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Environmental Degradation: Market, Institutional and Policy Failure

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ENVIRONMENTAL DEGRADATION: MARKET, INSTITUTIONAL AND POLICY FAILURE

(A Case of Water Resources in Andhra Pradesh)

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Water is widely considered as a mismanaged and degraded resource. Theoretically, degradation of water resources is attributed to the market, institutional and policy failures. These dimensions are easy to visualise, as the linkages seem obvious, but hard to relate in reality. This study is an attempt to establish the linkages between market, institutional and policy failures in water resource management in real life situations. Specifically, this study attempts to provide some real life examples of market, institutional and policy failures in water resource management. More over, water is often studied from the economic angle where as our focus here is on the environmental dimension of water resources. For this purpose we have covered three important aspects of water resources viz., surface water management, groundwater depletion and water quality. The study would not have been completed without the help of various people at different levels.

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ABSTRACT

Water resources are often studied from the economic angle. The present study is an attempt to understand the environmental perspective of water resources. Though limited to the state of Andhra Pradesh, the study reflects the reality in many parts of the world. The focus is mainly on quantifying the costs of water resource degradation and examining the reasons behind the process of degradation. For this purpose the study has focused on groundwater as well as surface water resources and water quality problems. The costs of environmental degradation are estimated in the case of groundwater and industrial pollution. In the case of groundwater the costs are substantial when compared to abatement costs. Moreover, the negative externalities arising from degradation are resulting in iniquitous access to water resources threatening the food security of the poorer sections of the community. Policy interventions are necessary to internalise these externalities. Abatement measures to check degradation are necessary for sustaining the resource. These measures should be fostered with pricing of the resource as well as complementary resources like power. Equally important is the absence of property rights in groundwater resources. Based on our findings and observations it is argued that delinking of water rights from land could be the only solution for solving the access (equal) problem.

In the context of industrial pollution, the costs of degradation are estimated for crop loss, human health and livestock losses. Though limited to specific locations, the costs of industrial pollution at the household level are much larger and assume serious proportions in terms of human health. Due to the degradation (pollution) of groundwater bodies and surface water bodies' households have abandoned agriculture and become labourers. Besides, the communities in the polluted village are facing other problems such as social alienation. The policy response to the misery was a compensation package, which is no way near when compared to the magnitude of losses. As a result, the Coasein approach of negotiation has failed to solve the problem. Even the judiciary failed in delivering the justice to the helpless communities. Unless 'polluter pays' principle along with clearly defined property rights in resources is strictly followed it is difficult to address the externality problems.

Formalisation of irrigation institutions in Andhra Pradesh has helped in checking the environmental degradation relating to water to some extent in the canal commands. Access to water in the tail end areas has increased thus improving the livelihoods and ecological balance. However, further strengthening of the water user associations is required to improve the productivity and efficiency of the resource. On the other hand, it is observed that the Water user associations are not designed to suit the needs of the minor tank irrigation systems and hence are not found to be effective. Therefore, these institutions should be tuned to the needs of the resource system. It is argued that market principles and institutional arrangements should be integrated in order to make them effective. The present approach of treating them separately is bound to fail, as institutional arrangements are required to make markets more effective and vice versa.

EXECUTIVE SUMMARY

Water resource management is crucial for food and ecological security. In fact, livelihood security is critically linked with water security[1]. Water security is indispensable for addressing inter and intra regional as well as inter household inequalities in growth and development and sustaining the ecological balance. Despite the importance water assumes in the over all human development, it is the most mismanaged resources especially in the context of developing countries like India. Neglect of this important resource has resulted in environmental degradation of enormous proportions. However, water resources are often studied from the economic angle. Present study is an attempt to understand the environmental perspective of water resources. Though limited to the state of Andhra Pradesh, the study reflects the reality in many parts of the world. This study makes an attempt to synthesise the problem, based on our analysis, from three important perspectives i.e., market, institutional and policy failures. This would help in understanding the problem from different dimensions. Existence and use of water in different forms makes it imperative to examine the multi facets of the resource. While it is beyond the scope of the present study to cover all the forms and uses of water resources, it deals with three important aspects of water resources management with a focus on environmental degradation. These include groundwater, surface water and water quality management. The study narrates the context of managing these three forms of water resources that has led to their degradation threatening the livelihood security of the local communities.

Objectives and Approach

This study makes an attempt to address the environmental consequences of water, mainly irrigation, management practices in the State in lieu of the above trends. Some of the important aspects in this regard include: viability of irrigation practices in the context of land fragmentation and anthropogenic pressure; changes in the policy response to the degrading water resources due to mismanagement; and the costs of

1 Water security means that people and communities have reliable and adequate access to water to meet their different needs, are able to take advantage of the different opportunities that water resources present, are protected from water related hazards and have fair recourse where conflicts over water arise. (Sausson, 2002).

water pollution/scarcity to the rural economies. Besides, the relevance of the recent legislation regarding water user associations is critically reviewed. An attempt is made to gain insights regarding the State of water resources in the State and the role of markets, institutions and policy in the case of this particular resource. The specific objectives of the study include:

- to evolve/develop an integrated approach on market and institutional failures in the context of natural resource degradation,
- to examine the macro policy perspective of water resource management at the state level and its implications for environmental degradation and water scarcity/pollution,
- to critically evaluate the water user association legislation brought in by the State in the light of environmental problems faced by the command areas, and
- to explore the possibilities for integrating institutional and market aspects in water resource management and suggest policy options for sustainable water resource management.

This study is carried out at theoretical as well empirical levels. For the purpose of empirical analysis data are drawn from both secondary and primary sources. Specifically, state budget expenditure is analysed for the past six years to examine the trends in irrigation expenditure in the context of recent irrigation reforms. Besides, data are also drawn from sources like season and crop reports, statistical abstracts, etc. The primary data are collected from different locations (villages) that are experiencing various environmental problems. The sample villages represent diverse environments with regard to socio-economic, cultural, environmental aspects and also community practices and market mechanisms. Details of these sample villages are presented in the respective chapters. Further, the functioning of water user associations is evaluated based on our field visits to number of sites.

Specifically, five villages from the two districts were selected for the purpose of intensive analysis. These districts are Warangal and Medak. The groundwater region is represented by Warangal district while Medak represents the problem areas related to water pollution due to industrialization. Warangal district has recorded maximum number of cotton farmer's suicides due to (main reason) well failure, while Medak district has some of the industrial zones that are associated with the worst impact on rural livelihoods. The sample villages were selected purposively to examine the existing water management practices. Two villages representing the well irrigation / groundwater scarcity, one village representing well and tank irrigation linkages and two villages pertaining to water pollution were selected. Both Participatory Rural Appraisal (PRA) methods and survey methods were used as complements in order to get better insights into the problem. PRA methods were used to identify various resources and water use practices at the village level, to get the perceptions of the villagers/users regarding resource use and management practices. Survey methods were used to elicit the quantitative information on household features and their economic activities.

Status of water Resources

The present status and trends in irrigation development in the state can be better understood in the macro policy framework. For, the attitude, philosophy and ideology of the policy makers are crucial in determining the development path. The core philosophy of the policy makers dealing with water has not changed despite the process of reforms for a decade. The philosophy of water resource management continues to be supply sided to the neglect of demand side management. Supply side approach aims at supplying bulk water at any cost to meet the demand for irrigable land through development of new supply sources. In this approach emphasis is more on developing new sources of water. On the contrary, demand side approach stresses making water available to each individual farmer through improved water management. This is possible through reducing the wastage in water, adoption of technologies that would increase water use efficiency, etc. Pricing of water is one of the most effective demand management variables. Effective pricing policies are found to be resulting in conservation and efficient use of water in diverse situations (Reddy, 1996). Hither to efficiencies are improved through supply regulation in the supply side management by creating scarcity conditions. This, however, is only likely to make those farmers already in receipt of irrigation supplies, operate more efficiently and would do nothing for others who may have already been waiting many years for a supply. Besides, resource (financial) constraints would further aggravate supply regulation and hence shortages. The spiralling affect of this would result in acute shortages, as it happened in the case of drinking water (Reddy, 1996a). The implications of such macro policies (supply sided and biased towards major irrigation) at the micro level are examined in the following sections. These aspects are presented in the context of groundwater development and water pollution.

Groundwater

The policy bias against the drought prone regions is resulting in widening not only the economic inequalities but also the ecological divide between endowed and fragile resource regions. For, the neglect of resource poor regions in the provision of protective irrigation is further weakening their fragility. Even the recent policies in water management fail to take the needs of these regions in to account. Groundwater, the single most important source of irrigation, is totally left out of the purview of the water user association legislation. There are no efforts to integrate well and tank irrigation. While water user associations are found to be effective in the canal commands they are not serving the purpose in the case of tank irrigation though 80 percent of the associations are for tanks. Unless the needs of these regions are identified and addressed effectively, fragile resource regions will face irreversible ecological problems like desertification.

The first victims in the process, as indicated in our study, are small and marginal farmers. The impact of resource degradation on these farmers is in two ways. Firstly, while small and marginal farmers dominate the ownership of wells in general and open wells in particular, medium and large farmers dominate the ownership of bore wells. As a result of degradation (sharp fall in water tables) majority of these farmers loose access to water, as most of the open wells dry up. That is they are denied of their genuine share in the common pool resources. This is the result of appropriation externalities that are manifested in technical and legislative externalities. Secondly, one of the interesting observations of our study is that of late bore well technology is becoming cheaper making it size (owned land) neutral, though the process may be slow. As a result these farmers are also investing substantial amounts of money on bore wells. Such investments become unviable in the event of well failure. Besides, the poor quality of technology at lower costs is resulting in high maintenance costs and uncertainty in water supply. It is observed that groundwater markets will take care of the equity problems to a large extent (Shah, 1993). But, evolution of water markets is possible only in the regions where groundwater is available in sufficient quantities. Markets do not evolve when there is not enough water to share or sell (Reddy, 2000). This is true of our study region where groundwater markets do not operate, as the available water is not enough to irrigate the well owner's land. This indicates that addressing the issue of technical externalities through making the technology neutral (size) or through market penetration may not be sufficient to tackle the equity problems in groundwater distribution.

Unfortunately, there are no policies so far that address the equity and management aspects of groundwater. Though there are regulations on groundwater exploitation they are inadequate and ineffective. Even the proposed new policies are in the lines of regulation rather than designing innovative policies that would integrate market and institutional dimensions of resource management. More over, the policies should aim at correcting technical as well as legislative externalities. This calls for a shift in the policy from supply side management approach to demand side management approach, from populist approach to economic approach, from convenient approach to efficient approach, from engineering approach to institutional approach, from centralised approach to decentralised approach and from fractured approach to integrated approach. That is water policies should aim at integrating all sources of water in the regional context rather than treating them in isolation. Policies should provide effective legal and market framework to internalise the technical and legislative externalities. Policies should also provide conducive environment for institutional innovation and sustainability.

Surface Water

The macro policy is biased towards the development of major and medium irrigation to the neglect of minor irrigation. A lion's share of the irrigation expenditure goes towards major projects (about 80 per cent) followed by medium and minor irrigation schemes. Emphasis is more on new works rather than on rehabilitation of old ones, as the plan expenditure takes the major share in the increased budget expenditure. Despite the huge investments in major and medium irrigation, area under canal irrigation is either stagnant or declining. This indicates negative return on irrigation investments. Investments in new projects are less productive, as these investments are made more due to political reasons rather than economic reasons. Work expenditure is stagnant while interest charges are rising in the major and Medium irrigation. On the whole interest charges account for about 50 per cent of the total expenditure. Expenditure on staff accounts for more than 50 per cent of the work expenditure in most of the years. This is on the higher side by any standard. All the interest chargers are put under non-plan account leaving little scope for operation and maintenance work. Unfortunately, most of the borrowed money goes for interest payments (debt servicing). In most of the years interest charges account for about 80 per cent of the non-plan expenditure. If this trend continues there is a danger of irrigation department falling in to a debt trap. For, the recoveries are on the decline despite the increase (three times) in irrigation charges in 1997. As a result irrigation development is dependent more on borrowed funds, especially for rehabilitation and maintenance.

In a pioneering effort the Government of Andhra Pradesh has initiated irrigation reforms on a large scale, which is unprecedented. In fact, these reforms are ranked very high even at the global level and expected to be a future model in irrigation management. The state has shown the way that political will is the main ingredient for such initiatives. The most interesting feature of these reforms is that they are 'top down' with a 'bottoms up' approach. It has the advantage of greater reach (possible under 'top down') and intensity through involvement of the community (possible under 'bottoms up'). These reforms under the guidance of some committed officials at the state level have taken off in good spirit and received good support at the farmer level. Though, one may argue that flow of funds is the main factor in generating such response, it is necessary to support the ailing systems in order to generate trust among beneficiaries. For, over the years farmers have lost the trust in the government and in no position to respond to false promises. Therefore, the initial boost is necessary to regain the lost credibility and build the trust. Once this is in place institutional reforms from top becomes smooth and easier. But it is necessary to under stand the direction in which the reforms are progressing. This direction would ultimately determine the strength and sustainability of the reforms.

Water Quality (Pollution)

The impact of industrial pollution on rural communities is quite substantial in monetary terms alone. The costs of damage would be much higher if social costs such as alienation of the village (marriages, social visits, etc) by others are accounted for. Similarly, real impact on health, economic as well as psychological, is difficult to assess. While there is a possibility of over estimating the damages on the part of respondents we strongly believe that these excesses would be more if social costs were to be valued. More over, the losses due to permanent disability to the chief breadwinner of a household are rather difficult to assess. In this regard, it is difficult to assess the problem in pure economic terms of valuation of losses. Hence, the solution to solving the problem lies not in compensating the loss but in removing the problem altogether. Here compensation means giving right to the pollutee to pollute. Looking at the health impact in the present case no amount of compensation would suffice to address the problem. Beyond compensation something has to be done in order to end the problems forever. This could be in terms of strict regulation on the industries to adopt pollution mitigating technologies or face closure. However, this calls for a close look at the economics of pollution mitigating technologies, which will be a worthy exercise. State policy also has a major role to play in this regard.

This is a classic example of the failure of Pigouvian approach that talks about state intervention. The Coaseian approach (negotiation between two parties) would have worked with more compensation. But, the judiciary failed to play an effective role. Though the victims' did not agree with the negotiated amount, the negotiation could have been made more effective and acceptable to all the parties with the help of a mediator instead of going to court. In the process public policies have played spoil sport. A case in point is the recent policy announcements of exempting the small-scale industrial units, which are more polluting than others, from the regulation of PCB. Social and environmental issues cannot be tackled merely by passing laws. The law has to be implemented in its right perspective.

The role of civil society is also not satisfactory in the present case. Protests in front of the state Secretariat in the form of both *dharna* (mass squatting) and *rastha roko* (blocking roads) only resulted in lathi charge and arrests of the villagers and NGOs. Neither industries nor PCB responded to the protests. People turned aggressive and attacked the industries. Since then the industries stopped discharging their effluent in to the tank during daytime. Twice, the villagers caught the persons during nighttimes while discharging the effluent in to the village and beat them up severely. After that incident the industries were closed for three to four days and started again as usual. Despite all these actions, the community did not succeed in influencing either industries or regulatory authorities. Finally, the villagers gave up their struggle out of frustration. Thus, the present case study provides an apt example of failure on all fronts.

Need for an Integrated Approach

The problems associated with the three aspects of water resources we have studied clearly indicate how they are manifested in the failure of markets, institutions and policies. It may be noted that these failures are defined in a rather narrow sense here, as markets fall in the broader context of institutions. The problems associated with each of the aspects of water are rooted in one or more of these failures. Therefore, it is difficult to identify a particular problem related to water with a specific failure, though each aspect has a dominant failure type such as groundwater being a case (dominant) of policy failure. Moreover, these failures are inter linked and over lap with one another.

As demonstrated by our case studies the failures are more due to the partial nature of markets, institutions and policies rather than due to their absence, except perhaps in the case of groundwater. For, markets fail because they do not have the institutional support. We have seen in the case of canal irrigation systems in Andhra Pradesh and else where price policies need to be fostered with appropriate institutional arrangements in order to make the former effective. On the other hand, institutions fail in the absence of market mechanisms to sustain the institutions. For, institutions cannot survive longer with external support. This could well be the case with the WUAs in Andhra Pradesh, if the system does not adapt to an effective self-financing mechanism through appropriate price polices. The success of some of the initiatives in natural resource management, traditional as well as modern, is rooted in the integration of market and institutional approaches. Though our case studies do not deal with such success stories, they clearly drive the point home that the failures could be due to the absence of an integrated approach. Further, there is a need for coordination between water policies and other policies such as input and out put policies. They should work in tandem rather than working in diagonally opposite direction. These include input and out put policies such as input subsidies (including power), procurement policies, etc.

Such an integrated approach makes sense even on theoretical grounds. For, an integrated approach helps in keeping the transaction costs low, which is crucial for sustaining the institutions. Pricing mechanism leads to increased cohesion and cooperation within the community, as each member has a stake in the upkeep of the institution consequent upon his or her contribution. Increased cooperation means low transaction costs towards organising the community and keeping it together. However, equity in sharing the costs (user charges or contributions) on the basis of resource use is critical for sustaining the institutional arrangements. In the absence of equity, people contributing disproportionately higher shares may tend to under mine the collective action initiatives. Similarly, institutional back up for market approaches also reduces transaction costs, as they make compliance to rules and regulations (including pricing) easier and smooth. Recovery of irrigation charges tends to be high in the presence of appropriate institutional mechanisms. However, the process ought to be dynamic in order to address the changing contexts, market as well as institutional mechanisms.

CHAPTER I: INTRODUCTION

I Background

The neo-liberalist approach presumes that market failure is the main reason for mismanagement of natural resources in most of the developing countries. On the other hand institutional approach holds complex socio-economic and cultural factors responsible for environmental degradation in rural areas (Thilo, 1994). In the context of natural resource management these approaches are expected to be effective when used as complements rather than as substitutes. Though markets are expected to lead to efficient allocation of resources in the long run, their role in equitable distribution is questionable, especially in scarcity conditions. Similarly, institutions alone may result in inefficient allocation of resources and their role in equitable distribution of resources is rather ambiguous in the context of scarcity and changing socio-political dimensions. While the importance of institutional and market mechanisms is well recognised at the policy level, their application in an integrated fashion deserves much greater attention. The dismal performance (policy) with regard to natural resource management at the grassroots level cannot be attributed simply either to market or institutional failure. For, the main problem lies with integrating markets and institutions in a pragmatic manner.

Instances of market failures are more widespread and numerous in the case of natural resources mainly due to their public good nature. While the reasons for market failure in natural resource conservation are well documented in literature (see Postel, 1991; Panayotou, 1993 and Pearce and Warfod, 1993), why institutions fail has not attracted much attention. Institutional failure/success is often equated with policy failure/success rather than treating it separately. Policy interventions may lead to disintegration or reinforcement of existing institutions or they may promote new institutions also. Policy failures are often associated with the cases where the role of institutions at the grassroots level is neglected while formulating policies (Reddy, et.al, 1997). Similarly, neglect of market mechanisms also may lead to policy failure. Since institutional aspects are implicit in the context of market failure and vice-versa integration of these aspects is vital for formulating policies for natural resource management.

The chequered performance at the policy level with regard to natural resource conservation and the continued environmental degradation in rural areas, therefore, may be attributed to the absence of proper integration between institutional and market aspects. Failing to recognise these linkages has often led to erroneous conclusions such as, resource degradation in rural areas of developing countries is due to population explosion and poverty (Vyas, 1991; Leach and Mearns, 1991; Reddy, 1995). In the Indian context, while there are studies dealing with agrarian institutions (Bardhan, 1989) and common property resources (Jodha, 1986 and 1990), the role of institutions in natural resource management has remained more or less a neglected area. Similarly, there are few studies dealing with markets in natural resource conservation.

II Managing Resource Degradation: A Review of Approaches

There is growing evidence that common pool resources (CPRs) like water are being degraded, quantitatively and qualitatively, across the regions of developing countries. The apparent reasons for the decline are many and range from population pressure to socio-political and economic transition. Ignoring the role of common resources in complementing private resources like land could jeoparadise the overall policy objectives of food security and poverty alleviation. Hence, managing the natural resources in a sustainable fashion has become one of the leading policy issues to be reckoned with. As is obvious from the term CPR collective action is a prerequisite for commons management. Understanding and promoting collective action is central to commons management. While the role of institutions in promoting collective action in CPR management is well recognised, the process of institutional innovation and change is less understood. This is more so in the context of developing economies like India, which are experiencing disintegration of age-old local institutions in recent years.

Several authors have documented the case studies on natural resources and other rural institutions. Different approaches are used to explain various institutional arrangements existing in rural areas. These approaches include: property rights approach, game theoretic approach, transaction costs and limited information approaches of new institutional economics, and institutional analysis and development (for a detailed review see Reddy, 1998). Property rights approach focuses on different institutional arrangements ranging from private property rights to common property rights. The property rights school argues that private property rights, rather than community / common property rights, would result in an efficient allocation of resources and their management, while there is enough empirical evidence to support the contrary. The game theoretic approach emphasises understanding the individual's behaviour and his strategies in various CPR situations. The new institutional economics, unlike neo-classical economics, treats institutions as central to the development process and explains their growth and efficiency in terms of transaction costs. However, none of these approaches on its own seems to explain the diverse CPR situations characterised by the complex attributes of collective action in developing economies like India. The main bottleneck of these approaches is their emphasis on individual rationality while CPR management is based on collective action.

Recent attempts to provide a theoretical framework for collective action have tried to draw support from various disciplines and put it under the framework of Institutional Analysis and Development (IAD) (Ostrom, Gardner and Walker, 1994; Bromley, 1992; Ostrom, 1990). This approach is comprehensive and, in fact, fairly successful in explaining the success stories of collective action situations and has led to a shift in focus away from the so-called "tragedy of the commons." However, limited number of successful cases compared to failures makes it a specific rather than a general framework. More importantly, though it explains the institutional sustainability part very well, its applicability is limited as far as institutional innovation and change are concerned. The later are equally important, if not more, for understanding institutional success and failure in CPR management.

Central to the debate on commons management are the questions: *who* and *how? Who?* - private individuals, state or community - could manage the commons in an efficient and socially desirable fashion? And *how* could these management and control regimes be achieved and sustained? Strong and divergent views are held by different schools of thought with regard to *who,* while the discussion on *how* is mostly limited to understanding institutional arrangements pertaining to collective action.

The dominant schools of thought include the property rights approach (dealing with *who?*), the game theoretic approach, the institutional approach and the institutional analysis and development approach (all dealing with *how?*).

The review of various approaches reveals that formal and informal institutional arrangements, other than private property, are important in the management of common pool resources. There is no evidence to support the efficiency of private property over other property regimes. Moreover, privatisation of the commons would aggravate existing inequalities in the LDCs. Open access situations occur due to weak institutions or a weak state. As regards *how* institutional arrangements are evolved and sustained, most of the approaches fail to explain the commons dilemma in developing economies. For, the behavioural assumptions rely more on neo-classical individual rationality and non-co-operative behaviour. These assumptions do not reflect the reality of rural communities where trust, morality and ethics play an important role. In developing economies like India leadership and political economy aspects are crucial for institutional innovation and change. These aspects are not addressed duly in the approaches. Transaction costs economics provides useful insights in understanding institutional innovation but remains partial, as it does not take the political economy and leadership issues in to account. Similarly, IAD framework is also partial, as its focus is limited to institutional sustainability.

III Problem in Perspective

One of the most policy relevant areas in this regard pertains to water. Water is among the most ill managed resources in the country, which is resulting in severe scarcity, both for drinking and irrigation, as well as environmental problems such as water logging in endowed regions and desertification in fragile regions. Of late there has been great emphasis on the judicious management of water at the policy level. Market (pricing) and institutional (user participation) approaches are suggested to overcome the strident problems. However, these policy measures are mostly remained on paper while much deserves to be done at the implementation level. This is mainly due to the ineffective institutional arrangements existing at the operation and maintenance (irrigation department) level and also due to lack of political will. Moreover, even these policy changes so far have been limited to surface irrigation. An important segment of water resources (groundwater), which covers most of the rain-fed regions (covering 2/3 of the total cropped area) are more or less neglected. In the absence of any effective policy measures groundwater regions are plagued with water scarcity, inequitable distribution of water and environmental degradation. The situation seems to have aggravated during the recent years, especially in the arid and semi-arid regions of the country (Reddy, 1996).

Andhra Pradesh is experiencing three types of environmental problems as far as water resources are concerned. Firstly, large and medium irrigation projects are having the problem of under-utilistion of the created capacities in the recent years. This is mainly attributed to the mismanagement of the distribution systems resulting in siltation, water logging, poor drainage, etc. Consequently water availability is increasingly shrinking for the tail and middle reaches of the distributory systems. The gap between the potential created and the net area irrigated increased with growing investments in major works. The gap increased from 23.5 per cent in 1950-51, to 46.2 per cent in 1991-92 and to 56.4 per cent in 1995-96 for major and medium irrigation projects.

Secondly, the age-old water harvesting and storage systems such as tanks and ponds are becoming the things of past due to the absence of any maintenance by the State or civil society. Traditionally local people through institutional arrangements managed these systems. These traditional systems of resource management have degenerated over time due to the State interventions and due to the socio, political and economic dynamics at the village level. As a result irrigation under these water bodies too experienced a growing gap between capacities, often created much before independence, and the net area irrigated. In fact, by 1995-96, the net area irrigated by tanks was just 7.47 lakh hectares; almost half of the 13.71 lakh hectares potential inherited under tanks in 1950-51. Loss of capacity of the tanks is not only the loss of tank irrigation but also loss of groundwater recharge in the tank dominant regions, which are relatively dry and drought-prone and dependent on wells as much (Reddy, 1998). Thirdly, the decline in groundwater tables in some of the regions has become alarming in the recent years resulting in the widespread phenomenon of desertification. Well irrigation recorded a phenomenal rise from 1950-51 i.e., moved from third position to first position in terms of area irrigated by a single source. This has in turn created enormous ecological and social problems. In order to address some of these exigencies the State Government has brought in legislation making water user associations' mandatory for managing irrigation water. But, one is not sure of its adaptation for various types of irrigation like canal, well, tank, etc., and its effectiveness at the implementation and operational levels.

The most strident consequence of the above three environmental problems is with regard to drinking water. Scarcity of surface water coupled with the degeneration of traditional water harvesting systems are resulting in serious water shortages amounting to declining per capita water availability and unhygienic water, especially in rural areas. It is often observed, especially in dry regions, rural households spend substantial amounts of time in fetching water and even spend money on buying water (Reddy, 1999). Besides, the increased use of agro-chemicals and urbanisation are making groundwater and surface water bodies like tanks unusable for drinking as well as irrigation purposes. The problems of industrial pollution are acutely felt in the villages surrounding the industrial townships. This has further reduced the quantity of usable water. This study is an attempt to examine the implications of the above trends and identify the reasons in terms of market, policy and institutional failure. This in turn would help in formulating appropriate policies for sustainable water resources management in the State.

IV Objectives and Approach

This study is an attempt to address the environmental consequences of water, mainly irrigation, management practices in the State in lieu of the above trends. Some of the important aspects in this regard include: viability of irrigation practices in the context of land fragmentation and anthropogenic pressure; changes in the policy response to the degrading water resources due to mismanagement; and the costs of water pollution/scarcity to the rural economies. Besides, the relevance of the recent legislation regarding water user associations is critically reviewed. Specific attempt will be made to gain insights regarding the State of water resources in the State and the role of markets, institutions and policy in the case of this particular resource. The specific objectives of the study include:

- to evolve/develop an integrated approach on market and institutional failures in the context of natural resource degradation,
- to examine the macro policy perspective of water resource management at the state level and its implications for environmental degradation and water scarcity/pollution,
- to critically evaluate the water user association legislation brought in by the State in the light of environmental problems faced by the command areas, and
- to explore the possibilities for integrating institutional and market aspects in water resource management and suggest policy options for sustainable water resource management.

This study is carried out at theoretical as well as empirical levels. For the purpose of empirical analysis data are drawn from both secondary and primary sources. Specifically, state budget expenditure is analysed for the past six years to examine the trends in irrigation expenditure in the context of recent irrigation reforms. Besides, data are also drawn from sources like season and crop reports, statistical abstracts, etc. The primary data are collected from different locations (villages) that are experiencing the above said environmental problems. The sample villages represent diverse environments with regard to socio-economic, cultural, environmental aspects and also community practices and market mechanisms. Details of these sample villages are presented in the respective chapters. Further, the functioning of water user associations is evaluated based on our field visits to number of sites.

Specifically, five villages from two districts are selected for the purpose of intensive analysis. These districts are Warangal and Medak. The groundwater region is represented by Warangal district while Medak represents the problem areas related to water pollution due to industrialization. Warangal district has recorded maximum number of cotton farmer’s suicides due to (main reason) well failure, while Medak district has some of the industrial zones that are associated with the worst impact on rural livelihoods. The sample villages are selected purposively to examine the existing water management practices. Two villages representing the well irrigation / groundwater scarcity, one village representing well and tank irrigation linkages and two villages pertaining to water pollution are selected. Both Participatory Rural Appraisal (PRA) methods and survey methods are used as complements in order to get better insights into the problem. PRA methods were used to identify various resources and water use practices at the village level, to get the perceptions of the villagers/users regarding resource use and management practices. Survey methods are used to elicit the quantitative information on household features and their economic activities.

Though the study does not deal with evaluation or impact of any particular programme, it is concerned with the impact from the point of resource management practices of households or firms or government. Such impact assessment will be biased if appropriate method is not used. Main problem is that we cannot observe the practicing agents without the practices at the same time. One way of addressing this problem is to have a control group, which is similar to the practicing group in all respects except the programme. Control group provides the counter factual of the practicing group. But this is not straight forward, as it is difficult to find such a matching group at least in terms of observable indicators. Alternatively, one can compare before and after situations of the same households adopting particular management practices. This approach calls for baseline data, which is not available in all situations. Second best solution in this regard is 'reflexive comparison' where before and after scenarios are compared for the same households. This would provide reasonable estimates of the impact provided that there is no serious memory lapse problem among the respondents. Other wise, this method will give biased assessment (Ravllion, 2001). Memory lapse is directly linked with the time lapsed after initiating the programme. These biases can be further minimised by using the 'double difference' method where before and after situations are examined for both control and participating groups (Ravallion, 2001).

For the purpose of the present study both 'double difference' and 'reflexive' methods are used depending on the situation. Reflexive method of analysis is used in the case of well irrigation where the objective is to capture the changes. Where as double difference method is used in the case of water pollution. Further, Contingent Valuation Method (CVM) is used to estimate the willingness of the households to accept compensation at the given level of water pollution. However, canvassing of CVM questionnaire was found to be a difficult task in the sample villages due to the seriousness of the pollution problem. Hence, CVM is canvassed in a limited fashion and hence its use. More details on methods are discussed in the respective chapters. However, before going in to the analytical aspects it would be pertinent to discuss the concepts used and their scope in the present study.

V Concepts and Scope

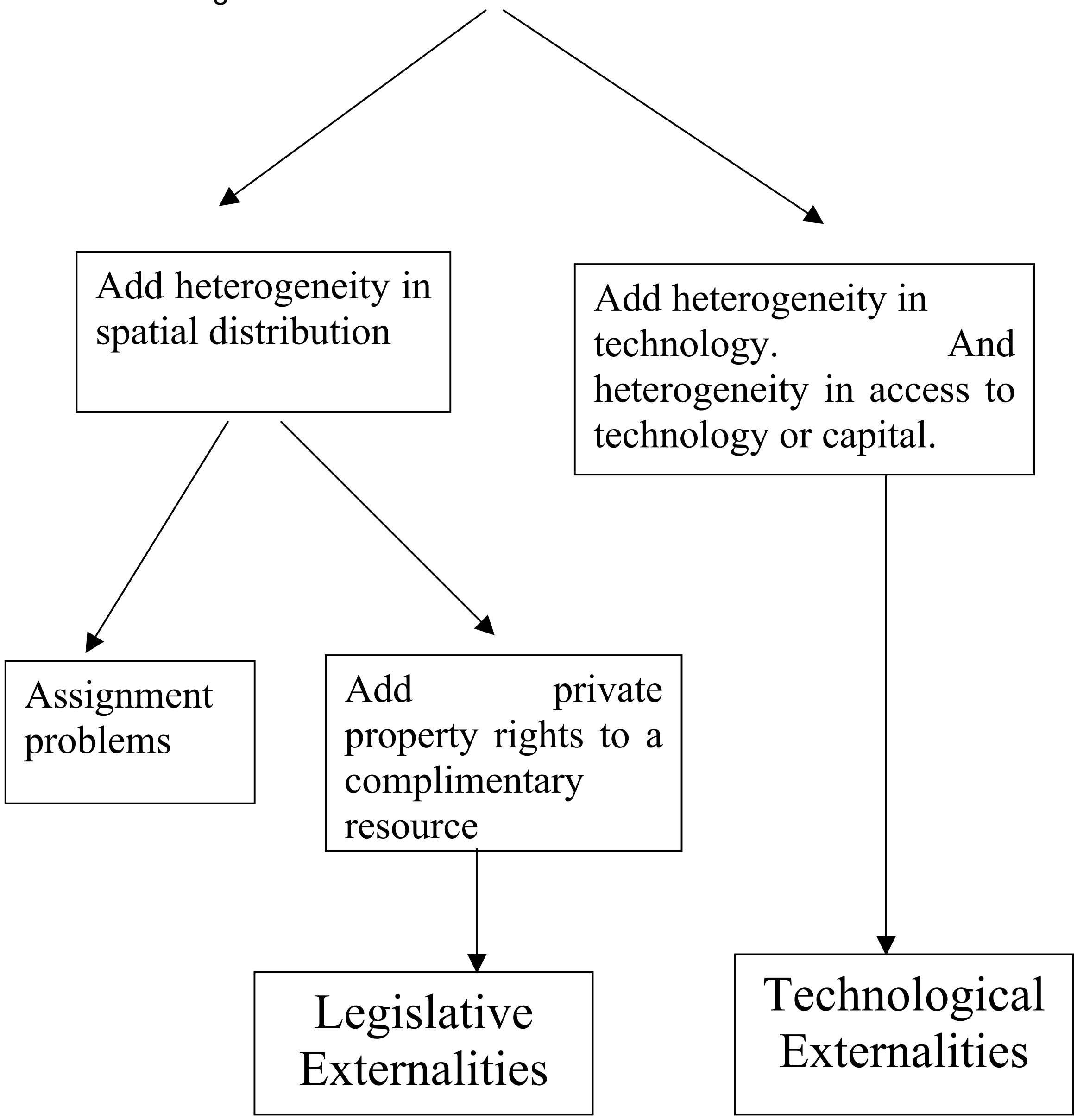
The resource we are dealing with here (water) is a common or public good in nature. Water resources in the form of tanks, groundwater, canal water are often termed as common property resources. Here we chose to use common pool resources as the term common property conveys different meanings and often is confused with other forms of property regimes like state property and open access resources. Generally, common resources fall under three categories, i.e., open access, state property and communal property (Berkes and Farvar, 1989). It is important to distinguish open access and common property resources as *property* connotes a specific meaning. As pointed out by Ciriacy-Wantrup and Bishop (1975) "Common property is not 'every body's property'. The concept implies that potential resource users who are not members of a group of co-equal owners are excluded. The concept of 'property' has no meaning without this feature." Open access resources are often interpreted as common property and hence their destruction is attributed to the failure of common property regimes (Bromley, 1992). According to Bromley: "There is no such thing as a common property *resource*; there are only resources controlled and managed as common property, or as state property, or as private property" (p.4). However, resources controlled and managed by a community or the state at one time may turn in to open access resources in other time due to weak institutions or a weak state. In most cases, there are no open access resources in official terms as most of the common (non-private) resources are legally owned by certain (state) agencies, but they belong to village communities in a *de facto* sense. Therefore, management regimes differentiate between open access and other forms of property resources. While the latter are labelled as property regimes (Bromley, 1982 and 1989), when addressed together (open access and other forms) they are termed as common pool resources (CPRs). CPRs are defined as natural or manmade resources with attributes of non-exclusion (large enough to exclude other users costless or with low costs) and substractability (consumption of the resource by one user will reduce its availability to others) (Ostrom, Gardner and Walker, 1994; Singh, 1994). These resources include common (village) grazing lands, community forestlands, waste lands, village ponds, rivers and rivulets as well as their banks and beds, watersheds, ***state-owned irrigation water supplies and groundwater basins***.

It may be noted, however, that all these resources may not fall strictly under the above definition in all situations. In reality, most of these resources do not represent pure forms of open access, communal or state property, as they are mixtures of these three idealised types (Berkes and Farvar, 1989). A classic example is groundwater in India. A groundwater basin is a common pool resource in the sense that exclusion of multiple users (pumpers) is difficult and costly. Groundwater tables go down, as water is extracted beyond optimum yield level (withdrawals exceed replenishing capacity of the aquifer) and may even lead to drying up of the aquifer in fragile environments. But due to inequitable distribution of assets and inequitable access to manmade resources like capital across individuals, a few individuals in a community controlled groundwater. The capital intensity of groundwater extraction makes it easier to exclude rival users. This feature is common in fragile resource regions where the high cost of groundwater extraction coupled with low and inequitable asset ownership makes the resource privy to a few well-to-do households. This is similar to technological externalities (as termed by Ostrom, Gardner and Walker, 1994).

Heterogeneity in spatial distribution of groundwater creates the problem of assignment. But it involves a further complication as land (under which groundwater lies) rights are privately owned. The intertwining of private and common resources results in further externalities, which can be termed as *legislative externalities* (Figure 1). Legislative externalities arise when there is no clear-cut legislation demarcating and protecting different property regimes. For instance, in India property rights in land may be purely individual (highly concentrated), or purely collective (attenuated) though there exist many intermediate forms between these two extremes (Bell, 1990).

On the other hand, while groundwater is a CPR in which rights are limited to use and income deriving, it is also sold and transferred along with land due to its link with land. But, legislation is not clear in specifying how groundwater should be managed judiciously and distributed equitably. As a result, farmers make private investment thinking that they have absolute rights to the groundwater aquifer beneath their land. Similarly the spatial distribution of irrigators of a large (public) irrigation system may result in exclusion of tail-end users by the head-end users (assignment problems). These situations arise not only due to the nature of the resource but also due to the existing institutional arrangements. For, in other situations (California, USA) a groundwater basin is treated and used as a CPR in the pure sense of the term (Ostrom, Gardner and Walker, 1994; Chapter. 13).

Figure 1: APPROPRIATION EXTERNALITIES



Source: Adopted with modification from Ostrom, Gardner and Walker (1993).

Institutions

Institutions are defined and interpreted in many ways in the CPR literature (for a review of definitions see Bromley, 1989a; Uphoff, 1986; Eggertsson, 1990 and 1994; Wolz, 1995). North (1990) made a crucial distinction between institutions and organisations. He defines institutions as: “the rules of the game in a society or, more formally, the humanly devised constraints that shape human interaction”(p.3) and organisations as: “groups of individuals bound by some common purpose to achieve objectives”(p.5). In other words, institutions are clusters of roles, norms and societal concepts while organisations are the instrumental concretisations of institutional patterns (Kötter, 1988)[2]. It is difficult to draw a line between institutions and organizations, as these terms are often used interchangeably and refer to different but overlapping sets of social phenomena. According to Uphoff “*Organizations*, whether institutions or not, are structures of recognized and accepted *roles*, while *Institutions*, whether organizations or not, are complexes of *norms and behaviours* that persist over time by serving collectively valued purposes”(Uphoff, 1995, p.184).

Broadly, institutions can be divided into formal and informal (North, 1990) or conventions and rules/entitlements (Bromley, 1989a). The formal (rules/entitlements) ones are rules devised by human beings such as socially recognized and sanctioned expectations by everyone in a society with regard to *de jure* or *de facto* legal relations that define the choice sets of individuals with respect to choice sets of others. The informal (conventions) ones are the conventions and codes of behaviour, i.e., ‘a structured set of expectations about behaviour, and of actual behaviour, driven by shared and dominant preferences for the ultimate outcome as opposed to the means by which that outcome is achieved’ (Bromley, 1989a, p.42). In the context of analysing the role of institutions involving collective action in the management of CPRs, institutions are understood as regularised patterns of behaviour between individuals and groups in society, or complexes of norms, rules and behaviours that serve a collective purpose (de Janvry et.al, 1993, p.556). In the present context we

2 Organisations are usually a manifestation of, but are not synonymous with, institutions. Not all institutions have an organisational manifestation. For instance, marriage, money, the law or land tenure are institutions but not organisations. A particular family, a local church, a specific co-operative or a regional market are organisations but not institutions. The central bank, the Supreme Court, the family are institutions that are organisations and vice-versa (Uphoff, 1995, p. 184).

use the term *institutions, formal and informal,* to identify local level rules, regulations, norms and customs that emerged or evolved, either internally or with the help of external forces, in an historical process to solve the common problems in a village community. These may be in the form of user associations or organisations to manage water resources such as water user associations, water councils (*pani panipanchayats*) to manage irrigation and drinking water, and other forms of arrangements promoting such activities involving collective action for the common good (water).

Apart from common pool resources and institutions we have use three key concepts that are central to the study. They are market, institutional and policy failures. These concepts are widely used in the literature and often refer to very broad aspects and inter linked as well. For, markets are also institutions in a broader sense of the term. Similarly, market and institutional failures could be the result of policy failure. It may be noted these concepts are used in a rather narrow sense here. An attempt is also made to differentiate from one another though we are not sure how far we are able to achieve in this regard.

Market Failure:

Markets fail due to ill-defined or non-existant property rights, un-priced or under priced resources or thin markets, public goods, market imperfections, high discount rates due to myopia arising out of poverty, impatience, and risk or uncertainty that affect individuals but not the society as whole, etc. In the context of water resources we define market failure as improper or under-priced water, poorly defined property rights or existing markets (in the case of groundwater) are thin and imperfect.

Institutional Failure:

Institutional failures occur due to non-existence of institutional arrangements (formal or informal (local or outside)) for managing the resources, weak (ineffective) institutions. Often institutional failure occurs due to policy failure. Institutions fail when policy environment does not support the existing institutional environment. Institutions tend to become weak when institutional arrangements are not designed properly for the management and distribution of benefits from the commons. Here institutional failures are defined as disintegration or weakening of age-old institutions (informal) that were involved in resource management due to socio-economic and policy changes. Recent times have seen the evolution of new institutional initiatives such as water user associations (WUAs) apart from strengthening role of Panchayati Raj institutions in resource management. Institutional failures are also defined as the ineffectiveness of these formal institutions. Here the link between institutions and policy is rather indirect, as policies cannot guarantee the functioning of the institutions.

Policy Failure:

Market, institutional and policy failures are also inter linked. For, often policies such as subsidies lead to market failure. Lack of appropriate policies result in environmental degradation. In majority of common pool resources either there are no policies or policies are ineffective resulting in degradation of these resources by turning them into open access resources. For instance, there is no proper legislation on groundwater exploitation. Similarly, in the absence of clearly defined property rights majority of the common grazing lands are used as open access resources. Here, we define policy failure as the states failure to check degradation through the use of appropriate economic and institutional instruments. Some examples of policy failures are irrigation subsidies, legalising encroachments, etc. Some of the recent policy successes are joint forest management (JFM), water user associations (WUAs), etc. Here, irrigation subsidies are a policy failure, which has resulted in market failure leading to degradation. But, irrigation subsidies per se do not represent market failure. Here, policy is indirectly causing market failure. Similarly, the evolution of JFM is a policy success to the extent of their success in the larger context. The ineffectiveness of JFM in certain contexts is termed as an institutional failure rather than policy failure.

VI Organisation of the Study

The study is organised in six chapters. Following the introductory chapter, which presents the background and the theoretical dimensions of the study, chapter two examines the status of water resources in Andhra Pradesh. This is carried out from the policy angle where we presented the overall water resources development scenario based on the fund allocations to various sectors. Chapters 3 to 5 deal with the three important dimensions of water use and management namely groundwater, surface water bodies and water quality (pollution). The analyses in all the three chapters, except chapter four, are based on the detailed primary data collected at the household level. And the last chapter synthesises analysis and formulates the problem in the perspective of market, institutional and policy failure.

CHAPTER II: STATUS OF WATER RESOURCES IN ANDHRA PRADESH

I Sources and Status

Of late there has been great emphasis on the judicious management of water at the policy level in the state. Market (pricing) and institutional (user participation) approaches are suggested to overcome the strident problems. However, these policy measures are mostly remained on paper while much deserves to be done at the implementation level. This is mainly due to the ineffective institutional arrangements existing at the operation and maintenance (irrigation department) level and also due to lack of political will. The result is unbalanced and unsustainable water resource development. The analysis is mainly based on the secondary data especially the annual budget document. State budget documents for irrigation sector were analysed for the past six years to understand the pattern of allocation towards major, medium and minor irrigation sectors[3]. This chapter is organised in three sections. The first section presents the status of irrigation by source. While the second section analyses the expenditure pattern, the last section draws concluding remarks. Let us examine the status of water resources in the state.

Table 2.1: Changes in Land Utilization in Andhra Pradesh (in Million Hectares)

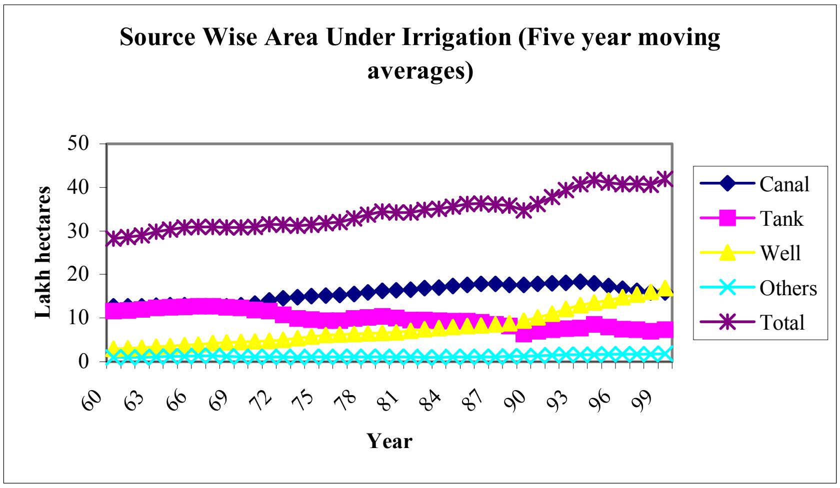
Classification	1960-61	1970-71	1980-81	1990-91	2000-01
I. Geographical Area	27.42	27.44	27.44	27.44	27.44
1. Forests	5.97	6.34	6.18	6.27	6.20
2. Non Agricultural Uses	1.82	2.10	2.19	2.36	2.51
a) Barren & Uncultivable land	2.29	2.25	2.31	2.08	2.11
3. Permanent Pasture & Grazing	1.17	1.03	0.92	0.83	0.67
land	0.29	0.29	0.27	0.26	0.27
a) Misc. Tree Crops & Groves	1.54	1.08	0.89	0.77	0.77
b) Cultivable Wasteland	3.09	3.00	3.65	3.41	3.86
4. Fallow Land	0.86	0.93	1.38	1.41	1.53
a) Other Fallows	2.23	2.07	2.27	2.60	2.33
b) Current Fallows	10.74	11.36	11.03	10.84	11.22
5. Net Area Sown	11.82	12.77	12.70	13.04	13.63
6. Gross Cropped Area	110	112	115	120	123
7. Cropping Intensity (%)	2.91	3.31	3.46	4.31	4.54
II. Net Irrigated Area	3.47	4.22	4.34	5.37	6.09
III. Gross Irrigated Area					

Source: Economic Survey 2001-2002, Government of AP.

3 The budget data were crosschecked with the officials from the irrigation department. In fact, the results were presented to the department.

Land use pattern determines the economic efficiency of the resource use. Besides, it determines the ecological sustainability of land resources in the long run. There have been marginal changes in land utilization in Andhra Pradesh between 1955-56 and 2000-2001 (Table 2.1). Land use pattern is more or less stable over the period. Net sown area remained more or less stagnant at 11 million hectares from 1955-56 onwards. However, area under irrigation and cropping intensity continued to increase during 1980s and 90s. Cropping intensity increased from 110 per cent in 1955-56 to 123 per cent in 2000-2001. This is mainly due to the increase in area under irrigation, which has grown from 2.68 million hectares in 1956-57 to 4.54 million hectares in 2000-2001. Area under fallow lands is stable in the state when compared to all India, which had recorded a decline.

Figure 2.1



Along with the area under irrigation the composition of irrigation has changed over the period especially in the recent years (Figure 2.1). The proportion of area under Canal and Tank irrigation has declined while the importance of well irrigation has gone up substantially. This may be attributed to the decline in public investment in agriculture in the recent years. These changes have environmental consequences. The increase in area under well irrigation coupled with the decline in tank irrigation invariably results in over exploitation of groundwater resulting in environmental problems such as desertification. Across the regions, Telangana and Rayalaseema have experienced drastic shifts in the composition of irrigation. By 1980s well irrigation has become the dominant source of irrigation replacing Tank irrigation in Telangana and Rayalaseema regions. Though Canal irrigation still dominates in the Coastal Andhra region, well irrigation replaced Tank irrigation for the second place.

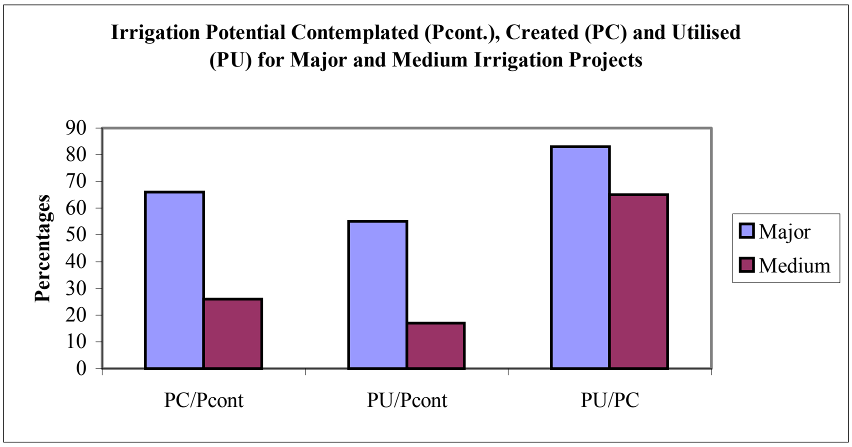
Let us examine the present status and development of these three sources of irrigation in the state.

Canal Irrigation:

While huge expenditures on major and medium projects were incurred, there was no proportionate allocation for the maintenance and infrastructure, which, interalia resulted in poor utilisation. Thus, after fifty years and an investment of over Rs.7000 crores, additional area irrigated under major and medium irrigation in Andhra Pradesh was 17.87 lakh hectares at a cost of Rs. 42000 per hectare. Major and medium irrigation is dominated by canal irrigation. Interestingly, despite huge investments, the area under canal irrigation after recording a positive growth till 1990 started declining during the 1990s. The evolution of novel institutional arrangements like WUAs during the late 1990s does not seem to have helped in altering the trend (Fig. 2.1)[4]. The total potential created in major and medium irrigation sector is slightly more than the 13.313 lakh hectares potential bequeathed to the State at the beginning of the planning era (prior to 1950-51). There are gaps in potential contemplated, created and utilized (Fig. 2.2). These gaps are wider in the case of medium irrigation when compared to major irrigation projects. Capacity utilisation in medium projects is 65 per cent against 83 per cent in the case of major irrigation projects. More importantly there is wide gap between capacity contemplated and actually created. It is as low as 26 per cent in the case of medium projects and 66 per cent in the case of major projects (Fig. 2.2).

4 Our discussions with the irrigation department officials and other experts in the field revealed that the decline in canal irrigation could be due to under reporting of area, as there were no breakdowns in any of the on going projects. The problem of under reporting is expected to be nullified with the advent of WUAs (see last section). Data for the next two years is likely to reflect this. However, it is felt that the correction would, at the most, give a picture of stagnation in the area under irrigation rather than resulting in an increase.

Figure 2.2



Ground Water

Groundwater development in Andhra Pradesh is about 42 per cent leaving apparently a large potential for future development[5]. At present there are 22.23 lakh wells in the state. Of which 13.36 lakhs in Telangana, 4.71 lakhs in Rayalaseema and 4.16 lakhs in Coastal Andhra regions. Further, 11.46 lakh wells are estimated to be feasible with a distribution of 3.89, 1.38 and 6.19 lakh wells in the respective regions (with groundwater development of 85 per cent). It is clear that the potential for well irrigation is limited in Rayalaseema, as groundwater development in this region has crossed 50 per cent. Similarly, Telangana has also limited potential. Between 1975 and 1999 well population increased from 8.20 lakhs to 22.22 lakhs, while the area increased from 10 lakh hectares to 26.44 lakh hectares. Despite the advent of new technologies in water lifting in recent years area irrigated per well has gone down marginally from 1.22 to 1.19 indicating declining water yields (Fig. 2.3). Decline in area per well is higher in Rayalaseema followed by Coastal Andhra region whereas Telangana recorded an increase in the area irrigated per well. Problem seems to be more serious at the local level. For, 62 per cent of the villages in 9 dark mandals in Rayalaseema region fall under dark category due to over exploitation of groundwater (Table 2.2). In both Rayaseema and Telangana regions majority of the wells are of 10-20 meter depth. This is reflected in the growth in tube wells in these regions. Well population is increasing at the rate of 56000 wells per year of which 60 per cent is in the Telangana region alone. Given the present low irrigation levels in

5 It may be noted that all this potential is not utilizable as it includes groundwater resources in inaccessible areas like forest and hilly regions.

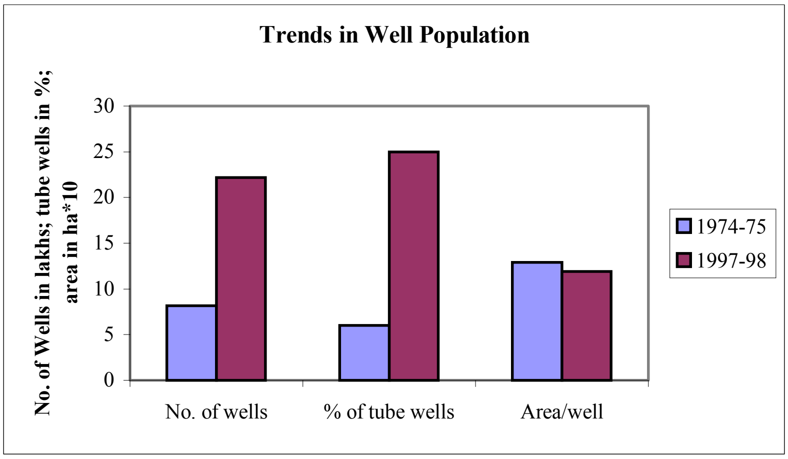
these regions (Rayalaseema and Telangana) coupled with the absence of any potential canal irrigation possibilities, these regions have to depend more on tank irrigation and improving the groundwater potential through rain water harvesting and percolation tanks. The increased stress on groundwater is clearly reflected in the faster growth of bore wells (compared to dug wells, which are drying up in most of the areas) and the declining area irrigated per well.

Table 2.2: Groundwater Development in Andhra Pradesh (1999-2000)

	Coastal Andhra	Rayalaseema	Telangana	Total
1. Level of GW development (%)	34	51	49	42
2. No. of Dark Mandals (% villages)	2 (2)	9 (62)	4 (35)	15 (45)
3. No. of wells with depth of				
a) 0-2 meters				
b) 2-5 meters	10	0	2	12
c) 5-10 meters	28	11	5	44
d) 10-20 meters	67	31	25	123
e) above 20 meters	30	50	58	138
4. % of locations recording GW	16	12	18	46
a) Rising				
b) Falling	13	5	10	8
5. No. of Existing wells	87	95	90	92
6. No. of Feasible wells	416234	470750	1335523	2222507
	618683	137774	389190	1145647

Source: Water Conservation Mission, GOAP, 2000.

Figure 2.3



Tank Irrigation

There are about 70 thousand tanks in the state. Of which Telangana houses 44 per cent followed by Andhra (38 per cent) and Rayalaseema (18 per cent) regions. Interestingly, the region with highest dependence on groundwater (Rayalaseema) has the lowest number of tanks. A more serious problem is regarding the functioning of tanks. At the state level 69 per cent of the tanks are under repair, which account for 82 per cent of the area irrigated by tanks. Effectively only 18 per cent of the tank *ayacut* (command area) is being irrigated. The decline, quantitative as well as qualitative, in tank irrigation may explain the low feasibility of groundwater development in Rayalaseema and Telangana regions. Whereas, the situation is different in Andhra region due to the existence of perennial river basins like Krishna, Godawari, etc. Given the high complimentarity between well and tank irrigation, it is necessary to strengthen the tank systems in Rayalaseema and Telangana regions. A better option would be to convert the existing tanks into percolation tanks so that groundwater potential would improve.

The changes in the composition of irrigation across regions have two important repercussions as far as distributional aspects are concerned. Firstly, well irrigation is concentrated in the fragile resource regions. More importantly, private people mostly finance well irrigation, while canal and tank irrigation are financed by the state. This has resulted in aggravation of regional inequalities. Secondly, development of well irrigation is less favourable to small and marginal farmers when compared to canal and tank irrigation due to the high capital intensive and lumpy nature of the former (Figure 2.5). In most of the regions, especially fragile resource regions, groundwater irrigation has become privy to large farmers, denying the genuine right to small and marginal farmers in the common pool resources. Due to the high capital-intensive nature of extraction, groundwater is being treated as private property. Unless groundwater is made a common pool resource in the real sense of the term, it is difficult to ensure equity in its distribution. This could be done either through legislation or making the technology cost neutral.

Figure 2.4

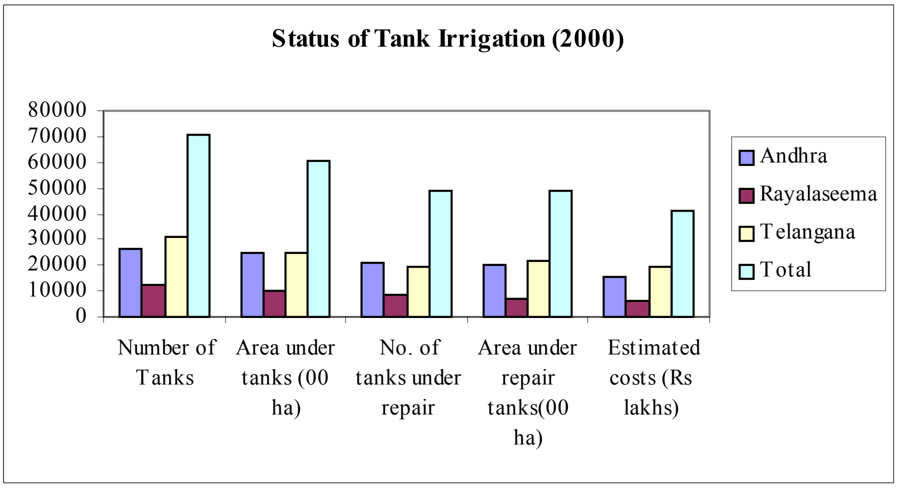


Figure 2.5

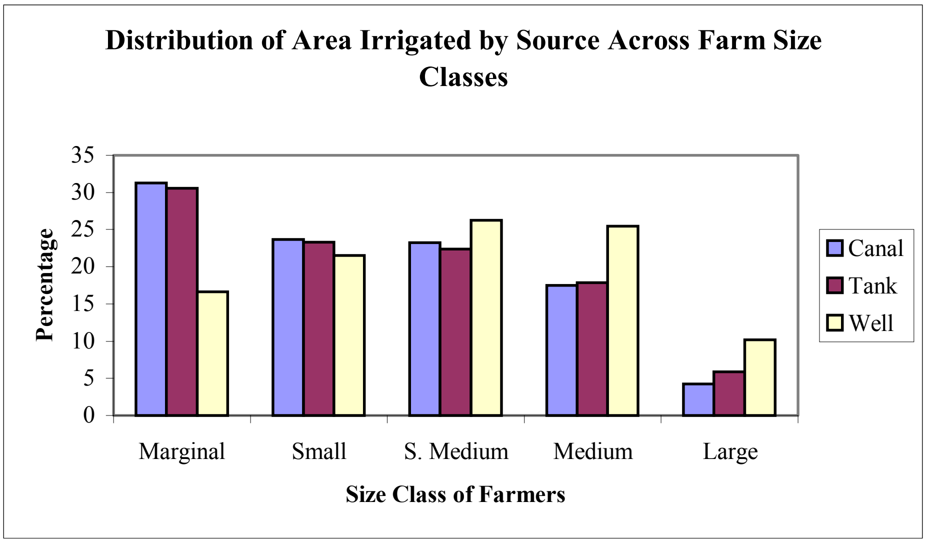


Table 2.3: Source Wise Area Irrigated (%) across Regions of Andhra Pradesh.

Year	% Canal			% Tank			% Well		
	Andhra	Rayalaseema	Telangana	Andhra	Rayalaseema	Telanga	Andhra	Rayalase	Telangan
1960	47	18	14	25	32	48	5	24	13
1970	32	16	14	13	15	25	4	19	12
1980	63	31	27	23	18	36	11	47	33
1990	59	27	22	21	15	23	13	56	49
1998	40	15	11	14	11	11	14	46	45

Source: Statistical Abstract of Andhra Pradesh (various issues).

Drinking Water

The most strident consequence of the above three environmental problems is with regard to drinking water. Scarcity of surface water coupled with the degeneration of traditional water harvesting systems are resulting in serious water shortages amounting to declining per capita water availability and unhygienic water, especially in rural areas. It is often observed, especially in dry regions, rural households spend substantial amounts of time in fetching water and even spend money on buying water. Compared at the all India level Andhra Pradesh is doing better in terms of coverage of households by tap water. But it seems to be the worst hit as far as the actual availability of drinking water is concerned. For, 8 percent of the state's population is managing with inadequate water in both rural and urban areas as against 3 percent at the all India level (Table 2.4). The rural urban divide is also large. Only 26 percent of the households in rural areas have access to safe drinking water as against 75 percent in the urban areas. On the other hand, rural households are better off as far as adequacy of drinking water is concerned. Besides, the increased use of agro-chemicals and urbanisation are making groundwater and surface water bodies like tanks unusable for drinking as well as irrigation purposes. The problems of industrial pollution are acutely felt in the villages surrounding the industrial townships. This has further reduced the quantity of usable water.

Table 2.4: Access to Safe Drinking water

State / Country	% of HH with access to tap water		% of HH reporting in-adequate drinking water		% of HH managing with inadequate water	
	Rural	**Urban**	**Rural**	**Urban**	**Rural**	**Urban**
Andhra Pradesh	26.2	75.6	22.1	30.1	08	08
All India	18.7	70.1	13.0	14.9	3.1	2.6

Source: NSS 54th Round, January – June 1998, NSSO, GOI, July 1999.

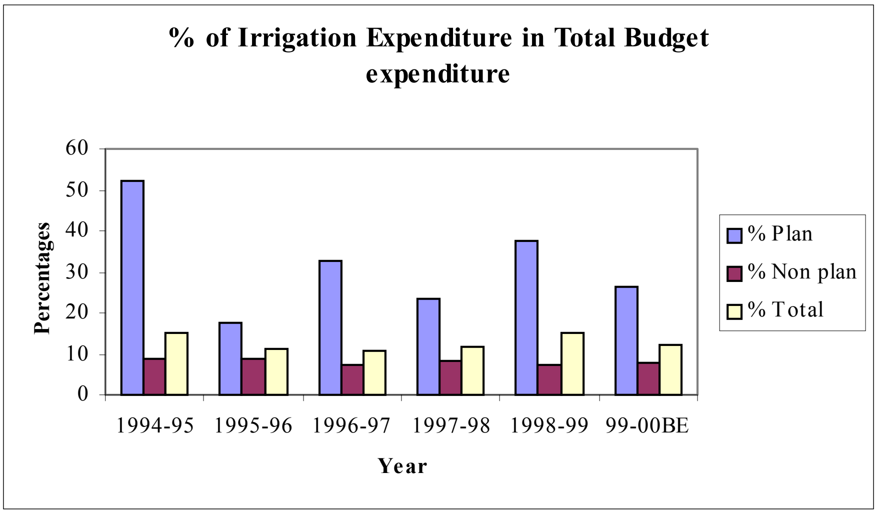
In order to address some of these exigencies the State Government has brought in legislation making water user associations' mandatory for managing irrigation water. For this purpose, the A. P. Farmer's management of Irrigation Systems Act 1997 has been enacted. In June 1997 elections were conducted to the water user's associations (WUAs) for all major, medium and minor schemes. In November 1997 elections to the distributary committees were also completed. It is proposed that project level committees will also be constituted soon in order to effect total transfer of management to the farmer's organisations. There are 10292 water user associations in the state.

At the moment these WUAs seem to be working well especially in the canal commands. In majority of the cases it is observed that tail-end locations are getting sufficient water for the first time in five years. This is facilitated by the A. P. Economic restructuring project (irrigation component) funded (Rs.4994 crores) by World Bank, NABARD and Accelerated Irrigation Benefit Programme (AIBP). However, the long run sustainability of these associations is a big question mark ones the funds dry up by the end of the year 2000. For, hither to active participation is ensured through proper flow of funds. The impact of poor funding is obvious in the functioning of the watershed committees. Another draw back in the approach is that groundwater irrigation (especially private) is not integrated with other sources of irrigation. Groundwater is the single largest source of irrigation and highly dependent on surface water sources like tanks. In the absence of any institutional arrangements for managing groundwater, its sustainability is uncertain. For all practical purposes groundwater is treated as a private source and hence none of the numerous regulations on the use of groundwater was effective. Unless groundwater is brought under the purview of community management, it would be impossible to ensure sustainability (ecological) and equity in its distribution.

II Trends in Irrigation Expenditure in Andhra Pradesh

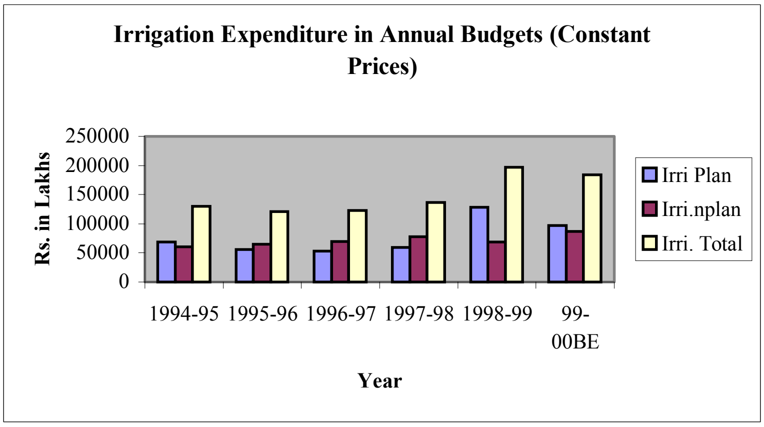
Irrigation accounts for a lions share in the total budget allocations. It is as high as 15 per cent during 1998-1999. Even other wise it hovers between 10 and 15 per cent of the total budget (Fig. 2.6). Its share in plan expenditure is very high compared to the non-plan expenditure. During the recent years the average share of plan irrigation expenditure in the total plan expenditure is about 30 per cent, while the non-plan share is below 10 per cent in all the years. This indicates that more emphasis is placed on new projects rather than maintaining the old systems. This is clearly reflected in the increasing trend in the irrigation, especially plan, expenditure during the last five years (Fig. 2.7).

Figure 2.6



Note: 99-00 BE figures are budget Estimates

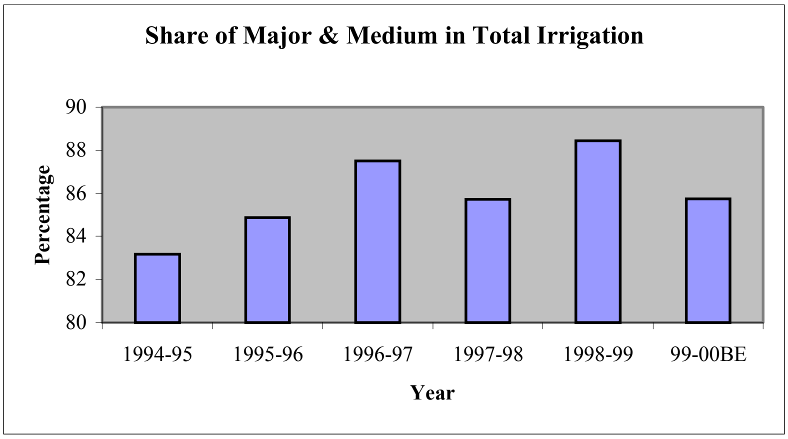
Figure 2.7



Note: Constant Prices based on wholesale price index 1993-94. 99-00 BE figures are budget Estimates

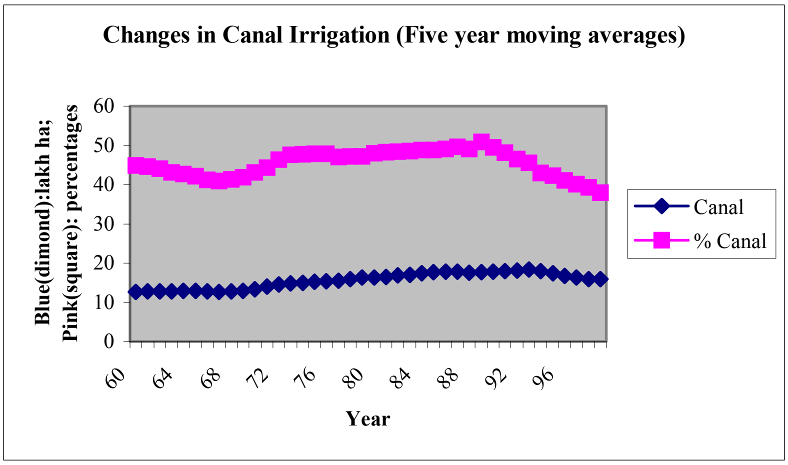
Within the irrigation sector the share of major and medium irrigation is above 80 per cent and it has risen considerably during the last five years (Figure 2.8). In fact, its share is about 90 per cent during1998-99. Of this major irrigation accounts for more than 90 per cent leaving little scope for medium irrigation. Despite the enhanced emphasis on major and medium irrigation area under canal irrigation has not shown any improvement. On the contrary it has saturated, if not declined, during the recent years (Fig. 2.9). Moreover, it has slipped to second position during the 1990s, while well irrigation gained in importance. The emphasis on plan expenditure could be the reason for stagnation in area under canal irrigation, as major projects have longer gestation periods. For, there would be a time gap, usually long, before the new investments fructify in the case of major and medium irrigation works. Besides, the long term under investment in maintenance work has also led to this decline (Oblitas, et. al, 1999). However, the substantial decline in canal irrigation in some areas needs further probing. Area under canal irrigation is observed to decline in all the three regions of the state. The specific districts and projects where area irrigated under canals has declined substantially need to be probed further to get a clear picture.

Figure 2.8



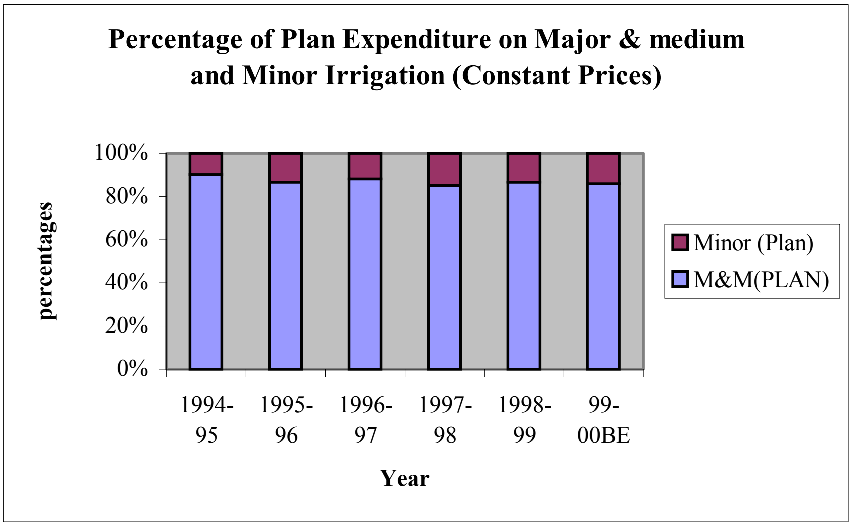
Note: 99-00 BE figures are budget Estimates.

Figure 2.9



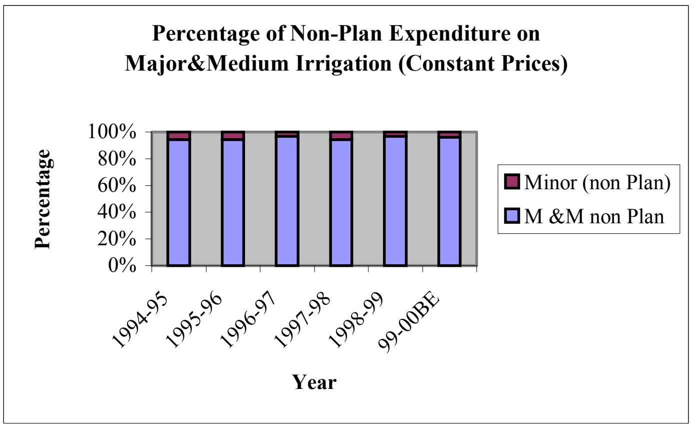
As far as minor irrigation is concerned it has been receiving low priority over the years. It accounts for only about 10 per cent of the total plan expenditure on irrigation, which is more or less stagnant during last five years (Fig. 2.10). Its share in the non-plan expenditure is much lower and declined during the recent years (Fig. 2.11). The actual expenditure on minor irrigation by plan and non-plan clearly reflects this (Fig. 2.12). This indicates, as in the case of major and medium irrigation, new schemes are given more importance over rehabilitating the old ones. This would affect mainly the minor tank and lift irrigation schemes, as the state promoted groundwater development is marginal. It may be noted while the potential created and utilised under minor irrigation in the period 1951 to 1999 is between 31 per cent and 36 per cent of that for major and medium irrigation the expenditure on minor irrigation was only 15 per cent of that of major and medium irrigation in this period. Further, the total area under minor irrigation is around 66 per cent of that under major and medium irrigation yet the Non-Plan expenditure is only a fraction of that for major and medium irrigation.

Figure 2.10



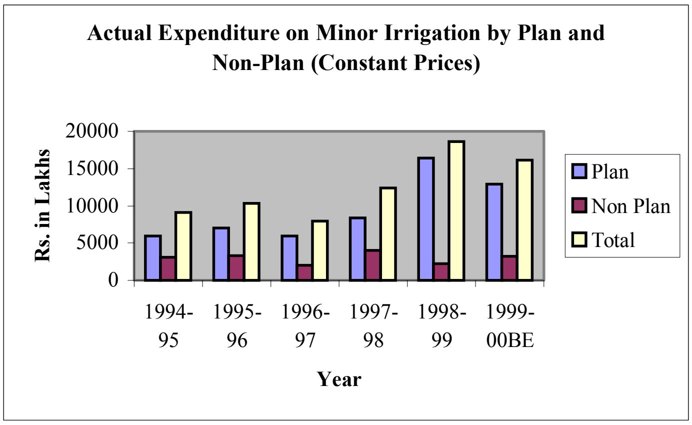
Note: Constant Prices based on wholesale price index 1993-94. 99-00 BE figures are budget Estimates

Figure 2.11



Note: Constant Prices based on wholesale price index 1993-94. 99-00 BE figures are budget Estimates

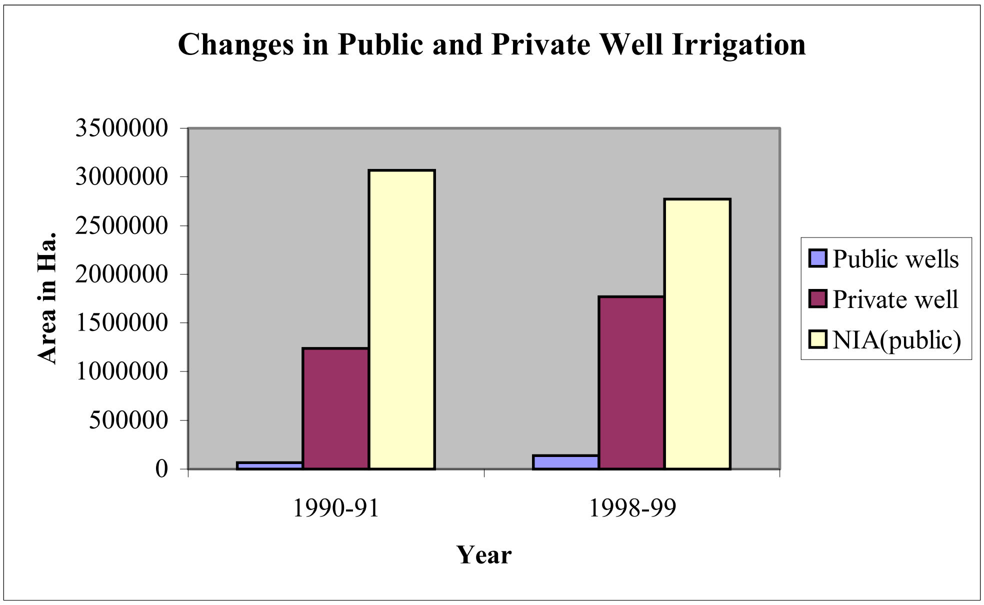
Figure 2.12



Note: Constant Prices based on wholesale price index 1993-94. 99-00 BE figures are budget Estimates99-00.

In terms of area under minor irrigation well irrigation is the main contributor followed by tank irrigation. Well irrigation is the one, which has recorded continuous growth, while tank irrigation declined till 1990s and stabilised there after (Fig. 2.1). Importantly, private individuals mostly develop well irrigation while tanks are developed by public funds, including Panchayati Raj funds. But, tank and canal irrigation complement groundwater resources. Public irrigation wells contribute a smaller portion of the total well irrigation (Fig. 2.13). If the area irrigated by private wells is taken out from the total net irrigated area we get area irrigated under public sector, which has declined between 1990-91 and 1998-99. This clearly indicates that the increase in area irrigated in the recent years is fuelled by private investment. At the same time the public investment in this sector has been ineffective or unproductive yielding negative economic returns. One can, however, argue that public investment in canal and tank irrigation has indirectly helped the private investment in groundwater exploitation through improvement in groundwater tables. This needs to be examined in terms of establishing the link between investments in canal and tank irrigation and well irrigation across the regions. In what follows we examine the ways in which public funds on irrigation sector are spent.

Figure 2.13.



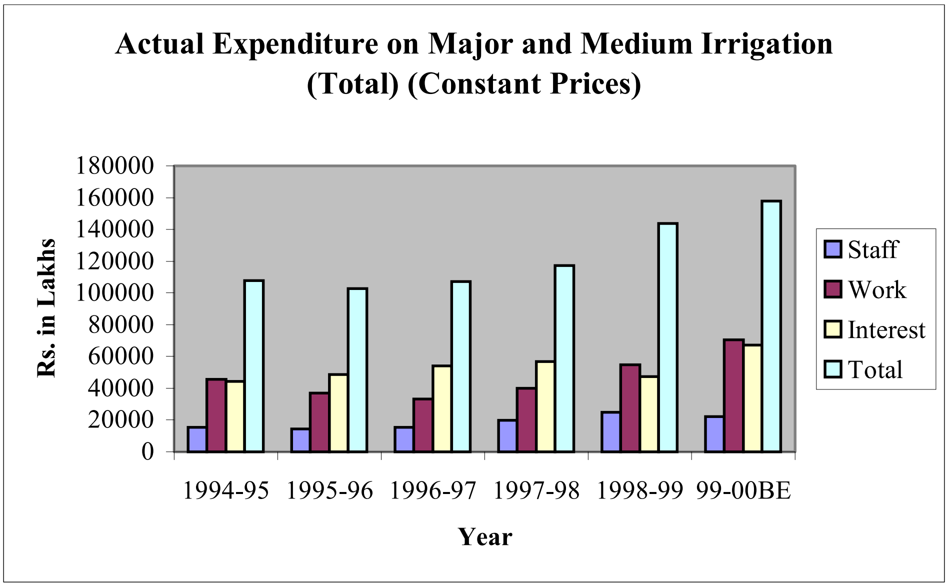
Note: NIA= Net Irrigated Area.

Pattern of Public Expenditure

Major and Medium Irrigation: The plan and non-plan break up of expenditure on major and medium irrigation indicates a shift in expenditure towards plan expenditure during the year 1998-99 (Fig. 2.7). Moreover, 1998-99 experienced a jump in the total expenditure on irrigation even in constant prices. As per the latest budget estimates the increasing trend in expenditure (constant prices) is being maintained, as the difference between budget estimates and actual expenditure is marginal in most of the years (Fig. 2.14). As far as the pattern of expenditure is concerned interest payments (debt servicing) is the most important item followed by expenditure on works and staff. Debt servicing accounts for about 50 per cent of the total expenditure on major and medium irrigation. It may be noted that in the year 1994-95 expenditure on works was the major component of expenditure followed by interest payments. The burden of debt servicing has started going up after 1994-95. If the budget estimates of 1999-2000 are any indication interest payments are continuously rising except in 1998-99. Staff costs account for 50 per cent of the expenditure on works in most of the years, which is on the higher side by any standard. As a result only about 30 per cent of the total expenditure is left for works.

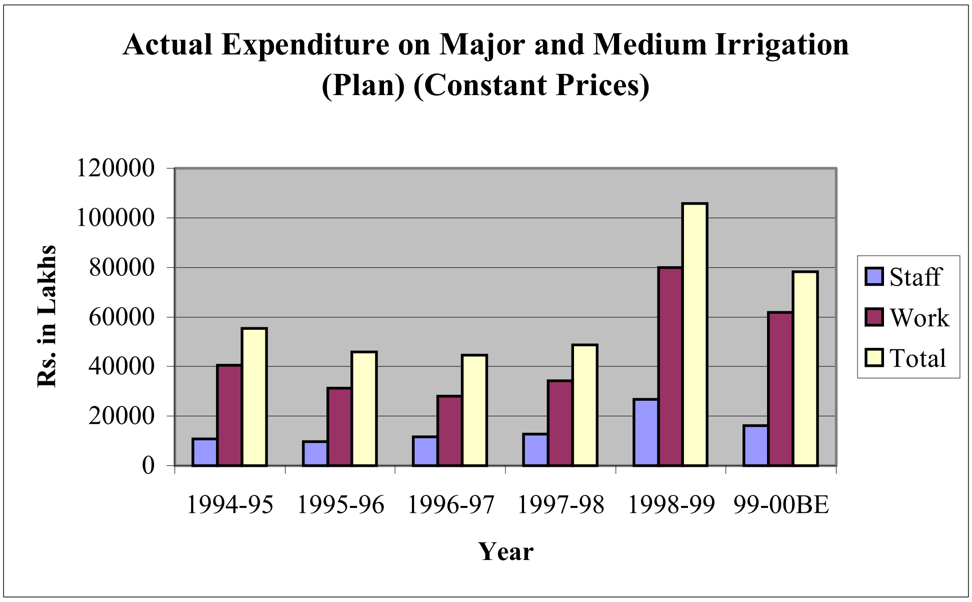
Given the declining quality of works in the recent years (various news reports), the productive work carried out could be limited.

Figure 2.14



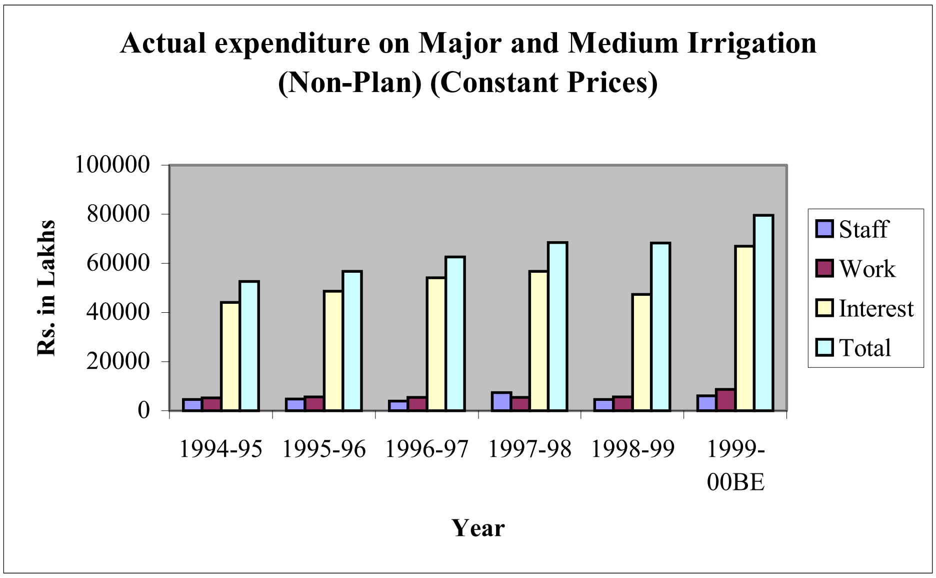
Note: Constant Prices based on wholesale price index 1993-94. 99-00 BE figures are budget Estimates.

Figure 2.15



Note: Constant Prices based on wholesale price index 1993-94. 99-00 BE figures are budget Estimates

Figure 2.16

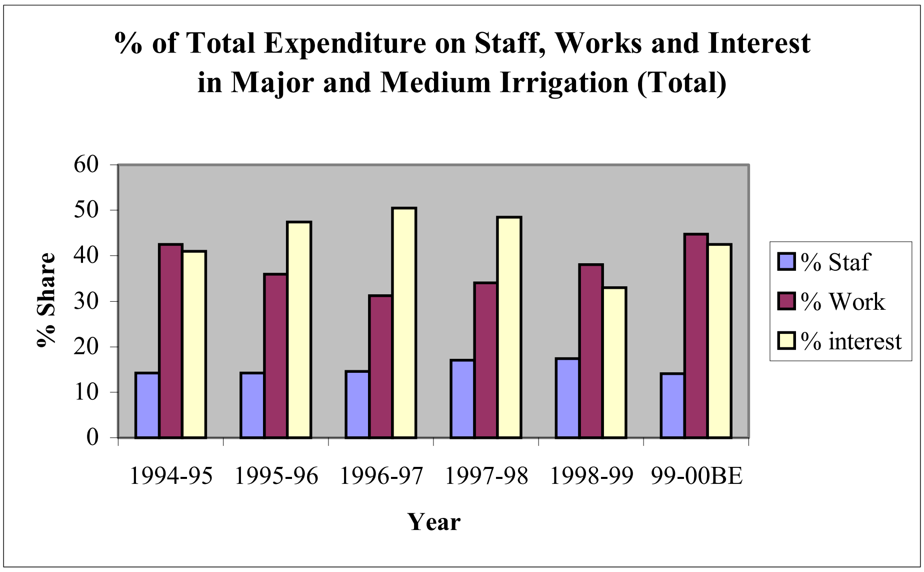


Note: Constant Prices based on wholesale price index 1993-94. 99-00 BE figures are budget Estimates.

Sub-head wise break up of plan and non-plan expenditure reveals that entire interest burden is put in the non-plan. This indicates that all the borrowings are meant for rehabilitation and operation and maintenance works. Unfortunately in the recent years most of the borrowed money is going for interest payments. Very little is left for works after interest payments and staff expenditure (Fig. 2.16). The department seems to have got in to a debt trap. It is forced to borrow more to repay the old debts rather than utilising it for productive purposes. When the borrowings are substantial (over and above the interest charges and staff expenditure) then there is scope for expenditure on works (as the case could be in 1998-99). But, the impact of these borrowings will reflect in terms of catching up of interest payments is reflected in the budget estimates of 1999-2000. The impact of substantial borrowing during 1998-99 has also resulted in a jump in the plan expenditure (Fig. 2.15). The evidence of a debt trap is clearly shown in the increasing gap between expenditure on interest payments and work expenditure during the period expect in 1998-99 (Fig. 2.17). It appears that the gap can be narrowed down only through more borrowings or repayment of loans by increasing the user charges (collections). Irrigation charges were increased by more than three times in 1997 (Raju, 2000). But, the trends in recoveries (including irrigation charges) do not provide any evidence of improvement in the collections (Fig. 2.18). Actual as well as estimates of recoveries have declined during the past five years. Even going by budget estimates the recoveries in 1999-

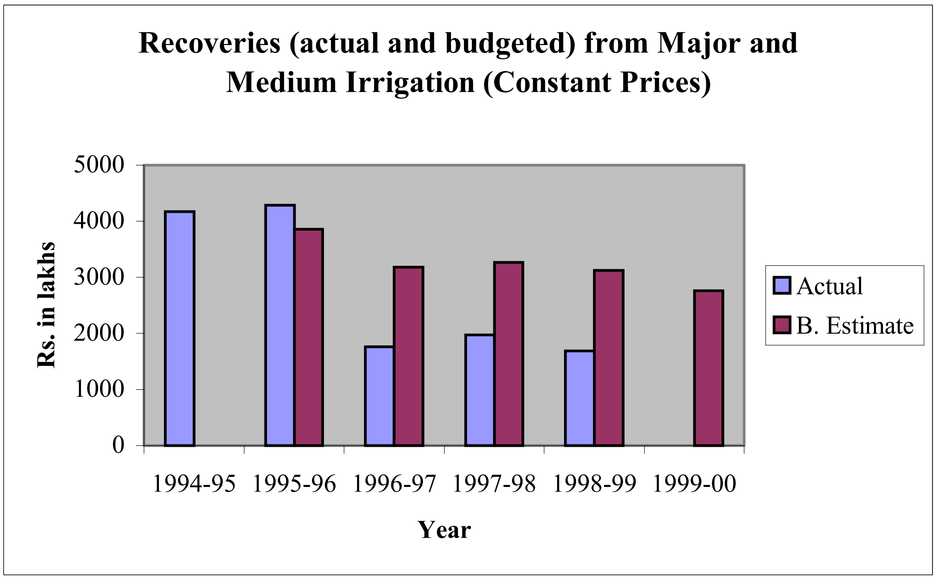
2000 will be lower than that of 1994-95. The share of recoveries in the total expenditure has come down from 4 per cent in 1994-95 to 1.75 per cent during 1999-2000 (Fig. 2.19). It may be noted that at this stage we are not sure of what other items that go in to the category of recoveries.

Figure 2.17



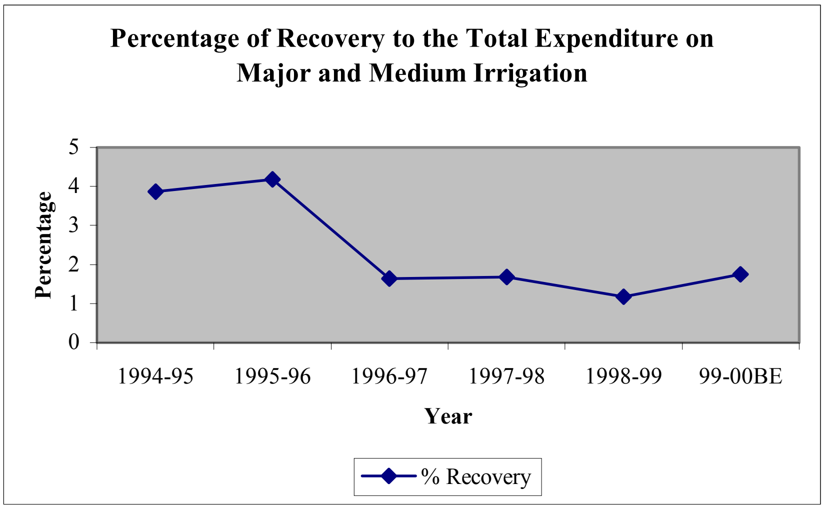
Note: 99-00 BE figures are budget Estimates.

Figure 2.18



Note: Constant Prices based on wholesale price index 1993-94. 99-00 BE figures are budget Estimates

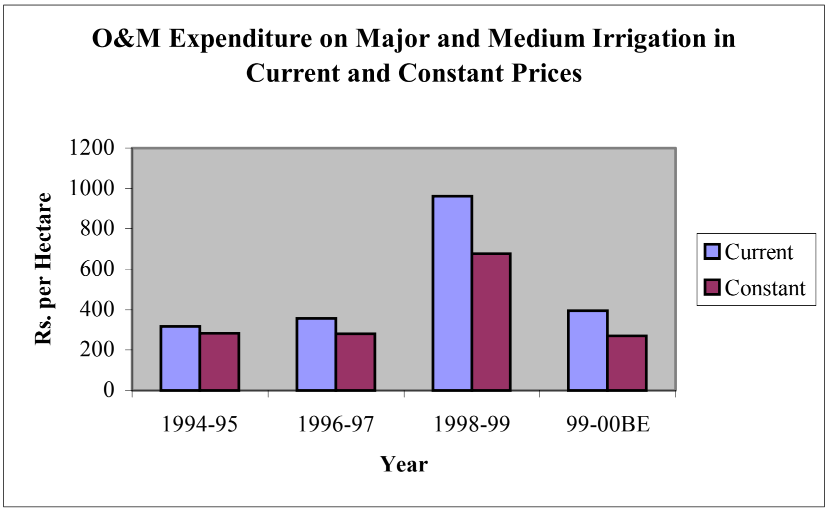
Figure 2.19



Note: 99-00 figures are budget estimates. 99-00BE figures are budget estimates

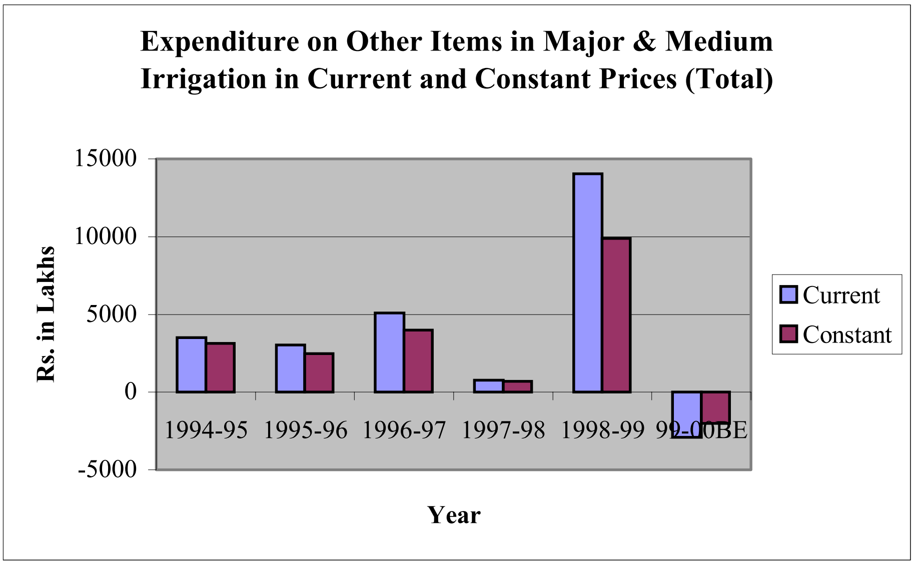
Except during the year 1998-99 the operation and maintenance expenditure is below the required level of Rs. 300 per hectare (Fig. 2.20). However, more data on this front, especially on borrowings and recoveries from water charges, is essential to substantiate the argument (see the section on further work). Another interesting feature of 1998-99 irrigation expenditure is the significant jump in 'others' category for which data are not available (Fig. 2.21). Interestingly, budget estimates for 1999-2000 the expenditure on 'others' has become negative. This has occurred mainly in the non-plan expenditure accounting for 15 per cent of the expenditure during 1998-99 while it was negative in most of the years, including the budget estimates for 1999-2000 (Fig. 2.22). This explains the reason for the stable expenditure between 1997-98 and 1998-99 despite the decline in interest payments and other expenditure, which include professional charges like lawyer fee, etc., (Fig. 2.16).

Figure 2.20



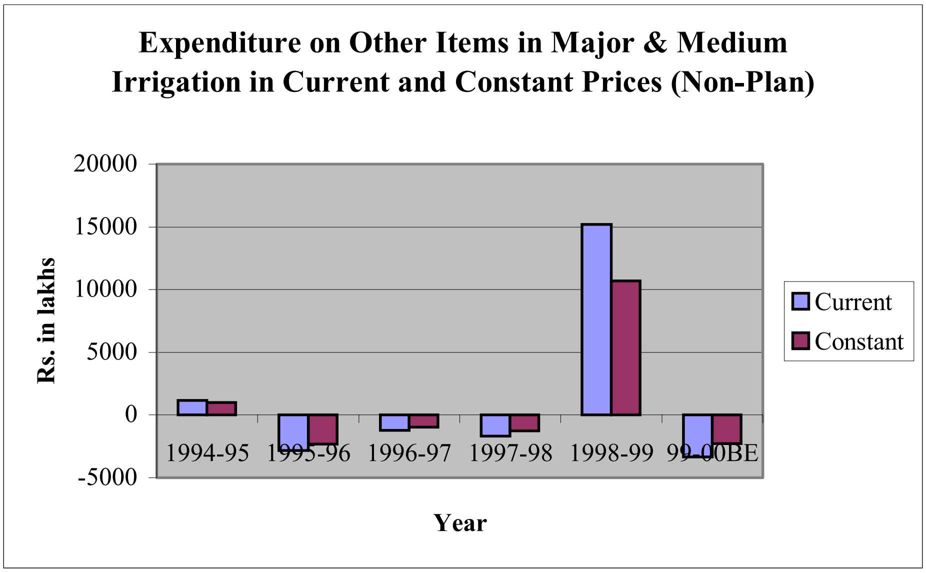
Note: Constant prices based on wholesale price index 1993-94. 99-00 BE figures are budget estimates.

Figure 2.21



Note: Constant prices based on wholesale price index 1993-94. 99-00 figures are budget estimates.

Figure 2.22

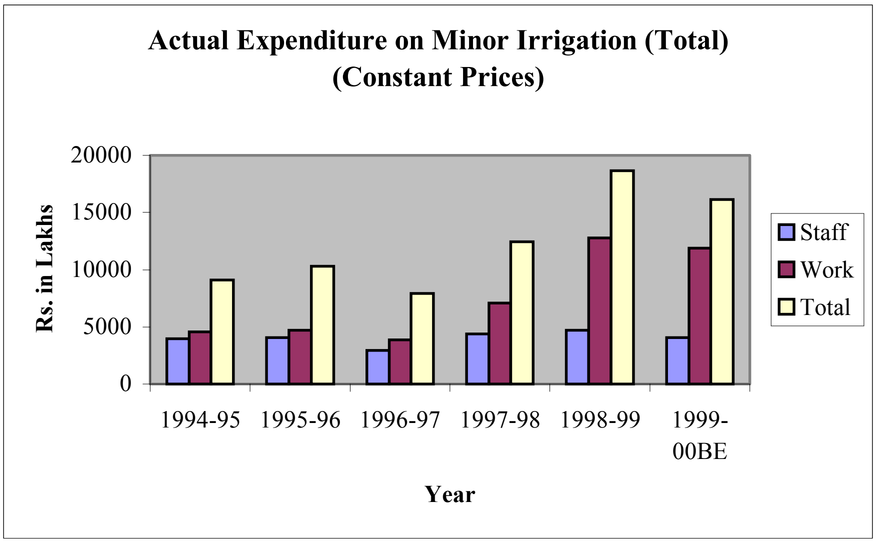


Note: Constant prices based on wholesale price index 1993-94. 99-00 BE figures are budget estimates.

Minor Irrigation:

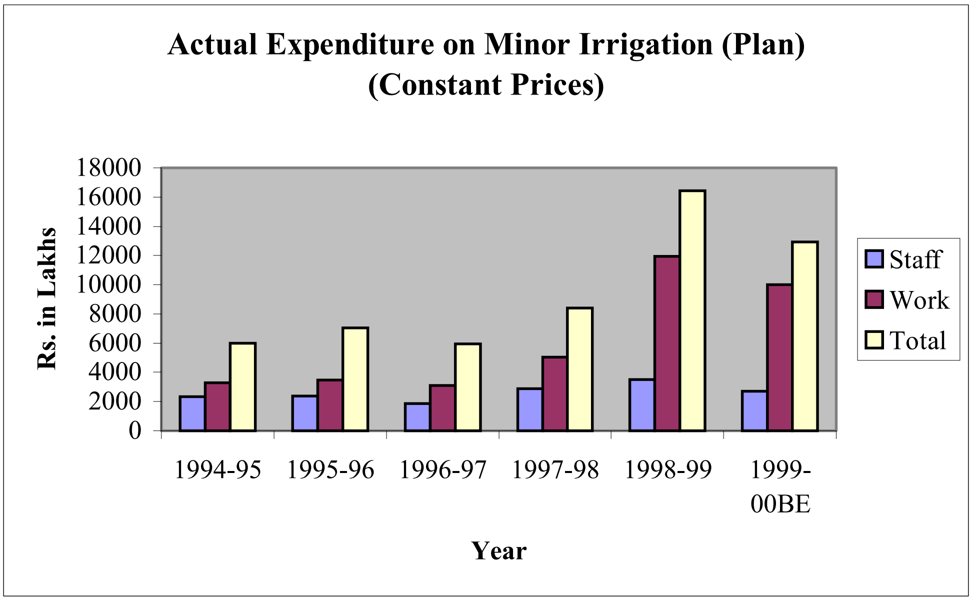
Pattern of expenditure in minor irrigation is more or less on the same lines as major and medium irrigation except for the fact that minor irrigation does not have the interest payment component. Apparently, minor irrigation is totally funded through internal sources. However, we are not sure about this, as some minor irrigation under Andhra Pradesh State Irrigation Development Corporation (APSIDC) is funded through loans and central government bonds. The emphasis on new works to the neglect of existing ones is more conspicuous in the case of minor irrigation. While total expenditure along with plan expenditure has recorded an increase during the last five years the non-plan expenditure has declined substantially during 1998-99 (Figs. 2.23-2.25). During 1998-99 there was a substantial over run of the budget estimates (Fig. 2.23). Another important feature is that staff costs account for more than 50 per cent of the work expenditure in all the years except 1998-99 and 1999-2000 (Budget estimates). In the case of non-plan expenditure staff costs are more than work expenditure in all the years except 1997-98 and 1999-2000 (Fig. 2.25). The low priority accorded to maintenance is reflected in the number of tanks (69 per cent) requiring repairs and defunct lift irrigation schemes. Besides, majority of the lift irrigation schemes fail due to inadequate design and specification. Moreover, discriminatory pricing of power is another reason for the non-cooperation of the people in managing these schemes. For, while power is charged on flat rate basis for private well owner, power is metered and charged on per unit basis for the lift schemes.

Figure 2.23



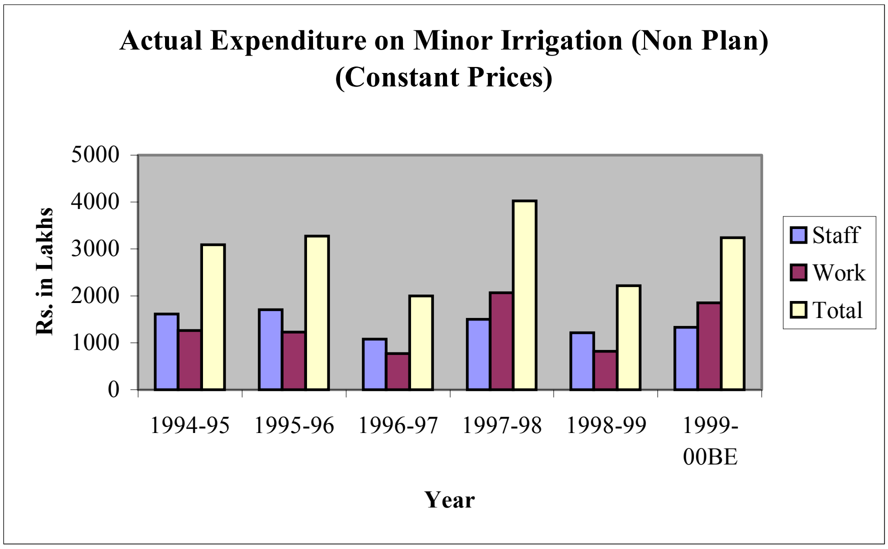
Note: Constant prices based on wholesale price index 1993-94. 99-00 BE figures are budget estimates.

Figure 2.24



Note: Constant prices based on wholesale price index 1993-94. 99-00 BE figures are budget estimates.

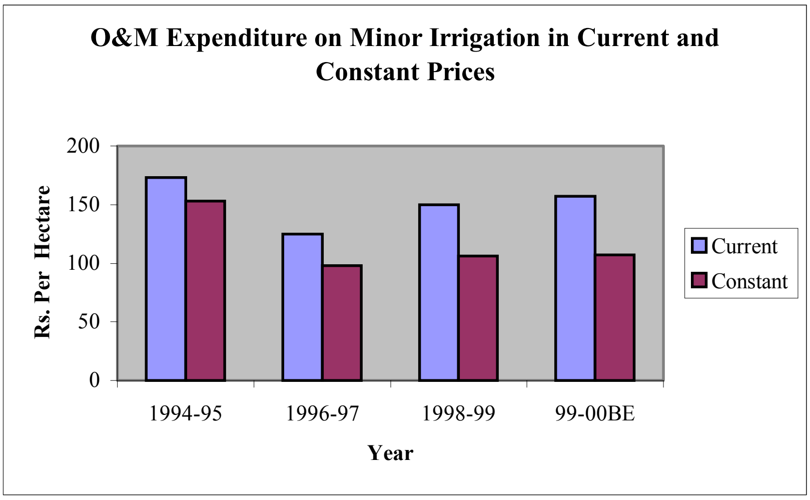
Figure 2.25



Note: Constant prices based on wholesale price index 1993-94. 99-00 BE figures are budget estimates.

Though there is an increase in the Non-Plan expenditure during 1999-2000 (Budget estimates) it is below the level of 1997-98. Poor maintenance of minor irrigation systems like tanks will have two important repercussions, especially in the fragile resource regions. One is the direct decline in area irrigated by tanks, which is already conspicuous, and the other is the indirect impact on well irrigation. Maintaining minor systems also makes economic sense, as the operation and maintenance costs of minor irrigation are half that of major and medium irrigation (Figs. 2.18 and 2.26). However, we hasten to add that minor irrigation is not a substitute for major and medium irrigation. But at the same time the latter is not a panacea for all geographical and geological locations. There are regions where promotion of minor irrigation would be more effective, economically, ecologically and socially. Therefore, blanket promotion of major and medium projects would be futile, as they are not economically viable and hence would not sustain in the long run.

Figure 2.26



Note: Constant prices based on wholesale price index 1993-94. 99-00 BE figures are budget estimates.

III Conclusions

To recapitulate the preceding analysis:

- A secular increasing trend is observed in the irrigation expenditure during the last five years even in constant prices. There is a spurt in the expenditure during the year 1998-99 in major and medium as well as minor irrigation, which has again fell in with the trend during 1999-2000. The spurt in 1998-99 is mainly due to the increase in plan expenditure.

- A lion's share of the irrigation expenditure goes towards major projects (about 80 per cent) followed by medium and minor irrigation schemes.

- Emphasis is more on new works rather than on rehabilitation of old ones, as the plan expenditure takes the major share in the increased budget expenditure. Plan expenditure has gone up in 1998-99 in terms of work as well as staff expenditure. While the increase in staff expenditure could be due to the implementation of pay commission recommendations of higher scales to all state government employees, the increase in work expenditure could be due to the new projects, on going or initiated.

- Despite the huge investments in major and medium irrigation, area under canal irrigation is either stagnant or declining. This indicates negative return on irrigation investments. Investments in new projects are less productive, as these investments are made more due to political reasons rather than economic reasons.

- Work expenditure is stagnant while interest charges are rising in the major and Medium irrigation in all the years except 1998-99. On the whole interest charges account for about 50 per cent of the total expenditure. Expenditure on staff accounts for more than 50 per cent of the work expenditure in most of the years. This is on the higher side by any standard.

- All the interest chargers are put under non-plan account leaving little scope for operation and maintenance work. Unfortunately, most of the borrowed money goes for interest payments (debt servicing). In most of the years interest charges account for about 80 per cent of the non-plan expenditure except in 1998-99. If this trend continues there is a danger of irrigation department falling in to a debt trap. For, the recoveries are on the decline despite the increase (three times) in irrigation charges in 1997. As a result irrigation development is dependent more on borrowed funds, especially for rehabilitation and maintenance.

- In the case of Minor irrigation, there are no interest charges indicating that minor irrigation, perhaps, is internally funded. Plan expenditure in minor irrigation has gone up while the non-plan expenditure has gone down during the last 5 years. Except in the year 1998-99, expenditure on staff accounts for more than 50 per cent of the plan expenditure on minor irrigation.

- The neglect of operation and maintenance is more conspicuous in the case of minor irrigation despite the fact that operation and maintenance costs of minor irrigation are half that of major and medium irrigation.

The present status and trends in irrigation development in the state can be better understood in the macro policy framework. For, the attitude, philosophy and ideology of the policy makers are crucial in determining the development path. The core philosophy of the policy makers dealing with water has not changed despite the process of reforms for a decade. The philosophy of water resource management continues to be supply sided to the neglect of demand side management. Supply side approach aims at supplying bulk water at any cost to meet the demand for irrigable land through development of new supply sources. In this approach emphasis is more on developing new sources of water. On the contrary, demand side approach stresses making water available to each individual farmer through improved water management. This is possible through reducing the wastage in water, adoption of technologies that would increase water use efficiency, etc. Pricing of water is one of the most effective demand management variables. Effective pricing policies are found to be resulting in conservation and efficient use of water in diverse situations (Reddy, 1996). Hither to efficiencies are improved through supply regulation in the supply side management by creating scarcity conditions. This, however, is only likely to make those farmers already in receipt of irrigation supplies, operate more efficiently and would do nothing for others who may have already been waiting many years for a supply. Besides, resource (financial) constraints would further aggravate supply regulation and hence shortages. The spiralling affect of this would result in acute shortages, as it happened in the case of drinking water (Reddy, 1996a). The implications of such macro policies (supply sided and biased towards major irrigation) at the micro level are examined in the following chapters. These aspects are presented in the context of groundwater development and water pollution.

CHAPTER III: GROUNDWATER: EPITOME OF POLICY FAILURE

The Macro perspective clearly reflects the continuation of colonial legacy. The policy bias against minor irrigation continues though maintaining tank systems make ecological as well as economic sense. Availability of tank irrigation is highly linked with the year on year rainfall fluctuations. These variations become acute if tanks are silted up and bunds are not maintained in good condition. More importantly, most of the tanks are traditional structures designed for the needs of the population at that time. Apart from increasing population pressure on these tanks the needs of the population have also changed in terms of cropping patterns, modern technologies, etc. As a result most of these tanks are not in a position to support the demands of the local communities and hence lost their importance to well irrigation. While well irrigation is a remunerative option in the short run its long run sustainability is critically linked with replenishing mechanisms like tanks, watersheds, etc. In the absence of these mechanisms well failure has become a common phenomenon in the recent years, especially in the drought prone regions. In fact, recent cotton farmer's suicides in the state are attributed, to a large extent, to well failure.

Impact of the macro policies is clearly reflected in the micro realities. Tank irrigation and well irrigation are treated as substitutes while the former compliments the latter. Minor irrigation is more or less left to private initiatives and very little is spent on maintaining the existing tank systems. Perpetuation of these trends would be a recipe for ecological disaster. The signs of such ecological problems are already evident in drying up of wells and well failure. This chapter looks in to the process of such ecological degradation in the context of groundwater depletion. The objective here is to examine the implications of the lopsided macro policies on groundwater in different ecological contexts and across different size classes of farmers.

I Approach

Three villages were selected from Warangal district. These villages represent different levels of groundwater situation and reflect the overall situation in the district as well as the state. The three villages are Vanaparthy, Teegaram and Vaddicherla representing no-scarcity (good), average and scanty (scarce) groundwater status respectively. Thus, the sample villages range from reasonably good availability of groundwater to acute shortages (including drinking water). There are no alternative sources of supply in two of the villages, while in one village an existing tank has been converted in to a percolation tank, where the water situation is much better (Vanaparthy). This village provides us an opportunity to explore the linkages between tank and groundwater. The analysis was carried out at two levels. At the first level, well census was carried out in all the villages in order to get a complete picture of well irrigation and its status. Basic information on well irrigation was collected using a small questionnaire from all the well owners in all the sample villages. At the second level, detailed information regarding various socio-economic aspects was collected using a detailed questionnaire from a sample of 25 households owning the wells. These sample households were selected using the probability proportionate (to size) sampling. Details of the sampling are presented in Table 3.1. The method of before and after scenarios was used in order to understand the impact of the changes in recent years. Care was taken to minimise the problems relating to memory lapse[6]. This was done through the method of cross checking at different points of interview as well as with the information collected from well census. Moreover, memory lapse was not very serious, as the focus of eliciting information is restricted to the last five years. That is, households were asked to narrate the changes in groundwater situation during the last five years. Before taking up the detailed analysis, it is pertinent to examine the profile of the sample villages.

Table 3.1: Details of the Sample Size

Village	Total Area (acres)	% area Irrigated	No. of Wells			Sample Size	
			Open	Bore	Total	Well-0wners	Intensive
1. Vanaparti	3791	25	50	105	155	Census	25
2. Teegaram	2124	19	104	61	165	Census	25
3. Vaddicherla	2970	15	30	145	175	Census	25

6 Though using panel data over a period of time is the best to address this problem, it is beyond the scope of the study due to the time constraint.

Profile of the sample villages

Important socio-economic features of these villages are presented in Table 3.2. There are wide variations among these villages regarding their Socio-economic features. Village size in terms of numbers of households and geographical area vary. The size of the villages is about 860 hectares in Teegaram, 1687 hectares in Vanaparti and 1754 hectares in Vaddicharla. Similarly, Teegaram consists of 350 households followed by Vanaparthy (700) and Vaddicherla (800). The average household size is almost same around 5 in all the villages. The average farm size of the households ranges from 3.75 acres in Vaddicharla to 6.07 acres in Teegaram. In terms of social composition, a majority (38 percent) of the households belong to SC/ST category in Teegaram while BC category households are in majority (50 percent and 53.57 percent respectively) in the other two villages.

Table 3.2: Socio-economic Characteristics of the Sample Villages

Village	No.of House holds	% of Sample House holds	Average Farm Size	Average House-hold size	**% Households belonging to**							
					Economic Categories					Social categories		
					LF	Md.F	SF	MF	LL	OC	BC	SC/ST
Vanaparthy	700	3.4 (25)	5.5	4.78	11	25	29	32	03	29	53	18
Teegaram	350	7.2 (25)	6.1	5.15	07	43	34	16	0.0	26	36	38
Vaddicherla	800	3.1 (25)	3.8	5.52	9	19	25	41	06	25	50	25

Note: LF= Large farmers; Md. F=Medium farmers; SF= Small farmers; MF= marginal farmers; LL= Landless labour; OC= other castes; BC= Backward castes; SC/ST= Scheduled castes and tribes. Figures in brackets are sample size.

Vanaparthi has the highest proportion of area (25 per cent) under irrigation followed by Teegaram (19 per cent) and Vaddicherla (15 per cent) (Table 3.1). It may be noted that proportion of area under irrigation reflects the status of groundwater situation in the sample villages. Moreover, in Vaddicherla and Teegaram the effective area under irrigation is sinking over the years as most of the open wells have dried up. Tube well irrigation is the 1990s phenomenon in Vanaparthy and Vaddicherla. For, according to 1991 census data area under irrigation was zero in Vaddicherla. Vanaparthy had 8 per cent of its area under irrigation of which 77 per cent was irrigated under tank and the remaining under open wells. Where as in Teegaram the entire 13 per cent of its area was irrigated by bore and open wells (District Census Handbook, Warangal District, 1991). In the recent years the tank in

Vanaparthy was converted in to percolation tank giving way to rapid increase in bore wells. Moreover, the presence of the percolation tank in Vanaparthy has helped in sustaining the bore wells.

Basic features of these villages (Vanaparthy, Teegaram and Vaddicherla) are almost similar in terms of occupational pattern, cropping pattern, infrastructures and social services. In all the villages small and marginal farmers are in majority except in Teegaram where the proportion of medium size farmers is quite high (Table 3.2). There are no landless households in Teegaram village. Despite this Teegaram has the lowest average annual household income. Of the three sample villages, Vanaparthy has the highest average household income followed by Vaddicherla and Teegaram (Table 3.3). This is mainly due to the reason that the main livelihood activity in these villages is cultivation and the main source of irrigation is well. That is, household income is dependent on the status of groundwater. And Vanaparthy has the highest proportion of its area under irrigation. Besides, the cropping pattern, which influences average household income, in these three villages differs substantially.

Table 3.3: Economic Status of the Sample Households

Village	Large farmers	Medium farmers	Small farmers	Marginal farmers	Main Occupation	% of area Irrigated	Average Income (Rs./HH/year
Vanaparthy	3(12)	6(24)	10(40)	6(24)	Cultivation	56.33	21900
Teegaram	3 (12)	7(28)	10 (40)	5(20)	Cultivation	41.13	12500
Vaddicherla	9(36)	4(16)	7(28)	5(20)	Cultivation	37.64	16600
Overall	15(20)	17(23)	27(36)	16(21)	Cultivation	45.03	---

Note: Figures in brackets are respective percentages to total sample.

Paddy is the most important crop in all the villages. Paddy is the single most important crop across all farms though there are variations across size classes. Cropping pattern is determined by the soil suitability and availability of water. Paddy is the only crop grown under fully irrigated conditions. All the other crops like cotton, chillies, etc., are grown in dry or irrigated-dry conditions. Allocation of area towards paddy is directly related to the availability of groundwater (Table 3.4). Proportion of area under paddy ranges from 46 per cent in Vanaparthy to 37 per cent in Vaddicherla. Across the size classes there is a clear inverse relationship between farm size and area under paddy in all the villages i.e., small and marginal farmers devote more area towards paddy. This indicates better availability of water among these farmers and the risk aversive nature of these farmers, as they prefer subsistence crops to commercial crops[7]. In all the villages marginal farmers devote more than 60 per cent of their area towards paddy as against about 30 per cent among the large farmers. On the other hand, they devote very low proportion of their area towards commercial crops like cotton, chillies, etc. While gingelly (*till*) is the second most important crop followed by cotton, chillies and castor in Vanaparthy; cotton is the second most important crop followed by castor + red gram mixed crop, chillies and green gram in Teegaram. In Vaddicherla also gigelly occupies the second position followed by castor and cotton. It may be noted that gingelly and castor are grown under dry conditions while chillies and cotton are grown under irrigated dry conditions depending on the availability of water. This is reflected in the lower proportion of area devoted to chillies and cotton in the Vaddicherla when compared to other two villages. Though number of other crops are also grown the area devoted to them is marginal.

Table 3.4: Cropping Pattern (important crops) in the Sample Villages across Size Classes
(% Area)

Land Category	Paddy	Cotton	Chillies	Gingelly	Castor	Castor+ Red gram	Green-gram	Ground-nut
Vanaparthy	46.27	11.30	10.52	13.48	6.19	---	---	1.24
Large Farmers	31.65	15.53	27.82	16.48	9.7	---	---	2.59
Medium farmers	20.11	14.87	12.63	18.71	9.22	---	---	1.60
Small Farmers	66.11	12.78	1.63	9.35	2.2	---	---	0.31
Marginal Farmers	67.00	2.00	0.00	9.36	3.63	---	---	0.47
Teegaram	45.69	21.35	7.56	---	---	12.33	5.62	3.03
Large Farmers	29.46	27.91	21.70	---	---	17.83	3.11	3.55
Medium farmers	41.55	22.36	7.55	---	---	15.67	7.35	3.01
Small farmers	49.36	16.31	1.0	---	---	12.82	9.10	3.11
Marginal farmers	62.37	18.82	0.0	---	---	2.98	2.91	2.44
Vaddicherla	37.42	8.51	---	17.62	12.86	---		0.84
Large Farmers	29.18	6.75	---	16.86	24.63	---	---	0.52
Medium Farmers	23.29	16.87	---	16.58	14.47	---	---	0.88
Small Farmers	36.68	7.78	---	21.22	7.08	---	---	1.55
Marginal Farmers	60.52	2.64	---	15.79	5.27	---	---	0.40

* remaining area is covered by other crops, which include jower, bajra, maize, korra, ragi, tobacco, sunflower; Bengal gram, onion, chillies, etc.

7 Interestingly paddy happens to be the most remunerative crop in these villages (see later section)

As far as other facilities are concerned Vanaparthy and Vaddicherla villages are having high schools up to 10th standard while Teegaram village has elementary school facility upto 5th standard. For further studies above 5th standard students have to go to near by town, which is 10 km away. All the sample villages are having postal facilities. All the villages, except Teegaram (a remote village), are having telephone facilities. All the villages are having bus facilities and connected with pucca road facility and are fully electrified for both domestic and agriculture purposes. There are public health centers (PHC) in Vanaparthy and Vaddicherla. No PHC is available in Teegaram village though a health assistant comes regularly. Drinking water is supplied through stand posts in all the sample villages. Besides, bore wells are also being used for drinking water purposes in all the sample villages.

II Status of Groundwater

Dependence on groundwater is total in all the sample villages. Sample Villages range from reasonably good availability of groundwater to acute shortages (including drinking water). There are no alternative sources of supply in two of the villages, while in one village an existing tank has been converted in to a percolation tank, where the water situation is much better. In the other villages also there are tanks but fallen to disuse due to various reasons. Concentration of wells, open as well as bore, is quite high in all the villages. Of late most of the open wells are converted in to bore wells by putting in-well bores, as most of the open wells have dried up and water tables have gone down substantially during the last 5 years.

Proportion of households owning wells range from 17 per cent (Vaddicherla) to 37 per cent (Teegaram) in the sample villages (Table 3.5). In absolute terms there are more number of wells than the number of households owning wells (Table 3.1). In other words, some of the households own more than one well. Well intensity per owner household is more in the case of Teegaram and Vaddicherla, which may be due to drying up of wells and well failure in the recent years. Distribution of wells is in favour of large and medium farmers in Vanaparthy, while it is in favour of small and marginal farmers in Teegaram and Vaddicherla (only small farmers)(Table 3.5). The higher proportion of ownership among small and marginal farmers in these villages may be due to large-scale well failures / drying up among small and marginal farmers (Table 3.6).

Table 3.5: Distribution of Well Owners by Economic Class and Well Type.

Land Category	Number of Households Having			
	Open Wells	Bore Wells	Both	Total
Vanaparthy [700]	43	100	9	152 (22)
Large Farmers [77]	13	37	7	57 (74)
Medium Farmers [175]	5	42	1	48 (27)
Small Farmers [203]	13	17	1	31 (15)
Marginal Farmers [224]	12	4	0	16 (07)
Teegaram [350]	69	40	21	130 (37)
Large Farmers [25]	2	1	4	07 (28)
Medium Farmers [50]	27	14	15	56 (37)
Small Farmers [119]	21	12	2	35 (29)
Marginal Farmers [56]	19	13	0	32 (57)
Vaddicherla [800]	19	108	8	135 (17)
Large Farmers [72]	2	11	3	16 (22)
Medium Farmers [152]	7	28	1	36 (24)
Small Farmers [200]	6	41	4	51 (25)
Marginal Farmers [328]	4	28	0	32 (10)

Note: Figures in [ ] indicate the total number of households. Figures in ( ) indicate the respective percentages to total number of households.
Source: Village Well Census survey.

During the recent years (last 5 years) 85 per cent of the wells, mostly open wells have dried in Vaddicherla while 45 and 52 per cent of the wells dried-up in Vanaparthy and Teegaram respectively. Interestingly, in all the villages, except Vanaparthy, the burden of well failure is borne mainly by small and marginal farmers. In Vanaparthy where groundwater is reasonably good, well failure among small and marginal farmers is substantially lower when compared to large and medium farmers. That is, small and marginal farmers become the first victims of the onset of environmental degradation. This is mainly due to the location disadvantages apart from the poor quality of soils they own. For, small and marginal farmers operate on small stretches of aquifers due to their small size of holdings. In most of the regions small and marginal farmers are endowed with rocky and poor quality soils where groundwater resources are limited and also difficult to extract. This is reflected in the depth of the bore wells as well as the horsepower of the engines used in the bore wells across the size classes. On an average bore wells owned by small and marginal farmers are deeper than that of large farmers but the area irrigated per well is much small (Table 3.7). These differences exist irrespective of the status of groundwater in the respective villages. That is, irrespective of the availability of groundwater small and marginal farmers are at a disadvangeous position. Area irrigated per well is substantially higher, in kharif as well as rabi seasons, in the better-endowed village (Vanaparthy).

Table 3.6 Proportion of Open Wells Dried-up Across Size Classes

Land Category	No. of Open Wells (1995-96)	No. of Open Wells (2000-01)	% of Wells Dried-up
Vanaparthy	97	53	45
Large Farmers	42	22	48
Medium Farmers	24	07	71
Small Farmers	18	13	28
Marginal Farmers	13	11	15
Teegaram	108	52	52
Large Farmers	06	04	33
Medium Farmers	46	34	26
Small Farmers	27	11	59
Marginal Farmers	29	03	90
Vaddicherla	120	19	85
Large Farmers	16	05	69
Medium Farmers	31	05	84
Small Farmers	44	06	86
Marginal Farmers	29	03	90

Source: Village Well Census survey.

Table 3.7 Depth and Area Irrigated by Wells across Size Classes

Land Category	Average Depth (in feet)		Avg. Horse - power of bore wells	Area Irrigated per bore well (acres)	
	Bore wells	Open wells		Kharif	Rabi
Vanaparthy	87 (110-200)	36 (30-50)	3.97	1.87	1.11
Large Farmers	118 (130-200)	34 (30-50)	3.00	2.50	1.24
Medium Farmers	81 (110-180)	32 (30-50)	4.28	1.87	1.03
Small Farmers	106 (110-180)	39 (30-50)	4.20	2.00	1.13
Marginal Farmers	127 (110-150)	39 (30-50)	3.67	1.11	1.04
Teegaram	116 (110-150)	45 (25-50)	3.53	1.37	0.55
Large Farmers	116 (110-130)	48 (42-50)	3.00	1.72	1.00
Medium Farmers	116 (120-130)	45 (25-50)	3.85	1.46	0.58
Small Farmers	129 (120-150)	47 (30-50)	3.92	1.32	0.37
Marginal Farmers	123 (150-150)	42 (30-50)	3.00	0.98	0.25
Vaddicherla	131 (60-300)	39 (24-60)	3.63	1.05	0.53
Large Farmers	163 (90-300)	31 (30-50)	2.89	1.23	0.87
Medium Farmers	125 (90-220)	48 (35-60)	4.57	1.23	0.51
Small Farmers	129 (60-200)	40 (30-50)	4.88	0.99	0.46
Marginal Farmers	108 (150-170)	30 (24-40)	3.00	0.76	0.28

Source: Village Well Census survey. Figures in brackets indicate range.

These farmers due to the greater depth of their wells tend to spend more money per well in terms of capital costs as well as running costs towards maintenance, etc (Table 3.8). Running costs mainly include maintenance (repairs) costs and electricity charges. Electricity is charged flat rate per year. These annual rates are Rs. 1080 per 3-horse power motor and Rs.1320 per 5-horse power motor[8]. Variations in costs across size classes would be much higher in terms of per unit of area irrigated, as the area irrigated per well is lower on small and marginal farms. Across the villages the capital costs range from about Rs. 26 thousand in Vaddicherla to Rs. 31 thousand in Teegaram while the working costs range between Rs. 2803 (Vanaparthy) and Rs. 2959. Interestingly, the per acre costs reflect the status of groundwater in the sample villages. On per acre basis both capital and running costs are the lowest in Vanaparthy (no-scarcity village) and highest in Vaddicherla (Scarcity village). Perhaps the high per unit costs may be responsible for driving the farmers in to debt trap. This aspect will become clear when we examine the net returns from irrigated crops.

Table 3.8: Costs of Bore Well Irrigation (in rupees)

Land Category	Costs per well		Costs per acre irrigated	
	Capital	Running	Capital	Running
Vanaparthy	29073 (16000-65000)	2803 (300-500)	9756	941
Large Farmers	27787 (20000-65000)	2711 (300-5000)	7430	725
Medium Farmers	29522 (16000-60000)	2920 (600-5000)	10180	1007
Small Farmers	32555 (22000-60000)	2695 (1200-4000)	10401	861
Marginal Farmers	25500 (18000-30000)	3150 (1200-1200)	11860	1465
Teegaram	31230 (15000-65000)	2941 (1200-3000)	16266	1532
Large Farmers	24000 (20000-25000)	2060 (1200-2400)	8824	757
Medium Farmers	23694 (15000-30000)	2196 (1200-2400)	11615	1076
Small Farmers	34785 (18000-60000)	3070 (1200-5000)	20583	1817
Marginal Farmers	48153 (15000-65000)	3769(2500-5000)	39149	3064
Vaddicherla	26753 (15000-60000)	2959 (1000-10000)	16932	1873
Large Farmers	26821 (20000-40000)	2796 (1000-10000)	12772	1331
Medium Farmers	25027 (15000-40000)	2760 (1200-6000)	14383	1586
Small Farmers	28094 (17000-35000)	3015 (1500-10000)	19375	2079
Marginal Farmers	26429 (20000-60000)	3278 (1500-5000)	25413	3152

Source: Village Well Census survey. Figures in brackets indicate range.

8 In April 2002 these rates are increased to Rs. 1800 and Rs. 2640 respectively.

III Resource Degradation and Well Irrigation

Groundwater situation in the region is changing year after year due to the ever-increasing pressure on the resource. In majority of the locations groundwater extraction has crossed the threshold level of maximum sustainable yield leading to drying up of swallow wells and bore well failures. This is mainly due to the mining of groundwater aquifers without improving the replenishing mechanisms. This, in turn, resulted in the degradation of resources, which ultimately affects well irrigation potential. In this regard the macro picture belies the micro realities due to aggregation problems. For the distribution and access to groundwater is very uneven and varies within a microenvironment (village). Access problems get aggravated in the light of deteriorating groundwater resources. Our sample villages provide an opportunity to understand the dynamics in terms of the impact of such degradation in diverse ecological situations. The sites range from extreme scarcity to good availability. Here we examine the recent changes in well irrigation and its impact on the village economy. This section is based on the intensive survey of the sample households of well owners. An attempt is made here to capture the changes in well irrigation during the last five years. It may be noted, at the out set, the estimates presented here do not perfectly match with the earlier table which are based on data collected from well census.

Table 3.9: Changes in Well Irrigation During the Last Five Years

Village/size class	Number of wells			Reasons for change (% of farmers)			
	2000-01	1995-96	% change	1	2	3	4
Vanaparthy	32	23	39	44	44	08	28
Large Farmers	3	3	00	67	67	0	67
Medium Farmers	10	5	100	17	17	17	0
Small Farmers	13	10	30	30	30	10	20
Marginal Farmers	6	5	20	83	83	0	0
Teegaram	32	21	52	48	0	16	16
Large Farmers	7	4	75	33	0	0	0
Medium Farmers	7	4	75	43	0	14	28
Small Farmers	12	8	50	70	0	20	10
Marginal Farmers	6	5	20	20	0	20	20
Vaddicherla	37	22	68	56	0	0	28
Large Farmers	15	13	15	44	0	11	44
Medium Farmers	8	3	167	100	0	0	0
Small Farmers	9	3	200	71	0	0	29
Marginal Farmers	5	3	67	20	0	0	20

Note: 1= Groundwater level decreased, Open wells dried-up; 2= Tank converted in to Percolation tank; 3= Neighbour farmers installed bore wells, 4= No other sources are available. Change is due to bore wells only, as the number of open wells declined over the years. Source: Intensive sample survey.

Over the last five years well population (bore wells) in the sample villages has gone up in all the villages. The extent of growth ranges from 39 percent in Vanaparthy to 68 percent in Vaddicherla (Table 3.9). The growth in well population does not seem to have any relation either with the status of groundwater or the rate of well failure. In all the villages the expansion of well irrigation (number of wells) is mostly on large and medium farmers though small farmers have recorded higher rate of expansion in Vaddicherla. The most important reason, according to the farmers, for the increase is the declining water table and drying up of open wells (Table 3.10). In Vanaparthy the expansion is attributed to the conversion of an irrigation tank in to percolation tank in the recent years. The second important factor is that the natural expansion, as there is no other source of irrigation. While the first reason stems out of the externality problems trigger mechanism does not seem to be an important reason (3) for the expansion. Impact of declining water table and the drying up of open wells is reflected in the changes in the composition of wells over the period. In all the villages there is significant decline (about 60 per cent) in the number of open wells (Table 3.10). On the other hand, number of bore wells has increased many folds in all the villages. In majority of the cases small and marginal farmers have resorted to bore wells consequent to the decline in open wells. In other words, the cost of resource degradation is mainly born by the small and marginal farmers. This coupled with their fragile resource base could explain the suicide phenomenon in this region to some extent. However, these villages have not experienced any suicides, as cotton is not the main crop in these villages. More over, marginal farmers devote more than 60 per cent of their area towards paddy and it declines along with the increase in size classes.

Table 3.10: Changes in Well Irrigation During the Last Five Years by type of Well

Village/size class	Number of open wells			Number of Bore wells		
	2000-01	1995-96	% change	2000-01	1995-96	% change
Vanaparthy	07	18	-61	25	05	400
Large Farmers	02	02	00	01	01	00
Medium Farmers	01	05	-80	09	00	@
Small Farmers	02	08	-75	11	02	450
Marginal Farmers	02	03	-33	04	02	100
Teegaram	05	12	-58	27	09	200
Large Farmers	00	00	00	07	04	75
Medium Farmers	02	02	00	05	02	150
Small Farmers	01	06	-83	11	02	450
Marginal Farmers	02	04	-50	04	01	300
Vaddicherla	07	21	-67	28	01	2700
Large Farmers	05	12	-58	08	01	700
Medium Farmers	01	03	-67	07	00	@
Small Farmers	00	03	-100	09	00	@
Marginal Farmers	01	03	-67	04	00	@

Note: Decline in open wells is due to drying up.
@ indicates changes either from zero to positive or positive to zero.
Source: Intensive sample survey.

Apart from changing composition of the wells depth of wells has increased considerably over the period of five years. Increased depth of wells mean higher capital and running costs. Capital costs increase due to deepening of open wells, conversion of open wells in to in-well bores and replacement of open wells with bore wells. All the open wells have motors with 3 HP while most of the bore wells have 5 HP motors. All the sample villages experienced substantial decline in water levels in open wells during the last five years (Table 3.11). While the average depth of open wells is more or less same in all the villages presently, the depth was substantially more in Vaddicherla five years back reflecting the water stress. Since open wells usually do not cross 50-60 feet the average dept has saturated at 50 feet in all the villages. The differences in the depth during the base year have resulted in marginal changes in depth in Vaddicherla. On an average open wells have recorded about 4 feet decline in water table per year in Vanaparthy and Teegaram while it is more than 2 feet in Vaddicherla. The decline is much sharper in the case of bore wells in these two villages. Depth of bore wells declined by 35 feet (7 feet per year) in Teegaram and 55 feet in Vaddicherla (11 feet per year) during the last 5 years. Where as, the decline was only 13 feet (2.5 feet per year) in Vanaparthy. This is mainly attributed to the percolation tank, as most of the bore wells have come up in the vicinity of the tank. It may be noted that as the water stress increases small and marginal farmers tend to go deeper in search of water. For, large farmers could invest in deeper wells even before the scarcity sets in. In the event of scarcity small and marginal farmers are forced to go deeper. Besides, location disadvantage of these farmers adds to their owes. However, this is not true in the case of open wells, which are labour intensive and hence small and marginal farmers are at an advantageous position.

Table 3.11: Changes in Depth of the Wells During the Last Five Years by type of Well

Village/size class	Depth of open wells (in feet)			Depth of Bore wells (in feet)		
	2000-01	1995-96	% change	2000-01	1995-96	% change
Vanaparthy	48	29	67	108	95	13
Large Farmers	40	24	67	120	80	50
Medium Farmers	40	30	33	100	100	100
Small Farmers	45	24	87	100	90	11
Marginal Farmers	65	36	80	110	110	00
Teegaram	50	29	75	133	98	36
Large Farmers	50	24	108	140	90	56
Medium Farmers	50	24	108	150	110	36
Small Farmers	50	30	67	120	100	20
Marginal Farmers	49	36	36	120	90	33
Vaddicherla	50	38	31	150	96	56
Large Farmers	49	36	36	120	85	41
Medium Farmers	50	40	25	150	90	67
Small Farmers	60	40	50	150	100	50
Marginal Farmers	40	36	11	180	110	64

Note: Positive change in depth indicates declining groundwater table. Depth is measured in terms of availability of sufficient water below the ground level, as perceived by the farmers. However, some farmers may go deeper than this keeping long-term interests and affordability.
Source: Intensive sample survey.

While declining water tables and well failure is the first and second casualties of groundwater degradation, decline in irrigated area, cropped area, shifts in cropping pattern and declining yield rates are the ultimate impact of these casualties. Despite the increase in number of bore wells and depth of the wells the area under well irrigation declined in all the sample villages (Table 3.12). The decline is more in terms of gross area irrigated than net area irrigated indicating that rabi crops were affected more. Decline in net area irrigated range from 10 per cent in Vanaparthy to 24 per cent in Teegaram. Where as, the decline in gross area irrigated ranges from 14 per cent in Vanaparthy to 30 per cent in Vaddicherla. Size class wise variations indicate that the loss of area under irrigation is more on marginal holdings in the scarcity villages. This supports our earlier observation that small and marginal farmers suffer more as the water stress increases. It may be noted that rabi crops (gross area irrigated) are affected more in the scarcity village (Vaddicherla) when compared to kharif crops (net area irrigated). Thus, the huge costs incurred on bore wells by farmers failed to keep the area under irrigation in tact. This is mainly due to the appropriation externalities coupled with the degradation of the resource.

Paddy is the main crop grown in the sample villages. Paddy is the most preferred crop despite poor groundwater conditions in the region. Despite the adoption of high value crops like cotton, chillies, groundnut, etc., farmers still prefer paddy. Farmers are not willing to shift away from paddy (not yet) even after the recent glut in the paddy market. The reasons could be that paddy continues to be more profitable than other crops in these villages and the efforts (supervision) involved in paddy crop are much less compared to commercial crops like cotton or chillies. In fact, paddy is known as lazy mans crop. Despite high preference as well as profits farmers are forced to shift away from paddy due to water scarcity during the recent years. Farmers are shifting towards irrigated dry crops in the place of paddy. In some of the villages farmers more or less stopped growing rabi paddy. The actual shifts in cropping pattern in the sample villages are presented in Table 3.13. Paddy is the only rabi crop grown in the sample villages. All the villages recorded a decline in the area under rabi crop. The decline ranges from 17 per cent in Vanaparthy to 50 per cent in Vaddicherla. Even the area under kharif crops has declined in two of the villages while it has gone up in Vanaparthy. This indicates that water stress has adversely affected the net sown area. The decline is more (5 per cent) in the scarcity village (Vaddicherla) when compared to the moderate village (Teegaram).

Table 3.12: Changes in Area Under Irrigation

Village/ Size class	Net Area Irrigated (acres)			Gross Area Irrigated (acres)		
	5 years back	Present	% change	5 years back	Present	% change
Vanaparthy	71.75	64.5	-10	113.75	99.5	-14
Large Farmers	15	15	00	24	21.5	-10
Medium Farmers	22	18	-18	34	27.5	-19
Small Farmers	24.5	21.5	-12	39.5	34.5	-13
Marginal Farmers	10.25	10	-03	16.25	16	-02
Teegaram	63	47.7	-24	101.5	77.7	-24
Large Farmers	16	14	-13	24	19	-21
Medium Farmers	18	10	-44	33	28	-15
Small Farmers	20	16.5	-18	31.5	22.5	-29
Marginal Farmers	9	7.2	-20	13	8.2	-37
Vaddicherla	72	59	-18	106.2	76.25	-30
Large Farmers	37.5	33	-12	53	40.5	-24
Medium Farmers	8.5	7.25	-15	15.5	10.75	-31
Small Farmers	15	12	-20	23.5	17.5	-26
Marginal Farmers	11	6.75	-39	14.2	7.5	-47

Paddy, kharif as well as rabi, is the main loser while dry and irrigated dry crops like gingelly, cotton, etc., have gained in terms of area allocations. Area under chillies has also declined though it is an irrigated dry crop but needs more irrigation than cotton. Area under kharif paddy declined by 17 per cent in Vanaparthy followed by 22 per cent in Vaddicherla and 30 per cent in Teegaram. Water stress will be severe during the rabi season, which is more prominent in the moderate (Teegaram) and scarcity (Vaddicherla) villages. However, variations in water stress between kharif and rabi seasons are not much due to the presence of the percolation tank apart from the natural situation. As in the case of well depth, small and marginal farmers tend to loose more, as the water stress increases. For, the decline in area under paddy, especially rabi paddy, is the highest among marginal and small farmers in scarcity and moderate villages. This is true even in the case of chillies. Apart from the changes in the cropping pattern yield rates, especially paddy, have declined over the period of five years. Since paddy is not only the most preferred crop but also the only irrigated crop in the sample villages. Moreover, changes in the yield rates are attributed mainly to water scarcity in the recent years. Depending on the water stress paddy yields have declined by 4 to 16 per cent during kharif season and by 8 to 10 per cent during rabi season. Vanaparthy has recorded the lowest decline in paddy yields (Table 3.14). Some of the other crops also have recorded a decline in yield rates though the decline is not directly attributable to water stress.

Table 3.13: Changes in Cropping Pattern (% change)

Village/ Size class	% change in area under crops							
	Paddy		Cotton	Gingelly	Chillies	Others	All Crops	
	Kharif	Rabi					Kharif	Rabi
Vanaparthy	-17	-17	163	86	-20	53	11	-17
Large Farmers	-20	-28	@	@	20	@	74	-28
Medium Farmers	-18	-21	100	-27	00	-20	-06	-21
Small Farmers	-20	-13	00	550	-67	20	00	-13
Marginal Farmers	-2	00	00	00	00	@	05	00
Teegaram	-30	-43	37	@	-60	50	-01	-43
Large Farmers	-33	-38	38	00	-50	75	00	-38
Medium Farmers	-44	20	17	@	-100	25	-08	20
Small Farmers	-18	-48	73	00	-67	50	10	-48
Marginal Farmers	-26	-75	33	00	00	@	-11	-75
Vaddicherla	-22	-50	27	138	-76	09	-05	-50
Large Farmers	-15	-52	83	100	-75	-03	-02	-52
Medium Farmers	-32	-50	00	@	-75	-25	-07	-50
Small Farmers	-20	-35	-67	00	00	600	-05	-35
Marginal Farmers	-39	-77	00	75	-100	-50	-35	-77

However, changes in cropping pattern and yield rates need not necessarily result in loss of income to the farmers. For, they may shift to more remunerative high value and low water intensive crops. But, the changes in the sample villages do not indicate any such shift, as paddy happens to be the most remunerative crop in these villages. It is somewhat puzzling that cotton and chillies are more remunerative elsewhere in the same district. This may be due to the soil factors. For, productivity of cotton and chillies in other parts of the district is double that of the sample villages. As a result paddy turns out to be the most preferred, economically or other wise, crop in these villages. The relative economics of the important crops are presented in Table 3.15. Relative crop economics are highly favourable to paddy both in kharif and rabi seasons. In most of the cases paddy has net returns that are double that of next most remunerative crop i.e., cotton. More importantly returns on per rupee investment (cost) are quite high for paddy when compared to chillies and cotton. This reflects the risk factor of the crop due to high investments. As a result, marginal farmers do not grow these two crops in two of the villages. Gingelly is the second most preferred crop, which has comparable cost-return ratios with paddy. But gingelly is not as remunerative (net returns) as paddy or cotton. Therefore, shift away from paddy is a net loss to the household farm income. Resource degradation in terms of groundwater table thus adversely affects household income through shrinking of area under irrigation as well as shifts in cropping pattern. Apart from these impacts there are other externalities due to groundwater decline, which include decline in grazing land quality, vegetative cover, etc. These aspects are very much reflected in the household's perceptions about the impact of the decline in groundwater table (see appendix table 1). The following section makes an attempt to estimate the actual losses due to degradation of groundwater at the farm level.

Table 3.14: Changes in Yield Rates of Paddy (quintals / acre)

Village/ Size class	Changes in yield per acre of (quintals)					
	Paddy (Kharif)			Paddy (Rabi)		
	2000-01	1995-96	% Change	2000-01	1995-96	% Change
Vanaparthy	24	25	04	28	28	00
Large Farmers	23	23	00	26	28	07
Medium Farmers	24	26	08	27	28	04
Small Farmers	23	25	08	25	27	07
Marginal Farmers	26	26	00	25	30	17
Teegaram	26	31	16	27	30	10
Large Farmers	30	35	14	28	32	13
Medium Farmers	25	30	14	30	32	06
Small Farmers	22	30	27	25	30	17
Marginal Farmers	26	28	07	25	26	04
Vaddicherla	24	28	14	24	26	08
Large Farmers	22	25	12	22	26	15
Medium Farmers	27	30	10	24	25	04
Small Farmers	25	30	17	25	25	00
Marginal Farmers	24	28	14	25	29	14

Table 3.15: Net Returns from Important Crops (Rs. Per acre)

Village/ Size class	Net Returns per acre of				
	Paddy		Cotton	Gingelly	Chillies
	Kharif	Rabi			
Vanaparthy	8848 (2.6)	8797 (1.9)	6823 (1.8)	3406 (3.0)	3398 (0.8)
Large Farmers	8111 (2.8)	8625 (1.5)	4812 (1.1)	3270 (4.8)	2840 (0.7)
Medium Farmers	10186 (3.4)	9410 (2.0)	4767 (1.3)	4120 (4.7)	3665 (0.9)
Small Farmers	7046 (2.0)	8490 (2.0)	10889 (3.5)	3110 (2.5)	3690 (0.9)
Marginal Farmers	10148 (2.5)	8660 (1.9)	---	3320 (2.0)	---
Teegaram	9577 (2.6)	7672 (2.4)	3754 (0.6)	---	3782 (0.8)
Large Farmers	12812 (4.4)	7160 (2.1)	7688 (1.5)	---	3730 (0.9)
Medium Farmers	9205 (2.8)	8480 (2.5)	1938 (0.3)	---	---
Small Farmers	6536 (1.4)	7975 (2.5)	-668 (-0.08)	---	5360 (0.7)
Marginal Farmers	9755 (2.6)	7080 (2.6)	6060 (1.4)	---	3782 (1.20)
Vaddicherla	8851 (2.7)	7755 (2.0)	4257 (0.9)	2902 (2.5)	6268 (1.7)
Large Farmers	8698 (3.1)	5970 (1.3)	3898 (0.6)	3595 (2.6)	6485 (1.5)
Medium Farmers	11161 (3.7)	7845 (2.5)	5842 (1.4)	3640 (2.7)	6050 (2.0)
Small Farmers	9128 (2.2)	7380 (2.0)	3031 (1.0)	2650 (2.4)	---
Marginal Farmers	6417 (2.2)	7110 (2.0)	---	1725 (2.2)	---

Note: Figures in brackets indicate cost-return ratios.

IV Costs of Degradation

In this section an attempt is made to estimate the costs of groundwater degradation. There are number of appropriation (negative) externalities associated with groundwater depletion. These externalities range from decline in area irrigated to drying of trees and desertification. While all these impacts are not observed in the study region, a few of the negative impacts can be quantified in monetary terms. The actual costs of externalities can be compared with the abatement costs (assuming that the impacts are not irreversible yet) for policy action. Abatement costs are the costs of converting the existing tanks in to percolation tanks that would replenish the groundwater. The positive externalities of percolation tanks are evident from one of the study villages (Vanaparthy). The difference in losses between Vanaparthy and other two villages can be attributed to the percolation tank. This implies that there are some savings or benefits in Vanaparthy due to the positive externalities of the percolation tank. These benefits can be compared with the costs of restoring percolation tank. A part of these costs could be internalised (depending on the benefits) and a part can be born by the state in the public interest.

Despite large private investment in groundwater exploitation the area under irrigation declined over the period of five years. Besides, the cropping pattern has shifted away from the more remunerative water intensive paddy crop to other less remunerative dry crops. As a result farmers have incurred net losses that include the direct costs and indirect costs. Direct costs include the investments made in bore wells and loss of capital due to drying of open wells. These costs may be termed as 'sunk costs' in the case of drying up of open wells and 'replacement costs' in the case of new bore wells that have replaced the old open wells. Direct costs are one time costs and are likely to increase over time along with the drying up of open wells and increase in the number of bore wells. These costs cumulate till groundwater tables totally dry-up or go down beyond reach (too expensive). Indirect costs are those costs that are incurred due to decline in the area under irrigation (paddy) and the changes in cropping pattern. Indirect costs are recurring costs that may grow at an increasing rate as the water table goes down. Since all the irrigated area is devoted to paddy crop, indirect costs are estimated at two levels. Firstly, the loss in net returns per acre due to the decline in net sown area under irrigation. Here net returns are taken from the paddy crop, as paddy is the only crop grown under irrigated conditions. Secondly, losses due to cropping pattern changes are estimated by taking the net return differential between paddy and other crops (weighted average)[9] that replaced paddy and the decline in area under paddy are used to estimate the losses due to shifts in cropping pattern. It may be noted here that we are not estimating all the indirect costs due to groundwater degradation due to lack of full information and measurement problems. Therefore, we limit our estimation to some of the prominent costs like area and crop changes, which are more relevant for private investment decisions.

The direct (sunk + replacement) costs range from Rs. 2744 per acre in Vanaparthy to Rs. 13159 per acre in Vaddicherla (Table 3.16). At the household level these costs are substantial ranging from Rs. 18 to 42 thousand among the sample villages. Though there is no clear pattern in these costs across size classes at the household level, on per acre basis the burden seems to be much higher on small and marginal farmers in all the sample villages. These high costs result in destabilising the household economy, as the withstanding capacity of these farmers is marginal. This is more so in the scarcity villages where burden is more coupled with the instability in crop production. Compared to direct costs the burden of indirect costs is much lower, in terms of per household as well as per acre. Indirect costs range from Rs. 605 per acre in Vanaparthy to Rs. 1910 per acre in Vaddicherla (Table 3.17). In the case of indirect costs also the burden is disproportionately born by small and marginal farmers in most of the cases though the reverse is true if we look at per household losses. On per household basis these costs range from Rs. 4990 in Vanaparthy to Rs. 8173 in Teegaram.

Table 3.16: Direct (Sunk + Replacement) Costs of Groundwater Degradation (in Rs)

Village/ Size class	Open wells			Bore wells					Total Direct Costs	Direct cost per house-hold	Direct cost per acre
	No.of wells Dried up	Cost of wells	Total cost (sunk)	No. of Bores			Cost of a bore	Total cost (replacement)			
				1995-96	2000-01	New bores					
Vanaparthy	44	17429	766876	31	123	92	29073	2674716	3441592	22642	2744
Large	20	16739	334780	13	54	41	27787	1139267	1474047	25860	1782
Medium	17	17000	289000	10	47	37	29522	1092314	1381314	28777	4667
Small	05	18071	90355	4	18	14	32555	455770	546125	17617	5354
Marginal	02	18250	36500	4	4	0	25500	0	36500	2281	1259

9 Weighted average is calculated based on the proportion of area under the crop.

Teegaram	56	19134	1071504	21	63	42	31230	1311660	2383164	18332	3831
Large	02	21667	43334	4	5	1	24000	24000	67334	9619	732
Medium	12	17278	207336	12	31	19	23694	450186	657522	11741	1889
Small	16	19696	315136	3	14	11	34785	382635	697771	19936	5673
Marginal	26	22053	573378	2	13	11	48153	529683	1103061	34471	11031
Vaddicherla	101	19725	1992225	6	146	140	26753	3745420	5737645	42501	13159
Large	11	15742	173162	3	28	25	26821	670525	843687	52730	6158
Medium	26	23752	617552	1	37	36	25027	900972	1518524	42181	10694
Small	38	19300	733400	1	53	52	28094	1460888	2194288	43025	17696
Marginal	26	20750	539500	1	28	27	26429	713583	1253083	37909	36855

Table 3.17: Indirect Costs of Groundwater Degradation (in Rs)

Village/ Size class	Decline in paddy area		Differential Net returns*	Total loss		Total loss	Loss per household	Loss per Acre
	Kharif	Rabi		Kharif	Rabi			
Vanaparthy	69.25	39	7007	485235	273273	758508	4990	605
Large Farmers	41	37	6154	252314	227698	480012	8421	580
Medium Farmers	22	15	8464	186208	126960	313168	6524	1056
Small Farmers	14.5	5.5	5177	75067	28473	103540	3340	1020
Marginal Farmers	.35	0	10015	3509	0	3509	219	120
Teegaram	89.75	51	7549	677523	384999	1062522	8173	1708
Large Farmers	9	7	8323	74907	58261	133168	19024	1455
Medium Farmers	86.5	10	8062	697363	80620	777983	13892	2236
Small Farmers	10.75	11.25	6761	72681	76061	148742	4250	1209
Marginal Farmers	11.5	9.75	9095	104593	88676	193269	6040	3248
Vaddicherla	21.25	92.43	7327	155691	677235	832926	6170	1910
Large Farmers	7.75	31.36	6998	54234	219457	273691	17106	2001
Medium Farmers	18.35	25.65	8798	161443	225669	387112	10753	2733
Small Farmers	13.15	16.13	8825	116049	142347	258396	5067	2091
Marginal Farmers	15	28.5	6055	90825	172567	263392	8231	7747

Note: Differential net return is arrived at by subtracting the net returns of the crops that replaced paddy from the net returns of paddy.

On the whole the total costs (direct and indirect) of degradation range from Rs. 3349 per acre in Vanaparthy to Rs. 15069 per acre in Vaddicherla (Table 3.18)10. On both the accounts the costs are substantially lower in Vanaparthy. This is mainly due to the presence of percolation tank in this village. For in all the villages more than 80 per cent of the respondents felt lack of proper maintenance of the tank or its low capacity as the reasons for the present status of groundwater. And the next important reason is the increased number of bore wells. The differential loss between Vanaparthy and the other two sample villages is Rs. 2190 per acre in Teegaram and Rs. 11720. The magnitude of losses increases, as the farm size declines. On the other hand, the losses in scarcity and moderate villages can be termed as the benefits that would have accrued if there were percolation tanks in these villages. That is the differential loss is totally attributed to the absence of percolation tank. Though this seems to be a strong assumption one of the recent studies dealing with the ecological impact of tank restoration programme in drought

10 This methodology can be used to estimate the costs of degradation at the district level based on the changes in number of wells, open as well as bore. However, estimating the indirect costs is somewhat difficult.

prone areas strongly supports this view (Reddy, et. al., 2001). These differential losses or benefits are likely to increase at an increasing rate over time. However, we assume that these losses would be constant over the period of five years mainly to avoid estimation problems. These losses are comparable with the costs of renovating an existing or converting it in to a percolation tank, which ranges between Rs. 4000 to Rs. 6000 per acre depending on the size[11]. As it is, the incremental losses are above Rs. 1000 per acre per year in Teegaram and Vaddicherla villages. In fact, conversion of old tanks into percolation tanks is more effective as far as the impact on groundwater is concerned. Though watershed development also helps in improving groundwater table, it is long term in nature and also depends on the soil and climatic conditions. Watershed development does not necessarily generate irrigation facilities in all climatic situations especially in arid regions where average annual rainfall is below 700 mm.

Table 3.18: Total Costs (direct and indirect) of Groundwater Degradation (Rs./acre)

Village/ Size class	Costs due to groundwater degradation		Total costs (Rupees per acre)
	Direct	Indirect	
Vanaparthy	2744	605	3349
Large Farmers	1782	580	2362
Medium Farmers	4667	1056	5723
Small Farmers	5354	1020	6374
Marginal Farmers	1259	120	1379
Teegaram	3831	1708	5539
Large Farmers	732	1455	2187
Medium Farmers	1889	2236	4125
Small Farmers	5673	1209	6882
Marginal Farmers	11031	3248	14279
Vaddicherla	13159	1910	15069
Large Farmers	6158	2001	8159
Medium Farmers	10694	2733	13427
Small Farmers	17696	2091	19787
Marginal Farmers	36855	7747	44602

Though the cost-benefit comparison of groundwater depletion vis-à-vis its abatement (replenishment) costs makes economic as well as ecological sense to invest in the replenishment mechanisms, there are no private initiatives in this direction. For, these initiatives are community based rather than individual based due to the lumpy ness of the investment. Besides, as in the case of watershed development and management collective action is pre requisite in tank restoration and management.

11 Smaller the size higher the per acre costs. But 90 per cent of the tanks in Andhra Pradesh are smaller in size

Such an approach calls for state intervention in order to revive and restore the traditional systems. The intervention should be more in terms of a facilitator or catalyst for collective action at the community level. Participation of local NGOs would facilitate such policy. While communities expect financial support from the state, a part of the investment can be generated at the community level through user contribution and charges. This enhances the communities stake and responsibility in managing the systems. Though, this is a difficult task requiring proper institutional arrangements, it may not be an impossible task given the costs and benefits from such a programme. In fact, some NGOs have demonstrated the feasibility of high user contribution (Reddy, et. al., 2001). Such investments, private or public, would benefit the poor farmers more.

V Public Policy and Environment

To recapitulate, exploitation and degradation of groundwater resources is progressing at an alarming rate. The first victims of this process are small and marginal farmers, who are not in a position to access the resource. Even when they have the financial capability they are not in a position to compete with the large farmers in deepening their wells. As a result, the costs of groundwater degradation are disproportionately born by these farmers. The impact of resource degradation on these farmers is in two ways. Firstly, while small and marginal farmers dominate the ownership of wells in general and open wells in particular, medium and large farmers dominate the ownership of bore wells. As a result of degradation majority of these farmers loose access to water. That is they are denied of their genuine share in the common pool resources. Secondly, one of the interesting observations of our study is that of late bore well technology is becoming cheaper making it size (owned land) neutral, though the process may be slow. As a result these farmers are also investing substantial amounts of money on bore wells. Such investments become unviable in the event of well failure. Besides, the poor quality of technology at lower costs is resulting in high maintenance costs and uncertainty in water supply. It is observed that groundwater markets will take care of the equity problems to a large

i.e., less than 100 acres of command area (Reddy, et. al., 2001).

extent (Shah, 1993). But, evolution of water markets is possible only in the regions where groundwater is available in sufficient quantities. Markets do not evolve when there is not enough water to share or sell (Reddy, 2000). This is true of our study region where groundwater markets do not operate, as the available water is not enough to irrigate the well owner's land.

This is clear case of appropriation externalities resulting from technological and legislative externalities. For, groundwater extraction technologies are presently expensive and beyond the reach of the small and marginal farmers. This externality is adversely affecting them in accessing groundwater. Added to this are the legislative externalities, which fail to specify the property rights in groundwater in an equitable fashion. At present, the legislation does not guarantee equity in access to groundwater resources to all sections of the community irrespective of their land ownership. Moreover, there is no legislation that supports sharing of groundwater equitably. Therefore, there is strong case for internalising these externalities in a systematic fashion. One way of doing it is, to minimise the externalities by strengthening the resource base i.e., improving the replenishing of groundwater through rainwater harvesting. Technological externalities can be addressed through making technology neutral to economic position of the farmers. This calls for policy changes towards prioritisation of minor irrigation in the fragile regions as well as supporting cheaper access to technology.

Small and marginal farmers draw maximum benefits from the abatement (replenishment) measures. The cost-benefit comparison is in favour of investment in replenishment mechanisms such as irrigation tanks and percolation tanks. The situation of over extraction and the resultant environmental degradation is a consequence of lack of appropriate and adequate policies (policy failure) for managing the subsurface water resources. Hither to, groundwater policies are in the lines of encouraging over exploitation. These policies are in the nature of providing incentives for groundwater development such as subsidised credit and for groundwater exploitation such as subsidised power or diesel / kerosene. While these policies helped in promoting groundwater development in the regions where groundwater development was below potential, they have led to over exploitation of the resource in fragile resource regions. On the other hand, no attempts were made (at the policy level) to strengthen the natural resource base in terms of replenishing the water table. On the contrary, groundwater development is seen as a substitute for tanks, which are main agents of replenishment. In this regard State has become a mere spectator, as this process conveniently shifted the financial burden to private people. This has resulted in the concentration of public funds in the endowed regions (especially on surface irrigation development) and private funds in the fragile resource regions.

The policy bias against the drought prone regions is resulting in widening not only the economic inequalities but also the ecological divide between endowed and fragile resource regions. For, the neglect of resource poor regions in the provision of protective irrigation is further weakening their fragility. Even the recent policies in water management fail to take the needs of these regions in to account. Groundwater, the single most important source of irrigation, is totally left out of the purview of the water user association legislation. There are no efforts to integrate well and tank irrigation. While water user associations are found to be effective in the canal commands they are not serving the purpose in the case of tank irrigation though 80 percent of the associations are for tanks (see next chapter). Unless the needs of these regions are identified and addressed effectively, fragile resource regions will face irreversible ecological problems like desertification.

Unfortunately, there are no policies so far that address the equity and management aspects of groundwater. Though there are regulations on groundwater exploitation they are inadequate and ineffective. Even the proposed new policies are in the lines of regulation[12] rather than designing innovative policies that would integrate market and institutional dimensions of resource management. This calls for a shift in the policy from supply side management approach to demand side management approach, from populist approach to economic approach, from convenient approach to efficient approach, from engineering approach to institutional approach, from centralised approach to decentralised approach and from fractured approach to integrated approach. That is water policies should aim at integrating all sources of water in the regional context rather than treating them in isolation. Demand

12 Based on the recent meetings of state water mission of Andhra Pradesh, Andhra Pradesh.

management is equally, if not more, important especially in the context of scarce resources, as the supplies are limited. Demand management helps in efficient and sustainable use of the resources when compared to supply regulation.

In the context of groundwater management the following issues need immediate policy attention:

1. Integrated approach of groundwater development / exploitation with surface water bodies like tanks. These two sources of water should be treated as complements rather than substitutes. As a first step all traditional tank systems should be revived and converted in to percolation tanks wherever necessary. The benefits from such a programme would be enormous when compared to the losses due to degradation and hence it makes economic and ecological sense.
2. So far, groundwater is regulated through supply regulation of electricity rather than fixing the electricity charges appropriately. That is only 9 hours of power supply is being provided in a day in rural areas due to power shortages. Though this has helped in checking the degradation in short run it is not a real solution in the long run. For, by the end of 2002 Andhra Pradesh is set to be a power surplus state. This coupled with subsidised power prices would aggravate the process of environmental degradation. Therefore, economic pricing of electricity with proper monitoring facilities would be more appropriate.
3. Institutional arrangements are required to make groundwater a common pool resource in the true sense of the term. In this regard delinking of water rights from land rights would help addressing the equity issues effectively. However, the transactions costs for enforcing such system would be enormous. In this context the experience of some NGO (*Pani Panchayat*) experiments in the country where water rights are given even to land less households would be helpful. Similarly the experiences of countries like South Africa where attempts are being made to effectively abolish the riparian rights on water would through some light in this regard.
4. In the event of high transaction costs involved with enforcing the separation of water rights from land rights, adding the scarcity price of water to the electricity, which amounts to discriminatory pricing of power depending on the

status of water resources in the region. Resources generated from such scarcity rent can be diverted towards the development of the sections of the local community that are unable to have access to water for various reasons.

CHAPTER IV: SURFACE WATER: INSTITUTIONAL IMPERATIVES

I Background

As indicated in the macro analysis (Chapter II) surface water resources (canal and tank) account for the largest share (above 50 per cent) in the total area irrigated. Of these surface systems canals account for more than 70 per cent of the area. Tanks used to be the most important source of irrigation in Rayalaseema and Telangana regions prior to 1960s. The share of tank irrigation has declined uniformly in all the regions over the period. Though it is difficult to pinpoint the exact causes for this decline, the decline in tank irrigation has come about in phases. The literature on tank irrigation identifies numerous reasons such as socio-economic, institutional and physical for the decline of tank irrigation (von Oppen and Subba Rao, 1980a; Reddy, 1990; Shankari, 1991; Reddy et al, 1993; Janakarajan, 1993; Reddy, 1995; Gireesh, et. al, 1997). Historically, the decline in tank irrigation is linked with increasing population density (von Oppen and Subba Rao, 1980b). The relation between tank irrigation and population density is portrayed as an inverted 'U' shaped curve indicating that tank irrigation would increase along with population density till a certain point and then declines with any further increase in population density. This may be due to the reason that as the benefits from tanks decline due to increased population pressure (declining carrying capacity) communities loose interest in maintaining them and let them decay.

Decline in tank irrigation is also linked to the development of well irrigation though it is difficult to determine the cause and effect. For, as the benefits from community based technology / source (tank) declined people shifted towards individual based technology / source (well). This, however, connotes a wrong notion of substitutability between tank and well irrigation while tanks complement groundwater development in reality, which is clearly demonstrated in the previous chapter. The decline therefore is a cumulative effect of policy and institutional failure.

Tanks were traditionally treated as protective sources of irrigation. These systems were providing protective irrigation on a limited scale. They were maintained by village communities, which were nurtured by the benevolent local rulers. Institutional arrangements such as *Dasabandam* and *Kudimaramat* were in place to protect these systems from decay[13]. Under *Dasabandam*, tank lands were created and given to a person in the village (*poligars*) for the purpose of maintaining the tank. Under *Kudimaramat* community voluntarily participates in maintaining the tank. However, the policy shift towards major and medium irrigation during the British period coupled with the change in the policy perception about irrigation development i. e., treating it as a productive (revenue generating source) rather than a protective source has resulted in the degeneration of these institutions. Besides, overall environmental degradation resulting from population pressure, especially in the drought prone regions, led to silting up of tanks and shrinking of their capacities. This, in turn, has led to the shift towards the individual based well irrigation. The declining of tank irrigation and expansion of well irrigation has stabilised towards the end of British period and continued till 1980s.

The second phase of this trend was triggered by the advent of energisation of groundwater lifting mechanisms. The new technologies in pumping systems during 1980s coupled with the benefits of green revolution have resulted in an unprecedented expansion of groundwater development. Further, the capital-intensive nature of these technologies, especially during the initial stages, has made the groundwater resources privy to large and medium size farmers. For, open wells have started drying up in the drought prone regions. In fact, well failure (including bore wells) has become a common phenomenon in the recent years indicating an impending ecological disaster (see Chapter III). All the while, unfortunately, the state has been a silent spectator and party to this ecological mismanagement. The declining role of tanks in irrigated agriculture belies the importance of these systems. For, tanks replenish groundwater table and help maintaining the ecological balance. The declining tank irrigation coupled with the expansion of groundwater development is a recipe for disaster, especially in the drought prone regions. The problem lies in treating tanks and groundwater in isolation rather than following an integrated approach.

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[13] There are numerous examples of institutional arrangements for managing traditional water harvesting systems across the country. For details see Agarwal and Narain (1997).

The status of major and medium irrigation (canal) is no different though the reasons for it are. As clearly brought out in chapter two the problem is not of policy neglect but mismanagement. Despite ever increasing budget allocations towards major and medium irrigation funds available for operation and maintenance (O & M) are inadequate resulting in poor maintenance of the systems, unsatisfactory service and ecological problems. While tail end regions are facing severe water shortages due to poor maintenance of distributory systems head reaches are having water logging and salinity problems due to poor drainage facilities. The vicious circle of -low allocations to O & M, poor service, declining area under irrigation, low yields and incomes, low recovery of irrigation charges and low allocations- is common in all the Indian States (Raju, Gulati and Meinzen-Dick, 1999).

In order to address some of the exigencies in the context of surface water resources the State Government has brought in the legislation making water user associations' mandatory for managing irrigation water. For this purpose, the A. P. Farmers' Management of Irrigation Systems Act 1997 has been enacted. In June 1997 elections were conducted to the water users' associations (WUAs) for all major, medium and minor schemes. In November 1997 elections to the distributary committees were also completed. It is proposed that project level committees will also be constituted soon in order to effect total transfer of management to the farmers' organisations. This chapter makes an attempt to critically review the act and examine the functioning of the WUAs in a general context. Our intention here is not to assess the impact, as the institutional arrangements are still evolving and far from complete. While some of the micro level observations (including ours) suggest a positive impact on area irrigated, it is yet to reflect at the aggregate level. This chapter is mainly based on the review of some of the early studies on water user associations and also based on our field visits to some of the WUAs in canal commands in the coastal districts (Nagarjuna Sagar right canal) and tank systems in the Rayalaseema region. Besides, the effectiveness of WUAs in the context of tank irrigation is examined on the basis of a comparative analysis of an NGO model of tank restoration with that of state promoted WUAs in Rayalaseema region.

II Evolution of the Institutional Reforms

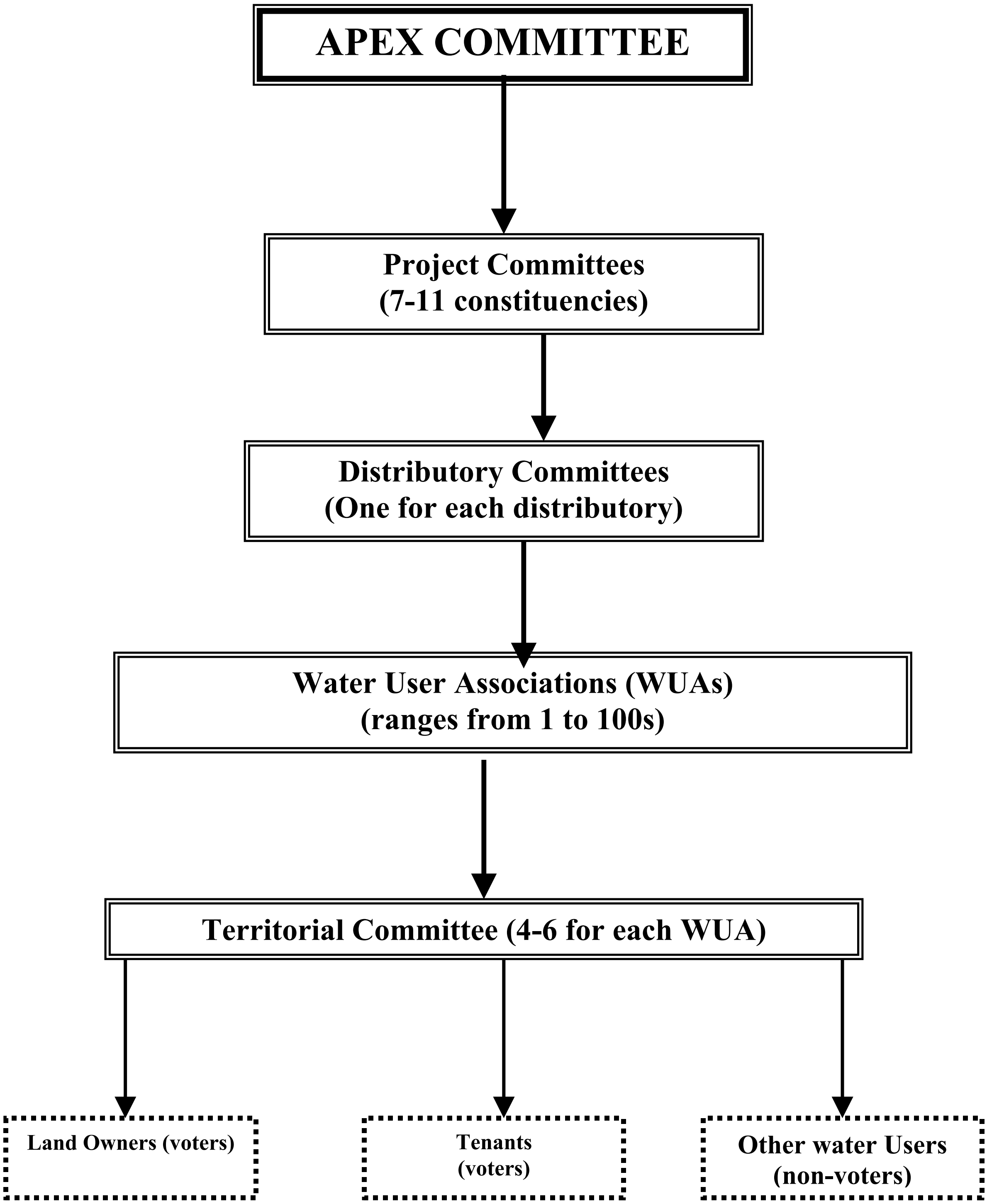
Andhra Pradesh is the first state in India to initiate large-scale institutional reforms in irrigation management. In 1997 the state has brought in the legislation to create Water User Associations (WUAs) under the Andhra Pradesh Farmer Managed Irrigation Systems Act under the framework of participatory irrigation management (PIM). The main objectives include i) realising the maximum irrigation potential, ii) ensuring equitable and reliable supplies, iii) improving the efficiency of the existing irrigation network, and iv) managing water resources better through stakeholder participation and withdraw the department from O & M. Under this act 10292 WUAs have been created so far (Table 4.1). Of these, for 9800 WUAs elections were conducted and the WUAs were formalised by March 2000. Elections were not conducted in 492 WUAs for various reasons such as court stay order or Government stay order. Interestingly, elections were unanimous in majority of the cases (Jairath, 2001). About 80 per cent of these WUAs are in minor systems. The evolution of water user associations is mainly facilitated by the A. P. Economic restructuring project (irrigation component) funded (Rs.4994 crores) mainly by World Bank, NABARD and Accelerated Irrigation Benefit Programme (AIBP).

Table 4.1: District / Sector Wise WUAs (as on 23/03/2000)

Name of the District	Total No. of WUAs Notified			Total Notified (3+4+5)	WUAs Formed			Total Elections Conducted (7+8+9)	Total Election to be Held	Total No. of WUAs (10+12)
	Major	Medium	Minor		Major	Medium	Minor			
(1)	(2)	(3)	(4)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Adilabad*	35	27	221	283	35	27	212	274	9	283
Anantapur	46	7	305	358	46	7	302	355	3	358
Chittoor	0	51	644	695	0	48	616	664	31	695
Cuddapah	74	8	276	358	74	8	259	341	17	358
E. Godava#	106	12	225	343	106	12	215	333	10	343
Guntur	245	8	81	334	239	8	76	323	11	334
Karimnagar	249	10	586	845	249	10	571	830	15	845
Khammam	51	5	181	237	50	5	180	235	2	237
Krishna	189	12	288	489	166	12	256	434	55	489
Kurnool	116	12	153	281	114	12	145	271	10	281
Mahabubna	21	31	478	530	21	29	473	523	7	530
Medak	0	12	585	597	0	12	551	563	34	597
Nalgonda	91	45	541	677	91	44	541	678	1	677
Nellor	110	58	695	863	100	57	612	769	94	863
Nizamabad^	78	13	267	358	78	13	228	319	39	358
Prakasam	124	5	317	446	113	4	291	408	38	446
Rangareddy	0	3	165	168	0	2	165	167	1	168
Srikakulam	37	28	459	524	37	28	442	507	17	524
Visakhap**	28	18	375	421	28	18	369	415	6	421
Vizianagara	0	22	439	461	0	21	422	443	18	461
Warangal	29	18	683	730	28	18	623	669	61	730
W. Godavar	71	6	217	294	70	6	205	281	13	294
Total	1700	411	8181	10292	1645	401	7754	9800	492	10292

Note: *Includes 9 WUAs under Vattivagu & Chelamalavagu.
**Includes Tandava (Part Only) #Includes 12 WUAs under Tandava ^Includes 7 WUAs under Koulsanala.
Source: Department of irrigation, Govt. of Andhra Pradesh.

Figure 1: Structure of the Participatory Irrigation Management in Andhra Pradesh



Institutional Structure[14]

As per the act all the surface irrigation schemes, major, medium and minor, are covered under the programme. The exceptions being the schemes under the panchayati raj institutions and all minor water bodies in the scheduled areas of Andhra Pradesh. Command area of the project will be delineated on hydraulic basis that would be administratively and functionally viable. Each farmer's organisation will have even number of territorial constituencies or committees (TC) with in the WUA. Area covered by each constituency depends on the nature of the project and size of the command area. It ranges between 150 and 250 hactares in the case of Major and medium projects and between less than 50 and 200 hactares in the case of minor irrigation projects. Each TC will have an area between 250 and 600 hectares. The area under the WUA ranges from 250 to 3500 hectares. The area will be much less in the case of minor systems. Depending on the type of irrigation scheme, one to three tier systems of associations / committees will be in place. Each assistant engineer will be in-charge for a maximum area of 4445 ha and four to five times of this area would be under a deputy engineer. The basic structure of the PIM is presented in Figure 1.

Water user associations are the primary structures of irrigation water users. Number of WUAs under each scheme would depend on the size of each irrigation scheme, which could range from one to a few hundreds of WUAs in each scheme. The main role of WUA is to regulate and distribute water with in its command area. The total command area will be divided into 4-10 constituencies. Each constituency will elect a member of the WUA managing committee and directly elect the president of the WUA. All the landholders, title holders as well as tenants, within localised / authorised area are members of the WUA with voting rights. All other water users will be co-opted members without voting rights. A group of WUAs under a distributory or a small group of distributaries comprises a distributory committee (DC), which will look after the distributory related issues. All the WUA presidents are members of the DC and they elect the managing committee and the president of the DC. All the DC presidents will be members of the project committees (PC). PCs are in-charge of the entire project command area, which is often divided in to 7-11 constituencies. The

14 For more details see Pangare (2002); Jairath (2001) and Raju (2000).

members of the PC will elect the president and 7-11 managing committee members from each constituency. Above all an apex committee headed by the minister for major and medium projects shall be constituted to formulate broad policy guidelines and to resolve disputes.

Functions of these bodies include preparation of operational plans at the beginning of each season, maintain an inventory of irrigation systems such as tanks, ponds, wells, etc., within the command area, maintenance of records, plan and execute the distributory and drainage systems maintenance, water budgeting, resource mobilisation, conflict resolution, etc. One interesting feature of the WUAs is the right to recall the president if his functioning is not satisfactory. The general body can remove him with one-third majority. However, the institutional structure misses out on some important aspects that are necessary for the success and sustainability of the institutions. There is an in-built bias against minor irrigation, as the minister for major and medium irrigation is heading the apex committee though there is separate ministry for minor irrigation. The apex committee provides the broad policy frame and hence it is but natural to favour major irrigation. This reflects in the performance of the WUAs in the two sectors (discussed later). All the rights in WUAs are given to land owning and tenant cultivators to the neglect of land less and other water users such as land less women, fishermen, etc. This denies equitable access to a common pool resource. As a result, the huge public investments in this sector benefit only a section of the community, though in a majority. Equal distribution of water rights is seen as vital for sustaining water institutions (Deshpande and Reddy, 1990).

Financial Aspects

The whole process is funded through external funding. Under the Andhra Pradesh Economic Restructuring Programme each WUA and DC got Rs. 50 per acre during the first year (1998-99) and Rs. 100 per acre in the second year (1999-00). Of this WUA at the minor level gets 60 per cent, DC gets 20 per cent and PC gets 20 per cent share. Though the allocations look small on per acre basis at the aggregate level this could be any where between Rs. 50,000 to 8,00,000 per WUA in the canal commands. Where as in the case of tank WUAs the amount would be below Rs. 5000 per WUA in majority of the cases. During the year 1998-99 Rs. 1070 million were spent of which Rs. 1030 million were spent just in 45 days. This has led to rent-seeking attitude at the department level as every bill has to be passed by the accounts officer before going to the WUA. Besides, every year WUAs in the major canal commands receive Rs. 200 per acre (Rs.100 per acre for WUA and Rs. 100 per acre for the DC). Under this during 1999-2000 Krishna delta got Rs. 123.6 million; Nagarjuna Sagar left canal Rs. 60 million; medium projects got Rs. 3 million; and minor projects got Rs. 10.4 million (Raju, 2000). Moreover, in the canal WUAs entire money is spent on repairing the distributory network while in the case of tank WUAs tanks as well as the distributaries need restoration requiring more investments. Present funding when compared to the actual requirement for tank restoration is grossly inadequate (see later section). This clearly reflects the bias in favour of canal WUAs.

Table 4.2: Revised Water Rates for Different Crop Categories

Crop Category	Type of source wise water rates per acre in Rs.			
	Category I		Category II	
	Old	New	Old	New
1. First / Single wet crop	60	200	40	100
2. 2nd and 3rd wet crop	60	150	40	100
3. 1st crop irrigated dry	40	100	20	60
4. 2nd and 3rd irrigated dry crop	40	100	20	60
5. Two-season crops per year	120	350	80	350
6. Aquaculture per year	00	500	00	500

Note: old rates with effect from July 1986 and the new rates from July 1996.
Source: APERP Project Implementation Plan, 1998.

As indicated earlier the PIM programme is entirely funded by external sources. Though user contribution of 15 per cent is imbibed in the PIM act there is no evidence of any contribution from farmers so far. In fact, there are no efforts to collect this contribution. However, it is expected that WUAs would become self-sufficient over time through hike in water rates coupled with better recovery. As a first step water rates were raised by 3 times during 1996-97 (Table 4.2). After the revision, it was reported, water fee collection has increased by 9 per cent from 54 per cent to 65 per cent during 1997-98 (Raju, 2000). But, this is not reflected in any way in the budget figures during or after the year 1997-98. Such idiosyncrasies could be due to the absence of devolution of powers to the WUA level. As per the act WUAs are expected to become self sufficient in managing their affairs. They are expected to assess the command area and collect the water cess. Since the entire fee is retained at WUA, DC, PC and local body level there is no incentive for under reporting of area. The proposed revenue sharing pattern is presented in Table 4.3. The first step in this direction was initiated during the current year (2001-2002) though the approach is cautious. Initially, the plan was to plough back 50 per cent of the revenue collected to WUAs (25 per cent) and DCs (25 per cent). But, irrigation department is still carrying out the collection of water charges. The impact of this new system is expected to reflect in the next year data. However, it is a long way before the devolution of power takes place. Till then the PIM in Andhra Pradesh would have to sustain on external sources of funding.

Table 4.3: Proposed Revenue Sharing Pattern among the PIM Structures (%)

Level	Major	Medium	Minor
Water User Association (WUA)	50	60	90
Distributory Committee (DC)	20	30	---
Project Committee (PC)	20	---	---
Local Government	10	10	10

III Impact of the PIM: Some 'Early Bird' Views

It is too early to assess and evaluate the PIM programme in Andhra Pradesh, as the process of implementation is just falling in line. While some of the early studies indicate the positive aspects of the programme, most of them raise questions on the sustainability of the programme once the external funding dries up. But, by then the WUAs are expected to be financially self sufficient, socially stronger and politically united to manage the systems efficiently. Therefore, it would be hasty to brand the PIM in Andhra as a success or failure[15]. In this section we present the observed impact of the WUAs based on field studies and our field observations. The impact appears to differ between canal WUAs and tank WUAs. The impact of canal WUAs has been positive, especially in terms of providing irrigation to tail end farmers who were not getting water for the fast 5-10 years (Raju, 2000; Jairath, 2001). The tangible benefits include: a) area under irrigation has increased mainly in the tail reaches by 10-15 per cent due to the increase in carrying capacity of canals by 20-

15 To capture both the views see Pangare (2002), Jairath, (2001), Raju (2000), Reddy (1999) and Peter and Pingle (1999).

30 per cent; b) increase in paddy yields from 2.5 tonnes per acre to 3.5 tonnes per acre; c) increase in revenue collections by 20 per cent (Raju, 2000).

These are some of the aggregate level observations while the micro level reality is different. In a detailed study (Parthasarathy and Joshi, 2001) of water user associations located in three different regions of Andhra Pradesh it was revealed that the performance of WUAs has only a limited success in terms of participation as well as impact (Tables 4.4 and 4.5). This is mainly due to the fact that these WUAs are too young to evaluate. In fact, majority (51.5 per cent) of the households are not even aware of WUAs though there are variations across the regions (Table 4.4). Participation levels are very low. The highest participation is in the WUA election, which stands at 7 per cent followed by R & R work (5.8 per cent), motivation (2.5 per cent), etc. Only about 17 per cent of the households are contributing labour as their share. And most of this contribution comes from small farmers and tail end farmers. Only 13 per cent of the households participate in the annual general body meetings. Majority of the tail ender farmers attend the meetings when compared to head reach farmers despite greater awareness of the WUAs among the head reach farmers. On the other hand, participation among the committee members is quite high. This clearly indicates the absence of general awareness and interest regarding the WUAs.

Table 4.4: Farmers Participation WUA Activities Across Locations

Details	WUA I (Telangana)	WUA II (Coastal Andhra)	WUA III (Rayalaseema)	Andhra Pradesh
1. % of HH participating in WUA activities				
--Motivation	---	---	---	2.5
--Election	---	---	---	7.0
--R&R work	---	---	---	5.8
--Water distribution	---	---	---	1.1
2. % of HH contributing labour by farm size				
--Small	---	---	---	21.7
--Large	---	---	---	5.0
--Total	---	---	---	16.7
3. % of HH contributing labour by location				
--Head	---	---	---	25.4
--Middle	---	---	---	11.9
--Tail	---	---	---	62.7
4. % of Farmers participating in Annual General meetings by farm size --Small	20.8	40.0	15.4	14.9
--Large	16.7	10.0	23.1	17.0
--Total	19.8	8.5	10.8	13.1
5. % of Farmers participating in Annual General meetings by location --Head	58.3	20.0	15.4	38.3
--Middle	12.5	---	15.4	10.6
--Tail	29.2	80.0	69.2	51.1
6. % of farmers not aware of WUA by farm size --Small	25.0	30.4	27.2	27.6

--Large	4.2	5.4	13.6	8.6
--Total	39.7	47.5	67.5	51.5
7. % of farmers not aware of WUA by location --Head	43.8	16.4	17.3	38.3
--Middle	25.0	7.3	12.3	10.6
--Tail	31.3	76.4	70.4	51.1
8. Participation of the committee members in Joint Survey (%)	80.0	62.5	83.3	73.7
9. Participation of the committee members in 1999 meetings (%)	80.0	71.4	66.7	72.2
10. Participation of the committee members training and exposer visits (%)	100.0	75.0	16.7	63.2

Note: Compiled from Parthasarathy and Joshi (2001)

In comparison with participation impact of the WUAs is marginal. Only 2 per cent of the sample households reported increase in area under irrigation, which is consistent across the regions (Table 4.5). After 5 years of WUAs still above 60 per cent of the farmers are reporting deficit in water supplies. In coastal Andhra 85 per cent of the farmers are complaining about the deficit. Interestingly, small and tail end farmers are reporting better access to canal water. For, these farmers report use greater number of irrigation and lower proportion of these farmers report severe shortages when compared large farmers or tail end farmers. It is somewhat puzzling, as the data does not clearly indicate whether the prevailing situation is due to the advent WUA. It is unlikely that head reach farmers use less number of irrigations apart from facing more severe shortage of water when compared to the tail end farmers.

Table 4.5: Impact of WUAs Across Locations.

Details	WUA I (Telangana)	WUA II (Coastal Andhra)	WUA III (Rayalaseema)	Andhra Pradesh
1. % of HH reporting increase in area due to WUA	2.5	1.7	2.5	2.2
2. Avg. no. of irrigations (all crops) by location --Head	---	---	---	4.3
--Middle	---	---	---	12.7
--Tail	---	---	---	9.3
3. Avg. no. of irrigations (all crops) by farm size --Small	---	---	---	16.3
--Large	---	---	---	02.7
4. % of WUA plots reporting Deficit waterings up to --1 to 3	27.6	80.6	14.5	52.1
--4 to 6	13.2	11.5	22.4	14.5
--7 to 10	9.2	3.0	25.0	19.6
--above 11	50.0	3.0	25.0	19.6
--All	45.8	85.6	54.2	61.6
5. % of WUA plots reporting high Deficit (>11) waterings by location --Head	---	---	---	35.0
--Middle	---	---	---	34.5
--Tail	---	---	---	11.6
6. % of HH reporting high Deficit (>11) waterings by farm size --Small	---	---	---	32.7
--Large	---	---	---	40.5

Note: Compiled from Parthasarathy and Joshi (2001)

These findings, however, indicate that WUAs seem to be working well especially in the canal commands. In majority of the cases it is observed that tail-end locations are getting sufficient water for the first time in five years. In one of the tail end villages we have visited in the Nagarjuna Sagar Right Canal area it was observed that the area under irrigated paddy has gone up from 500 acres before the advent of the WUA to 2000 acres after its advent. And the area under irrigated paddy is increasing steadily. However, these benefits are not reflected in the data at the state level or regional level, which supported by the regional level study (Parthasarathy and Joshi, 2001). As reflected in our analysis, the reform process initiated in irrigation sector in particular does not seem to have made any dent in increasing the area under irrigation or increase in revenue collection or an increase in paddy production by 40 per cent. Apart from this the success of WUAs is attributed mainly to the availability of external funding and the sustainability of the programme is critically linked with the availability of resources (Raju, 2000). Besides, investments may not bear any fruit, as this money is not productively invested in terms of social capital development. This, in turn, blocked the hard decisions envisaged in the reforms, such as implementation of user charges effectively.

On the other hand, evolution of Water User Associations (WUAs) is focused on operation and maintenance of the existing systems. Success of WUAs is linked with the funding, as little effort is being made to make them self-sufficient or financially independent. Our discussions with some of the WUA members revealed that the formation of WUAs helped in taking water to tail end areas. Here also the success is dependent on the cooperation and collective action potential at the village level. Beyond this, so far the WUAs achieved little. They could not even reduce the under reporting of area irrigated. For the official figures on area under canal irrigation show a decline, while most of the tail-end locations are reporting substantial improvement in the availability of water after the advent of WUAs. There seems to be a nexus between farmers and Village Level Workers (VLW who collects the area statistics). It is indicated that often 60 per cent of the irrigated area is reported for the collection of water charges and the charges on 20 per cent of the area are taken by the VLW. Effectively the farmer will be paying for 80 per cent of area irrigated by him. This is a mutually beneficial arrangement. These arrangements are widespread in the regions where WUAs are not strong. In fact, it was observed that in some cases the irrigation department has not yet revealed the details of command area under each WUA. There is widespread feeling that the department is not keen in strengthening the WUAs, as their continuation will go against the department's interests. In some regions WUAs have turned into mere political entities. Moreover, in majority of the cases contractors have turned into WUA presidents. As a result, WUA's have become moneymaking ventures.

The approach at the policy level seems to be to sustain WUAs through injecting more funds (borrowed). This is in the interest of policy makers and political entrepreneurs. For, it perpetuates rent-seeking activity as well as populism. User contribution has not really materialised, as it goes against political interests. As a result, economic efficiency gets least priority though talking about it is in vogue. Political compulsions are the hackneyed excuse. This approach is myopic at its best, as it would fail to achieve economic as well as political gains in the long run. Supporting the WUAs is rewarding to political entrepreneurs as well as policy makers in the short run i.e., as long as funds are available. The sustainability of WUAs is in danger once the funds dry up. Approach of the state is not to build social capital by making the best use of the available resources, but to dilute it by giving political colour. Consequently, neither the bureaucracy nor the beneficiaries are motivated enough to sustain these institutions. Though it is not feasible to make these institutions totally apolitical, an integrated approach would have been more rewarding.

Hitherto the active participation (though low) of people is ensured through proper flow of funds. Further, groundwater irrigation is not integrated with other sources of irrigation. Groundwater is the single largest source of irrigation and highly dependent on surface water sources like tanks. In the absence of any institutional arrangements for managing groundwater, its sustainability is uncertain. For all practical purposes groundwater is treated as a private source and hence none of the numerous regulations on the use of groundwater was effective. Unless groundwater is brought under the purview of community management, it would be impossible to ensure sustainability (ecological) and equity in its distribution. However, of late, there appears to be some progress in this direction under the guidance of water conservation mission established in the state.

Another important dimension of WUA's is the emphasis on elections. Elections are fought on the party basis, which makes people insensitive to common good. Besides, the WUA election is one among the five such committees electing their office bearers five years. Party politics have already made a dent in the village unity. The frequent elections to the newly created institutions would aggravate the situation. The indications are already there, especially in the case of watershed committees. This goes against the basic philosophy of participatory development and management. For, these institutions in their present form tend to dilute the social capital rather than strengthening it.

Environmental Concerns and PIM

While it is too early to observe any substantial impact on environment, field observations revealed declining soil and water salinity after the advent of the programme in the Godavari delta due to the improved drainage facilities (Vermillion, 1999 as quoted in Pangare, 2002). Availability of sufficient water in the tail ends has facilitated the flushing of salts from soils and also reduced dependence on groundwater, which has high levels of salinity (Pangare, 2002). However, the in-built bias against minor irrigation in the PIM militates against the objective of bringing ecological balance in the fragile resource regions. The support received by minor systems is inadequate to revive them and check the environmental degradation in terms of groundwater depletion and soil erosion (wind). A majority (81 per cent) of the WUAs promoted by the State cover minor irrigation tanks. Despite this area under tank irrigation continues to fall and groundwater tables continue to deplete indicating that there is no discernible impact of the programme as far as minor irrigation is concerned. Unlike in the case of canal irrigation micro observations do not provide any evidence to the contrary. This is mainly due to the fact that the programme is not designed to suit actual needs of these systems. This mismatch becomes clear if we look at some of the NGO initiatives in tank restoration in comparison with the formal institutional arrangements.

The formation of formal WUAs is complex. WUAs are formed on the basis of hydraulic boundary. On the other hand some of the NGO initiatives attempt to revive the traditional tank systems and manage them in a sustainable fashion with people's participation. Here we examine one such initiatives supported by SPDW (Society for Promotion of Wasteland Development) in the Rayalseema region. In this case Tank Management Committees (TMCs) are formed to take up the tank restoration works and management. The main difference between the formal WUA and TMC is the coverage of area. TMCs are tank or village based while WUAs are area based. As a result, even the members of WUA are not aware of the command area details (Raju, 2000). The approach of WUA is to strengthen the distribution network for efficient use of water. As a result the funds provided for tank WUAs i.e., Rs. 100 per acre of command area are not sufficient for taking up the tank restoration works. Our case studies reveal that the cost of restoration ranges between Rs. 4000 to above Rs. 6000 per acre of command area given the small size of the tank command area in majority of the cases. Unless tanks are restored fully there is no point in spending money on minor repairs of distributory network. The insufficiency of funds for tank WUAs is well recognised at the official level and there is imbalance between tank WUAs and canal WUAs in terms of fund allocations. In this regard the SPWD's approach is practical and sustainable.

The responsibilities of WUAs include: a) maintaining irrigation system within its command area, b) preparation of operational plans at the beginning of the crop season, c) ensuring equitable distribution of water and resolving the conflicts among members, d) maintaining records, collection of water charges, etc. Further, WUAs are given power to raise funds locally for its activities. The practical problems faced by WUAs are well recognised. It is clear that when WUA is not familiar with its command area it is unreasonable to expect them to ensure equitable distribution of water. They are yet to show improvement in the collection of water charges. Other important criticisms against tank WUAs include: dominance of upper class farmers from the ruling party, no proper representation for women and other tank users such as fishermen, washer men, etc (Venkateswarlu and Srinivas, 2001).

On the other hand, the process of tank restoration appears to be much better and sustainable in Adepalle village where a local NGO (Chaitanya) has initiated the process. In this village the flow of benefits and the condition of the tanks are maintained even after five years after the completion of the programme (Reddy, 2001). The activities of Chaitanya in Adepalle village provide some useful insights in this regard (see Box 1).

Box 1:Tank Restoration: The 'Chaitanya' Experience

'Chaitanya' is an NGO in Anantapur involved in tank restoration programme for a long time. 'Chaitanya' is the PIA in Adepalle. The approach of Chaitanya's to the process of tank restoration was through demonstration effect. Initially, it has conducted study tours for the farmers of Adepalle to some of the percolation tank sites elsewhere in the district. After seeing the impact farmers were eager to restore their tanks and approached the NGO for help. In this way the demand drive is imbibed. The result of this is higher contribution from the farmers towards the expenditure on tank restoration. Higher contribution creates higher stakes in protecting the tank. In fact, farmers who are having wells under the tank come forward voluntarily to take up the repair works at their cost. Providing the silt free of cost to the farmers encourages desiltation of tank on a regular basis.

'Chaitanya' keeps the equity conflicts at bay through continuous follow up support. It helps the farmers to get 50 per cent of the cost as loan from banks for community wells in the tail ends of percolation as well as irrigation tanks. Besides, well owners sell water to others. The price of water varies according to the availability of water in the tank. When water is plenty well owners charge at Rs. 5 per hour of pumping and when water is scarce they charge Rs. 10 per hour. These water markets help in pacifying equity conflicts.

Source: Reddy (2001).

The issue of percolation versus irrigation tanks is also important. Conversion of old tanks in to percolation tanks raises property rights and equity issues. Farmers in one of the villages in Anantapur district had gone to court against the conversion of their irrigation tank in to percolation tank. But, ultimately they have withdrawn the case after seeing the benefits from the percolation tank, thanks to the delay in the judicial system. In Adepalle two of the tanks are converted in to percolation tanks after lot of persuasion and demonstration of benefits from percolation tanks elsewhere. Though percolation tanks are more beneficial in the long run, it goes against the interests of the command area farmers who were getting cheap or free water earlier. Moreover, the improved groundwater benefits may not be accessible to all sections of the farmers due to lumpy and capital intensive nature of groundwater lifting technology.

Follow up support systems are required to safeguard the equity aspects. This is applicable even in the case of irrigation tanks though in a limited way (tail-end farmers).

The experience of informal institutions in comparison with the formal ones brings out the wide gaps in the approach to address the issues at hand in the fragile environments. It also indicates that the approach needs to be more specific in these regions rather than following a blanket approach by placing them along with the endowed regions. These regions have long been victims of the policy neglect resulting in severe regional imbalances. Unless the present opportunity is effectively used to correct these imbalances it would perpetuate the on going environmental degradation and economic inequalities. The recent policies on rainwater harvesting and establishment of water conservation mission are a few instances in this regard. Besides, watershed development programme was launched on a massive scale to address the problems of water conservation in the rain fed regions. About 5000 watershed committees were formed to manage the watersheds. The scale and the approach of these programmes are unprecedented in the country.

IV Strengthening and Sustaining the Institutions

Institutional factors are considered as the key for improving the efficiency of irrigation systems. Moreover, for shifting towards demand management (through pricing and technological variables) institutional arrangements ought to be in place. For, mere increase in the price of water may not result in financial sustainability of the systems unless and until the pricing policies are backed by institutions to recover the charges (Reddy, 1999). It is often argued that the reason for the ills of irrigation management is the alienation of farmers / beneficiaries from the process of planning and implementation. Maintenance and management of irrigation systems through user societies and participatory process is expected to bring in efficient and equal distribution of water resources. It was observed in Philippines that the participatory units obtained improvements over non-participatory units in terms of irrigation fee collections and thus improving the viability of the system (Sengupta, 1991). In the case of Japan the Land Improvement Districts (LIDs), which are nothing but farmers organisations carry out comprehensive land and water management programme in order to improve agricultural productivity. These institutions are not only engaged in the operation, maintenance and smooth distribution of water but also conceive new ideas, new schemes to be implemented through construction activities (Mitra, 1992). However, some argue that most of these studies are based on the experience in east Asian countries where irrigation systems are small, their replicability in the context of large irrigation systems such as in India is rather unclear if not a difficult proposition (Wade, 1988 a & b; Moore, 1991; Sengupta, 1991).

But, in a pioneering effort the Government of Andhra Pradesh has initiated irrigation reforms on a large scale, which is unprecedented. In fact, these reforms are ranked very high even at the global level and expected to be a future model in irrigation management. The state has shown the way that political will is the main ingredient for such initiatives. The most interesting feature of these reforms is that they are 'top down' with a 'bottoms up' approach. It has the advantage of greater reach (possible under 'top down') and intensity through involvement of the community (possible under 'bottoms up'). These reforms under the guidance of some committed officials at the state level have taken off in good spirit and received good support at the farmer level. Though, one may argue that flow of funds is the main factor in generating such response, it is necessary to support the ailing systems in order to generate trust among beneficiaries. For, over the years farmers have lost the trust in the government and in no position to respond to false promises. Therefore, the initial boost is necessary to regain the lost credibility and build the trust. Once this is in place institutional reforms from top becomes smooth and easier. But it is necessary to under stand the direction in which the reforms are progressing. This direction would ultimately determine the strength and sustainability of the reforms.

Our review of WUAs clearly brings out that it is too early to talk about the impact of the WUAs. Obviously, there is greater need to strengthen them in terms of people's participation and involvement. Immediate need is increase the awareness about the WUAs and the advantages of these institutions. In what follows we discuss briefly some pointers for strengthening and sustaining this important policy initiative.

1. There is an immediate need to bring the balance between minor, major and medium irrigation systems through judicious fund allocations under the purview of WUAs.

2. Minor irrigation sources of tanks and groundwater should be treated in an integrated fashion. For this groundwater needs to be brought under the purview of the WUAs. This calls for major initiatives in legal and legislative reforms to address the rights on groundwater. The experience of South Africa would help in understanding the issues delinking of water rights from land. In fact, South Africa has effectively abolished the riparian rights.

3. The reforms should initiate the process to convert water in to an economic good through introduction of volumetric pricing at least in the canal commands to start with. Effective reforms require integration of market and institutional dimensions. Though short run political interests may go against this, it would have multiplier effect on the long run political and economic gains. At the same time proper devolution of powers to local level institutions would help in addressing the political bottlenecks effectively.

4. Transfer of powers and responsibilities to the WUAs at the minor level should be done in an effectively though in a phased manner. Hither to, WUAs are entrusted with responsibilities without any rights.

5. There is need for exploring the possibility of integrating the panchayati raj institutions in to the reform process for sustaining the reforms in the long run. For, these local bodies are totally bypassed by the new initiatives.

6. Similarly, integration of tank restoration with watershed development would not only strengthens the ecological base but also gets the community support as it would enhances benefits from both these programmes (Reddy, 2001).

CHAPTER V: WATER QUALITY (POLLUTION): THE BLIND SPOT

An important dimension of water resources that has not received due attention is it's quality aspects. While the magnitude of the problem is limited and spread over the losses due to its impact is quite substantial. This is mainly due to its direct impact on human health and livelihoods. This chapter makes an attempt to address this aspect. The focus here is to study the environmental impact of water pollution on the rural communities in general and on agricultural production, human health, and livestock in particular. Some of the important issues in this regard are: a) linkages between the industrial development and changes in micro (local) environment, b) damage to crop and animal husbandry due to industrial pollution and, c) impact on human health in the rural communities. These issues are studied in detail with the help of primary (household level) data collected from an intensive study of two villages – one a pollution-affected village and another a control village (not affected by pollution) located in the industrial belt near Hyderabad. This chapter is organised in five sections. A review of studies on the impact of industrial pollution on agriculture and health is presented in the following section. Section three discusses the data used and the methodologies adopted in the study. Based on the data analysis, impact and valuation of the damages due to pollution are estimated in section four. And the last section narrates the failures and options in correcting the problem.

I Impact of Industrial pollution: A Review

The pervasive spill over effects between sectors that are kept outside the domain of market is one of the important market failures, which leads to severe environmental degradation both in developed and developing countries (Panayotou, 1993). The impact of industrial pollution on other sectors is one of the most classic examples of this sort. The main reason behind this is market failure. Externalities and public good nature of environmental goods and services are responsible for market failure. One way to overcome the problems of market failure is to enforce property rights. However, in many externality type situations, the cost of enforcing property rights is found to be high and difficult to enforce. The problem is acute, especially, when it comes to the environmental problems related to industrial pollution. Theoretically it is true that air and water pollution problems arise mainly because the atmosphere and watercourses are not and cannot be privately owned. It means each individual / organisation has no incentive to take into consideration the effects of his use on other individual / organisation. In the case of negative effects of industrial pollution, the social cost, which is equal to the sum of the costs to all individuals, is greater than the private cost to the individual using air and water for waste disposal. The implication of this is that a decision-maker does not take into account the societal costs while making decision on how much to dump in to the environment.

The crux of the problem lies with how to internalise the externalities by taking the social costs in to account. Certain policy instruments such as Command and Control (CAC) and economic instruments would help in the process. These policy instruments require political will and institutional strength to implement them. However, it is seen that the government often fails to implement such policies due to various economic and political compulsions. Some argue that Coase's theory of costless collective bargaining among the relevant agents can be an alternative. However, Coase theorem does not seem to work in the real life as far as environmental goods and services are concerned. The main drawbacks associated with Coase theorem is that of uncertain externalities and large number of economic agents involved. When a couple of firms are polluting the streams or rivers, one is not sure who is polluting much. Similarly, when the number of agents (polluters and victims) is large, it is quite impossible to bring together without transaction costs for bargaining. (Dasgupta and Maler, 1997).

On the other hand, economic and institutional measures could help in addressing the problems to a large extent. Economic measures, when used properly, would help in reflecting the real value of the goods and services. However, valuation of environmental impact is very much essential for designing appropriate economic measures. Environmental damages impose costs on societies that are not reflected in market prices, need to be valued to compare the benefits of environmental protection with the costs of remedial action in order to make better policy decisions. Quantifying the impact of environmental damages can provide a more secure basis for policies (e.g., taxation, charges, subsidies etc.) to induce more careful environmental use.

The rapid industrialisation in developing countries has not only contributed to economic development but also contributed to the heavy loss of economic welfare in terms of effects on agricultural activities, human health and ecosystem at large through air and water pollution. Basically water pollution poses a serious challenge due to its impact on a large number of economic activities. The problem of water pollution acquires greater relevance in the context of an agrarian economy like India.

Though there are number of empirical studies on agricultural related environmental problems, such as soil degradation, wind and water erosion, only a few studies have dealt with environmental problems associated with industrial pollution and its impact on agriculture and other sectors. Though at the macro level Pearce and Warford (1993) have estimated the costs of environmental degradation in terms of human health, soil erosion, deforestation, etc., most of the indicators are not directly related to industrial pollution. It is shown (Pearce and Warford 1993) that the damage costs in the developing countries are higher than the developed countries. According to their estimates the environmental costs in the developing countries are about 5 per cent of their GDP.

However, a few studies have dealt with the impact of industrial pollution on agriculture, human health and ecosystem in the developed countries (Pearce, et. al; 1978). For instance, Pinock (as cited in Pearce et al 1978) has analysed the effects of different levels of water quality on output and incomes for irrigated agriculture. Using the time series data, he studied three levels of electrical conductivity (EC) of irrigated water and its impact on crop yields and budgeted income: EC = 1.25 (1960), 1.44 (1980), 1.93 (2010). He estimated the damage for two points, one at $1350 for crop loss for the year 1980 and the other one is projected damage in the year 2010 (estimated at $854,679) due to crop loss. The projected loss cannot be considered as it is because one is not sure of the future EC levels. Vincent and Russel (as cited in Pearce et al, 1978) have presented a more comprehensive analysis of saline water damages in the Colorado River basin. These studies have examined the losses to municipal, industrial and agricultural sectors as well as the indirect losses to the regional economy. Based on this they have estimated the total damage costs for 1980s at around $26 million.

Human health is one of the most important factors influencing economic development in any economy. For, a healthy workforce is very much essential to the development of an economy. A healthy workforce requires a healthy environment, i.e., clean air, water, recreation, wilderness, etc. Pearce and Warford (1993) have argued that the most important and immediate consequences of environmental degradation in the developing world take the form of damage to human health. Further they argued that Diarrhoea is a common occurrence in many developing countries where three million to five million cases are reported every year. Each case is estimated to involve a loss of 3-5 working days, amounting to 9 million working days lost in a single year.

It has been found that the developing countries are facing serious problems relating to water borne diseases due to lack of safe drinking water. Walsh and Warren (as cited in Pearce and Warford, 1993) have estimated mortality and morbidity from water borne diseases in Africa, Latin America, and Asia. According to them water borne diseases due to water pollution have definite impact on morbidity and mortality. And ultimately it has serious negative impact on economic activities in the form of loss of working days, death of trained workers, expenditure on hospitalisation, etc. Besides, number of attempts has been made to estimate the economic costs of health damage due to water pollution in developed countries. Pearce, et. al. (1978) has reviewed some of the studies conducted in the USA to estimate national health costs of polluted water. Outbreaks of the disease were monetarised on the basis of ten days-lost income and resource cost of a five-day stay in hospital. It was estimated that the social cost per case was $100 and there were approximately 1 million cases of Gastroenteritis per annum in the USA. In fact, two million working days are lost in the USA due to acute Gastroenteritis and Diarrhoea at an average wage loss of $30 a day. Recently Yongguan, et. al (2001) has made an attempt to estimate the impact of industrial pollution on agriculture, human health and industrial activities in Chongqingm, which is one of the heavily polluted mega cities in China. It is estimated that the total costs of industrial pollution are 1.2 per cent of Chongqing's gross product. Of this 56 per cent is in agriculture sector, while the damages to human capital and industrial sector are 20 and 18 per cent respectively. From these studies reveal that industrial pollution imposes severe costs on other related sectors in an economy.

In India, industrial pollution seems to be one of the most important factors causing water pollution due to weak regulatory system. Industries release effluents in to the water bodies, which contain chemical and biological matter that impose high demand on the oxygen in the water. Apart from this, industrial wastes contain chemicals and heavy metals like arsenic, lead, mercury, cadmium and zinc, which are harmful to human health and ecosystem. When used for irrigation purposes, polluted water has serious impact on land productivity. Heavy concentration of chemicals and metals in both surface and groundwater bodies cause serious damage to the ecology of various river systems. The consequences of water pollution due to heavy discharge of industrial effluents are being witnessed by majority of the industrially booming towns in India. Surveys carried out in some of the industrial towns show that pollutants exist beyond acceptable range in water, soil and air. The impact of pollution is found even in the food chain in some places (Down to Earth, 1998; Reddy, 1998). In the recent years, attempts have been made in India to estimate the various impacts of industrial pollution and sewage on human health, agriculture and livestock and other sectors of the economy (Shankar, 2001; Dasgupta, 2001; and Markandya and Murty, 2000). In one of the studies in Tamilnadu, the impact of tannery effluents on water quality, human health and soil use in Ranipet and Vaniyambadi regions in the North Arcot District is found to be conspicuous. Using the secondary data sources like Public Works Department (PWD), Central Pollution Control Board (CPCB) and Soil Survey and Land use Organization, etc., along with primary data on people's perceptions regarding the impact of industrial pollution, the study showed that the various parameters of water have crossed the normal range resulting in substantial damage to human health, agriculture and livestock (Shankar, 2001). Dasgupta (2001) has tried to estimate the health damages from the water pollution in urban Delhi by using a health production function. The costs of illness (including the costs of wage-loss and cost of treatment) are about Rs. 1094.31 per household. Another comprehensive study on a cost-benefit analysis of the Ganga Action Plan carried out by Markandeya and Murty (2001) estimated both user and non-user value of benefits from the Ganga Action Plan and shows the economic viability of the project.

II Profile of the Study Region

The study region falls in the Patancheru, Jeedimetla and Bollarum industrial belt of Andhra Pradesh. People living in and around these industrial estates have suffered damages in terms of losses to crops, cattle and agricultural equipment such as pump sets; contamination of drinking water, diseases and deaths due to water pollution. In Jeedimetla and Patancheru industrial estates, it is estimated that more than 7000 acres of productive farmland have been contaminated with toxic chemical run-offs, while more than 5,00,000 people have been adversely affected, either through diseases arising out of water pollution, or loss of traditional livelihoods (Murty, et. al, 1999). In Jeedimetla industrial estate within 10 km. radius of Ayodhyanagar, all the drinking water and agricultural wells are contaminated with toxic chemicals. The effect on traditional livelihoods is equally devastating. Toxic factory emissions have burnt out the tops of toddy palms within a radius of 1 km, depriving toddy tapers of their only source of income (Sarangi and Cohen, 1995). A study prepared by the National Environment Engineering Research Institute (NEERI, 1991) has identified the extent of losses to agricultural production and cattle in the villages near Patancheru and Bollarum industrial areas. According to this study, as many as 629 farmers are affected in 15 villages and 1602 hectares of cropland is damaged. The value of crop loss is estimated at Rs. 517 lakhs. Also as many as 1323 cattle deaths were reported in seven villages in this area due to industrial pollution. About 150 pump sets were reported to have rusted and become obsolete due to water pollution in this area. About 59 fishermen and 40 washer men have had to change their professions due to pollution of ponds and streams. Many agriculturalists have turned industrial workers due to water pollution.

Another study conducted by a research team from the Institute of Economic Growth in 1995 (as mentioned in Murty, et. al. 1999) shows that polluted land per family is 2.7 acres. The annual per household and per capita income losses of the affected households in the area covered by the industrial estates of Patancheru, Bollarum and Jeedimetla are estimated at Rs. 10, 992 and Rs. 1,615 respectively. It is also observed that groundwater pollution has affected drinking water in most of the villages. Of late, drinking water is being supplied to some of the villages from Manjeera river project, which is priced at Rs. 20 per month per household. Many other villages are currently using contaminated groundwater. Manickam (2001) has carried out a study in both Kazipally and Gandigudem villages on the impact of industrial pollution on soil and water and also made an attempt to estimate the remedial measures to clean up the environment. It shows that the extent of water and soil pollution in the village is much higher than the acceptable range. The estimated costs of cleaning the environment (replacement costs) are presented in Table 5.1. The replacement costs of industrial pollution range between Rs. 63 lakhs in Kazipally to Rs. 47.5 lakhs in Gandigudem. A lion's share of these cost go towards desilting of the tanks i.e., clearing them off the toxic material and soil.

Table 5.1: Money Required for Remedial Measures for various impacts of industrial pollution in Kazipally and Gandigudem villages.

Remedial Measures	Money Require in (Rs)
Kazipalle:	
1. Supply of Potable Water	240000
2. Repair and Restoration of the existing hand pumps and dug wells	100000
3. Extensive health Check up	200000
4. Improvement of animal husbandry	500000
5. Desilting of tank	5360000
Gandigudem:	
1. Extensive health checkups	400000
2. Improvement of animal husbandry	600000
3. Desilting the tank	3750000

Source: Manickam (2001)

However, most of these studies were not systematic in their approach. The estimates are made on the basis of single reference point. They have not taken in to account the changes over the period or compared the affected situations with that of a controlled situation. This study is an attempt to estimate the costs of industrial pollution on various aspects of rural livelihoods in systematic and authentic manner. Such an approach assumes importance in the context of policy formulations. For, policy interventions have already been made in this region to address the problems without much success. In fact, a judicial committee after enquiry has come up with a compensation package to the rural household, which was rejected. This study would help us to understand the reasons for the policy failure.

III Data and Methodology

Two villages were selected, one is pollution affected and other one is without pollution impact, to collect detailed information regarding the damage costs due to industrial pollution. The village Kazipalle represents the polluted villages while Shambhapuram village represents the non-polluted villages. Detailed household level information was collected pertaining to the damages and losses due to pollution. All the households (census) in the command area of the two tanks (one in the polluted village and another in the non-polluted village) have been interviewed with the help of a structured questionnaire. On the whole 118 households (78 in the polluted and 40 in the non-polluted village) were surveyed. The household survey was conducted during July 2001. Both direct and indirect techniques were used to collect the detailed information on various impacts of industrial pollution (on agriculture, on livestock, and on health). Direct approaches such as contingent valuation method (CVM) were used to collect the information on willingness to accept by asking the respondent directly to state the minimum in one time and per year compensation (amount of money) she/he would be willing to accept for the damages due to industrial pollution. Indirect methods such as effects on production (EOP), replacement costs (RC), and human capital (HC) approaches were used to estimate the damages and losses (crops, agricultural equipment and health). A brief description of the methods is discussed below.

a) *The Effects on Production Approach (EOP):* The effects on production approach principle states that an activity may affect the output, costs and profitability of producers through its effect on their environment. If there is a market for goods and services, the effects of environmental impact can be represented by the value of the change in output i.e., the reduced value of fish caught as a result of river pollution. EOP has also been used to trace the impact of environmental changes such as soil erosion, deforestation, wetland and reef destruction, and air and water pollution on agriculture, forestry, fisheries, power, public services and other sectors (Winpenny, 1991). In our study the impact of water pollution (irrigated water) on agricultural productivity has been determined, and annual losses the households are incurring have been estimated by putting actual current market prices.

b) *Replacement Costs (RC):* Replacement cost (RC) approach states that if the environment has already been damaged, in order to restore it to its original state one has to spend some money. For example the victims of environmental damage replace their environment by moving away from the effected area. The costs, which the victims incur by moving to a clean environment, are called replacement costs. One of the techniques adopted in the replacement cost method is that of direct observation of actual spending on safeguards against environmental risks (Winpenny 1991 pp 48). In this study the replacement cost method has been adopted in order to estimate the damage costs of pump sets due to water pollution. Data pertaining to the damage costs are based on the households actual spending on repairs and replacement.

c) Human Capital (HC): The human capital approach considers people as the economic capital and their earnings as return to investment. Environmental economics focuses on the impact on human health due to bad environmental conditions, and the effect this has on the individuals and society's productive potential (Winpenny, 1991). Here the method would estimate the economic costs of illness of a productive human being. Two variants of this can be taken into account while measuring economic costs of illness due to environmental factors, first, the loss of earnings (working days) due to illness and second, the cost of medical treatment. In our study, we have calculated the loss of productive time and annual expenditure on health care, and then arrived at the total economic loss due to illness. However, it may be noted that we have not taken any help of medical science or epidemiological data to correlate the illness with pollution. But, the laboratory tests of various water samples from the village suggest equivocally that there are enormous possibilities of water related diseases. Our discussions with the local doctors vindicated the linkage between water pollution and the prevailing diseases in the villages.

d) Contingent Valuation Methods (CVM): CVM states that where the market is totally absent to obtain the actual value measure of benefits and costs of changes in environmental quality, the most straightforward way of assessing the benefits and costs would be simply to ask people their willingness to pay (WTP) and willingness to accept (WTA). CVM provides a way of tracing the demand curve for a commodity that cannot be revealed through market data (Murty, et. al, 1999, pp217). The two concepts most widely used are willingness to pay for an environmental benefit, and willingness to accept compensation for loss of environmental quality. Despite all the credibility and popularity, CVM is not free from various criticisms (for critical reviews in the Indian context see Reddy, 1998; Murthy, et. al, 1999 and Markandeya and Murty, 2000). In the context of the present study, an attempt was made to elicit information on Willingness to Accept (WTA) for damages due to industrial pollution through a bidding game approach. Two bidding charts were formulated, one was for annual compensation and another one was for one time compensation of the total damages due to pollution. In the bidding game approach, the most important bias that creeps in during the execution of the questionnaire is that of *Starting Point* bias. In our study, we have taken the help of one of the previous study that was carried out in one of the neighbouring villages, which estimated per year per household damage due to pollution (Behera and Reddy, 2002). On the basis of that study we have put in an average of Rs. 20000 per household per year as a starting point for the bidding game of compensation[16]. However, the WTP approach could not be executed satisfactorily due to the reluctance on the part of agitated respondents. Consequent to unsatisfactory responses we have dropped this aspect from our analysis.

Methods such as with and without and before and after are often used to assess the impact. In the case of with and without method the problem is that we cannot observe the pollution affected households without the pollution affect at the same time. One way of addressing this problem is to have a control group, which is similar to the pollution-affected group in all respects except the pollution. Control group provides the counter factual of the affected group. But this is not straight forward, as it is difficult to find such a matching group at least in terms of observable indicators. Alternatively, one can compare before and after situations of the same households

16 This particular study estimated the losses due to pollution to the tune of Rs. 36000 per household.

participating in the programme. This approach calls for baseline data, which is not available in all situations. Second best solution in this regard is ‘reflexive comparison’ where before and after scenarios are compared for the participating households. This would provide reasonable estimates of the impact provided that there is no serious memory lapse problem among the respondents. Other wise, this method will give biased assessment of the impact (Ravllion, 2001). Memory lapse is directly linked with the time lapsed after initiating the programme. These biases can be further minimised by using the ‘double difference’ method where before and after situations are used together with ‘with’ and ‘without’ scenarios (Ravallion, 2001). For the purpose of our study we have adopted the ‘Double Difference’ method.

At the outset, it may be noted that in most of the enquiries of this nature there is a tendency on the part of respondents to over estimate the damages. Therefore, it is necessary to minimise the bias of overestimation. All efforts are made to minimise, if not eliminate, the bias. The ‘double difference’ method, which compares before and after as well as with and without scenarios takes care of the over estimation problem to some extent. Further, our discussions with the local Non Governmental Organisations (NGOs) and medical practitioners have helped in cross checking the damage losses.

IV Impact of Industrial Pollution: An Economic Analysis

i. Profile of the Sample Villages

As we have mentioned above that two villages were selected to represent the polluted and non-polluted villges i.e., Kazipally and Shambhpram. The selection of the two villages is based on the status of irrigation tanks. The two villages have similar socio-economic and occupational pattern. These two villages are divided by a stretch of hillocks. These villages are located at 21 km to the northeast of Hyderabad, the capital of Andhra Pradesh. The villages fall under Zinnaram Mandal of Medak district. In Kazipalle, there are two tanks, one is completely polluted by the industrial pollution and the other one is functioning well. According to the farmers the symptoms of pollution have just started in the non-polluted tank. Apart from that there are five small *kuntas* (ponds), which are also not polluted and provide irrigation. Shambhpuram, which represents the non-polluted village, is having two tanks, both are working well. The basic characteristics of the two villages are that agriculture is the dominant sector in both the villages. It is observed that along with cultivation, most of the villagers go out for work to nearby industries in Bollarum as casual labourers during the off-season. Further, it may be noted that the marginal farmers going for work on a regular basis.

Table 5.2: Social category-wise Distribution of households

Category	**Kazipalle (polluted)**		**S. Puram (non-polluted)**	
	No. HH	Occupation	No. HH	Occupation
SC	77	Cultivation & Labourer	16	Cultivation & Labourer
BC	126	Cultivation & Labourer	81	Cultivation & Labourer
OC	16	Cultivation & Labourer	-	
Total	219		97	

Source: Village Survey.

Table 5.3: Size-class Wise Distribution of land holdings

Category of cultivators	No. of house-holds	% of total cultivators	Samples of cultivators taken	Area owned by sample cultivators (acres)	% of total area (acres)	Average farm size (acres)
Kazipalle (polluted)	219	100	78	119	100	3.19
Marginal cultivators	110	50	51	39	33	0.76
Small cultivators	60	27	19	42.5	36	2.23
Medium cultivators	45	21	5	20.5	17	4.1
Big cultivators	4	2	3	17	14	5.67
S. Puram (non-polluted)	97	100	40	30.5	100	1.33
Marginal cultivators	37	38	37	24.5	80.3	0.67
Small cultivators	60	62	3	6	19.7	2

Note: Big Cultivators > 5 acres, Medium Cultivators 3-5 acres, Small Cultivators 2-3 acres, Marginal Cultivators 0-2 acres.
Source: Village Survey.

In both the villages majority of the population belongs to the backward castes of the society (Table 5.2). Around 70 per cent and 80 per cent of the population in both the sample villages are illiterate. The land distribution pattern among the households is presented in Table 5.3. The households in both the villages predominantly belong to BC and SC category. And small and marginal farmers are in majority in both the sample villages. Around 50 per cent of cultivators belong to marginal farmers in the polluted village, where as in case of non-polluted village 38 per cent of the households belong to marginal farmers and 62 per cent belong to small farmers. In addition, small farmers own highest percentage of area in both the villages (38 per cent in the polluted and 80.3 per cent in the non-polluted village). There are no medium and big farmers in the nonpolluted village.

ii. Extent of Pollution in Kazipalle village

The industrialization in the Kazipalli area started during mid 1980s. According to the villagers, they started realising the impact of industrial pollution in the early 1990s. Initially, the villagers thought that the industrial effluents would be beneficial for agricultural production, because they thought that the coloured chemical water would contain some fertilizer and hence provide more fertility to land. In 1991-92, the villagers witnessed a rapid change in the colour of tank water and at the same time they witnessed the death of fish everyday. By 1994, there were no fish left in the tank. In 1991-92, farmers have realised the impact of polluted tank water on crops. To their utter shock, farmers harvested more of husk than grain from their paddy fields during that year. Since 1993 most of the farmers ceased to cultivate the lands and left them fallow without any crops. The impact of pollution on health has also become conspicuous, as most of the villagers have started suffering from water borne (pollution-related) diseases. The problem further escalated when the cattle became the victims of various diseases by drinking polluted water from tank and drains. As a result, the village has been incurring heavy losses due to loss of bullocks, cows, and other valuable cattle. By 1994-95, villagers realised that their groundwater sources have become salty and undrinkable. According to the villagers, some old people died due to choking from air pollution, as they could not tolerate the acute smell of toxic air, which the industries release during late night.

By the middle of 1990s the village became socially as well as economically isolated from other parts of region. For, the relatives from other villages stopped coming to the village due to the fear of pollution and nobody was coming forward to give their daughters in the village. Their products like milk, rice remain unsold or they have to sell at a very cheap rate in the market. As a result, pollution has posed a great threat to the entire village in terms of its health and economy. It is unfortunate that the village has become the victim of pollution without getting any benefits from the industrialization in Kazipalli-Gadda Potharam region. There are only a couple of educated youth who are employed in Bollaram and other industrial belts.

The source of pollution that the Kazipalle tank is from the Gadda Potharam industrial belt, which is located at 4 km to the north-eastern boundary of Kazipalle village. The industrial estate is located at the border of the village. A rocky terrain separates the village and the industrial belt. This industrial estate is housing around 40 industries most of them are producing chemicals. These chemical industries are letting out their effluents directly in to the tank either through pipes or drains, which have contaminated both the surface and groundwater.

iii. Impact of Pollution

The impact of pollution has been widespread in all aspects of the village life. However, here we focus on three important impacts for an in-depth analysis. These are a) impact on health, b) impact on crop production and other agricultural activities, and d) impact on livestock. Before going in to the details of analysing the impacts of pollution on various aspects, it would be pertinent to examine the impact of industrial pollution on water sources or bodies. For, the impact on village community is rooted through water bodies.

Impact on water sources:

Water sources, ground as well as surface, have been badly affected by pollution, which is considered to be the main source of all impacts. For the purpose of understanding the extent of water pollution, water samples from different sources from both affected and control village have been obtained and tested. Water samples were collected in sterilized bottles of one litre each from different sources such as bore-well and tank water. Table 5.4a presents the results of the tested water samples, which show that almost all the parameters have been crossed the limit of normal range in the case of polluted village. Samples I, II and III have been collected from Kazipalle (polluted) village. These samples pertain to non-polluted tank, bore well and polluted tank respectively. Sample-IV and V have been collected from Shabhpuram (non-polluted) village (tank and bore well respectively). In Sample II and sample III, almost all the parameters are showing above the normal range indicating severe pollution levels in ground and surface water due to industrial pollution in Kazipalle village. The most important features of the water analyses are

EC (Electrical Conductivity) level in the water bodies, which determine the agricultural productivity. High EC levels along with other important indicators are observed in the polluted tank as well as from bore wells. All the samples except the tank water in the non-polluted villages have revealed higher than normal range values. Interestingly, the bore-well sample from the non-polluted village (S. Puram) has also revealed high EC levels. This indicates that the groundwater in the control village has also got polluted. As we can see that the EC level and other important parameters of Sample V is quite high in comparison to the normal range, indicating that the water is not usable for any purposes. The bore-well in this village was drilled recently for drinking water purposes. However, people are not using the well, as the water is salty. Drinking water is being supplied by overhead tank by the local bodies. Since the farmers of Shambhpuram (non-polluted village) do not use groundwater either for irrigation or drinking the impact is not conspicuous. And the tank water they use for irrigation cultivation is fairly clean. Though they have not realized so far the impact of water pollution on agriculture, one cannot rule out such possibilities in the near future. The use of groundwater for irrigation purposes would have definite impact on crop productivity, once the farmers' start using it.

Table 5.4a: Results of Water sample tested showing concentration of various water parameters and its normal range (acceptable range)

Parameters	Normal Range	S- I	S- II	S- III	S- IV	S- V
PH	7.0-8.5	9.75	7.34	6.36	7.8	7.29
EC mho	750	469	1890	8590	308	2820
TDS mg/1	500	297.5	1136.5	5802	188.5	1639.5
Chloride mg/1	200	44.1	225.42	2058.2	29.4	313.63
Sulphates mg/1	200	131	131.7	1072	12.4	120
Phosphates mg/1	0.180	0.180	0.186	0.692	0.120	BDL
COD mg/1	3	38	BDL	600	26	0.19
Calcium mg/1	75.0	20.8	87.36	499.2	16.64	91.92
Magnesium mg/1	30.0	5.10	30.32	101.06	2.53	20.21
Total hardness mg/1	100	73	343.2	1664	52	312
Alkanity mg/1	75	50	370	40	110	440
Arsenic mg/1	0.05	BDL	BDL	1.34	BDL	BDL

Source: EPTRI Laboratory, Hyderabad
Note: TDS = Total Dissolved Solids, EC = Electrical Conductivity, COD = Chemical Oxygen Demand, BDL= Below Danger Level.
Figures in bracket indicate Normal range of Parameters.
S- I = Non polluted Kazipalle tank; S- II = bore-well from Kazipalle ½ km away from the polluted tank; S- III = Kazipalle polluted tank; S- IV = S. Puram tank; S- V = bore well from S. Puram

The tank water in the polluted village has a dangerous element arsenic at very high levels i.e., the actual level of 1.3 mg /l as against the normal of 0.05 mg/l. These high levels of pollution would have adverse effects on human and livestock health and on crop production. The death of cattle and the serious diseases reported from the polluted village could be attributed to the high levels of this poisonous metal. Arsenic poisoning leads to changes in skin colour, skin allergy, etc. The morbidity rates in this area (25 per cent) are much higher than the national or state average (10 per cent). The dominant causes of morbidity are orthopaedics (30 per cent) and skin problems (22 per cent). Women and children are the worst affected. Six deaths related to pollution are reported from the neighbouring villages (Rao, 2001).

Yield responses are sensitive to salinity (EC) and TDS levels. Table 5.4b shows yield responses to irrigation water with different concentration of salinity and TDS. A comparison of Tables 5.4a and 5.4b reveals that the actual levels of TDS and EC in three of the sources are high enough to adversely affect the yields of many crops. This is very much reflected in the impact of pollution on crop production. Similarly the high levels of pollutants in most of the samples indicated that water is not good for human or livestock consumption. However, these polluted sources are not used for drinking water at present. The villages are mostly dependent on the municipal drinking water supply. Local municipality has started providing piped water only recently. Prior to that villagers were drinking contaminated water resulting in severe health problems. The problem of drinking water in Kazipalle is very acute. The piped water does not come regularly. People have to store the drinking water for three to four days. Some people go long distances to fetch drinking water from a small town, which is 2.5 kilometres from the village and gets regular municipal water supplies. Increased drudgery and time spent in fetching water is another dimension of environmental degradation. The details on problems related to drinking water are presented in Table 5.5.

Table 5.4b: Crop Responses to Irrigation Water with Different Levels of Salinity and EC levels.

Crop responses	TDS (mg/1)	EC (mho)
1. Water for which no detrimental effects will usually be noticed	Less than 500	Less than 750
2. Water, which can have detrimental effects on sensitive crops.	500-1000	750-1500
3. Water that may have adverse effect on many crops.	1000-2000	1500-3000
4. Water that can be used only for salt tolerant plants.	2000-5000	7000-7500

Note: TDS = Total Dissolved Solids, EC = Electrical Conductivities. Source: Goel P.K and Sharma K.P (1996).

Before the pollution households in Kazipally village used to get sufficient drinking water from the Kazi tank and the tube well, which are located in the vicinity. Since the industrial pollution has polluted both the surface (tank) and groundwater the villagers totally dependent on municipal water. The supply of municipal water is erratic. The supplies are neither timely nor regular. The data pertaining to time spent on fetching drinking water in both the villages clearly reflects the increased drudgery in the polluted village. Prior to the pollution problem mostly men used to be involved in fetching water. Where as, after the pollution in the water bodies' men, women and children are involved in fetching the water (Table 5.5). This is not only due to the irregular and erratic supplies of municipal water but also due to the reason that households walk distances to fetch water from far of sources in the case of water shortage. As a result, the time spent on fetching water has more than doubled in most of the cases in Kazipally while it is more or less constant in the non-polluted village. Most importantly the children are pressed into service to fetch drinking water. There are no clear variations across size classes though in the case of large farmers where children are not engaged in fetching water. The water shortage is also reflected in the number of days a household manages with collected water from municipal source.

Table 5.5: Details of Fetching Drinking Water in the Sample Villages.

Village/ Size class	Avg. No. of people involved in fetching Drinking water per hh.						Avg. time spent for fetching water (minutes)		Time spent per 10 litres of water collected (mint)		No. of days managed with the municipal water	
	Before			After			Before (mint)	After (mint)	Before	After	Before	After
	M	W	C	M	W	C						
Kazipalle												
LF	1	0	0	1	1	0	10	60	2.5	6.0	2	4
MdF	1	0	0	1	1	1	10	120	2.0	20.0	2	3
SF	1	1	0	1	1	1	15	50	4.0	10.0	1	3
MF	1	0	0	1	1	1	15	45	3.5	8.5	1	3
S. Puram												
SF	0	1	0	0	1	0	15	15	5.0	4.5	1	1
MF	0	1	0	0	1	0	20	22	6.0	7.0	1	1

b. Impact on Health:

The entire village of Kazipalle (polluted village) has been suffering from various diseases arising out of water pollution. Some of the widespread water-borne diseases frequented in the polluted village include skin infection, teeth corrosion, joint pain, loss of appetite, defective vision, fever, abdominal pain, respiratory diseases, diarrhoea, etc. Besides, general muscular weakness, immature growth, chronic cold and cough in the middle aged and children have been noticed in the village. Majority of the complaints are in the form of lung diseases, fever and joint pain. There are cases where the chief income earner of the family was affected by serious diseases, resulting in the deterioration of economic conditions of these families. Though people do not drink the polluted water directly they get exposed to the toxic chemical water while working in the farm, taking bath, washing clothes and also through food chain especially milk and vegetables. This causes serious health problems including loss of hair for women.

Table 5.6 presents the percentage of households reporting about the frequency of occurrence of various diseases across the size classes in both affected and control villages. Almost all the categories of farmers are suffering from joint pain and fever after the on set of pollution in Kazipalle. Among the medium size class farmers, the occurrence of joint pain, skin problem, fever and stomach pain is quite high in comparison to the situation of before pollution. Majority of them (60 per cent) reported daily joint pain and 40 per cent each in the case of skin, fever and stomach pain with weekly frequency. Similarly 95 and 86 per cent of small and marginal farmers respectively reported daily joint pain. Sixty-three and 72 per cent of small and marginal farmers reported monthly fever after pollution. In the control village, only fever was the major complaint among all the category of farmers that too the frequency is monthly and yearly. Small farmers reported increased occurrence of yearly fever from 33 per cent to 66 per cent, where as in the case of marginal farmers it has declined from 38 per cent to 35 per cent.

Table 5.6: Percentage Households Reporting about Occurrence of Various Diseases

Disease/frequency	Kazipalle								S. Puram			
	Before				After				Before		After	
	LF	MdF	SF	MF	LF	MdF	SF	MF	SF	MF	SM	MF
Joint Pain:												
Daily	-	-	-	-	67	60	95	86		-	-	-
Weekly	-	-	-	-	33	-	5	2		-	-	-
Monthly	-	-	-	-	-	20	-	10		3	-	3
Yearly	-	-	16	20	-	-	-	-		-	-	-
Skin:												
Daily	-	-	-	-	-	40	5	-		-	-	-
Weekly	-	-	-	-	-	-	-	-		-	-	-
Monthly	-	-	-	-	-	-	-	-		-	-	-
Yearly	-	-	-	-	-	20	-	2		-	-	-
Fever:												
Daily	-	-	-	-	67	20	10	-	-	-	-	-
Weekly	-	-	-	-	33	40	16	22	-	-	-	-
Monthly	-	-	-	-	-	20	63	72	33	3	33	3
Yearly	-	-	32	41	-	-	-	-	33	38	66	35
Stomach:												
Daily	-	-	-	-	-	-	5	-	-	-	-	-
Weekly	-	-	-	-	-	20	-	-	-	-	-	-
Monthly	-	-	-	-	-	40	-	-	-	-	-	-
Yearly	-	-	-	2	33	20	5	-	-	-	-	-

The most important feature of health problem due to pollution is that the women are the worst affected (Table 5.7). The percentage of affected females in each household is higher. This is because women do the entire household work often with contaminated water like washing, nursing children, etc. This is true even in the control village, especially in case of marginal farmers category where about 80 per cent of the women complained or reported of various diseases. This can be attributed to the contaminated water from the tube well (groundwater) in the village. They do all the household works with the water from the village tube well, which has high levels of pollutants (Table 5.4a). Apart from this, the average number of days sick and unable to work per household per year is substantially higher in the polluted village when compared to the non-polluted village. The number of days lost due to pollution is the difference between before and after pollution situation regarding the number of days sick and not available for irrigation in both the villages. While the before and after scenarios in the polluted village gives the absolute incidence of sickness after the incidence of pollution, the double difference between before and after situations in both the villages [(Bi-Ai)-(Bj-Aj), where i and j represent polluted and non-polluted villages] gives the net impact of pollution. The before and after difference in the non-polluted case is due to natural factors, which needs to be netted out even in the case of polluted village. These two measures are estimated and presented as scenarios one and two. The differences between the villages and before and after situations in the polluted village are substantial (Table 5.7). Similar procedure is followed for all the other indicators also.

The incidence of sickness and unable to work due to pollution is 50 days in the case of scenario-I and 48 days in scenario- II. This indicates the loss of income and expenditure on health care due to the incidence of pollution. Similarly the number of visits to the doctors before pollution and after pollution and its expenditure reveal a substantial increase. It appears that before pollution people from both the villages used to visit doctors 4-5 times in a year and spent Rs. 110-150 on health but after pollution it has increased substantially in Kazipally. This has an adverse influence on the socio-economic conditions of the people in the affected village. The expenditure on health depends on two factors i.e. (a) the severity of diseases and (b) the economic condition of the family. The small farmer's average visits to doctors are 20 per annum and their expenditure on medical services is Rs 1200/-. However, in case of medium and large farmers the average number of visits to doctors is 25 and 12 and the amount spent medical expenses is Rs1700 and Rs, 2500 respectively after pollution respectively. These differences can be attributed to two factors mentioned above. Where as in the case of control village the difference between before and after in all these aspects of health impact is marginal.

Table 5.7: Impact of Pollution on Human Health

	Kazipalle					S. Puram		
	LF	MdF	SF	MF	All	SF	MF	All
Total No. of people effected -male -female	6 (33) 3 (27) 3 (43)	15 (50) 5 (36) 10 (63)	27 (26) 13 (25) 14 (30)	92 (50) 40 (41) 52 (58)	35 (40) 15 (32) 20 (49)	6 (37) 3 (33) 3 (43)	88 (64) 37 (51) 51 (80)	47 (51) 20 (42) 27 (62)
Average No. of days sick &unable to work/ HH/yr Before: After:	10 60	20 80	15 68	17 64	16 68	25 26	20 24	23 25
Impact: S-I **Impact: S-II**	**50** **--**	**60** **--**	**53** **52**	**47** **43**	**52** **50**	-- --	-- --	-- --
Average No. of visits to doctor/ HH Before: After:	2 12	5 25	6 20	6 23	5 20	4 5	4 4	4 5
Impact: S-I **Impact: S-II**	**10** **--**	**20** **--**	**14** **13**	**17** **17**	**15** **14**	-- --	-- --	-- --
Average amount spent on (Rs.) medical/ HH Before: After:	100 2500	110 1700	80 1200	150 1450	110 1713	150 500	142 400	145 450
Impact: S-I **Impact: S-II**	**2400** **--**	**1590** **--**	**1120** **770**	**1300** **1042**	**1603** **1299**	-- --	-- --	-- --

Note: Figures in Brackets are percentages to total number of people. HH= Household
S- I= scenario one and S- II= Scenario two as explained in the text.

We have estimated the total cost on health due to pollution (Table 5.7). The average expenditure on health per household is calculated on the basis of working days lost due to illness and the expenditure incurred to cure the diseases. The average number of days unable to work is estimated at 52 in scenario- I and 50 days in scenario-II. There are variations across size classes in this regard, i.e., 50, 60, 53, and 47 for big, medium, small and marginal cultivators respectively in scenario-I and 52 and 43 for small and marginal farmers respectively in scenario-II. Similarly, the medical expenditure is estimated at about Rs. 1600 in scenario-I and Rs. 1300 in scenario-II. Across the size classes the expenses range between Rs. 2400 (large farmers) and Rs. 1120 (small farmers). Similarly the average loss of wages due to losses of working days has been calculated. The average per year per household loss of working days is calculated using the market wage rate in the villages (i.e., Rs.50 per day). The estimated average loss per household due to loss of working days is Rs. 2500 in scenario-I and Rs.2600 in scenario-II. The total loss per household due to health impact is estimated at Rs.4203 per annum (scenario-I). The net impact of pollution is estimated at Rs. 3799 per household per annum (scenario-II).

c. Impact on Livestock.

Livestock is generally considered as one of the main source of income in rural areas. Since all the local water bodies are polluted in the polluted village, it has posed serious threat to the livestock economy in the village. In the absence of sufficient municipal water supplies, livestock is forced to depend on polluted water. Livestock have been suffering from various diseases as they drink polluted water and graze on contaminated grasses or grazing fields. It was reported by the villagers that around 149 cattle died due to drinking polluted water during the last 8 years. Majority of the cattle is becoming sick over the years. Another serious problem observed in the village is that some cows have lost their reproductive capacity. These cows have become a liability to their owners. Grazing contaminated grasses and water has resulted in poor quality of milk and dung. On account of fear of further deaths of cattle, people have sold their cattle at very low rates.

Table 5.8a: Status and Composition of Livestock Holdings among the Households

Village	Before pollution				After pollution			
	Buffaloes	Ox	Cows	Goats	Buffaloes	Ox	Cows	Goats
Kazipalle	211	89	83	392	39	45	39	20
Big cultivators	7	6	00	00	6	6	00	00
Medium cultivators	33	8	66	30	1	6	4	20
Small cultivators	38	29	4	162	13	11	30	00
Marginal Cultivators	70	46	13	200	19	22	5	00
S. Puram	08	16	00	25	08	16	00	29
Small cultivators	2	4	00	00	2	4	00	00
Marginal Cultivators	6	12	00	25	6	12	00	29

Composition and holdings of livestock have experienced drastic changes due to the incidence of pollution in the affected village (Table 5.8a and 5.8b). On the contrary, the composition and holding of livestock showed a little change in the non-polluted village, the only exception being the positive change (16 per cent increase) in the case of goats among marginal farmers (Table 5.8b). It may be noted that the density of livestock is very low in non-polluted village when compared to the polluted village. The decline in livestock population across all categories in Kazipally is mainly due to the reasons that either the livestock have died consequent to drinking polluted water or the people have sold their cattle on account of fear of death. Except in the case of buffaloes the decline in livestock holding is higher in the case of small and marginal farmers. Besides, farmers have started depending more on tractor to plough their land even in the unpolluted tank command rather than buying bullocks, because of the risk of death.

Table 5. 8b: Changes in Livestock holdings due to Pollution (%).

	Buffaloes	Ox	Cow	Goat
Kazipalle	-82	-49	-53	-95
Big cultivators	-14	0	-	-
Medium cultivators	-97	-25	-94	-33.3
Small cultivators	-66	-62.1	86.7	-100
Marginal cultivators	-73	-52.2	-61.5	-200
S. Puram	0	0	0	16
Small cultivators	0	0	0	0
Marginal cultivators	0	0	0	16

Table 5.9: Death of Livestock due to Pollution and its Market value in Kazipalle

Category of Livestock	LF	MdF	SF	MF	All
Bullock:					
No.	-	2	1	2	5
Value	-	4000	4000	15000	23000
Buffalo:					
No.	2	5	4	16	27
Value	20000	27000	16000	103000	166000
Cows:					
No.	-	-	6	-	6
Value	-	-	14000	-	14000
Goat:					
No.	-	-	111	-	111
Value	-	-	115000	-	115000
Avg. Loss per HH (Rs)	6667 (1333)	6200 (1240)	7842 (1568)	2313 (463)	4077 (815)

Note: Figures in brackets indicate the losses per annum calculated over the last five years.

On the whole, 149 cattle were reported to have died during the last five years (since 1995-96) by drinking polluted water in Kazippaly village (Table 5.9). A majority of them were goats followed by buffaloes, cows and bullocks. The market prices of these livestock units were obtained from the cattle owners. Based on this the average loss per annum was calculated as Rs 815/ per household. Annual losses are the highest among small farmers (Rs. 1568) followed by large farmers (Rs. 1333), medium (Rs. 1240) and marginal farmers (Rs. 463). Where as in the non-pollution village no cattle deaths and diseases due to pollution were reported. However, the villagers are aware of cattle deaths in the neighbouring villages. They never let their cattle to cross over to Kazipalle and other polluted areas.

d. Impact on Agriculture:

Agriculture sector is the worst affected of all due to pollution. About 102.5 acres of cultivable land has become uncultivable by soil pollution leading to drastic changes in livelihood systems in Kazipally village (Table 5.10). The turning of productive land into barren land in Kazipalle village can be solely attributed to irrigation with the polluted water from the tank and bore well. As mentioned earlier, the water from these two sources of irrigation are found to have high concentrations of electrical conductivity (EC), which is the main indicator of irrigation water quality (Pearce, et al 1978). Electrical conductivity conveys the intensity of salinity of water bodies. The results (Table 5.4a) clearly indicated the high concentration of salinity as well as TDS in the polluted tank as well as in tube well in Kazipalle. These coupled with other pollutants not only affects crop production but also damages the agricultural machinery like pump sets that come in to direct contact with water. Here we estimate the losses due to loss of production and replacement costs of the pumpsets.

Table 5.10: Estimation of Damage Costs of Agricultural Activities due to Pollution (loss of production).

	Kazipalle				
	LF	MdF	SM	MF	All
Pump sets damaged.					
Number:	3	2	2	-	7
Cost (Rs.):	42000	18000	11000	-	71000
Per unit cost (Rs.):	14000	9000	5500	-	10143
Cost Per Household (Rs.)	14000	3600	579	-	910
Cost / HH / year	2800	720	116	-	182
Average amount of land became uncultivable (acres/HH)	5	4	1.76	0.66	1.31

Note: HH = household.

Apart from the decline in agricultural productivity, the polluted water imposes enormous costs on various agricultural activities, like corrosion of agricultural equipment, damage of pump sets, repairing costs of machines, etc (Behera and Reddy, 2002). Only the damage of pump sets is reported from Kazipalle village, though other problems like corrosion of equipment, repairing costs might have occurred earlier. For, the decline of cultivation activities during the last 8 years and hence they are not able to remember about repairing costs or loss of equipments due to pollution. As pump sets damage impose a major loss to farmers, it is still fresh in the minds of cultivators. Irrigation water containing detergents washes out the lubricants from irrigation oscillates and pumps. And an excessive amount of suspended solids in the water will require frequent cleaning of filters and nozzles (Pearce , et al 1978). As a result, extra costs in the form of repairing and servicing of electric motors, damage of pump sets, etc., are common.

At least 7 pump sets have been damaged during the last five years of cultivation in Kazipalle village. Its total costs are estimated at about Rs 71,000 (Table 5.10). These costs are incurred during the last five years. Accordingly per annum costs of repairing and damage of pump sets has been calculated. The average total cost on agricultural activities due to pollution per annum per household is Rs 182/. The cost of damage of pump sets is mainly born by large and medium farmers. For, only these farmers own bore wells. None of the marginal farmers own a bore well. Per unit as well as per household costs are high on large farmers. Table 5.10 also shows the average land that has become uncultivable across the size-classes. At the village level the average land became uncultivable is around 1.31 acres. There is an inverse relation between farm size and the area becoming uncultivable for obvious reasons that large farmers have larger area under irrigation per household in absolute sense.

Table 5.11 indicates the changes in the area under cultivation and yield per acre per season in terms of quintals of paddy before and after the pollution. The amount of land under cultivation has declined drastically (by 88 per cent) due to the incidence of pollution in the case of all categories of farmers in Kazipalle village. That is, for big, medium, small and marginal the difference of area under cultivation after pollution is 15 acres, 20 acres, 33.5 and 34 acres respectively. In proportionate terms the decline is the highest among medium size farmers followed by large farmers, marginal farmers and small farmers. These differences are attributed to uncultivable land under the polluted sources. Cultivation no longer takes place under polluted sources. Most of the cultivable land after pollution is under unpolluted tank in Kazipally. Marginal farmers are badly affected due to pollution, as 34 acres of their land has become unproductive. Loss of yield is estimated by subtracting the total production of paddy in the before and after situations. Physical losses are converted in to monetary terms using the current prices of paddy. This region is a mono crop region growing only paddy[17]. It may be noted that per acre yields seem to have declined even in the case of non-polluted tank. For, per acre yield of paddy after pollution is the present yield in the command area of the unpolluted tank of Kazipalle village. Interestingly yield losses are highest among large farmers followed by marginal, small and medium farmers. Taking area losses together with yield losses we have estimated the total losses due to loss of production of paddy in the polluted village. In the non-polluted village there are no changes in area and yield though land productivity is low in this village when compared to Kazipally.

Table 5.11: Impact of pollution on agricultural productivity and area under Cultivation.

Cultivators	Area cultivated (in acres)		Average yield per acre per season in quintals		Total loss of paddy due to pollution. (in quintals).	Loss of Paddy in value terms (Rs)	Per HH loss of paddy (Rs)
	B.P	A.P	B.P	A.P			
Kazipalle	119	16.5	21	15	2251.5	1125750	14433
Big cultivators	17	2	22	14	346	173000	57667
Medium cultivators	20.5	0.5	20	16	402	201000	40200
Small cultivators	42.5	9	22	15.5	795.5	397750	20934
Marginal cultivators	39	5	20	14.5	708	354000	6941
S. Puram	30.5	30.5	12.5	12.5	0	0	0
Small cultivators	6	6	12	12	0	0	0
Marginal cultivators	24.5	24.5	13	13	0	0	0

Note: B.P. = Before Pollution (1992); A.P = After Pollution (2001).

The loss of income from agriculture is estimated on the basis of the difference between average income earned by the households before pollution (1992) and after pollution (2001). It may be noted here that after pollution the farmers under polluted tank are not cultivating at all. In order to estimate the losses of paddy of unproductive

17 Entire land has been devoted to paddy before as well as after the pollution.

land we have multiplied the per acre yield of before pollution with their respective unproductive land (area under cultivable BP-AP). The household level loss due to loss of production is determined on the basis of market prices of paddy. The market value of one-quintal paddy is Rs 500/ approximately. The average loss of income due to pollution is estimated as Rs 14433 per household per year. Per household loss of production is directly related with the farm size. The average losses incurred by the cultivators in the form of pump sets damaged are around Rs 182 per household per year. Together the average cost per household due to the losses to the agricultural sector is (14433 + 182) Rs.14615. While the costs due to loss of production are recurring annually the replacement costs are sunk costs, as the farmers have stopped cultivating their lands under the polluted tank. However, converting the sunk costs in to annualised costs would give the per annum costs at the given point in time. In our case these costs are for the year 2001.

Table 5.12:Total Loss per Household per Annum in Kazipalle Village (Rs.)

Loss on health	3799
Loss on livestock	815
Loss on agriculture	14615
Total	19229

The estimated average loss per household per annum to the pollution-affected households in Kazipalle village is about Rs. 19000 (Table 5.12). The calculation is based on the census study (all households) under the polluted tank. The total loss to the village can be calculated by multiplying total per household loss with total number of household that is Rs. 19229 X 78 = Rs. 1499862. Similarly, the total loss to the village for the last nine years can be calculated. The average loss to the crops is calculated for one season (rabi). Though farmers cultivate two crops in a year, majority of the farmers argued that kharif crop is highly uncertain. For, large area of land remains flooded during the rainy season. Looking at this uncertainty over the Kharif season, the loss to crops during kharif season is not taken into account.

e. Impact on Employment

While industrial pollution imposes severe negative externalities on rural communities, advent of industries in the region could possibly lead to some positive externalities such as employment and income generation. On the other hand, loss of employment due to the reduction in area under cultivation is another negative impact. Assessment of these aspects would help us understand the extent of net (indirect) compensation to the communities. After pollution there was a drastic change in the pattern of employment in Kazipalle village. Most of the people who were depending on agriculture before pollution have shifted to industry, business and other sources. Majority of them have become daily labourers. Those who are employed in industry, majority of them complained that they are working in a very hazardous conditions. On the whole, employment per year has declined drastically in Kazipalle across the size classes (Table 5.13). The worst affected is the large farmers in the village. Before pollution they used to get employment or engaged in agricultural activities for 250 days out of 360 days. However, after pollution it has declined to a meagre 85 days. For, as the data indicates, the large farmers have not changed their occupation after pollution. They are still cultivating their remaining land i.e., working on their own farm. On the other hand, other size class farmers have shifted to industry or agricultural labour on other farms. This may be due to the false status of the large farmers, as they do not hire themselves out. In the case small and marginal farmers number of days employed in a year declined only marginally while it has remained same in the case of medium farmers. In the control village per year employment has increased marginally for small farmers from 120 days to 122 days. In case of marginal farmers the increase is from 135 days to 150 days.

Table 5.13: Impact of Industrial Pollution on Employment

Village/ size-class	Before						After					
	Avg. no. of working persons	Working in own farm	Hired out to farm work	Hired out to Industry	Others	Total	Avg. no. of working person	Working on own farm	Hired out to farm work	Hired out to Industry	Others	Total
Kazipalle												
LF	3	250	-	-	-	250	3	85	-	-	-	85
MdF	4	165	-	-	-	165	4	25	20	120	-	165
SF	3	110	25	-	-	135	3	25	20	80	-	125
MF	3	85	65	-	20	170	2	15	40	70	40	165
S. Puram												
LF	-	-	-	-	-	-	-	-	-	-	-	-
MdF	-	-	-	-	-	-	-	-	-	-	-	-
SF	2	60	30	30	-	120	2	65	25	32	-	122
MF	3	45	50	40	-	135	3	50	60	40	-	150

V. Conclusions

To recapitulate, the impact of industrial pollution on rural communities is quite substantial in monetary terms alone. The costs of damage would be much higher if social costs such as alienation of the village (marriages, social visits, etc) by others are accounted for. Similarly, real impact on health, economic as well as psychological, is difficult to assess. While there is a possibility of over estimating the damages on the part of respondents we strongly believe that these excesses would not be more if social costs were to be valued. More over, the losses due to permanent disability to the chief breadwinner of a household are rather difficult to assess. In this regard, it is difficult to assess the problem in pure economic terms of valuation of losses. Hence, the solution to solving the problem lies not in compensating the loss but in removing the problem altogether. Here compensation means giving right to the pollute to pollute. Looking at the health impact in the present case no amount of compensation would suffice to address the problem. Beyond compensation something has to be done in order to end the problems forever. This could be in terms of strict regulation on the industries to adopt pollution mitigating technologies or face closure. However, this calls for a close look at the economics of pollution mitigating technologies, which will be a worthy exercise. State policy also has a major role to play in this regard.

In the present case the Sangareddy Pollution Control Board (PCB), which is a regional office, is responsible for the area of Kazipalle and Bollarum industrial estates. The villagers have complained number of times regarding the loss of crops, loss of cattle, and pollution of tank and tube well water. In response to these complaints, the officials visited the village and surveyed the area. They took various water samples and got tested. According to the villagers, this has become a routine for PCB, and no action was initiated against the industries. The member Secretary of APPCB has visited the village and promised to clean up the tank but nothing has happened so far. It is believed that there is nexus between the officials and the industrialists and hence the matter is conveniently ignored. This nexus is further strengthened by the support of the politicians to the industrialists. The loopholes in the regulatory system further assist this process.

Bringing the judiciary in to the picture also did not help much in solving the problem. Judiciary entered the scene after a public litigation suite, as the negotiations between polluters and victims' the year 1994-95 with regard to compensation for damages. The industries offered to pay a one-time compensation of Rs. 3000/ per acre for the damage to crops due to pollution. But the villagers did not agree for this and collectively decided to file a case in Supreme Court with the help of a Zilla Parishad member who is an advocate and other NGOs. Supreme Court had, in fact, ordered that a report regarding the damage due to pollution should be submitted and also ordered that even one drop of effluence cannot be discharged into the tank. The Supreme Court entrusted the district judge of Medak the responsibility of estimation of damage cost. The district judge has estimated Rs. 1500/ per acre of agricultural land, leaving other damages such as health and livestock. However, it is not clear how the estimates are arrived at. Our estimation shows that per household damages due to crop failure alone is about Rs. 14000. The damage to crop production itself is Rs. 9460 per year. Therefore, the compensation offered in both the cases is a gross under estimation of the actual losses. It is but natural that the community refused to accept it. On the contrary Supreme Court's compensation package was propitious to industries rather than to the rural community. For, the compensation recommended by the judicial committee was half that of the amount offered by the industry on their own. Moreover, even after three years of the Supreme Court judgment, the compensation did not reach the people, though some of the neighbouring villages have received the compensation. The Court order was that the money should be collected from the polluting industries and deposited in the account of district judge. The judge will distribute the money among the victims. Some villagers even approached the industries for the compensation, the industries denied saying that they have already given their money to the district judge. The villagers' visits to the judge have also gone in vain. As a result, the villagers continue to be the victims in the hands of the judiciary as well as the industries.

This is a classic example of the failure of Pigouvian approach that talks about state intervention. The Coaseian approach (negotiation between two parties) would have worked with a better compensation package. But, the judiciary failed to play an effective role. Though the victims' did not agree with the negotiated amount offered by the industries, the negotiation could have been made more effective and acceptable to all the parties with the help of a mediator instead of going to the court. In the process public policies also play spoil sport. The recent policy announcements of exempting the small-scale industrial units, which are more polluting than others, from the regulation of PCB. Social and environmental issues cannot be tackled merely by passing laws. The law has to be implemented in its right perspective.

The role of civil society is also not satisfactory in the present case. Protests in front of the state Secretariat in the form of both *dharna* (mass squatting) and *rastha roko* (blocking roads) only resulted in *lathi* (cane) charge and arrests of the villagers and NGOs. Neither industries nor PCB responded to the protests. People turned aggressive and attacked the industries. Since then the industries stopped discharging their effluent in to the tank during daytime. Twice, the villagers caught the persons during nighttimes while discharging the effluent in to the village and beat them up severely. After that incident the industries were closed for three to four days and started again as usual. Despite all these actions, the community did not succeed in influencing either industries or regulatory authorities. Finally, the villagers gave up their struggle out of frustration. Thus, the present case study provides an apt example of failure on all fronts.

CHAPTER VI: DEGRADATION OF WATER RESOURCES-MARKET, INSTITUTIONAL AND POLICY FAILURE

Water resource management is crucial for food and ecological security. In fact, livelihood security is critically linked with water security[18]. Water security is indispensable for addressing inter and intra regional as well as inter household inequalities in growth and development and sustaining the ecological balance. Despite the importance water assumes in the over all human development, it is the most mismanaged resources especially in the context of developing countries like India. Neglect of this important resource has resulted in environmental degradation of enormous proportions. However, water resources are often studied from the economic angle. The present study is an attempt to understand the environmental perspective of water resources. Though limited to the state of Andhra Pradesh, the study reflects the reality in many parts of the world. This chapter makes an attempt to synthesise the problem, based on our analysis, from three important perspectives i.e., market, institutional and policy failures. This would help in understanding the problem from different dimensions. Existence and use of water in different forms makes it imperative to examine the multi facets of the resource. While it is beyond the scope of the present study to cover all the forms and uses of water resources, it deals with three important aspects of water resources management with a focus on environmental degradation. These include groundwater, surface water and water quality management. The study narrates the context of managing these three forms of water resources that has led to their degradation threatening the livelihood security of the local communities. Before attempting the synthesis let us recapitulate the main analysis of the study.

The costs of environmental degradation are estimated in the case of groundwater and industrial pollution. In the case of groundwater the costs are substantial when compared to abatement costs. Moreover, the negative externalities arising from degradation are resulting in iniquitous access to water resources threatening the food security of the poorer sections of the community. Policy interventions are necessary to internalise these externalities. Abatement measures to check

18 Water security means that people and communities have reliable and adequate access to water to meet their different needs, are able to take advantage of the different opportunities that water resources present, are protected from water related hazards and have fair recourse where conflicts over water arise. (Soussan, 2002).

degradation are necessary for sustaining the resource. These measures should be fostered with pricing of the resource as well as complementary resources like power. Equally important is the absence of property rights in groundwater resources. Based on our findings and observations it is argued that delinking of water rights from land could be the only solution for solving the access (equal) problem.

In the context of industrial pollution, the costs of degradation are estimated for crop loss, human health and livestock losses. Though limited to specific locations, the costs of industrial pollution at the household level are much larger and assume serious proportions in terms of human health. Due to the degradation (pollution) of groundwater bodies and surface water bodies' households have abandoned agriculture and become labourers. Besides, the communities in the polluted village are facing other problems such as social alienation. The policy response to the misery was a compensation package, which is no way near when compared to the magnitude of losses. As a result, the Coasein approach of negotiation has failed to solve the problem. Even the judiciary failed in delivering the justice to the helpless communities. Unless 'polluter pays' principle along with clearly defined property rights in resources is strictly followed it is difficult to address the externality problems.

Formalisation of irrigation institutions in Andhra Pradesh has helped in checking the environmental degradation relating to water to some extent in the canal commands. Access to water in the tail end areas has increased thus improving the livelihoods and ecological balance. However, further strengthening of the water user associations is required to improve the productivity and efficiency of the resource. On the other hand, it is observed that the Water user associations are not designed to suit the needs of the minor tank irrigation systems and hence are not found to be effective. Therefore, these institutions should be tuned to the needs of the resource system.

The problems associated with the three aspects of water resources we have studied clearly indicate how they are manifested in the failure of markets, institutions and policies. It may be noted that these failures are defined in a rather narrow sense here, as markets fall in the broader context of institutions. The problems associated with each of the aspects of water are rooted in one or more of these failures. Therefore, it is difficult to identify a particular problem related to water with a specific failure, though each aspect has a dominant failure type such as groundwater being a case (dominant) of policy failure. Here we formulate the issues pertaining to the different aspects of water in the context of these three failures. It may be noted at the outset that these three failures are linked to one another and hence often over lap with each other.

a) Market Failure

Market failure is defined in the present context as improper or under-priced water; poorly defined property rights and the existing markets are thin and imperfect. Market failure is the common feature and a major reason for all the three types of problems we have addressed. The main problem is that property rights are not clearly defined in none of the cases. In the absence of clearly defined property rights markets fail to operate. This is conspicuous in the case of surface water and water quality (pollution), where water resources are treated as open access resources. Access to the resource is based on riparian laws. This has led to over discharge of effluents (pollution) in to the water bodies by the industries. Since rural communities only have usufruct rights and do not have any legal rights on the water bodies they could not contain discharge of effluents in the given legal framework. This has resulted in the failure of markets or price mechanisms to operate. In general these mechanisms operate through negotiation between the victims and the polluters. The price mechanism can work effectively provided the property rights are well specified and enforced. But in our situation, the tank, which gets polluted, is a common property resource (CPR). In these circumstances, the bargaining could be made between the victims and polluters, which is the main principle of Coaseian approach to internalise the externality, at a zero transaction cost. However, the market failure in this case is not attributed to the problem of zero transaction costs assumption, as this problem is overcome to a large extent with the involvement of local NGOs. In fact, there was a negotiation between polluters and victims' during 1994-95 with regard to compensation for damages. But, after two years of this settlement farmers realised that the compensation was not sufficient to compensate their losses and collectively decided to file a case in Supreme Court with the help of a Zilla Parishad member who is an advocate and other NGOs, expecting a better compensation package. Supreme Court had, in fact, ordered that a report regarding the damage due to pollution should be submitted and also ordered that even one drop of effluence cannot be discharged into the tank. The Supreme Court entrusted the district judge of Medak District the responsibility of estimating the damage costs. However, this single man committee, in the absence of any experts on assessing the damage costs, has estimated the losses at Rs. 1500. The community did not agree for this either, as the actual losses are much higher (about Rs. 18000 per acre as per our estimate).

In the case of surface water market failure is due to under pricing of the resources, which is a consequence of the subsidy policies. Under pricing of water coupled with the existence of riparian rights has led to excess use of canal water in the head reaches and scarcity in the tail end regions. Water prices are far below the economic value of water. Even the existing price policies are not effective, as the recovery rates are quite low. Institutional support is necessary in order to make the price policies effective. In the present context, attempts are made to increase the price of canal water and strengthen the institutional support through the creation of water user associations (WUAs). But, water cess recoveries continue to be low, as they do not even cover the operation and maintenance costs of the canal systems (see chapter two). Again the problem is that WUAs are yet to be given the clear rights on the water or water cess collected. WUAs are not even entrusted with the responsibility of collecting the water charges. In the absence of such rights WUAs do not have any incentive to assess and report the area under irrigation correctly. However, under the WUA legislation it is proposed that the responsibility to collect the water charges and utilising a part of the collection for their own benefit of maintenance at some stage in the process. This needs to be matched with the cost based pricing of water resources and prices should be linked to the actual use. That is volumetric pricing of water is a prerequisite for getting the prices right. This calls for substantial investment in the sector on the technologies. Unless the institutional reforms are integrated with market mechanisms of appropriate pricing policies it is difficult to sustain the reforms in the long run.

Groundwater is a typical case of misinterpreted property rights. For, groundwater is a common pool resource but treated and used as a private resource. Interestingly, while its' use is governed by private property rights (including the ultimate right to transfer), its' management falls under the common property regime. For, replenishment and distribution of groundwater is beyond the purview of private individuals. This idiosyncrasy is mainly due to the linking of water rights with land rights (riparian laws). This has resulted in the over exploitation and degradation of the resource by a few depriving the majority and denying their genuine right on this precious common pool resource. Delinking water rights from land rights would help in addressing the distributional problems to a large extent. But, the problem of resource degradation would still persist even under the new regime of rights. This calls for institutional and market mechanisms that would facilitate the sustainable use of the resource. Community based institutional arrangements fostered with the pricing of the main (water) as well as complementary resource such as electricity would help in ensuring sustainable rates of exploitation of the resource. Our case study clearly demonstrates that the costs / losses due to degradation of groundwater far exceed the replacement / replenishment costs. This suggests that there is scope for imposing a kind of Pigouvian tax on groundwater use, which in turn can be used for sustaining the resource through restoration of the traditional tank systems. Electricity is the main source of energy for groundwater exploitation. Prices of electricity should reflect its economic value. Hither to electricity to farm sector is highly subsidised resulting in over exploitation of groundwater. Therefore, the solution could be a mix of getting the property rights right and internalising the externalities of groundwater exploitation through pricing of groundwater on a lump some (per acre of irrigated area) basis and the complementary source of electricity. Though the feasibility of such initiatives is rather difficult, some useful lessons can be drawn from elsewhere in the country such as *pani panchayat* in Maharastra as well as out side the country like the initiative to abolish the riparian laws in South Africa.

b) Institutional Failure

Institutional failure is defined as the absence of institutions or the presence of ineffective and weak institutions. These institutions could be formal (state promoted) or informal (evolved at local level). In the wake of market failure in managing the natural resources like water in a sustainable fashion, it is widely believed that institutional approaches are more appropriate to tackle the environmental problems. It is argued that community based initiatives (collective action) are expected to be more effective in dealing with the issues at hand. The role of community action is important to have a capacity to bargain or to force the regulatory bodies to respond to their problems. In the present context, these institutions, community based or other wise, seem to have failed to deliver due to the reason that either the existing institutions are weak / ineffective or there are no appropriate institutional arrangements. Let us examine the failures in the context of our case studies.

In the context of water pollution formal as well as informal institutions are ineffective. The situation has the potential and ripe for collective action. Though civil society was organised to tackle the issue the effectiveness of community action is not satisfactory. This is mainly due to the absence of any legal support in defining and protecting the property rights on water bodies. There was no response from any quarters of government authorities to initiate action against the polluting industries despite the community's efforts to bring it to the notice of the government since 1994. The community initiatives range from peaceful Gandhian ways such as *dharna* (mass squatting) in front of the state Secretariat and *Rastha Roko* (blocking roads) to more militant ways of beating up the agents of polluters. However, it did not give any positive results, instead the villagers were *lathi* charged (caned) and arrested. The polluting industries on their part stopped discharging their effluent during the daytime into the tank but continued to do so during nights. Twice, the villagers caught the persons during the night while discharging the effluent and beat them up severely. After the incident the industries were closed down for three to four days and started as usual. The only success the community could boast off was involvement of the judiciary and the resultant compensation package offered by the committee appointed by the Supreme Court. However, the package was not satisfactory to the village community and hence they rejected it.

More importantly, the state promoted formal institutions like the pollution control board (PCB) and the judiciary have also failed in solving the problem. PCBs in general are weak in terms of regulation, as they do not have powers. While they have regulatory powers, they are not ultimate. PCBs regulatory powers could be challenged in the court. Often industries facing the wrath of PCBs approach the courts and obtain stay orders making the PCBs ineffective. Even the working of common effluent treatment plant established by the industries is not satisfactory

(Behera and Reddy, 2002). PCBs are also weak in terms of financial and technical persons. Judiciary, on the other hand, also could not deliver the justice in the absence of perfect information regarding losses incurred by the community due to pollution. The compensation package offered was rather arbitrary without any scientific basis. No attempts were made to assess the actual damages incurred by the community. While the interference of judiciary in such issues is not warranted, it is necessary to strengthen the PCBs and make them effective with more autonomy and powers.

In the context of surface water resources institutions are incomplete and hence ineffective and tend to fail. Surface water resources are now governed by the state promoted formal institutions. These institutions are not yet fully developed and hence their functioning is not satisfactory and sustainable, as mentioned in the context of market failure. In their present form they are partial in addressing the complex issues. These institutions while effective in addressing the problems associated with canal irrigation they are not effective in tackling the problems related to tank irrigation systems. Source specificity need to be taken in to account while formalising the institutions. For the problems of tank systems are different from that of canals. In the case of canal irrigation improving the distributory and drainage systems is enough to solve the problem. Where as in the case of tank systems the need is to restore the tank systems as well as the distributory systems. This calls for larger fund allocations, which is not provided in the present institutional structure. Therefore, institutions in their present form fail in the context of minor irrigation sources. This is resulting in the perpetuation of widespread environmental degradation in fragile environments.

No institutions, formal or informal, exist for the management of groundwater though there are a few cases of community managed groundwater irrigation systems in the state. This is mainly due to the reason that groundwater development takes place privately. Curiously, the formal institutions promoted by the state do not integrate the groundwater systems in to the overall water resource management framework, though groundwater is the single largest source of irrigation. As a result groundwater continues to be over exploited resulting in severe degradation of the resources. Though the need for proper institutional arrangements is strong in order to manage the resource in a sustainable fashion no efforts are made by the state in this direction. Informal and local institutions do not evolve due to its private orientation of the resource. While it is argued that institutions evolve in order to minimise the transaction costs, in the context of groundwater the initial transaction costs are quite high in terms of enforcement of groundwater regulations, organising the communities, etc. Though the benefits would be substantial when compared to the costs, individuals or private parties are unlikely to come forward to bear the costs. For, the interests of various groups in the community work at cross-purposes. While large farmers are interested in continuing the present status of groundwater management, small and marginal farmers are keen to have institutional arrangements that facilitate their access to groundwater (Reddy, 2000). Hence there is strong case for state initiative in this direction.

c) Policy Failure

Policy failure here is defined as the absence of policies or ineffective policies resulting in degradation of resources. Policies could be over reactive or under reactive to the needs of the communities and hence they fail. Often policy failure is equated with market and institutional failures due to the over lapping nature. For, state policies such as farm subsidies may result in market and institutional failures. But this is not necessarily true in all the contexts. Policies not only deal directly with market and institutional mechanisms but also create conducive environment for their evolution and sustenance. It is argued that when market mechanism fails to address certain environmental externalities, the third party intervention (state policies) into the system to control the externalities. This is the interventionist approach or Pigouvian approach, which suggests that the state should intervene with various effective policies. The Pigouvian approach to address the problem of negative externalities would need a strong regulatory system through a benevolent state intervention to control and regulate the pollution. As far as water resources are concerned there is no comprehensive water policy at the national level or state level. What we have at the national level in the name of water policy is an indicative out line of the approaches to water resources management. At the state level we have only sectoral policies such as irrigation policies where water is the main focus issue. However, there are policies at the state level, which deal with water resource management directly. How these policies fail or insufficient to address the three problems is discussed below.

In India, the Ministry of Environment and Forests was established to monitor the environmental pollution and degradation at the central level. But it is pointed out that environment is a State subject and much will depend on how the States implement the various measures being formulated by the centre. To implement various measures at the State level, the Ministry of Environment has established the Pollution Control Boards (PCBs) in every State. Likewise, A.P. Pollution Control Board was established in 1976 under the Water (prevention and control of pollution) Act 1974. The PCB has enormous powers especially after the enactment of the Environmental Protection Act 1986. After the enactment of the Environmental Protection Act, the PCB has got the right to order for the closure of the industries violating its norms. Moreover, it is obligatory and precondition to establish an industry to take license from the PCB that it is well equipped to handle the effluents it generates. Frequent inquiries and inspections to the industry are expected by the regional office and report to PCB.

Though these arrangements look sound and effective policy measures, in reality they do not work properly. The PCB has completely failed in Kazipalle to handle the problems of pollution. Initially, when industries were set up, in Bolarum and Kazipalli, the problems of pollution was overlooked in order to promote rapid industrialisation. Often policies concerning industries or economic development over run the environmental policies. For, environment is often at the bottom of the policy agenda. Though the issue at hand is serious and deals with livelihoods their importance is marginalized in the over all context. A policy framework that requires strict adherence to environmental regulations may push the industry away from the state due to cost implications. Therefore, environmental policies and regulations are soft on implementation. Policies fail, as they are weak and ineffective.

In the context of surface water the policies appear to be inappropriate and lop-sided. As our case studies clearly bring out that there is no integration of various water bodies under the purview of the recent policy initiatives. While groundwater is totally alienated, the policy is biased against the minor surface irrigation systems. As a result, minor irrigation systems largely located in the fragile resource and backward regions are left to degenerate. However, of late there are some attempts in the direction of reviving these water bodies. In the absence of such policies the regional imbalances tend to perpetuate and aggravate the ecological divide. For, the inter linkages surface water bodies like tanks and groundwater coupled with the imbalance in the development of these two resources is resulting in the degradation of both the resources in the long run. Besides, there is coordination between policies related to water and other aspects of agriculture such as price policies. While the recent water policies in the state strive to improve the economic efficiency of water, agricultural price policies tend to promote inefficient water use practices. The case in point is the state intervention in paddy markets to hedge against the falling prices when there is glut in the market. The support price mechanism, especially for paddy, encourages the farmers to grow more paddy, which is highly water intensive, through keeping the paddy prices artificially high. This results in excess and inefficient use of water resources. For, more value addition could have been achieved through the reallocation of water to other crops.

Similarly, in the case of groundwater the policy of subsidised power tariff structure for agriculture in resulting in the wide spread degradation of the resources. More so in the absence of any specific policies dealing with groundwater. There are no policies, except for some regulatory ones linked with institutional credit; dealing with groundwater despite the fact that groundwater is the single largest source of irrigation in the state. Groundwater is conspicuously missing in the recent water user association legislation. Even in the context of *neeru-meeru* (water and people) programme the stress is more on supply side i.e., recharging the aquifers rather than managing the resources in a more efficient and equitous manner. A major contentious issue in the case of groundwater is regarding its equitable distribution providing access to all sections of the community. But, no policy initiatives are made in this regard. The policy has chosen to be blind to this important issue. The policy failure (lack of policies) is clearly reflected in the aggravation of groundwater degradation in many regions. Therefore, there is an immediate need for policy initiatives towards judicious management of the groundwater resources.

Towards an Integrated Approach

As seen above the failures are more due to the partial nature of the policies rather than due to their absence, except perhaps in the case of groundwater. For, markets fail because they do not have the institutional support. We have seen in the case of canal irrigation systems in Andhra Pradesh and else where price policies need to be fostered with appropriate institutional arrangements in order to make the former effective (Reddy, 1998). On the other hand, institutions fail in the absence of market mechanisms to sustain the institutions. For, institutions cannot survive longer with external support. This could well be the case with the WUAs in Andhra Pradesh, if the system does not adapt to an effective self-financing mechanism through appropriate price polices. The success of some of the initiatives in natural resource management, traditional as well as modern, is rooted in the integration of market and institutional approach. Though our case studies do not provide any evidence of such success, they clearly drive the point home that the failures could be due to the absence of an integrated approach. Further, there is a need for coordination between water policies and other policies such as input and out put policies. They should work in tandem rather than working in diagonally opposite directions. These include input and out put policies such as input subsidies (including power), procurement policies, etc.

Such an integrated approach makes sense even on theoretical grounds. For, an integrated approach helps in keeping the transaction costs low, which is crucial for sustaining the institutions. Pricing mechanism leads to increased cohesion and cooperation within the community, as each member has a stake in the upkeep of the institution consequent upon his or her contribution. Increased cooperation means low transaction costs towards organising the community and keeping it together. However, equity in sharing the costs (user charges or contributions) on the basis of resource is critical in sustaining the institutional arrangements. In the absence of equity, people contributing disproportionately higher shares may tend to under mine the collective action initiatives. Similarly, institutional back up for market approaches also reduces transaction costs, as they make compliance to rules and regulation (including pricing) easier and smooth. Recovery of irrigation charges tends to be high in the presence of appropriate institutional mechanisms. However, the process needs to be dynamic in order to address the changing contexts market as well as institutional mechanisms.

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Appendix

Table 1a: Households Perceptions About the Impact of the Declining Groundwater.

Village/ Size class		Large	Medium	Small	Marginal	All
Teegaram	Avg.Decline (feet)	1.5	2.29	1.45	1.40	1.68
% Farmers reporting	Area Change	100	100	100	100	100
	Crop Change	100	100	100	100	100
	Vegetation	100	100	100	100	100
	Grazing land	100	100	100	100	100
	Drinking water	100	71	80	60	76
	% wells reported decline in water	100	100	100	100	100
Vanaparthy	Avg.Decline (in feet)	2	1.33	1.50	1.67	1.57
% Farmers reporting	Area Change	100	100	100	100	100
	Crop Change	100	100	100	100	100
	Vegetation	100	100	87	100	95
	Grazing land	100	100	90	84	88
	Drinking water	100	83	60	50	68
	% wells reported decline in water	100	100	100	100	100
Vaddicherla	Avg.Decline (in feet)	2.56	2.50	1.86	1.80	2.20
% Farmers reporting	Area Change	100	100	100	100	100
	Crop Change	100	100	100	100	100
	Vegetation	100	100	100	100	100
	Grazing land	89	100	100	100	96
	Drinking water	89	100	85	80	88
	% wells reported decline in water	100	100	100	100	100