a craze to buy and sprinkle pesticides. Farmers I spoke to estimated that at least half the crop was lost if not more. It was believed that the overuse of tank water had increased susceptibility to pest other than a cool climate during the flowering time.

Farmers in this region routinely included climatic factors such as cloud cover, lower or higher than normal temperature, morning dew and the general level of humidity in the air in their analysis of crop yield and pest control. Clouds, they believe, during flowering time increase susceptibility to pests and reduces yield; morning dew and higher humidity than normal reduce need for irrigation. If there is cloud cover during flowering time, wheat and white jowar are strictly not irrigated. Dry climate and enough sunlight are needed during the flowering time for a good yield of white jowar and wheat. On a similar line, farmers also believe that because there is always flowing water in the canals, the microclimate is cooler in the atchakat than outside of the atchakat, which reduces yield.

For example, a farmer explained to me that he has two pieces of land in the atchakat. He got 6-7 bags of white jowar per acre from the land located in the LBC tail end, whereas he received 7-8 bags per acre on the land irrigated with the RBC. The land on the RBC side was planted with double the number of seeds per row than the land on the LBC side. According to the farmer, the produce on the RBC side was half the produce because planting density on the RBC side was double that of the LBC side. He explained that the microclimate on the RBC side was too cool during the flowering time, which considerably reduced the yield. His land in the LBC tail end benefited from both assured irrigation and a dry climate during the flowering time and hence had a good yield. Cotton especially is irrigated at least four to five times with bavi water in order to avoid pest infestation. Another farmer got 25 bags of cotton from 0.8 hectares of land on the RBC side, which he irrigated with bavi water and fertilised with green manure. He got only 40 bags (when he had expected 100 bags) from two hectares of land on the LBC side, which he irrigated only with tank water. According to him, he would have received a yield comparable to that of the LBC side if he had applied 20 litres of pesticides.

TABLE 8.1: Number of landholders using different sources of water.

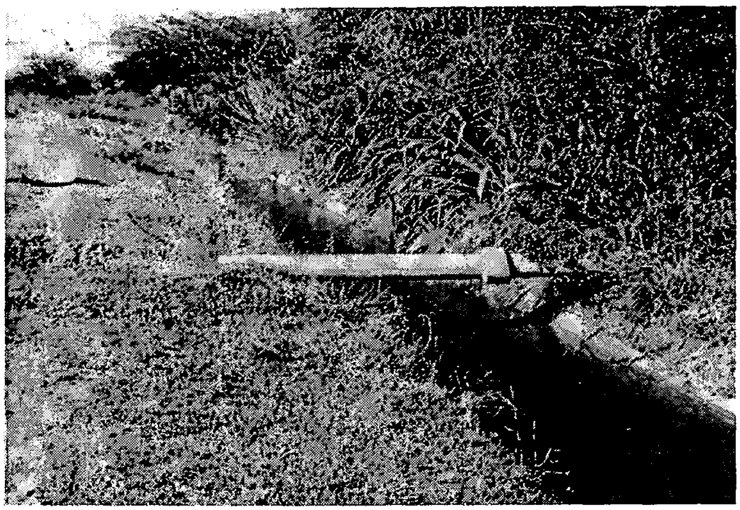
Total number of landholders	*Only Canal*	*Canal + bavi*	*Canal + bavi + halla*	*Canal + halla*
86 on RBC side	26	56	1	3
65 on LBC side	20	30	13	2

Farmers here use at least three sources of water, namely tank, bavi and halla, to support intricately orchestrated cropping patterns in their carefully divided pieces of land in the atchakat. Out of 320 hectares of atchakat, 260 hectares use either bavi or halla water in addition to tank water and only 60 hectares exclusively depend upon tank water. An approximate break up of the number of farmers using different water sources is tabulated in table 8.1.

Not only are different types of crops rotated on different types of land, but different water sources are used for different crops. A family of four brothers has 4.4 hectares of irrigated land in the tail end of RBC. They rotate different crops in different parts of their land. One part is sown with white jowar and wheat in September or October, before jowar tithi, irrespective of whether the tank has received enough water or not. Both wheat and white jowar survive on rain until mid November when the tank sluice is generally opened for irrigation. In case the tank has not received enough water by then, only part of the crop that is sown survives on rain and bavi water; in any case at least 40 percent can be reaped. After harvesting jowar and wheat, this piece of land is kept fallow until March and during *mahanavami* (a local festival) and in mid-March cotton is sown here and harvested in September or October. Cotton is irrigated with bavi water and supplemented with tank water. In another piece of land sunflower is sown after the cotton seeds have sprouted, i.e. 15 days after sowing of the cotton, and harvested three and half months later. This piece of land is then kept fallow until September for wheat and white jowar. The source of irrigation is not that crucial for sunflower but it is usually irrigated with tank water. Another small piece of land is sown with millet in August or September and onion during June to October. The millet is entirely rainfed while the onion is entirely irrigated with bavi water. After harvesting cotton, onion is transplanted to a part of this land in December and irrigated with only bavi water.

All these different types of crops have varied irrigation needs depending upon the type of soil, its levelling, rain and other microclimatic factors already mentioned. Generally, white jowar and wheat need irrigation at least once a week and during the entire crop period they are irrigated with bavi water at least four to five times to avoid pest attacks. Cotton needs water once a week during March, April and May and later once in fifteen days when rain starts; it is irrigated with bavi water and intermittently with tank water depending upon pest problems. Onion needs irrigation totally fifteen times and is irrigated only with bavi water, but some farmers irrigate it with tank water in case of shortage of bavi water two months after transplanting. Sunflower needs water once a week for the first two months and tank water is used as long as it is available. This discussion shows that farmers rotate different pieces of their land with varied fertility, irrigation and labour needs for both types of crops – grown either entirely for subsistence or for the market.

FIGURE 8.3: Water from a bavi located outside the atchakat being brought to atchakat land.



What is presented here is the simplest and comprehensible version of how farmers rotate different crops according to varied irrigation needs. For the sake of simplicity, how farmers rotate different types and amount of land for different crops is not taken into consideration although it strongly influences irrigation demand. Nevertheless, one gets an idea that adjusting the amount and timing of water demand with the availability is not as straightforward as the advocated rotation model may suggest.

they wished. Tail end farmers, on the other hand, especially those who grow cotton in summer, preferred gated outlets expecting that it would result in less wasteful water use in the head reach. The MID has imposed a condition that unless all farmers agree to follow the warabandi rotation schedule – rotation among all the outlets and also among the land irrigated from one outlet – and form a water users' association, they will not provide gated outlets.

What difference would it make? Some head reach farmers argue that if there are a limited number of outlets it does not matter if there are gates or not as a rotation schedule has to be followed in principle among the land irrigated by one outlet, hence the rotation schedule should be the focus of dispute rather than the gates. But summer crop growing tail end farmers hope that gated outlets that can be locked and unlocked would reduce wastage of water. Tail end farmers are more worried about wastage than higher withdrawal of water in head and middle reaches; they complain that upstream farmers would not bother to close the outlet after they finished their irrigation. Head reach farmers, on the other hand, fear that the lockable outlets will severely curtail their freedom to irrigate their lands as per their timings and as per their choice of crops. In my opinion, the amount of water withdrawn from the canals is hardly an issue here. Unlike paddy, semi dry crops do not respond to a higher quantity of water; in fact excess irrigation can even damage them. Freedom to irrigate as per their timings and as per their crop choice is, therefore, the key issue.

The conflict thus seems to be between a system that can provide enough flexibility in terms of irrigation timings and the system that can provide security of water availability in the tail end. However, the cropping pattern in the tail end is not radically different than the head reach one. The availability of bavi water, the size of landholding and the general economic condition of the farmer, and not the availability of tank water alone, decide whether s/he would grow a summer crop or not. A small farmer with one hectare of land in the mid reach without bavi never grows onions, or sunflower or cotton in the summer, even if his neighbours do so and even if the tank has enough water. The planting intensity of wheat and white jowar and yield in the tail end are not affected by tank water availability or timing.

Especially when the tank has excess water (explained below), a lack of water is hardly an issue. The lack of water in the tank has a significant impact only on summer cropping. Both the availability

This entails that careful investment of labour and select rotation of different crops on different types of land are the key elements in organising diverse types of agricultural land within and outside the atchakat. Diverse form of labour investment leave farmers with a much lower degree of leverage to follow a stringently time bound irrigation schedule. The irrigation schedule does not capture the nuances of their cropping pattern. In my interpretation, the making of separate field channels for each piece of land is actually a rejection of the rotation model adopted in the project, which as per the design implies an inflexible rotation schedule. Farmers' dependence on tank water is not complete. In fact, their agricultural practices are not entirely dependent on any one environmental factor, least of all tank water.

Rejection of Water Rotation Design

Both RB and LB canals have ten outlets and each outlet irrigates 10-15 hectares of land owned by four to five farmers. The water distribution schedule, as per the design on paper, is planned to a minute detail: what time each piece of land would receive water during a particular irrigation day during rabi or kharif season. As per the design, outlets are supposed to be operated continuously from morning till evening. Each outlet would have received water for two hours a day during which time water should be rotated among the lands irrigated by that outlet. At the time of fieldwork, most farmers had levelled only a part of their irrigable land, and did not irrigate all their levelled land during one season. The amount of land each farmer actually irrigates changes every season depending upon the land s/he has levelled and other factors such as her/his financial and labour investment capacities.

The choice of water distribution and rotation method is a bone of contention. The farmers, at least in head reach, rejected the rotation model, called warabandi model, as engineers had explained to them. They referred to the warabandi system as a "close" system[3], meaning outlets are provided with lockable gates, rotation is observed among all the outlets and among land irrigated from one outlet. Farmers in the head reach opposed outlet gates when the outlets were being fixed on the RB canal and asked for what they called an "open" system, meaning a system with piped outlets without gates. This would have allowed them to irrigate at any time of bavi and tank water decides the possibility of summer cropping. Only those who have a bavi grow cotton, but they also cultivate cotton only if the tank has at least three to four feet of water in the beginning of March. However, after the white jowar and wheat are harvested, there is excess water in the tank.

Excess Water

Signs that the tank had excess water were evident in the month of February when white jowar and wheat were a few days away from harvest. Just before the harvest, when irrigation had stopped, water at full canal capacity was being discharged in the halla unused. Farmers, whose lands were located outside the atchakat, complained that while their lands suffered serious water scarcity, almost three feet of water from the tank was discharged unutilised. The reason they gave was fishery. In the month of June every year, the contractor throws seeds in the tank. The fish have to be harvested before the month of April when the first rain starts in this region. It is not easy to harvest unless the water level is reduced to three feet. Hence canals full of water were flowing to the halla.

Two reasons, both related to the designs, can account for the non-utilisation of tank water. Firstly, as already explained, farmers use other sources of water to support a diverse cropping pattern and use tank water only to irrigate wheat and white jowar. Farmers, particularly on the RBC side, prefer bavi to tank water for certain crops such as cotton and onion. A few irrigations with bavi water are considered necessary even for white jowar and wheat to prevent pest problems. Farmers without bavi do not cultivate a summer crop at all (even if the tank has water).

Secondly, some parts of the head reach on the LBC side are not able to use tank water because the LBC runs below ground level. The last reason needs further elaboration.

The local geology plays a key role here.[4] On the western side of the halla, on the RBC side, there is a geological formation of layered, pervious stone extending for three kilometres that can yield good water in bavi. On the eastern side of the halla, the LBC side, the same type of geological formation is available only for one kilometre. The RBC side has 54 bavis whereas the LBC side has only 25, although both canals are designed to irrigate the same amount of land. Moreover, the RBC side has better quality black cotton soil, whereas the soil on the LBC side is alkaline and sandy, mixed with small stones. Finally, the bavi water on the LBC side is more alkaline than on the RBC side. The RBC side is, therefore, better endowed than the LBC side hydro-ecologically. This has generated a difference in cropping pattern between the LBC side and the RBC side. Very few farmers grow cotton on the LBC side. Those, who grow cotton, need more tank water in order to leach out the salt accumulated in the soil as a result of irrigation with alkaline bavi water. Hence, ideally the tank should have been designed in such a way that the atchakat on the LBC side benefits more than the RBC side, if equity and also optimum use of water had been the considerations. But on the contrary, the sluice connected with the RBC is deeper than on the LBC side. It provides water for a longer duration than the one on the LBC side, although both canals as per the design irrigate the same area.

There are ways in which the discrepant distribution of resources between LBC and RBC has been reinforced. For the first two kilometres the LBC runs almost seven feet below ground. It comes to ground level with three feet depth for half a kilometre and then again runs below ground before emerging at the ground level half way through.

Both above mentioned, locally specific parameters have influenced tank water utilisation pattern. One could even argue that to identify these locally specific patterns of resource utilisation, a high degree of farmers' participation in the design process in not that critical. Even an engineer with a keen sense of observation and a few hours of conversation with farmers can easily understand these local nuances of resource utilisation. However, haw far the design methodology adopted by technical experts can permit incorporation of locally specific parameters needs further research, which might well add a third paradox in the tale of two.

The tale of two paradoxes of this chapter indicates that farmers' relationship with productive forces impinges fundamentally on collective attitudes towards land and water management. This is contrary to the claim made by some policy makers and experts that the ecological element of water scarcity is the main determinant of collective action. (See Wade (1988) for this strand of argument). Moreover, they assume that water scarcity is not only decisive in forming collective action but also view it independent of other aspects of the productive landscape – social and environmental.

With reference to the tank studied for this chapter, it could be concluded that since farmers do not form a collective, there is no water scarcity in the tank atchakat. However, such an interpretation would hinge on a narrow definition of scarcity: a simple mismatch between supply and demand. Water scarcity, looked at differently, is ingrained in every aspect of culturally and socially organised agriculture in this region. A significant part of agricultural practices are aimed at mitigating water scarcity that may even pose a threat to survival. Without socially organised forms of land and labour management to compensate water scarcity, agriculture would not have been possible in this region.

It seems to me that tank water is not optimally utilised in this tank. What needs to be explained is not the lack of scarcity and its relationship with the collective action but why there is unused water in a tank, in a water-parched region needs to be explained. Furthermore, when farmers organise a large part of agricultural practices to carefully manage water scarcity, what makes them irresponsible and wasteful in the atchakat needs to be explained. The excess water in a water-parched region signifies as much a lack of optimal design as it implies a degree of rejection by farmers of the way technology is organised. These contradictions in tank water utilisation are indicators that the tank irrigation method is not integrated but superimposed on the productive practices followed by farmers.

In summing up, I suggest that destroying outlet structures to make new ones implies a rejection of water distribution designs. In the case of this tank, there is a mismatch between farming practices and the assumption on which designs of water distribution are based. This forms one of the two paradoxes resulting in excess, unutilised water in a tank located in a water-parched region. The second paradox relates to the first one. It pertains to the nature of collective action in the irrigated area. When the MID made an attempt to form a water users' association, the farmers declare that water stored in the tank belongs to the government and hence the government should only manage the water distribution. The chapter concludes that tank irrigation is not entirely integrated in farming practices, but is to a great extent superimposed on local agricultural practices.

Notes

[1] The fact that I was a doctoral student and had nothing officially to do with the Karnataka government was treated with suspicion. First time ever during my visits to several tanks in Karnataka, a group of farmers asked me to show written proof that I was not sent by the government. I showed a letter from my university and also a letter given by the chief engineer of MID certifying that I was a doctoral student.

[2] This is a proverb in Hindi that literally translates, "the buffalo belongs to the man with a stick". It can be interpreted to mean, "the brute force of power decides the course of events".

[3] Farmers used the words "close" and "open" in English to describe two different types of systems, as they perceived them.

[4] This was explained to us by a local expert, who generally is known as "the person who shows water".

9

Summary and Discussion

"... the main question of democratic politics is not how to eliminate power but how to constitute forms of power that are compatible with democratic values. To acknowledge the existence of relations of power and the need to transform them, while renouncing the illusion that we could free ourselves completely from power, this is what is specific to the project of 'radical and plural democracy.... ... ... Modern democracy's specificity lies in the recognition and legitimation of conflict... (and) to make room for dissent and the institutions through which it can be manifested."

— Mouffe (1999: 5)

Wittgenstein said "philosophising leaves everything as it was" (as quoted in Bauman 1987: 101). Bauman, (1987: 4-5), on the other hand, while describing what he calls the modern strategy of nineteenth and twentieth century intellectual work, has taken an opposing view, namely that intellectuals are "legislators". Bauman argues that the keen eyes of intellectuals capture the nuances of actors' behaviour – actors who presumably do not know what they are doing. The unknown structure of actors' behaviour is visible to the trained eyes of an intellectual-social scientist who then embarks on the huge task of social engineering to produce a common good.

This book has been neither and endorsement of Wittgenstein's nor Bauman's position. My intention has been to re-present my findings, with all uncertainties and consequences, in front of the "social" or "public" by means of translating, interpreting and analysing my findings. The intent has been to participate in the larger sphere of "politics" around the issue of tank irrigation. I have no expectations that any my findings will result in immediate, perceivable change (policy or otherwise), nor have I offered any of my interpretations keeping such a goal in mind.

The Book

The central research concern of this book was to understand how democratic the water utilisation practices in tank-irrigated areas are. The view that communities are better managers of natural resources is often expressed in academic and policy circles (see for example Agarwal and Narain 1997). Globally initiated irrigation reform policies are also based on the notion that communities are better managers of natural resources.

This proposition that communities are better managers of natural resources and hence the state should withdraw from managing them raises a fundamental concern. How does a hierarchically organised social order distribute its water resources mediated through tank technology? This concern has formed the central question of this research. How do social relations of power in a particular agro-climatic, historical and agrarian context shape tank designs? And how is a certain form of social arrangement reproduced by means of technological designs? By showing how tank designs are shaped by its productive context - social and agrarian, I hope, that by showing how tank designs are shaped by their productive context - social and agrarian, I have fruitfully participated in the debate on democratisation of natural resource management and utilisation.

Chapters in this book are arranged in a descending order of structural and spatial specificities. Chapter 1 provided the theoretical background to the research questions. Chapters 2 and 3 took a macroscopic view at history and the political economy of agrarian change to understand the relationship between paddy cultivation and tank irrigation. Chapter 4 elaborated on the diversity of tank designs and their transformation in different agro-climatic regions of Karnataka.

Chapters 5 to 8 focused on one tank each with diverse cropping patterns located in different agro-climatic locations. More specifically, chapters 5 to 8 explored how tank designs are crystallised as a result of a certain balance of power in a particular local context.

This chapter summarises, discusses and further analyses what is presented in the previous chapters. The historical relationship between paddy cultivation and tank designs is summarised first. Transformations in tank designs are traced subsequently in the context of changing state society relationships and commercialisation and diversification of cropping pattern. Designs and power relations are discussed later on. The chapter ends with a short note on the notion of democratisation and possibilities for future research.

To facilitate the discussion, I have named the tanks discussed in chapter 5, 6, 7 and 8 as tank-5, 6, 7 and 8 respectively.

Paddy cultivation and tank designs

Paddy is predominantly grown in tank-irrigated areas located in the wet and mixed regions of western and southern Karnataka. Tanks in this part were constructed during the pre-colonial period and hence are several centuries old. Tank density declines when traversing the Karnataka landscape from south to north as the importance of paddy cultivation in tank-irrigated areas declines. Tanks in the north and the north-eastern parts of Karnataka were largely constructed during and after the colonial period and only lightly irrigated crops have been cultivated in these areas. Paddy thus has a spatial and temporal connection with tanks.

Designs of paddy irrigating tanks are coded with certain characteristics that have been shaped in a specific historical context. For instance, the design principle of a labour intensive construction method of embankments carries the imprint of the historical era that rested on a rigidly built, hierarchical social order which exerted a considerable degree of control over labour. Chapter 2 further described how the choice of other design parameters such as the method of field to field irrigation, the plug and pole type of sluice and the field layout suited paddy cultivation. Thus, tank designs are historically coded with the requirements of paddy cultivation and with the social arrangements specific to that historical era.

I further argued in chapter 2 that the ecological characteristics of paddy cultivation necessitate continuous cultivation. The process by which paddy fields acquire their stability and higher productivity is gradual, progressive and cumulative. Repeated cycles of paddy cultivation change the nature of soil permanently, which makes it further suitable for paddy cultivation. Intensification is thus an integral part of the continuation of paddy cultivation. However, the shift in the nature of the soil facilitates but also perpetuates paddy cultivation and creates a barrier to shift to any other type of cultivation, especially to lightly irrigated crops. Continuous paddy cultivation for centuries in tank-irrigated areas has transformed the nature of fields resulting in a type of atchakat layout that enables paddy cultivation in current times but constrains the cultivation of other crops.

The constraints and opportunities provided by historically specific tank designs in the context of diversifying and commercialising the cropping pattern in current times was discussed in detail in chapter 4 and also in chapters 5 to 8.

Tanks, at present, largely continue to support paddy cultivation in diverse ways depending upon the location of tanks and hydrological parameters. Paddy cultivation otherwise also remains a favoured option due to a favourable paddy price policy at the state and national level. However, there are signs of a transition from paddy to lightly irrigated cash crops especially in the mixed region of Karnataka for which a shift in tank designs is pertinent. Chapter 4 discussed the transformation of tank designs in the context of an intensification of paddy cultivation in the wet region of western Karnataka and in the interface of paddy and non-paddy cultivation in the mixed region of southern and northern Karnataka.

State-society relations and tank irrigation policy

Cultivation practices in tank-irrigated areas are facilitated or constrained by historically contingent tank designs; they are at the same time closely influenced by state policy. Chapter 3 discussed how in the aftermath of the green revolution a hegemonic class of owner cultivators emerged at the all India level and how that ushered in a phase of new agrarianism. The populist politics of this class has succeeded considerably in tilting paddy price policy in the favour of farmers. As a result paddy cultivation has become a profitable enterprise even for small landholders. Attention was also given, therefore, in Chapter 3 to the populist politics of new agrarianism at the national and regional level, followed by a discussion on its impact on paddy price policy in Karnataka.

There is further discussion in Chapter 3 on how the decade of the 1980s marked a crisis period for state policy on tank irrigation. The state was expected to invest in management and maintenance of tank resources on an unprecedented scale as a part of the larger demands of the new farmers' movement for more resources for rural infrastructure. I showed how the roots of decentralisation in the state of Karnataka have grown as part of the politics of new agrarianism. The policy of decentralisation resulted in transferring a sizeable number of tanks to newly formed Zilla Parishads and in a considerable rise in financial resources allocated for tanks in the decade of the 1980s.

The crisis period for tank resources, first of all, suggests that the inherited tasks of maintaining and managing tank resources became a burden for rural elites, who wanted the state to invest in them financially. Secondly, this demand of the rural elites was closely intertwined with other changes in social arrangements for maintenance and management of tanks. As discussed in chapters 5, 6 and 7, it is becoming increasingly difficult to mobilise labour for maintenance and management of tanks through traditionally organised means. Social arrangements such as canal cleaning, sluice operation and field-to-field irrigation which had largely been shaped by the hierarchical caste relations at the village level can no more be reproduced in their entirety. In the irrigated context of these tanks lower caste labourers can no more be easily mobilised for a variety of tasks that they traditionally performed. This push and pull – the push that rural elites are increasingly less inclined to invest in tank resources and the pull that traditional social arrangements to mobilise lower caste labour cannot be reproduced in their entirety – has created a crisis in terms of management of tank resources.

This crisis is apparent in the form of the uneasy tension between elite farmers in the vicinity of the tanks discussed in chapters 5 to 7 and the MID. Mobilising labour for canal cleaning, water distribution and maintenance of other structures has already become a problem or is showing early signs of problems in the case of tanks-5 to 7. The members of the Irrigation Organisation of tank-5 argue that maintaining physical structures is MID's responsibility, but they at the same time do not want MID officials to become members of the IO. The reason is that MID officers, on becoming members of the IO, may insist on following the official cropping pattern that prohibits paddy and sugarcane cultivation in the atchakat. Along with the official cropping pattern, MID officers may also bring with them new found normative models of equality of all irrigators. That means, historically privileged groups occupying head reach land officially may not be allowed to grow wet crops. This may significantly undermine the authority of the

IO and the hold of farmers who grow wet crops.

The farmers of tank-7 also face this dilemma. Tail end farmers, whose increasing economic might has collectively earned them an important voice with regard to tank management and maintenance do not want MID's involvement in what they call their internal affairs. On the one hand, the historically privileged group of farmers in the head reach, who seem to have considerably lost their power over matters concerned with tanks, advocate MID's involvement and argue that MID's legally enforceable rules will bring order in their tank area. This, "to be" or "not to be" dilemma faced by especially elite farmers with respect to MID's role is indicative of the crisis which has emerged. Elites want financial resources that the MID would bring but not involvement that may directly or indirectly restructure power relations.

It was also pointed out in chapter 3 that there is an apparent contradiction between the demands of rural elites who want the state to play a larger role in maintaining and managing tanks and internationally funded irrigation reform policy that advocates a reduced role of the state and an increased role of communities in the management of tank resources. The point of interaction between this pull and push, between local and global forces, is a topic for further research.

One of the central aims of chapter 3 was to demonstrate that the state is not all pervasively powerful in driving society. State policies are made in a politically contested field in which various sections of society actively participate. Farmers' politics at the state level has indirectly influenced the way designs of new tanks are now done. The proposition and choice of a site for a new tank has to now come from the MLA, which was previously decided largely by the engineering staff of the MID. So the preferences of the MLA's constituency are represented in the site selection. Previously, site selection was based largely on technical criteria.

The conventional notion of design that emerged with bureaucratically created and managed irrigation systems was based on the belief that engineering designs have to be rationally made by engineers by means of the application of scientific principles. Many critiques advocating farmers' participation in the design process emerged with what is called the social turn in irrigation sciences (cf. Meinzen-Dick 1997). However, farmers' participation is often narrowly defined. Farmers are often understood to participate at the level of a specific project to influence the design parameters of, for instance, location and dimensions of physical structures. Their participation is also sought for, and consequently understood, to create and sustain institutional arrangements for collective action to manage a specific irrigation scheme.

It was illustrated in chapter 3 that farmers participate in the larger political process around management of natural resources in a variety of ways. The chapter showed how by means of the new farmers' movement and other loosely formed alliances farmers have influenced state policies on paddy price, decentralisation of administrative power, and also tank irrigation. Farmers' participation needs to be understood in a broader sense, namely in terms of the complexity and dynamism of their politics and how it affects different sections of the peasantry. For instance, some scholars have termed the new farmers' movement as the landed farmers' movement (Gupta 1998; Brass 1995). How this political participation of farmers results in a direct or indirect change in design parameters, standards and procedure should also be a topic of further research.

Intensification, commercialisation and diversification of agriculture and tank designs

Chapter 3 also briefly sketched the broad aspects of commercialisation and diversification of agriculture in the 1980s and 1990s. Two aspects, in particular, commercialisation and diversification of the cropping pattern have a significant impact on tank designs. Firstly, as Nadkarni observes, rice, beginning in the late 1980s, was predominantly grown by small landholders. Paddy became a lucrative option given the assured market and steady rise in the support price in the late 1980s and as a result paddy cultivation steadily increased in tank-irrigated areas. This was the case also in tank areas discussed in chapters 6 and 7. With the intensification of paddy cultivation, water demand in the tank atchakat of both tanks escalated, and a whole new techno-managerial design of resource utilisation emerged. In fact a whole new cropping regime in tank-irrigated areas emerged, which largely displaced coarse cereal crops such as ragi and millet.

The intensification of paddy cultivation, at the same time, has generated new interests and new institutional arrangements around resource utilisation. Encroachments of canal banks, disappearance of main canals that would have possibly rotated water between head reach and tail end, and a complete shift to field to field irrigation from head to tail that gives strategic advantage to head reach farmers, are examples of shifts in designs as a result of intensification of paddy cultivation. A contrary example is discussed in chapter 7. In the case of the tank-7 the collective insistence of tail end farmers to reverse the rule of "head reach first" emerged in the context of intensification of paddy cultivation in the atchakat.

Secondly, intensification of paddy cultivation is also accompanied by other changes in the cropping pattern such as introduction of new crops such as vegetables and cotton. Many scholars have shown that the cropping regime in the last two decades has significantly diversified with non-food grain crops fast replacing food grain crops (Patnaik 1996; Nadkarni 1996). Non-food grain crops such as cotton, vegetables, fruits and oil seeds have shown comparatively higher rates of growth in terms of area cultivated than food grain crops. Among food grains the area under coarse grains and pulses have declined whereas the area under rice has remained constant (Nadkarni 1996: A-67).

Replacement of food grain with non-food grain crops in general has direct implications for the utilisation of tank resources. Newly introduced crops such as vegetables not only compete with paddy cultivation, but also bring the new technology of bore wells to tank-irrigated areas. To a large extent tube wells in tank-irrigated areas of the mixed region of south and north Karnataka have come up in the context of commercialising and diversifying cropping patterns, unlike the tanks in the delta region of Tamilnadu where tube wells primarily provided supplementary irrigation to tank irrigation (Palanisami 1991). Tube wells in a tank atchakat in the mixed region of Karnataka support a largely different cropping regime than what tanks would have supported. For instance, in the case of tank-6, most of the tube wells in the irrigated area were installed in the last decade or so to mainly cultivate a variety of vegetables and maize during the times when tank irrigated paddy is not cultivated. In fact, the requirements of growing vegetables often come in to conflict with paddy cultivation. Repeated paddy cultivation needs land to be kept under submergence for a long time which consequently converts soil into hard lumps and makes it unsuitable for vegetable cultivation. Some farmers dig ditches around their plots – exclusively kept for tube well-irrigated vegetables – to keep the water out when the whole of the atchakat is reeling under streams of water to irrigate paddy. Some other farmers have brought soil from outside the atchakat to elevate the level of their plots to grow vegetables; paddy is strictly not grown here. Farmers of south Karnataka prefer to install tube wells in the tank atchakat and not on the dry lands because tube wells in tank atchakats yield water for a longer time than tube wells located outside the atchakat. But in such cases, the tube well irrigated cropping regime clashes with the tank-irrigated cropping regime. Should tank water be used as surface irrigation to cultivate paddy or allowed to recharge ground water and be used through bore wells to cultivate non-paddy crops? Especially when tank designs support paddy cultivation, coexistence of both cropping patterns is not an option. The struggle is as much about bore well vs. tank irrigation as it is about paddy vs. non-paddy crops.

Tube wells on dry lands have also accompanied a marked shift in cropping pattern in the wet and mixed regions. One of the farmers I interviewed said, "the focus of agriculture has now shifted to dry land". A variety of crops are grown on dry land supported by tube well irrigation but are of course dependent on other agro-climatic specificities as well. When tank designs predominantly support paddy cultivation, dry land provides the opportunity to grow crops with diverse economic value. Those farmers, who can afford it, would prefer to install tube wells on their dry lands as opposed to on tank-irrigated lands especially in the rain assured regions of Shimoga, Haveri and some parts of Dharwad. In the mixed region of southern Karnataka where lightly irrigated crops cannot be grown rainfed, they are grown with bore well irrigation in tank-irrigated areas. This changing focus of agriculture on dry lands has influenced the cultivation pattern in tank-irrigated areas.

The growth of tube well irrigation in wet and semi dry agro-climatic zones of Karnataka has a closer relationship with the transforming cropping pattern than with the changing nature of water availability in tanks. In that sense tube wells in many parts of Karnataka are not actually a direct threat to tank irrigation patterns. Rather, they are symptomatic of a threat posed by larger changes induced by globalisation and commercialisation of agriculture.

Furthermore, given the historical nature of tank designs and their relatively greater suitability for paddy cultivation, a shift from paddy to non-paddy cultivation in tank-irrigated areas may not prove easy. It may be easy to cultivate lightly irrigated crops on dry lands if agro-climatic conditions permit. In both cases, namely a shift of cropping regime from paddy to non-paddy crops in the tank atchakat or transposition of such change to dry land, it is possible that the physical structures in tank irrigated areas fall into considerable disrepair. However, I would like to clarify that such a trend is not yet fully visible. It remains to be seen whether tank designs will be adapted or the tank irrigation method would be abandoned if the shift from paddy to non-paddy crops continues.

I would like to point out in conclusion that lack of state investment for maintenance and management of tank systems may be one of the many factors that have contributed to the deterioration of tank infrastructure. However, my research indicates that even farmers' choices of cropping pattern, in the larger context of agrarian change, may play a decisive role in determining tank status.

Power relations and tank designs

Tank designs are not exclusively about dimensions and locations of physical structures. While the dimensions of physical structures have to be suitably devised in order for the technology to function, at the same time these structures have to be operated, managed and maintained. Their devising, operation, maintenance and management require labour coordination and knowledge about how to devise, operate, manage and maintain. In short, a social organisation is needed to devise the dimensions of physical structures and at the same time to devise rules and roles that can operate, maintain and manage these physical structures. Technological designs are aimed at achieving intended outcomes. In the case of the tanks discussed in the previous chapters, technological designs are primarily intended to facilitate agricultural production. Designs thus interact with social arrangements made around agricultural production.

Technological designs for this research were conceptualised in an inclusive way. They include engineering properties of physical artefacts, and rules and roles designed to operate, maintain and manage them. For instance, the atchakat layout and location of canals may be designed for field-to-field irrigation, but the institution of neerganti finally makes it functional. Hence, design of field-to-field irrigation includes the location of main canals, a particular arrangement of a field layout, a rule that fields located in the head reach would take water first and the role of neerganti to distribute water from field to field. The physical parameters, rules and roles when they all come together finally make a particular design aspect – field-to-field irrigation – function. Technological designs this way are conceptualised not in their idle physical state but in terms of their requirements for use (Kloezen and Mollinga 1992), i.e. in their functional mode.

This concept of a design of a technological system presupposes a social organisation to devise the physical structures, rules and roles to operate them and keep them functional and the organisation of production cycles. One can name these social arrangements as community, collective action or irrigation organisation, but the more important point is they exist. Without the presence of a social organisation to devise, operate and use the technology, no technology can function or even exist. Moreover, in a particular local context the social arrangements made around sharing of a collective resource on a continuous basis may be inflicted by conflict and chaos, but whatever the case might be it exists.

While the sharing of a common resource needs a social arrangement, the nature and form of this social organisation is influenced by the way technology is designed to mediate the collective use of the resource. If the resource is scarce, which it is most of the time, who gains and who loses is decided not entirely by the institutional arrangements but by the way water is distributed through technological means. Though technology is designed and operated through social arrangements, by delegating the task of institutionalising and sustaining a certain method of water distribution to certain technological parameters, the intended outcomes of such distribution methods are already inscribed on the technology. Technology, thus, by the means of taking over the task of deciding how much water should be given to whom, maintains social order. By means of reproducing these technological designs the social order and social arrangements around the resource utilisation are also reproduced.

For example, it is very common to find that historically and economically privileged groups of farmers own much of the head reach land. Correspondingly lower caste and service caste farmers occupy the tail end. The design principle of field to field irrigation gives strategic advantage to head reach lands because the tail end cannot receive water until the head reach releases it. Field to field irrigation thus takes over the task of skewed distribution of water between head reach and tail end or between historically privileged and disadvantaged groups of farmers. The powerful farmers of the head reach remain in a powerful position by removing main canals that can possibly rotate water between head and tail end and converting water distribution completely to field to field irrigation. That means powerful farmers reproduce the design of field to field irrigation and consequently their power as well. Designs thus are not only socially arranged but they reproduce social arrangements.

Another way to conceptualise this is to say that field to field irrigation which supplies water to the head reach first is naturalised. The atchakat usually slopes from head to tail according to the natural gradient of the topography. Fields are further arranged taking advantage of the natural gradient in such a way that movement of water is facilitated from head to tail. Even main canals, if they exist, slope from head to tail following the natural gradient and hence bring water first to the head reach. Thus, the natural topography of the atchakat is consolidated by means of technological designs in such a way that the head reach first norm is naturalised and normalised. It would be going against gravity, against natural laws, to challenge it. As one of my head reach respondents also described it, "how could you expect water to flow from toe towards head if you pour it on top of your head?"

In the case of the three tanks discussed in chapters 5, 6 and 7, historically and economically privileged groups own much of the head reach land. Head reach land is mostly occupied by historically and economically privileged groups through the consolidation of the natural topography of the atchakat, choice of certain canal parameters and field to field irrigation that favour the head reach.. Thus, the design principle of field to field irrigation is coded with an aspect of the social relations of power.

However, the rule of head reach first, consolidated and naturalised by means of technology, is not cast in concrete. In the case of tank-7, the newly acquired economic might of tail end Muslim farmers has earned them a powerful position vis-à-vis the historically privileged caste group (Jainas) located in the head reach. Tail end Muslim farmers have been successful in reversing this norm. Their challenge to the norm is based on an uncommon interpretation of the way earthen canals function. In their tank, there is heavy seepage from the main canals due to encroachments of canal walls and burrowing actions of rodents. Hence, "if canals irrigate four hectares, they waste water for four hectares". Tail end farmers argue that water should be first supplied to the tail end because when canals supply water to the tail end, the head and middle reach are automatically irrigated due to heavy seepage. They also say that main canals should supply water first to the tail end to take advantage of higher discharge in the canals at the beginning of the irrigation season, tail enders further argue. Once the water level in the tank depletes the discharge in the canals reduces, producing mere trickles at the tail end. Thus, tail enders in this tank have shown that supplying water first to the tail end is the only way water can be efficiently and equitably supplied to the whole atchakat.

The tail end challenge to the norm indicates that both technological designs and social arrangements around designs are contested, negotiated, subjected to conflict, defied or resisted and changed. Ultimately, these actions around sharing of water resource crystallises into a certain balance of power in the local context.

Similarly, several traditional tank irrigation practices have also been actively contested. While some practices have been abandoned, several others have been guarded with zeal and sustained and others transcended or even transformed. Which traditions were abandoned and which continue reflect a certain balance of power in the local context. For instance, ritualistic celebrations that marked the opening of the sluices in the beginning of the irrigation season are no more followed in tank-6. Whereas two decades ago celebrations took place and then sluices were opened after the Patel had granted permission to do so, now the celebrations are done on the initiative of service caste members. The elites are no more ready to economically invest in ritualistic celebrations since these rituals do not reproduce their economic and political power as in the past. Service castes members, who seem to have a stake in the economic resources of these celebrations, take pains to collect small donations and sacrifice a buffalo in the Durgamma temple. The earlier practice also ensured social locking of the sluices. Sluices, on most occcasions, could not be opened until the neerganti with other service castes members dived into the water and lifted the sluices under water pressure. Now, sluices are opened by the person appointed by the MID by turning the key spanner.

However, not all traditions have been transformed in the above-mentioned tank. Traditionally followed water distribution rules and their normative understanding of unequal distribution of water between different patches of lands are still considered legitimate, although not uncontested. What emerges is not a straightforward equation of traditions either abandoned or sustained in their entirety. Moreover, equally important, the picture is different according to the direction from which it is viewed.

A similar scenario exists in tank-7 where the tail end farmers have actively challenged the traditionally followed norm of water first supplied to the head reach. Along with this challenge other traditionally followed practices such as canal cleaning and water distribution practices have also been challenged. However, the same group of tail end farmers continue to join with other farmers at the tank level to guard and fight for their traditional right to receive water from the check dam. Viewed from the farmers' perspective there seems to be nothing sacrosanct about traditions: they are a means by which the present is made or remade more than a means by which the present is connected with the past. Like technology, traditions are also sites of political negotiations and contestations.

Community and Democratisation

This research has primarily aimed to show how relations of power, in a particular context, shape technological designs. It ultimately intends to contribute to the debate on democratisation of natural resource utilisation. Hence, notions of community and democratisation, while not centrally explored in this research, remain important concerns of this work. I end my book with a short discussion on community and democratisation, partly derived from my research and partly in response to the current debate on civil society organisations.

As discussed above, a variety of social alliances have emerged in the irrigated study areas around patterns of resource utilisation. In one tank area, several layers of social alliances have been formed, based on the circumstance of sharing of a resource with a particular technological design. These alliances also overlap and contradict each other. For instance, in the case of tank-5, the Irrigation Organisation at the tank level was formed twenty years ago with a set of formal rules for water distribution. This tank level organisation sustains its existence around the distribution of scarce water to landholders. The organisation represents all farmers while mediating with the Minor Irrigation Department and lobbying with other government departments to improve water availability in the tank.

At the tank level there are various other forms of alliances formed around the shared circumstance of water availability. For instance, an informal alliance exists among tail end farmers on the LBC side. These farmers, after they were displaced by a dam close by, extended the LB canal, and acquired and cleared uncultivated land around four decades ago. These lands located at the tail end face severe water scarcity during the peak paddy season. However, now these tail end farmers collectively negotiate with the neerganti to secure adequate supply of water during the peak irrigation season. Another such farmers' alliance at the RBC tail end allegedly bribes the neerganti to partially open the sluice for night irrigation to their lands so that they can grow lightly irrigated crops.

Similarly, in the case of tank-7, there exist multiple points of rift between tail end and head reach farmers. The tail end challenge to the otherwise normalised rule of head reach first also spills over in other aspects of management and maintenance of tank structures on which the tail end and head reach farmers increasingly contradict each other. But at the same time, interests of head and tail end farmers unite while securing water in their tank from the check dam. In the case of tank-6 there are multiple arenas in which these alliances overlap or come into conflict. Alliances or conflict emerge between head and tail farmers in the atchakat, paddy and non-paddy growing farmers, tube well owners and non-tube well owners, small landholders and neerganti – to name but a few.

Community participation has many facets, sometimes mutually contradictory and sometimes overlapping, Participation of all farmers in the tank level organisation does not necessarily preclude other forms of alliances with conflicting interests. Farmers may participate in the tank level alliance to secure adequate supply in their tank from the upstream tank, or in order to negotiate with the downstream tank or the Minor Irrigation Department. However, some farmers may simultaneously participate in a parallel alliance of, for instance, tail end farmers that may directly conflict with the tank level organisation or may undermine authority of the tank level of organisation. The sense of community is transient, fluid, multi-layered and formed around a common purpose and common goal. These community alliances make and break depending upon the common goal or purpose they intend to achieve.

This means that the notion of common good as well as the notion of "community" is continuously challenged and contested. De Souza (2001) calls them "imagined" communities built around a common theme or a narration. As De Souza further specifies, imagined communities are "always in the state of animated conflict" and manifest themselves "through the acts of sharing and conflict." De Souza's notion of community also captures the dynamics of a variety of negotiations and struggles that take place around resource utilisation in a particular tank. In other words, community alliances are formed and reformed through every day utilisation of the resource which is mediated through a certain form of technology.

The issue raised in much of the irrigation literature is how best to organise common users into an association. Some scholars working on collective action for management and use of an irrigation resource have debated when and how the common users organise into a group (cf. Wade 1988, Ostrom 1992). In addition to highlighting the importance of water users' associations to irrigation reform policy, another key issue raised is how best to organise farmers into an association. Farmers who refuse to organise into an association raise serious dilemmas such as whether technical rehabilitation of a tank should be carried out before farmers are organised or carried out as an incentive for farmers to organise into a group (Shah and Raju 2001).

The centrality of forming civil society associations and organisations outside the sphere of the state forms the background philosophy to these reform efforts. The notion that of water users associations are important is based on the underlying assumption that a consensus can be achieved among the users through the means of collective deliberation, in the common interest of all, by means of a common organisation. Many critiques of what is called the "associational notion of civil society" (Hann 1996; Foley and Edwards 2001) have pointed out that there is a need to shift the debates about civil society away from formal structures and organisations and towards an investigation of beliefs, values, every day experiences and politics (Hann 1996). Those who highlight the importance of formal association such water users associations and promote them in global irrigation reform policy do not take multifaceted community formations – "always in animated conflict" – into account. The associational notion of civil society is only remotely based on actual forms of social alliances and political negotiations that take place around resource sharing on an every day basis.

The politics of democratisation as Chatterjee (1998: 282) narrates "is carried out" not in civil society associations but instead "in much less well defined, legally ambiguous, contextually and strategically demarcated terrain of political society." Following Chatterjee, it is not only imperative to unearth and comprehend nuances of everyday forms of practices and politics but also what would lead the larger project of democratisation. Here it is necessary to distinguish, as Mouffe (1999) does, between politics and the political. Politics, according to Mouffe (1999), is "the ensemble of practices, discourses, and institutions that seek to establish a certain order and to organise human coexistence in conditions that are always potentially conflictual." On the other hand, she argues that the political refers to "the dimension of antagonism that is inherent in all human society, that can take many different forms and can emerge in diverse social relations." Laclau and Mouffe (1985: 155) further clarify that liberty and equality are the fundamental nodal points in the construction of the political. Without these nodal points and the corresponding transformation of the social, "politics could not be more than the repetition of hierarchical relations which reproduced the same type of subordinated subject" (Laclau and Mouffe 1985: 155). The problem of the political thus is the articulation of social relations of domination and subordination, in the societal force field as Thompson (1978: 151) describes it, or in a societal field criss-crossed with antagonism, as Laclau and Mouffe (1985: 155) describe it. The political, ridden with conflicts and antagonism, thus, is the arena of hope where challenges to the acts of domination are articulated.

This book is a beginning towards showing that technological designs are inherently political sites. Relations of power, their acts of domination and resultant contestations against acts of domination, are articulated in producing and reproducing technological designs. Or in other words, technological designs are crystallised as a result of the balance of power relations. While technology, by means of designs, creates boundary conditions for the various modes of alliances, designs are the sites where conflicts and contestations are articulated. In the field of producing and reproducing designs, by means of which water distribution is organised and ordered, the societal force field is criss-crossed with conflicts and contestations in which the process of democratisation takes place. Technological designs are thus shaped in inherently political fields and are vehicles for democratisation.

References

Abrams, Philip. 1982. *Historical Sociology*. Ithaca: Cornell University Press.

Adas, Michael. 1989. *Machines as the Measure of Men: Science, Technology and Ideologies of Western Dominance*. Ithaca: Cornell University Press.

Agarwal, Anil, and S. Narain. 1997. *Dying Wisdom: Rise, Fall and Potential of India's Traditional Water Harvesting Systems*. New Delhi: Center for Science and Environment.

Agrawal, Arun, and K. Sivaramakrishnan. 2001. *Social Nature: Resource, Representation and Rule in India*. New Delhi: Oxford University Press.

Agrawal, Arun. 1995. Dismantling divide between indigenous and scientific knowledge. *Development and Change* 26(3): 413-39.

------. 2001. Common property institutions and sustainable governance of resources. *World Development* 29(10): 1649-72.

Akrich, Madeleine. 1992. The de-scription of technological objects. In *Shaping Technology/Building Society*, eds. Wiebe Bijker and John Law, 205-224. Cambridge: The MIT Press.

Alary, Veronique. 1999. Rice cultivation in Telangana. *Economic and Political Weekly* 34(23): 1402-04.

Alvares, Claude. 1991. *Decolonising History: Technology and Culture in India, China and the West 1492 to the Present Day*. Goa: The Other India Press.

Anderson, Robert et al, eds. 1982. *Science, Politics and the Agriculture Revolution in India*. AAAS Selected Symposium 70. Boulder Colorado: Westview Press.

Assadi, Muzaffar. 1997. *Peasant Movement in Karnataka: 1980-94*. Delhi: Shipra Publications.

Baber, Zaheer. 1998. *The Science of Empire*. Delhi: Oxford University Press.

Baker, C. J. 1984. *An Indian Rural Economy 1880-1955: the Tamil Nadu Countryside*. Oxford: Clarendon Press.

Balgopal, K. 1986. Agrarian struggles. *Economic and Political Weekly* 21(32): 1401-05.

Bandyopadhyay, Arun. 1991. The technology of irrigation in a colonial agrarian context: the Tamil experience in the early nineteenth century. In *Science and Empire: Essays in Indian Context*, ed. Deepak Kumar, 87-100. Delhi: Anamika Prakashan

Bauman, Zygmaunt. 1987. *Legislators and Interpreters: on Modernity, Post-Modernity and Intellectuals*. Cambridge: Polity Press.

Benda-Beckmann, F., and K. Benda-Beckmann. 1999. Community Based Tenurial Rights: Emancipation or Indirect Rule? In *Papers of the XI International Congress "Folk Law and Legal Pluralism: Societies in Transformation"* of the Commission on Folk Law and Legal Pluralism, Moscow, August 18-22, 1997, eds. K. von Benda-Beckmann and H. F. Finkler.

Beteille, Andre. 1998. Science and tradition: a sociological perspective. *Economic and Political Weekly* 33(10): 529-32.

Bharadwaj, Krishna. 1994. Agricultural price policy for growth: the emerging contradictions. In *The State and Development Planning in India*, ed. Terence Byres, 291-346. Delhi: Oxford University Press.

Bligh, W. G. 1907. *The Practical Designs of Irrigation Works*. London.

Brass, Tom. 1991. Moral economists, subalterns, new social movements, and the (re-) emergence of a (post-) modernized (middle) peasant. *The Journal Peasant Studies* 18(2): 173-205.

------, ed.1995. *New Farmers' Movement in India*. Essex: Frank Cass.

Bray, Francesca. 1984. Patterns of evolution in rice-growing societies. *The Journal of Peasant Studies* 11: 5-31.

------. 1986. *The Rice Economies: Technology and Development in Asian Societies*. New York: Blackwell.

Breckenridge, Carol. 1985. Social storage and the extension of agriculture in South India: 1350 to 1750. In *Vijayanagara City and Empire*, ed. A. L. Dallapiccola, 44-72. Stuttgart: Steiner Verlag Wiesbaden Gmbh.

Bullock, Alan, and Stephen Trombley, eds. 1999. *The New Fontana Dictionary of Modern Thought*. London: HarperCollinsPublishers.

Butler, Judith. 2000. Restaging the universal: hegemony and the limits of formalism. In *Contingency, Hegemony and Universality*, Judith Butler, Ernesto Laclau, and Slavoj Zizek, 11-43. London: Verso.

Campbell, James. 1884. *Bijapur Gazetteer*. Bombay: Government Press.

Chambers, Robert, et al. 1989. *Farmer First: Farmer Innovation and Agricultural Research*. London: Intermediate Technology Publications.

Champakalakshmi, R.1981. Peasant state and society in medieval South India: a review article. *The Indian Economic and Social History Review* 18(3 & 4): 411-27.

Chandrashekar, B. K. 1984. Panchayati raj law in Karnataka. *Economic and Political Weekly* 19(16): 683-92.

Chatterjee, Partha. 1998. Community in the east. *Economic and Political Weekly* 33(6): 277-82.

Chattopadhyay, B. 1990. *Aspects of Rural Settlements and Rural Society in Early Medieval India*. Calcutta: Centre for Studies in Social Sciences.

Committee on Plan Projects. 1959. *Report on Minor Irrigation Works in Mysore State*. New Delhi: Government of India.

Cousens, Henry. 1905. *Bijapur, the Capital of Adil Shahi Kings: A Guide to its Ruins*. Poona.

Coward, Walter. 1980. Irrigation development: institutional and organisational issues. In *Irrigation and Agricultural Development in Asia*, ed. Walter Coward, 13-27. Ithaca: Cornell University Press.

Datye, H.R., and R.K. Patil. 1987. *Farmer Managed Irrigation Systems*. Bombay: Centre for Applied Systems Analysis in Development.

De Souza, Arun, 2001. Imagined communities and collective claims: an ethnographic study of the construction of a minor irrigation tank. Paper presented at the conference on "Cultural Politics of Water", held at Delhi University, 2-3 March.

Department of Soil and Water Conservation, introductions and Contributions to International Workshop. 1990. *Design for Sustainable Farmer-Managed Irrigation Schemes in Sub-saharan Africa*. Wageningen: Wageningen Agricultural University.

Desai, A.R, ed. 1986. *Agrarian Struggles in India after Independence*. Bombay: Oxford University Press.

Dev, Mahendra and Jos Mooij. 2002. Social sector expenditures and budgeting: an analysis of patterns and the budget making process in India in the 1990s. Working paper No. 43, Center for Economic and Social Studies, Hyderabad.

Dhanagare, D. N. 1995. The class character and politics of the farmers' movement in Maharashtra during the 1980s. In *New Farmers' Movement in India*, ed. Tom Brass, 72-94. Essex: Frank Cass.

Diemer, Geert, and Slabbers Jacques. 1992. Irrigators and engineers in developing countries. In *Irrigators and Engineers*, eds. Diemer, Geert, and Slabbers Jacques, 3-13. Amsterdam: Thesis Publishers.

Dikshi, G. S., et al. 1993. *Tank Irrigation in Karnataka: a Historical Survey*. Bangalore: Gandhi Sahitya Sangha.

Eaton, Richard. 1978. *Sufis of Bijapur: 1300-1700*. Princeton: Princeton University Press.

Elias, Norbert. 1984. Knowledge and power: an interview by Peter Lude. In *Society and Knowledge: Comparative Perspective in the Sociology of Knowledge*, eds. Stehr, Nico, and Volker, Meja, 252-291. London: Transaction Books.

Farmer, B. H.1986. Perspectives on the "Green Revolution" in South

Asia. *Modern Asian Studies* 20 (1): 175-99.

Feenberg, Andrew. 1991. *Critical Theory of Technology*. New York: Oxford University Press.

Ferguson, Eugene. 1993. *Engineering and the Mind's Eye*. Cambridge: The MIT Press.

Foley, Michael, and Bob Edward. 1996. The paradox of civil society. *Journal of Democracy* 7 (3): 38-52.

Frankel, Francine. 1971. *India's Green Revolution: Economic Gains and Political Costs*. Bombay: Oxford University Press.

Friedmann, Harriet. 1990. The origins of thirld world food dependence. In *The Food Question: Profits versus People?*, eds. Henry Bernstein et al, 13-31. London: Earthscan Publications Ltd.

Frykenberg, Robert. 1963. Traditional processes of power in South India: an historical analysis of local influences. *Indian Economic and Social History Review* 1 (2): 123-42.

Fukazawa, Hiroshi. 1998. *The Medieval Deccan: Peasants, Social Systems and States, Sixteenth to Eighteenth Centuries*. Delhi: Oxford University Press.

Galtung, Johan. 1979. Towards a new international technological order. In *Science, Technology and the Social Order*, ed. W. Morehouse, 277-300. New Brunswick: Transaction Books.

Geertz, Clifford. 1963. *Agricultural Involution: The Processes of Ecological Change in Indonesia*. Berkeley: University of California Press.

Genevose, Eugene. 1965. *The Political Economy of Slavery: Studies in Economy and Society of the Slave South*. New York: Random House.

Gilmartin, David. 1994. Scientific empire and imperial science: colonialism and irrigation technology in the Indus basin. *The Journal of Asian Studies* 53 (4): 1127-49.

GOI. 1968. *Mysore State Gazetteer, Kolar District*. Bangalore: GOI.

GOK. 1988. *Minor Irrigation Atlas*. Bangalore: Minor Irrigation Department.

------. 1993. *Minor Irrigation in Karnataka: 1993*. Bangalore: Minor Irrigation Department.

Govindaiah, T. 1994. *Tank Rehabilitation and Integrated Rural Development*. Bangalore: Institute for Research in Social Sciences.

Griffin, Keith. 1979. *The Political Economy of Agrarian Change*. London: The Macmillan Press Ltd.

Grist, D.H. 1986. *Rice*. London: Longman.

Guha, Ramachandra. 1988. The alternative sccience movement: an interim assessment. *Lokayan Bulletin* 6 (3): 7-25.

Gulati, Ashok, and A. Sharma. 1994. Agriculture under GATT: what holds for India?. *Economic and Political Weekly* 29 (29): 1857-63.

Gupta, Akhil. 1998. *Postcolonial Developments: Agriculture in the Making of*

Modern India. London: Duke University Press.

Gurukkal, R.1986. Aspects of reservoir system of irrigation in the Early Pandya state." *Studies in History* 2 (2): 155-64.

Halsema, van Gerardo. 2002. Trail and retrial: the evolution of irrigation modernisation in NWFP, Pakistan. Ph.D. Diss., Wageningen University.

Hann, Chris. 1996. Introduction: political society and civil anthropology. In *Civil Society: Challanging Western Models*, eds. Chris Hann and Elizabeth Dunn,1-26. London: Routledge.

Haraway, Donna. 1991. *Simians, Cyborgs and Women? The Reinvention of Nature*. New York: Routledge.

Hardiman, David. 1987. The Bhils and Shahukars of eastern Gujarat. In *Subaltern Studies*, ed. Ranajit Guha, Vol. 5. Delhi: Oxford University Press.

Harding, Sandra. 1996. *Whose Science? Whose Knowledge?: Thinking from Women's Lives*. New York: Cornell University Press.

Harring, Ronald. 1984. Economic consequences of local power configurations in rural South Asia. In *Agrarian Power and Agricultural Productivity in South Asia*, eds. Meghnad Desai, Susanne Rudolph and Ashok Rudra,198-249. Delhi: Oxford University Press.

Hess, David. 1997. *Science Studies: an Advanced Introduction*. New York: New York University Press.

Howe, Leo. 1991. Rice, ideology and legitimation of hierarchy in Bali. *Man* 26 (3): 445-67.

Hunt, Robert, and Eva Hunt. 1976. Canal organization and local social organization. *Current Anthropology* 17 (3): 389-411.

Indian Irrigation Commission. 1901-02. *Minutes of Evidence: Bombay Presidency*. Bombay.

Jairath, Jasveen. 1999. Participatory irrigation management: experiments in Andhra Pradesh. *Economic and Political Weekly* 34 (40): 2834-41.

Janakarajan, S. 1993. In search of tanks: some hidden facts. *Economic and Political Weekly* 28 (26): A-53 - A-60.

Jeffrey, C. J. 2001. 'A fist is stronger than five fingers': caste and dominance in rural North India. *Transactions of the Institute of British Geographers* 25 (2): 217-36.

Jurriens, M., P. P. Mollinga, and P. Wester, liquid Gold Paper 1. 1996. *Scarcity by Design: Protective Irrigation in India and Pakistan*. Wageningen: Wageningen Agricultural University, International Institute for Land Reclamation and Improvement.

Kakarala, Sitharamam, et al. 2003. Development Aid and 'Direct Funding': Changing Scenario of Multilateral and Bilateral Donor Aid Policy in India during the 1990s. Mimeo (in file with National Law

School of India University, Bangalore).

Kloezen, Wim, and Peter Mollinga. 1992. Opening closed gates: recognising social nature of irrigation artifacts. In *Irrigators and Engineers*, eds. Geert Diemer and Slabbers Jacques, 53-63. Amsterdam: Thesis Publishers.

Kohli, Atul. 1987. Karnataka: populism, patronage and piecemeal reform. In Atul Kohli, *The State and Poverty in India*, 145-85. Cambridge: Cambridge University Press.

------. 1994. State power and social forces: on political contention and accommodation in the thirld world. In *State Power and Social Forces: Domination and Transformation in the Thirld World*, eds. Joel Migdal, Atul Kohli, and Viviene Shue, 293-326. Cambridge: Cambridge University Press.

Kripa, A. P. 1992. Farmers movement in Karnataka. *Economic and Political Weekly* 27 (23): 1182-83.

Krishna Murthy, A. N. 1975. Shimoga, Mysore. In *Changes in Rice Farming in Selected Areas of Asia*, ed. International Rice Research Institute, 117-132. Manila: International Rice Research Institute.

Kumar, Deepak. 1997. *Science and the Raj*. Delhi: Oxford University Press.

Laclau, Ernesto, and Chantal Mouffe. 1985. *Hegemony and Socialist Strategy: Towards a Radical Democratic Politics*. London: Verso.

Laclau, Ernesto. 2001. Democracy and the question of power. *Constellations* 8 (1): 3-14.

Latour, Bruno. 1992. Where are the missing masses? The sociology of a few mundane artifacts. In *Shaping Technology/Building Society*, eds. Wiebe Bijker and John Law, 225-58. Cambridge: The MIT Press.

------. 2000. When things strike back - a possible contribution of science studies. *British Journal of Sociology* 51 (1): 105-23.

Leach, E. R. 1959. Hydraulic society in Ceylon. *Past and Present* 15: 2-26.

Lele, Sharachchandra. 2002. Beyond state: community polarization and bogus 'joint'ness —crafting institutional solutions for source management. Paper Presented at the 50th Anniversary Conference on "Globalisation and Poverty", Institute of Social Studies, The Hague, Netherlands, October 7-9, 2002.

Lindberg, Staffan. 1995. New farmers movement in India as structural response and collective identity formation: the case of the Shetkari Sanghatana and the BKU. In *New Farmers' Movement in India*, ed. Tom Brass, 95-125. Essex: Frank Cass.

Ludden, David. 1979. Patronage and irrigation in Tamilnadu: A longterm view. *Indian Economic and Social History Review* 63 (3): 347-65.

------. 1985. *Peasant History in South India*. Princeton: Princeton University Press.

------. 2001. *Reading Subaltern Studies: Critical History, Contested Meaning, and the Globalisation of South India*. New Delhi: Permanent Black.

Mackenzie, Donald, and Judy Wajcman, eds.1985. *The Social Shaping of Technology*. Philadelphia: Open University Press.

MIDS. 1983. *Tank Irrigation in Tamil Nadu: Some Macro and Micro Perspectives*. Madras: Madras Institute of Development Studies.

Manor, James. 1977. Structural politics in Karnataka politics. *Economic and Political Weekly* 12 (44): 1865-9.

------. 1984. Blurring the lines between parties and social bases: Gundu Rao and emergence of a Janata Government in Karnataka." *Economic and Political Weekly* 19 (37): 1623-32.

------. 1989. Karnataka: Caste, Class, Dominance and Politics in a Cohesive Society. In *Dominance and State Power in Modern India: Decline of a Social Order*, eds. Francine Frankel and M. S. A. Rao, 322-61. Delhi: Oxford University Press.

Meinzen-Dick, Ruth. 1997. Farmer participation in irrigation. *Irrigation and Drainage Systems* 11 (2): 103-118.

Meinzen-Dick, Ruth, and K. Palanisami. 2001. Tank performance and multiple users in Tamil Nadu, South India, *Irrigation and Drainage Systems* 15 (2).

Migdal, Joel. 1994. The state in society: an approach to struggles for domination. In *State Power and Social Forces: Domination and Transformation in the Thirld World*, eds. Joel Migdal, Atul Kohli and Viviene Shue, 7-34. Cambridge: Cambridge University Press.

Mollinga, Peter, and Jos Mooij. 1989. *Cracking the Code: Towards a Conceptualisation of the Social Content of Technical Artefacts*. Occasional Paper No. 18. Milton keynes: The Open University, Technology Policy Group.

Mollinga, Peter, et al. 2000. Participatory irrigation management in Andhra Pradesh, India: policy implementation and transformation in the Tungabhadra right bank low level canal. Paper Presented at the 8th Biennial Conference of the International Association for the Study of Common Property (IASCP), Bloomington, Indiana, USA, 31 May - 4 June 2000. Sourced at http://dlc.dlib.indiana.edu/documents/dir0/00/00/03/09/dlc-0000309/mollinga060200.pdf.

Mollinga, Peter. 1992. *Protective Irrigation In South India: Deadlock Or Development?* Working Paper 24. Milton Keynes: The Open University, Policy and Practice Research Group.

------.1998. On the waterfront: water distribution, technology and agrarian change in a South Indain canal irrigation system. Ph.D. Diss., Wageningen Agricultural University.

Mooij, Jos. 1998. *Food Policy and Indian State: the Public Distribution System in*

South India. Delhi: Oxford University Press.

Morrison, K.D. 1992. Transforming the agricultural landscape: intensification of production at Vijayanagara, India. Ph.D. Diss., University of California, Berkley.

Mosse, David. 1997a. Ecological zones and the culture of collective action: the history and social organization of a tank irrigation system in Tamil Nadu. *South Indian Studies* 3, January-June: 1-88.

Mosse, David. 1997b. The symbolic making of a common property resource: history, ecology and locality in a tank-irrigated landscape in South India. *Development and Change* 28 (3): 467-504.

------.1999. Colonial and contemporary ideologies of community management: the case of tank irrigation development in South India. *Modern Asian Studies* 33 (2): 303-38.

------. 2001. Ecology, uncertainty and memory: imagining a medieval irrigated landscape in South India. Paper presented at the conference on "Cultural Politics of Water", held at Delhi University, 2-3 March.

Mouffe, Chantal. 1999. Deliberative democracy or agonistic pluralism? *Social Research* 66 (3).

Mukundan, T.1988. The Ery systems of South India. *PPST Bulletin*, 16 (September): 1-37.

Mulkay, Michael. 1984. Knowledge and utility: implications for the sociology of knowledge. In *Society and Knowledge: Contemporary Perspectives on the Sociology of Knowledge*, eds. Nico Stehr and Meja Volker, 77-96. London: Transaction Books.

Nadkarni, M. V (assisted by Vedini, K. H.). 1996. Accelerating commercialisation of agriculture: dynamic agriculture and stagnating peasants?. *Economic and Political Weekly* 31 (26): A-63 - A-73.

Nadkarni, M. V. 1987. *Farmers' Movement in India*. Ahmedabad: Allied Publishers Private Limited.

Nandy, Ashish. 1983. *The Intimate Enemy: Loss and Recovery of Self Under Colonialism*. Delhi: Oxford University Press.

------. 1988. *Science, Hegemony and Violence*. Delhi: Oxford University Press.

Nandi, R.N. 2000. *State Formation, Agrarian Growth and Social Change in Feudal South India A.D. 600-1200*. Delhi: Manohar.

Noble, David. 1986. *Forces of Production: A Social History of Industrial Automation*. New York: Oxford University Press.

Omvedt, Gail. 1995. We want the return of our sweat: the new peasant movement in India and the formation of national agricultural policy. In *New Farmers' Movement in India*, ed. Tom Brass, 126-64. Essex: Frank Cass.

Oppen, von M., and K. V. Subba Rao. 1987. *Tank Irrigation in Semi-Arid Tropical India: Economic Evaluation and Alternatives for Improvement*.

Hyderabad: International Crops Research Institute for the Semi-Arid Tropics.

Ostrom, Elinor. 1992. *Crafting Institutions for Self-Governing Irrigation Systems.* Cambridge: Cambride University Press.

Palanisami, K. 1991. Conjuective use of tank and well water in tank irrigation system. In *Future Direction for Indian Irrigation: Research and Policy Issues*, eds. Ruth Meinzen-Dick and Mark Svendsen, 134-145. Washington D.C.: International Food Policy Research Institute.

------. 2000. *Tank Irrigation: Revival for Prosperity.* New Delhi: Asian Publication Services.

Pani, Narendra. 1997. Towards decentralized agrarian reform: lessons from Karnataka's 1974 experience. In *Land Reforms in India, Karnataka: Promises Kept and Missed*, eds. Abdul Aziz and Sudhir Krishna, 33-50. New Delhi: Sage Publications.

Papanek, Victor. 1997. *Design for the Real World: Human Ecology and Social Change.* London: Thames and Hudson.

Patnaik, Utsa. 1990. *Agrarian Relations and Accumulation: the 'Mode of Production' Debate in India.* Bombay: Sameeksha Trust and Oxford University Press.

------. 1999a. The cost of free trade: the WTO regime and the Indian economy. *Social Scientist* 27 (11-12): 3-26.

------. 1999b. *The Long Transition: Essays on Political Economy.* New Delhi: Tulika.

Pfaffenberger, Bryan. 1988. Fetishised objects and humanized nature: towards an Anthropology of technology. *Man* 23 (2): 236-52.

Pfaffenberger, Bryan. 1992. Social anthropology of technology. *Annual Review of Anthropology* 21: 491-516.

Pinch, Trevor, and Wiebe Bijker. 1984. The social construction of facts and artefacts: or how the sociology of science and the sociology of technology might benefit each other. *Social Studies of Science* 14 ( ): 399-441.

Pipin, Robert. 1995. On the notion of technology as ideology. In *Technology and the Politics of Knowledge*, eds. Andrew Feenberg and Alastair Hannay, 43-61. Bloomington and Indianapolis: Indiana University Press.

Playfair, R. E. 1866. *A Paper on Irrigation in the Deccan and Southern Maratha Country.* Bombay.

Ponnamperuma, F. N. 1985. Chemical kinetics of wetland rice soils relative to soil fertility. In *Wetland Soils: Characterization, Classification, and Utilization.* Proceedings of a Workshop held 26 March to 5 April 1984, Manila: International Rice Research Institute.

PWD 476. Records Connected with the Tank System in Mysore 40.

Bangalore, Karnataka State Archives.

Qaisar, Ahsan Jan. 1998. *The Indian Response to European Technology and Culture: AD 1498 - 1707.* Delhi: Oxford University Press.

Rai, G. K. 1976. Forced labour in ancient and early medieval India. *The Indian Historical Review* 3 (1): 16-42.

Rajan, M. A. S. 1981. *Land Reforms in Karnataka: An Account by a Participant Observer.* Delhi: Hindustan Publishing Corporation.

Rane, Wishvas. 1993. Farmers' rally against GATT proposals. *Economic and Political Weekly* 28 (44): 2391.

Reddy, Ratna. 1990. Irrigation in colonial India: a study of madras presidency during 1860-1900. *Economic and Political Weekly* 25 (18): 1047-54.

Reddy, Somashekara. 1991. *Forfieted Treasure: A Study on the Status of Irrigation Tanks in Karnataka.* Bangalore: Prarambha.

------. n.d. An Evaluation of World Bank-Aided Tanks in Karnataka. Mimeo.

Rice, Lewis. 1897. *Mysore Gazatteer.* London.

Rudolph, Lloyd, and Susanne Rudolph. 1987. *In Pursuit of Lakshmi: the Political Economy of the Indian State.* New Delhi: Orient Longman.

Rudolph, Susane. 2000. Civil society and the realm of freedom. *Economic and Political Weekly* 35 (20): 1762-69.

Russell, Stewart. 1986. The social construction of artefacts: a response to Pinch and Bijker. *Social Studies of Science* 16 ( ): 331-46.

Sakhtivadivel et al. 1996. *Nature of Small Tank Cascade Systems and a Framework for Rehabilitation of Tanks within Them.* Colombo: International Irrigation Management Institute.

Saldanha, Cecil. 1987. *Karnataka State of Environment Report: 1985-1986.* Bangalore: Center for Taxonomic Studies.

Sangren, Steven. 1995. Power against ideology: a critique of Foucaultian usage. *Cultural Anthropology* 10 (1): 3-40.

Scheer, S. H. 1996. Communication between irrigation engineers and farmers. Ph.D. Diss.,Wageningen Agricultural University.

Sen, S. R. 1994. From GATT to WTO. *Economic and Political Weekly* 29 (43): 2802-04.

Sengupta, Nirmal. 1985. Irrigation: traditional vs. modern. *Economic and Political Weekly* 20 (45,46,47): 1919-38.

------. 1991. *Managing Common Property: Irrigation in India and Philippines.* New Delhi: Sage.

------. 1993. *User-Friendly Irrigation Designs.* New Delhi: Sage Publications.

------. 1997. The rise of the bureaucracy in Tamil Nadu: water control vs. management. *Water Nepal* 5 (2): 125-35.

Sewell, R. 1990. *A Forgotten Empire (Vijayanagara): A Contribution to the*

History of India. New Delhi: Asian Education Services.

Shah, Tushar, and K. V. Raju. Rethinking rehabilitation: socio-ecology of tanks in Rajsthan, North-West India. *Water Policy* 3: 521-36.

Shankari, Uma and Esha Shah. 1993. *Water Management Traditions in India*. Chennai: PPST Foundation.

Shankari, Uma. 1991. Tanks: major problems in minor irrigation. *Economic and Political Weekly* 26 (39): A-115 - A-125.

Sigaut, Francois. 1994. Technology. In *Companion Encyclopedia of Anthropology*, ed. Tim Ingold, 420-59. London: Routledge.

Sreedhar, G. 1997. *Tank Irrigation in Semi-Arid Zones*. Bangalore: Sunrise Publications.

Srinivas, M. N., and M. N. Panini. 1984. Politics and society in Karnataka. *Economic and Political Weekly* 19 (2): 69-75.

Srinivasan, T. M. 1991. *Irrigation and Water Supply: South India, 200 B.C. - 1600 A.D.* Madras: New Era Publications.

Staudenmaier, John. 1990. Recent trends in the history of technology. *American Historical Review* 95 (June): 715-25.

Staudenmaier, John. 1994. Rationality versus contingency in the history of technology. In *Does Technology Drive History? The Dilemma of Technological Determinism*, eds. Merritt Roe Smith and Leo Marx, 257-73. Cambridge: The MIT Press.

Stein, Burton. 1980. *Peasant State and Society in Medieval South India*. Delhi: Oxford University Press.

Steven, Yearley. 1988. *Science, Technology and Social Change*. London: Unwin Hyman.

Thippaiah, P. 1997. *Study of Causes for the Shrinkage of Tank Irrigated Area in Karnataka*. Bangalore: Institute of Economic and Social Change.

Thompson, Edward. 1978. Eighteenth-century English society: class struggle without class. *Social History* 3 (2): 133-65.

Tiffen, Mary. 1983. *Alternative Design Concepts for Irrigation Systems*. ODI Network Paper 8e. London: Overseas Development Institute.

Uphoff, Norman. 1986. *Getting The Process Right: Improving Irrigation Water Management With Farmer Organisation And Participation*. Working Paper. Ithaca: Cornell University Press.

Vaidyanathan, A. 1992. *Strategy for Development of Tank Irrigation*. Madras: MIDS.

------. 1994. Transferring irrigation management to farmers. *Economic and Political Weekly* 29 (47): 2965-67.

------. 1998. *Tanks of South India*. Chennai: MIDS.

Vani, M. S. 1992. *Role of Panchayat Institutions in Irrigation Management: Law and Policy*. New Delhi: The Indian Law Institute.

Varshney, Ashutosh. 1998. *Democracy, Development and the Countryside: Urban-*

Rural Struggles in India. Cambridge: Cambridge University Press.
Vasantha Madhava, K. G. 1991. *Western Karnataka: Its Agrarian Relations AD 1500-1800*. New Delhi: Navrang.
Vasavi, A. 1996. The 'Millet Drought': oral narratives and the cultural grounding of famine-relief in Bijapur. *South Indian Studies* 2 (July-December): 205-33.
Vessuri, Hebe. 1980. Technological change and the social organization of agricultural production. *Current Anthropology* 21 (3): 315-27.
Vogel, Steven. 1995. New science, new nature: the Habermas-Marcuse debate revisited. In *Technology and the Politics of Knowledge*, eds. Andrew Feenberg and Alastair Hannay, 23-42. Bloomington and Indianapolis: Indiana University Press.
Wade, Robert. 1988. *Village Republics: Economic Conditions for Collective Action in South India*. Cambridge: Cambridge University Press.
Watanabe, I., and P. A. Roger. 1985. Ecology of flooded rice fields. In *Wetland Soils: Characterization, Classification, and Utilization*. Proceedings of a Workshop held 26 March to 5 April 1984, Manila: International Rice Research Institute.
Winner, Langdon. 1985. Do artifacts have politics? In *The Social Shaping of Technology*, eds. Donal MacKenzie and Wajcman Judy, 26-38. Milton Keynes and Philadelphia: Open University Press.
------. 1993. Upon opening the black box and finding it empty: social construction and the philosophy of technology. *Science, Technology and Human Values* 18 (3): 362-78.
Wittfogel, Karl. 1957. *Oriental Despotism: A Comparative Study of Local Power*. New Haven: Yale University Press.
Wolf, Eric. 1999. *Envisioning Power: Ideologies of Dominance and Power*. Berkeley: University of California Press.
World Bank. 1981. *Karnataka Tank Irrigation Project*. Washington D.C.: World Bank.
Yamada, N. 1965. Some problems of irrigation and drainage in rice culture. *International Rice Commission News Letter* 14 (3).
Yarlagadda, Tejaswini. 1993. Social groups and economic change: 7th - 13th century A.D." In *Social and Economic History of Early Deccan*, ed. Aparajita Parasher-Sen, 158-81. New Delhi: Manohar.
Yearly, Steven. 1988. *Science, Technology and Social Change*. London: Unwin Hyman.

Summary

Tank irrigation of south India is considered as "traditional" "alternative" or "appropriate" form of irrigation in the current academic and policy circles. A majority of tanks are considered historically, ecologically and culturally embedded being three to four centuries old and are acclaimed as emblem of continuity of tradition and heritage. Their small size and spatially dispersed nature are considered ideal for decentralised management by local communities. This counter hegemonic role ascribed to tank irrigation not only implies a wide-ranging criticism of modern technology but also provides a location for redefinition or reconstitution of the way irrigation resources are institutionalised and managed in general. In the last two decades, internationally funded development programmes have been initiated in the three south Indian states of Andhra Pradesh, Karnataka and Tamilnadu to rehabilitate tanks and to hand them over to communities for the management and use.

The policy reform initiatives and academic viewpoints that acclaim communities as better managers of their resources raises an issue of fundamental concern. Many historians and social scientists have shown grossly inegalitarian nature of south Indian society (cf. Ludden 1985). Some scholars have also raised the voice of concern that advocates of traditional knowledge rarely mention the grave inequality of traditional Indian society (Guha 1988:15). Agrawal (1995: 416) similarly points out that a significant shift in power relations in local communities would be prerequisite for empowering those who are on the margin.

This research is an attempt to address this concern. It intends to understand how tank irrigation technology is shaped as a result of relations of power in a particular historical, agrarian and social

context and how this technology in turn institutionalises a particular pattern of resource utilisation that favours some users and discriminates against some others. The research ultimately aims to participate in the debate on democratisation of natural resource use and management.

The research is based on a theoretical premise that technological designs are coded or scripted with preferences made by dominant sections of society. As Akrich (1992: 209) states it, "the world inscribed in the object is the world described by it." Technology is thus a product as well producer of social life. By means of shaping and reproducing technology, a certain form of social organisation or social arrangement is also reproduced. In the background of this theoretical position, the central question explored in this research is: how does a certain balance of power relations, in a particular historical, environmental and agrarian context, shape tank irrigation technology and institutionalise a certain pattern of water distribution practices.

In order to address the main concern of the research, two layers of analysis are adopted. Firstly, tank irrigation technology is located in the wider context of agrarian practices and their transformation with a focus on the last three decades in particular. This part of the analysis focuses on relating changes in tank technology with political, social and commercial choices made in a particular spatial and historical location. The focus for this part of the analysis is to understand how technology is related to changing state-society, market and production relations in the context of wider agrarian transformation. The scale of analysis here is regional (state of Karnataka). In this scale of analysis, the issue of power is kept central, although its manifestations are treated at a macroscopic level mainly in a political economy framework. The second layer of analysis, in a descending order of spatial and structural specificities, focuses on how relations of power in a specific agrarian and agro-climatic context shape tank designs that produce and reproduce patterns of water distribution. The second layer of analysis focuses microscopically at the individual tank. The first layer of analysis locates tank technology in spatial, temporal and agrarian contexts, but the second layer of query intends to understand how "power" forms the content or internal logic or designs of the technology.

In the background of two-layered analysis of this research, chapters 2, 3 and 4 discuss relationship of tank designs with paddy cultivation. Chapter 2 shows that tank designs have been specifically suited for paddy cultivation since they were originally constructed to facilitate paddy cultivation in the pre-colonial historical context. Chapter 2 is not an attempt to narrate history of tank irrigation but to show that designs of tank technology is embedded in social and political order and agrarian practices of the pre-colonial period.

Diverse tank trajectories across different agro-climatic regions are mapped in chapter 4 corresponding to agrarian transformation in the last three decades in the background of farmers' politics and state-society relations discussed in chapter 3. The decade of the 1980s was a crucial time for state policy on agriculture and irrigation as a result of the pressure exerted by the farmers' movement. In Chapters 3, it is argued that in the aftermath of the introduction of green revolution technology a hegemonic class of owner-cultivators emerged all over India and also in Karnataka whose populist politics ushered in a new era in Indian agrarianism. Their populist politics succeeded in creating an assured market for superior grains such as wheat and paddy with favourable terms of trade. This made paddy cultivation profitable even for small landowners. Moreover, this favourable policy for paddy brought in a whole new range of activities in tank irrigated areas.

Transformation of tank designs, in the context of intensification of paddy cultivation in the wet region and on the interface of paddy and non-paddy cultivation in the mixed region, are discussed in chapter 4.

The subsequent four chapters explain designs of the four selected tanks in the differing local contexts. In general, chapters 5, 6, 7 and 8 situate the process of making and remaking of tank designs by exploring every day forms of water distribution and management, and transformation of designs in the context of a transforming cropping pattern. These chapters explore how the designs crystallise a certain balance of power, and how they are coded with certain norms, values, preferences and choices made by the dominant section in a particular context.

Chapter 5 discusses a tank located in the mixed region of northern Karnataka irrigating paddy and dry crops. The chapter shows how the task of unequal water distribution is delegated to tank designs. A high degree of rule adherence in this tank area is as a result of tank designs meant to sustain a differential pattern of water distribution.

Chapter 6 discusses a tank located in the mixed region of the southern maidan. One crop of transplanted paddy is cultivated in the atchakat whenever the tank receives water up to full capacity. The chapter discusses the shifts in designs in the context of the changing cropping pattern in the atchakat and the shift in the authority in charge of the management of the tank. The chapter illustrates how the shift in designs and agricultural practices, as a result of choices made by different sections of farmers, emerged together.

Chapter 7 discusses the case of a tank in which the tail end farmers have challenged the established norm of irrigation first supplied to the head reach, and radically redefined the designs to assert a tail end first rule. The tank is located in the wet region of western Karnataka and irrigates broadcasted paddy and garden crops. The chapter shows how the rules of water distribution and the notion of right to water are intricately connected with designs of physical structures.

Chapter 8 is a tale of two paradoxes situated in the tank located in the dry region irrigating dry crops. The tank is newly constructed with World Bank assistance. The social environment of this tank, inflicted with chaos and conflict, illustrates the first paradox, namely that when the MID attempts to form a water users association the farmers claim that water stored in the tank belongs to the government and hence the government should manage water distribution. The mismatch between culturally organised farming practices and the assumptions on which the designs of a newly constructed tank are based is the second paradox.

Chapters 5 to 8 argue that technology emerges as an important variable that creates and sustains the internal dynamics among the community of irrigators. In fact the technology also creates new forms of alliances and sets boundaries for internal differentiation. Technological designs are thus not only scripted to facilitate the dominant interests of society but they are also sites subjected to contestations and conflicts. Designs thus are shaped in an inherently political field and hence are vehicles for democratisation. This point is briefly discussed in the final chapter of the book.

Nederlandse Samenvatting

In kringen van wetenschapsmensen en beleidsmakers geldt tankirrigatie in Zuid-Azie tegenwoordig als 'traditioneel', 'alternatief'of 'aangepast' (*appropriate*)'. Ze worden aangeprezen als een typisch historisch, ecologisch en cultureel erfgoed ingebed in drie, vier eeuwen traditie. Vanwege hun geringe omvang en verspreiding zijn ze ideaal voor gedecentraliseerde vormen van beheer door lokale gemeenschappen. Dat tankirrigatie geldt als symbolisch voor een maatschappelijke 'tegenstroom' impliceert kritiek op de moderne technologie, maar ook een locus waar de manier waarop irrigatie in het algemeen institutioneel en gemanaged wordt een nieuwe definitie en constitutie krijgt. In de laatste twee decennia zijn in drie Zuid-Indaise deelstaten, Andhra Pradesh, Karnataka en Tamilnadu met internationaal geld projecten van start gegaan om tanks te herstellen en over te dragen aan de lokale gemeenschap.

Deze initiatieven voor beleidshervorming en de academische invalshoek die aan lokale gemeenschappen betere managementcapaciteiten toeschrijven voor het beheer van hun water brengt een fundamentele kwestie.naar voren. Veel historici en sociale wetenschappers hebben aangetoond hoe weinig egalitair de maatschappij in Zuid-India is (bijv. Ludden 1985). Sommigen van hen maken zich er zorgen over dat voorstanders van traditionele kennis zelden melding maken van deze ongelijkheid (Guha 1988: 15). Agrawal (1995: 416) wijst er op dat er een behoorlijke machtsverschuiving in lokale gemeenschappen nodig is om de mensen in de marge van de maatschappij meer macht over hun lot te geven.

Dit onderzoek gaat in op deze zorg. Het beoogt inzicht te geven waarom de technologie van tankirrigatie vorm krijgt als gevolg van machtsverhoudingen in een bepaalde historische, agrarische en sociale context en hoe deze technologie op haar beurt weer een bepaalde vorm van gebruik van natuurlijke hulpbronnen institutionaliseert waar sommige gebruikers voordeel bij hebben en anderen nadeel. Het project wil bijdragen aan het debat rond democratisering van natuurlijke hulpbronnen en het beheer daarvan.

Het onderzoek stoelt op de theoretische aanname dat het 'script' voor elk technologisch ontwerp is ingegeven door de voorkeuren van de dominante groepen in de samenleving. Technologie is zowel het product (resultaat) als de producent (vormgever) van het sociale leven. Door technologie vorm te geven en te reproduceren, reproduceer je ook een vorm van sociale organisatie of arrangement. Tegen deze achtergrond moet men de centrale probleemstelling voor dit onderzoek beschouwen: hoe vormt een bepaalde machtsbalans in een bepaalde historische, agrarische en milieucontext, irrigatietechnologie en hoe institutionaliseert deze een bepaald patroon van waterverdeling?

Hiertoe maak ik gebruik van twee analyseniveaus. Ten eerste plaats ik tankirrigatie-technologie in de bredere context van de (transformatie van) landbouwpraktijken, met name die van de laatste drie decennia. Dit gedeelte van de analyse relateert veranderingen in de tanktechnologie aan politieke, sociale en commerciële keuzen die in een specifieke ruimtelijke en historische locatie worden gemaakt. De analyse poogt inzicht te bieden in de manier waarop de technologie samenhangt met veranderende verhoudingen tussen staat en maatschappij, en veranderende markt- en productieverhoudingen in de context van de agrarische transformatie die zich in bredere zin afspeelt

Het schaalniveau is regionaal (de staat Karnataka). Op dit analyseniveau staat het concept 'macht' centraal, en wordt macroscopisch behandeld met behulp van een politiek-economisch analysekader.

Het tweede analyseniveau, afdalend naar niveaus van ruimtelijke en structurele specificiteit, beschouwt hoe machtsverhoudingen in een agrarische en agro-klimatologsiche context bepalend zijn voor het ontwerp dat het patroon van waterverdeling produceert en reproduceert. Dit tweede niveau blijft op het micro-niveau van de tank - terwijl het eerste niveau de technologie rond de tank in haar context beziet (tijd, ruimte en landbouwkundige aspecten) betreft het tweede niveau de inhoud en interne logica of ontwerp van de technologie.

Als achtergrond waartegen de analyse op twee niveaus van dit onderzoek gezien kan worden behandelen de hoofdstukken 2, 3 en 4 gaan de verhouding tussen het ontwerp van een tank met rijstteelt. Hoofdstuk 2 laat zien hoe het ontwerp specifiek op rijstteelt is ingesteld aangezien de tanks oorspronkelijk waren ontworpen om rijstteelt in de prekoloniale historische context mogelijk te maken. Dit hoofdstuk heeft niet de pretentie de geschiedenis van tankirrigatie te vertellen, maar om te laten zien dat ontwerp van tanktechnologie is ingebed in de sociaal-politieke orde en de landbouwpraktijken uit de tijd voor de kolonisatie van India.

Een overzicht van verschillende tanktrajecten in regio's met verschillende typen landbouw is te vinden in hoofdstuk 4, overeenkomstig de transformatie in de landbouw van de afgelopen drie decennia, tegen de achtergrond van boerenpolitiek en de veranderde verhouding tussen staat en samenleving die in hoofdstuk 3 worden belicht. De jaren tachtig vormden een cruciale periode in de landbouw- en irrigatiepolitiek van de overheid. In hoofdstuk 3 stel ik dat na de invoering van de Groene Revolutie in heel India een hegemoniale klasse van landeigenaren-telers opkwam, ook in Karnataka waar de populistische politiek een nieuw tijdperk in de Indiase landbouw inluidde. Deze populistische politiek riep een robuuste markt in het leven voor de betere gewassen zoals graan en rijst met gunstige marktvoorwaarden. Zo werd rijst zelfs voor kleine boeren aantrekkelijk. Bovendien bracht het rijstteelt-vriendelijke beleid een heel nieuw scala aan activiteiten met zich mee in gebieden die met tanks worden geïrrigeerd.

De transformatie van tankontwerp tegen het licht van intensivering van de rijstverbouw in de natte regio en op het snijvlak van rijst- en niet-rijstverbouw in de gemengde regio komen aan de orde in hoocdstuk 4.

De daaropvolgende vier hoofdstukken verklaren het ontwerp van vier tanks in hun locale context nader. In het algemeen plaatsen de hoofdstukken 5, 6, 7 en 8 het proces van ontwerp en herontwerp van een tank in een context door een bespreaking van de alledaagse vormen van waterverdeling en -beheer, en de transformatie van het ontwerp in de context van een transformatie in het teeltpatroon. In deze hoofdstukken probeer ik te achterhalen hoe in het tankontwerp een bepaalde machtsverhouding tot uiting komt, en hoe deze in een specifieke context door de dominante klassen met bepaalde normen, waarden, voorkeuren en keuzen wordt 'gecodeerd'.

Hoofdstuk 5 behandelt een tank in de regio Noord-Karnataka, waar zowel rijst als droge gewassen worden geteeld. In dit hoofdstuk laat ik zien hoe de taak van de ongelijke waterverdeling wordt gedelegeerd aan het tank-ontwerp. Tanks zijn zodanig ontworpen dat de waterverdeling een gedifferentieerd patroon vertoont, met als gevolg dat in deze regio de regels in hoge mate worden nageleefd.

Hoofdstuk 6 behandelt een tank in de gemengde regio in de zuidelijke *maidan*. Overgeplante rijst wordt in de *atchakat* geteeld wanneer de tank op volledige capaciteit gevuld is. Ik behandel hier de veranderende ontwerpen in de context van veranderende teeltpatronen in de *atchakat* en in de gezagsverhoudingen bij het beheer van de tank. Ik laat zien hoe keuzen van verschillende groepen boeren resulteerde in gelijktijdige verandering van ontwerp en agrarische bedrijfsvoering.

Hoofdstuk 7 behandelt een gevalsstudie waarin boeren benedenstrooms in het tanksysteem bezwaar maakten tegen de gevestigde irrigatienormen waarbij de hoofdtak het eerst wordt geïrrigeerd, en het ontwerp radicaal herdefinieerden zodat zij de eerste rechten op water konden doen gelden. De tank ligt in de natte regio West-Karnataka en wordt gebruikt om breedwerpig gezaaide rijst en tuinbouwgewassen te verbouwen. Het laat zien hoe de regels die de waterverdeling regelen en het concept 'recht op water' nauw zijn verweven met het ontwerp van de fysieke infrastructuur.

Hoofdstuk 8 gaat over twee paradoxen die optreden in een met hulp van de Wereldbank aangelegde tank in de regio waar droge gewassen worden geïrrigeerd. De sociale context, vol chaos en conflicten, laat de eerste paradox zien: wanneer de MID probeert een watergebruikersgroep te vormen, beweren de boeren dat het water in de tank van de overheid is en dat de overheid de waterverdeling moet regelen. De tweede paradox betreft de wanverhouding tussen de naar culturele normen georganiseerde landbouwpraktijk en de aannamen waarop de aanleg van een nieuwe tank wordt gebaseerd.

In hoofdstuk 5 tot en met 8 stel ik dat technologie als belangrijke variabele naar voren komt en interne dynamiek binnen de irrigatiegemeenschap gaande houdt. Technologie roept nieuwe allianties in het leven en stelt grenzen aan interne differentiatie. Het technologisch ontwerp is dus niet alleen ingegeven door de voorkeuren van de dominante groepen in de maatschappij, maar ook *locus* van geschil en conflict. Tankontwerpen krijgen zodoende vorm in een uit de aard der zaak politieke arena en kunnen daarmee als vehikels voor democratisering fungeren. Dit punt komt kort aan de orde in het laatste hoofdstuk van dit boek.

Curriculum Vitae

Esha Shah was born on 30 May 1966 in Gujarat, India. After completing her graduation in Civil Engineering (B. E.) and post-graduation in Environmental Engineering (M. E.) from Regional Engineering College, Surat, she worked as Assistant Environmental Engineer with the Pollution Control Board in Gujarat. Disillusioned with how a government department functions, she decided to pursue her academic aspirations and joined Department of Rural Studies, South Gujarat University as a lecturer in 1990. She taught a course on Rural Technology to students predominantly of rural background between 1990 and 1994.

In the late 1980s, when appropriateness of large dams was questioned all over India, she became interested in pursuing a study on social and historical context of indigenous/local/traditional water management technologies. While she looked for financial and institutional support for her doctorate study, she worked for a brief while with Patriotic Peoples Science and Technology (PPST) group in 1993 helping them to organise water section for the first Congress on Traditional Science and Technology held in Indian Institute of Technology, Bombay.

After moving to Bangalore in 1995, while she continued to look for support for her doctoral study, she joined a local NGO and worked on the project that attempted to develop a sustainable and community based approach to solid waste management. In 1996-1997, she conducted three studies on economic feasibility of composting and health impact of plastic recycling as an independent researcher. She joined Ph.D. programme – Matching Technology and Institutions – of Irrigation Water Engineering Group of Wageningen University in 1998.

She is now working as a core faculty with Centre for Interdisciplinary Studies in Environment and Development located in Institute of Social and Economic Change in Bangalore.