Community-Based Groundwater Management in Andhra Pradesh, India

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Abstract

Increasing concern surrounds groundwater management throughout South Asia. The Green Revolution that emanated from the 1960s intensified agricultural practices in India has led to the overexploitation of groundwater in many districts. The management of groundwater in these places is increasingly complex due to the many stakeholders that utilise a resource that is largely hidden from view. This complexity is further compounded when the various physical and social aspects surrounding groundwater are considered. Hydrogeological and climatic factors influence the availability, capacity and recharge of the groundwater, all of which can vary substantially over an area at various scales. Further, social aspects relating to access, equality and the power structures within the Indian context of this research all add further dimensions that need to be considered in the management of the groundwater resource. The southern Indian state of Andhra Pradesh forms the focus for this study through which a community based approach to management is explored. The Andhra Pradesh Farmer Managed Groundwater Systems (APFAMGS) project was investigated as a means through which insight into this community based approach was gained. The project aimed to demystify the science of groundwater management and disseminate knowledge to farmers surrounding sustainable agricultural practices in drought prone areas of Andhra Pradesh. Utilising both qualitative and quantitative research approaches the project was investigated over three such districts involving four NGOs and approximately 140 farmers.

The analysis undertaken suggests that the APFAMGS project has been largely successful, with farmers citing the increased knowledge and skills in water measurement and management, crop rotations and appropriate fertiliser use as major benefits that they had gained through their participation. As it is the farmers themselves that undertake the monitoring, participants in this project have an enhanced understanding of the resource in comparison to those who have merely been told about the state of groundwater. The majority of farmers who have bore wells reported that they engaged in the monitoring of the groundwater level, with most conducting this twice a month. With this increased understanding of the groundwater resource within their area, farmers could effectively grow crops according to the
irrigation capacity of the resource and plan their farming regime accordingly. It was therefore evident that the project promoted good farming techniques as well as water management with many farmers stating that after the project they have enough water to grow their crops and enjoy greater security over their investments.

The involvement of NGOs in projects such as APFAMGS was cited as significant for their success by building rapport with participants, delivering expert input and initiating links between communities and other organisations. Likewise, and particularly in the early stages of implementation, local leadership was identified as a significant factor for success. The sharing of groundwater through community-owned bore wells and the selling of groundwater were also identified as important and this thesis highlights the equality issues associated with such initiatives in the highly stratified social contexts of rural Andhra Pradesh. Overall, this research explores these agro-ecological, social and economic issues associated with the management of groundwater and provides insight into the effectiveness of a community-based collaborative approach.
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<td>APFAMGS</td>
<td>Andhra Pradesh Farmer Managed Groundwater Systems</td>
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<td>APWALTA</td>
<td>Andhra Pradesh Water, Land and Trees Act 2002</td>
</tr>
<tr>
<td>APWELLS</td>
<td>Andhra Pradesh Groundwater Bore Well Irrigation Schemes Project</td>
</tr>
<tr>
<td>BIRDS</td>
<td>Bharati Integrated Rural Development Society (NGO)</td>
</tr>
<tr>
<td>CWB</td>
<td>Crop Water Budget</td>
</tr>
<tr>
<td>DIPA</td>
<td>Development Initiatives and People’s Action (NGO)</td>
</tr>
<tr>
<td>FAO</td>
<td>Food and Agriculture Organisation of the United Nations</td>
</tr>
<tr>
<td>FFS</td>
<td>Farmer Field School</td>
</tr>
<tr>
<td>FWS</td>
<td>Farmer Water School</td>
</tr>
<tr>
<td>GDP</td>
<td>Gross Domestic Product</td>
</tr>
<tr>
<td>GMC</td>
<td>Groundwater Management Committee</td>
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<tr>
<td>GoAP</td>
<td>Government of Andhra Pradesh</td>
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<tr>
<td>HUN</td>
<td>Hydrological Unit Network</td>
</tr>
<tr>
<td>NGO</td>
<td>Non-Governmental Organisation</td>
</tr>
<tr>
<td>NWP</td>
<td>National Water Policy 2002</td>
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<tr>
<td>PIM</td>
<td>Participatory Irrigation Management</td>
</tr>
<tr>
<td>SAFE</td>
<td>Society for Sustainable Agriculture and Forest Ecology (NGO)</td>
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<tr>
<td>SYA</td>
<td>Star Youth Association (NGO)</td>
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Introduction

Groundwater development is undoubtedly a resource regarded with high value in many regions of the world. Particularly for developing nations, groundwater has the potential to address many aspects of poverty and greatly increase the rural economy. This is mainly attributed to the fact that groundwater needs little transportation; being produced at, or near the required site and to an extent can be obtained on demand (Vaidyanathan, 1999). Over the previous decades agricultural development through groundwater expansion has occurred intensively. This is largely due to the influence of the Green Revolution on many agrarian economies, vastly changing the capacity of farmers to increase their produce, but also significantly altering the inputs required, namely; the level of irrigation, fertilisers, pesticides in combination with high yielding crop varieties. In India, as in many other areas of the world this has greatly increased the competitive nature of agriculture. This means that an increasing number of farmers are turning to the boring of wells to secure their required water needs, expand their agricultural capacity and to remain competitive with those that have already experienced such development.

Although the development of groundwater offers potential for improving the livelihoods of the poor, there have also been substantial shortcomings and problems that have come about through inadequate management. These have “hydrogeological, social, economic, cultural and political factors [that] can vary greatly at local or regional scales” (Datta, 2005, p.814). These, for a large part can largely undo many of the benefits that may have been delivered through the development of the resource. There are significant debates surrounding the development of groundwater, and both the associated benefits and resulting shortcomings have received substantial scholarly attention. Many of these are addressed through the literature review.

Current policy in many regions of India has a distinct focus on further development of groundwater over the management of the resource. Although legislation highlights the importance of effective management for attaining sustainability within the resource,
this is not occurring to the desired levels. For the state of Andhra Pradesh in which research was undertaken, highly subsidised power supplies have been given for agricultural purposes. These “place no premium on heavy pumping” and are viewed by some as contributing to the over-extraction of groundwater (Steenbergen, 2006, p.381). This forms one aspect of the conundrum through which the over exploitation of groundwater has occurred, further necessitating the need for effect management of the resource. One such approach that is gaining a footing is that of community based management.

Collaboration between the users of the groundwater resource is fundamental in a community-based approach through which participants are given the knowledge and ability to manage the resource. It also operates on the notion that ultimately it is the end users of the resource that undertake extraction and therefore they should be aware of the need for management and have a participatory role. For such an approach to be effective there needs to be cooperation from all users of a resource, otherwise those who participate will be comparatively disadvantaged and the prospect of attaining sustainability will be lessened (Ostrom, 1990). The conditions under which this occurs is therefore an important aspect of this thesis. Ideas of equality constitute a strong debate surrounding the development of groundwater, likewise through the establishment of groundwater markets. Although these improve the access to irrigation waters they have equally been cited for increasing and reinforcing inequalities within society. The issue is therefore how to engage and involve all members of the community in the management approach. Management projects are an example of such an effort, and forms the basis to which this thesis is orientated. These aim at promoting groundwater management at the local level and empowering communities.

1.1 The groundwater resource

Groundwater is an increasingly important resource in the Indian context. Over the previous decades reliance on the resource, particularly for agricultural purposes has increased dramatically. Groundwater irrigated areas throughout India have tripled over the previous decades, increasing from 11.9 million ha in 1970 to 33.1 million ha in 1998. Mukherji and Shah (2005) depict this rise as shown in Figure 1. Groundwater sources, namely wells and tubewells have undergone significant increases throughout
the latter half of the 20th century, showing very much a dominance of groundwater sourced for irrigation purposes. The number of bore wells that service this irrigated land is substantial with Andhra Pradesh alone having somewhere in the region of 2,350,000 registered (Steenbergen, 2006).

Groundwater is seen to be both replenishable and finite. Recharge occurs through water seeping down through soils to underground storage. The main sources of recharge are rainfall, although canal seepage and that from irrigation can also contribute (Chatterjee & Purohit, 2009). Thus, there is a strong link between surface and groundwater. Different soils and agro-climatic conditions influence the availability of groundwater, meaning it is highly variable throughout the country in turn influencing the management approach that is relevant (Chatterjee & Purohit, 2009). Likewise different soils will have different infiltration rates. These aspects of the groundwater resource highlight the need for a management approach that is specific to each locality.

1.2 Rational for research

It is evident that management projects can have a significant impact on increasing the security of irrigation for farmers in the developing world. This research was therefore born out of an interest in determining the factors that influence the success levels of these projects. The role of NGOs in such projects, or the level to which this is essential to the effective collaborative management of resources is an issue that has
received academic attention. The underlying purpose of this research is therefore to evaluate the effectiveness of this approach through the use of a case study: the Andhra Pradesh Farmer Managed Groundwater Systems (APFAMGS) project. This project was implemented in 7 drought prone districts of the state and aimed at empowering participants to effectively manage the groundwater systems, through promoting efficiency and water conservative agricultural practices.

1.3 Scope and participants of research

The research incorporated a range of literature and legislation that was necessary to frame and define the focus. Although some international literature was utilised, the focus remained on the Indian context. The studied project has been implemented through non-government organisations (NGO). Representatives of the four NGOs that research was conducted with formed one aspect, with the other being the farmers themselves. The criteria of farmer participants were that they had a landholding of some degree. There was discussion with a range of farmers, with the aim of gaining insight into the projects effectiveness over a cross section of the community.

1.4 Research aims and objectives

The aim of this research is to provide insight into community based groundwater management, the roles of various stakeholders and the conditions under which it is more likely to be effective. This aims to build on existing literature surrounding management projects and collaborative community based management.

In addressing the research aim the research questions are as follows:

1. To what extent do management projects promote collaborative management of groundwater and the sharing of the resource?
2. What are the main roles that NGOs play?
3. How effective成功的 are such projects?
4. What are the conditions in which such projects are more likely to be met with success?

The first question can be broken into two parts. The first relates to the promotion of collaborative management and hence strongly to the overall aim of the research. Sharing of the groundwater resource will be evaluated through looking at the
incidence of community bore wells and to an extent the prevalence of groundwater markets.

The second question relates to the role that NGOs play in the management process and the project itself. This will be investigated through both key informants from the NGOs and the farmers that have interacted and worked with them through the project. This will provide insight into the roles that they play and the value of this contribution.

The third question is general in nature, but constitutes an important aspect of this research. This relates to the impact that the project has within a community through the training and teaching received. The perception of the farmer relating to the level of success of the project will also play an important point.

The final question is important when concerning any practical application of the research. Such conditions are hoped to provide insight into the sorts of communities and factors within communities that have a strong influence on the potential success of such projects.

It is hoped that this research will provide useful information concerning the implementation and application of management projects. It is intended to provide insight into these projects, outlining strengths, weaknesses and the conditions under which they are more likely to be successful.

1.5 Research approach

This research follows a critical approach, with an interpretative underpinning as a theoretical framework. There were both qualitative and quantitative aspects to the research. This involved interviews with both Key Informants and farmers. As information was sourced from both sources it was important that a critical approach was taken through which an in-depth analysis of the research could be based. In applying and analysing the debates surrounding community-based management, a critical approach allowed for an understanding of and comprehension into the reasons that may be attributed for variations in the responses given. Responses of interviews were categorised and from this, overall ideas and comparisons could be obtained. An interpretative approach conjointly adopted allowed for a analysis of how people
interacted with each other. This aspect was particularly relevant when considering the community dynamics concerning the sharing of groundwater.

Qualitative methods were utilised in the conducting of interviews. However, statistical analysis was used for the analysis and extraction of information for many aspects of the interviews with farmers, thus, inducing quantitative aspects to the research. Research was undertaken in India during February and March, 2011. This included the carrying out of the aforementioned interviews, as well as observations, site visits, and interacting with both the NGOs involved and the farmers. As stated, the APFAMGS project forms the basis over which this community based management approach is considered. The limitations associated with this research and the approach taken, are considered in the Methodology Chapter.

1.6 Structure of thesis

The structure of this thesis is divided into six chapters. Chapter one has served as an introduction into the topic and the research, outlining briefly the groundwater issue and the idea community based groundwater management, the focus of this thesis. The following literature review goes further into the topic, examining why the necessity of effective management of groundwater has eventuated. Collaborative management of resources is put forward as a way through which this management can be achieved and is discussed. Keeping in mind the focus of the thesis, the literature review then builds on the ideas surrounding community based management and discusses management projects, the various roles of stakeholders and the factors that can influence them.

The context of the research is put forward in Chapter three. This focuses the literature put forward in the preceding literature review and builds on that which is relevant to the situation in which this research exists. Chapter four discusses the methodology used to gather both the qualitative and quantitative information, which the results of this thesis are based. This chapter also reflects on the research process and addresses the limitations that have been identified through this research process. This is particularly relevant when considering cross cultural research and the various implications this has for the collection of data.
Chapter five outlines the results of this research and subsequently puts forward discussion and analysis of these findings. It is split into sections that are predominantly a reflection of the data collected, but also in a manner through which the research questions are addressed as a whole. It could be put that this is a representation of the main themes within the findings of this research, but also in line with the methodological framework put forward in the preceding Chapter four.

The final chapter brings together and presents the concluding points of this research. The main findings put forward in the results and discussion are summarised, recommendations are put forward, overall reflections of the research are given and possibilities for further research are outlined.
2 Literature review

2.1 Introduction

This section of the thesis will outline the literature that provides a relevant framework for which community based groundwater systems can be managed and understood. An understanding of the environment in which management is occurring is fundamental to the discussion, as are the debates surrounding the various approaches and effects. Thus, important influencing factors particularly the Green Revolution are discussed, as they have contributed and greatly shaped agriculture in contemporary India. This incorporates developments in water extraction technologies, high yielding crop varieties, and synthetic fertilisers and pesticides. These have had a significant impact on the environment in which agriculture is occurring, deviating from more traditional approaches. Different levels of access to these developments have induced disparities between areas in terms of agricultural practices, levels of produce and the differing effects associated with the Green Revolution.

Section 2.3 then discusses electricity subsidies as a means of promulgating groundwater development and the associated benefits, but also how this contributes to groundwater overexploitation as the resource is tapped through an open access framework. It is argued that this largely constitutes a political or policy aspect to groundwater development through which changes prove difficult due to the various pressures asserted. The current stance of government concerning regulation and further development initiatives being preferred over management of existing schemes is then discussed in sections 2.4 and 2.5. This provides background to the overall approaches and the requirements for an effective approach. The following two sections focus on the need for a catchment wide approach in the management of groundwater and the spatial differences that influence the way or approach in which management of the resource should be undertaken.
The ideas of community based groundwater management are put forward in sections 2.8, 2.9 and 2.10, this being situated substantially within discussion of common pool resources in general. The theories behind the management of these resources and ideas of equality are discussed in relation to groundwater management. In essence, collaboration between users forms the basis of this approach. The conditions under which community based groundwater management may occur effectively forms an important aspect to this thesis. The debates surrounding equity considerations and the benefits associated with the development of groundwater and the implications for communities are discussed, providing insight into some of the positives as well as negatives.

Further debate is put forward concerning the establishment of water markets in section 2.11. Once again these are centred on equality and power issues within the community structure. Groundwater markets can provide for intensification of agriculture for a wider range of people through increased access, but equally, at times, can reinforce existing inequalities within rural society. NGO involvement in management programs that promote collective management of common pool resources are discussed in section 2.12. The basis of this is creating overall cohesion in the management effort, providing links between communities and with other organisations that can deliver benefits to participants. Whether or not NGO involvement is necessary in the management of groundwater in India is explored. Adoption of water saving technologies can provide a means whereby efficient use of water extracted is improved. Reasons for such adoption are put forward and discussed.

The aim of this review is to outline the literature that frames the situation in which community based groundwater management projects are being initiated in India. Following the literature review this thesis applies the discussion through specific application concerning a case study of the Andhra Pradesh Farmer Managed Groundwater Systems (APFAMGS) project, which as stated, forms the basis of this research.
2.2 The Green Revolution

It is important to outline the reasons why the need for groundwater management has eventuated and the agricultural conditions that underpin the debate. This section briefly investigates the Green Revolution and the resulting effects that have inevitably shaped the agricultural industry in many parts of India. The Green Revolution has greatly influenced the environment in which farming exists throughout South Asia, even to the extent that it is unclear which is more significant; the associated benefits or shortcomings (Tilman, 1998). Perhaps the notable benefit associated with the Green Revolution is that of attaining food self-sufficiency, a point reiterated by numerous authors (Evenson & Gollin, 2003; Hill, 2009; Parayil, 1992). However, equally cited are the associated negatives, such as over-exploitation and contamination of the groundwater resource and the various social implications such as equality gaps that influence rural economies and people (Shah et al., 2001; Hill, 2009). This section therefore investigates these associated positives and negatives.

Groundwater use in India as well as much of South Asia has undergone significant growth in recent times (Romani, 2007). Vaidyanathan (1999) highlights a number of reasons for this growth. Firstly, Green Revolution technologies for lifting and extracting groundwater have improved markedly, allowing for deeper aquifers to be tapped and lowering the cost of extraction. Scientific advances in crops that give high yielding varieties of many of the staple crops grown throughout the world have changed outputs of the agricultural industry, but also altered the required inputs. Significant advances in the development of fertilisers and pesticides, particularly those that incorporate synthetic nitrogen based minerals have changed the sorts and extent of fertiliser application. The combination of these constituted the Green Revolution and vastly changed the environment in which farming operated in these regions. Although the focus of this research is on groundwater management, it is hard to look at this in isolation of the other factors that influence the practices and environments that farmers contend with in India. It is important to note that many of the advances associated with the Green Revolution are interrelated and cannot be effectively looked at in isolation (Feder & Umali, 1993). This section of the literature review will therefore build on these notions, outlining what was delivered through the Green Revolution, and the associated positives and negatives.
2.2.1 Increasing groundwater use

Throughout much of India there have been vast increases over the last decades in the area irrigated by shallow and deep tube wells (Ramachandrula, 2008). This is largely associated with the increased inputs required through the Green Revolution. Some sources state that the irrigated area within India is now more predominantly served by wells and tube wells as opposed to surface water irrigation, with increasingly high use of the groundwater resource initiated over the last four decades (Shah et al., 2003; Romani, 2007; Hill, 2009; Yelda & Peddi, 2007). This increase was substantial with Menon (2007) stating that in 1960 1% of irrigated land was served by groundwater and by 1968 this had increased to 27%. This figure may now be as high as 58-60% of irrigation water (Yelda & Peddi, 2007).

Groundwater use has meant that cropping intensities can be raised and that farmers are more able to deal with seasonal climatic conditions (Vaidyanathan, 1999). Particularly for areas that have received little canal irrigation, groundwater use has increased the self-sufficiency of food production (Hill, 2009). However, this is far from uniform across South Asia as different physical regimes along with other factors influence the accessibility of the resource. Most notably the intensification of agriculture has largely influenced the amount required and the volume of water used (Hill, 2009). As a result the regions throughout South Asia that have sustainable groundwater balances are shrinking by the day (Menon, 2007). Depletion of the water table due to overdraft, water logging, salinisation and pollution are the main issues that are being faced on a worldwide stage. For instance, in some of the more agriculturally developed regions of Mexico groundwater levels were found to be lowering an average of 1.79-3.3 m every year (Shah et al., 2001).

The vast number of tube wells that have been sunk over the past several decades has increased the quantity of such areas in which withdrawal exceeds recharge (Shah et al., 2001). However, it is noticeable that specific areas are at a more advanced stage in respect of the consequences of over exploitation of groundwater in comparison to others. These regions are often identified as those that underwent the benefits of the Green Revolution and had access to the associated benefits of the technologies available (Hill, 2009). The consequences will vary greatly with locality. For instance,
in coastal areas the over-extraction of groundwater has meant that regions have experienced significant saline intrusion (Romani, 2007., Vaiyanathan, 1999).

The Indian state of Gujarat “generated previously unseen prosperity” through sustained overpumping of groundwater (Shah et al., 2001, p.4144). However, the end effect has been extensive saline intrusion, and ultimately the decline of the once prosperous agricultural industry. The Saurashtra coast of Gujarat was another area. There was rapid growth in the agricultural industry, which encompassed massive over-pumping of groundwater to meet the irrigation requirements. Saline intrusion now extends into the coastal aquifers as far as 7 km inland (Shah et al., 2001). A lack of appreciation for the environment in which pumping was occurring, as well as the resulting state of the resource has meant that severe over exploitation has occurred and equally led to a crash in the agrarian economy.

The effects of groundwater depletion will be greatest in areas that rely solely on groundwater for their irrigation requirements (Romani, 2007). Thus, the effects will not be as strong as in areas in which there are combinations of surface and groundwater sources for irrigation; acting as an integrated approach in which the two sources complements one another. At the other end of the scale indiscriminate or improper application of surface water for irrigation may lead to a rise in the water table that can result in water logging and salinity (Vaidyanathan, 1999). Education of farmers is essential if this problem is to be addressed so that such indiscriminate water application is avoided. Not only do the two sources of surface and groundwater compliment one another, in fact the expansion of the use of groundwater resources in command areas of surface irrigation may be able to curb some of the effects of groundwater table rising (Vaidyanathan, 1999).

This recent and substantial development is largely associated with the technological advances that have made tube wells and groundwater extraction devices available to a wider range of people. Therefore, perhaps most markedly there have been exponential increases in well density as more people initiate tube wells (Ramachandrula, 2008). Groundwater for much of India, is therefore, the predominant source for irrigation requirements. It is fair to say that the impacts of the Green Revolution have been far reaching, as too are the range of consequences experienced by those regions (Tilman, 1998).
2.2.2 Technological advances

Technological advances associated with the Green Revolution in India have been substantial. As stated, Green Revolution technologies have created access to the groundwater resource for a greater range of farmers throughout South Asia. In relation to extraction it resulted in high mechanical investment, such as tractors, electric tube wells and pumpsets (Jeffrey, 2001). Adiseshu (2008) largely attributed this to the increased availability of these technologies. Mukherji and Shah (2005) highlight this point also, especially in cases where there are affordable imports from China. Although this increased access has greatly increased the food generating capacity of many regions, inevitably there have also been significant consequences associated with such a degree of agricultural expansion (Menon, 2007).

As bore wells and pumps become more accessible the density of wells over a given area increases. This has an impact on the productivity and capacity of each individual well as the groundwater becomes over extracted through high demand in a competitive extraction market (Ramachandrula, 2008). As more wells get installed and the water table is lowered the cost of extraction increases and may reach a point where extraction is uneconomical. Water pressure also decreases with the lowering of the water table. Fundamentally this means that as the water level is lowered, it costs more to lift the water and less water is extracted. This of course introduces socio-economic implications as sectors of the community may get ‘priced out’ before others (Menon, 2007). This aspect is however devolved further in sections 2.9 and 2.10.

2.2.3 High yielding crop varieties and synthetic fertilisers

The Green Revolution undoubtedly changed the way in which agriculture is carried out for many parts of the world. This advent incorporated use of chemical fertilisers and high yielding crop varieties (Jeffrey, 2001). For India in particular, the differences in productivity between rain fed and irrigated agricultural areas of India became increasingly more apparent after the adoption of such high yielding seeds and fertilisers (Sen, 2008). It is apparent that there are multiple linkages between different aspects of the agricultural industry. These changes associated with the Green Revolution largely relate to the productivity of agriculture, but also incorporate the
changing inputs, such as fertilisers and increased irrigation requirements needed to maintain growth.

Research concerning modern or high yielding crop varieties began in the 1950s and by the 1960s many of these varieties began to be introduced to the Asian markets (Evenson & Gollin, 2003). Some authors stated that this aspect of the Green Revolution was very important in dealing with massive population increases. Improving cropping output could not be left to relying purely on favourable conditions, but should instead concentrate on raising the productivity of marginal farmers through such increases in technology (Wolf, 1986). Initially this meant expansion of agriculture into surrounding-unused land, increasing the net sown area (Hill, 2009). This was then followed by a sustained period of intensification from the mid-1960s, where the productivity of formerly marginal land was greatly increased (Evenson & Gollin, 2003; Hill, 2009; Parayil, 1992). However, this does not take away from the fact that it was areas that had the highest productivity potential that received the most benefit from Green Revolution technologies (Cleaver, 1972). This reinforced and at times created the inequalities that exist in many marginal farming areas of the developing world (Wolf, 1986).

A major factor in high-intensity agriculture is the use and dependence on pesticides and chemical fertilisers (Tilman, 1998). During early stages of the Green Revolution, both researchers and extension agents encouraged farmers to use more fertilisers, pesticides and irrigation in combination with newly bred, high yielding crop varieties (Wolf, 1986). This highlights an apparent focus on improving output, with little regard for the ultimate impacts that these initiatives may be having.

Areas of Asia that had the most substantial increases in fertiliser use, to a large extent reaped the most benefits, albeit in the short term (Wolf, 1986). For instance, large-scale nitrogenous fertiliser application was seen as a way in which the maximum yields could be obtained in a season. Flow on, long term effects in many cases were not considered. The sustainability of such practices is under question especially when the consequences are considered, including: soil fertility loss, erosion, contamination disease and various inputs required (Yelda & Peddi, 2007).
In comparison to organic fertilisers as much as 60% more nitrogen can leach into groundwater through the use of chemical fertilisers (Tilman, 1998). The main reason that is put forward for this is that the spike associated with synthetic fertiliser application might not be as in tune with nutrient demand of plants as the slow release of organic fertilisers (Tilman, 1998). There is a need for precision in the application of fertilisers, pesticides and irrigation. Some of the high yielding varieties of seeds produce no more, or even less than traditional varieties if there is inadequate or uncontrolled application of fertilisers as well as irrigation (Cleaver, 1972). This is particularly evident with synthetic fertilisers such as those with a base of nitrogen and/or phosphorus (Wolf, 1986).

The advent of the Green Revolution has for a large part, “broken what was once the tight, local recycling of nutrients on individual farms” (Tilman, 1998, p.211). Agricultural methods that often were built up over hundreds of years have been substituted for ‘modern’ practices involving seeds that have been used in the environment for equally as long (Parayil, 1992). These are potentially damaging for the environment if not managed adequately and ultimately less economical in the long run. These changes over a comparatively small amount of time highlight the speed at which the Green Revolution has altered the agrarian economy of India. Soil characteristics and nutrient balances vary greatly throughout India. In addressing these variations and deficiencies there needs to be fertiliser application that meets those specific requirements (Wolf, 1986). This also highlights the developments in management that need to occur through which the requirements of these ‘modern’ practices can be met.

The available literature on changes occurring since the 1960s in Asia suggests that through a lack of understanding of both the groundwater resource as well as the consequences that may result through over exploitation, the benefits that have been delivered through the Green Revolution may be undermined (Shah et al, 2003). The literature review will now discuss some of the external factors that have attributed to the rise in groundwater use and associated agricultural development.
2.3 Electricity subsidy for agricultural purposes

The uptake of mechanised groundwater extraction has had various factors influencing it. In many parts of India rural electricity programs implemented by successive governments have supplied power for agricultural use at a significantly subsidised rate. In several cases this has been a key election and political issue (Mukherji & Shah, 2005). Minimising the cost of extraction for the farmer has contributed to the over-exploitation of groundwater of many regions of India (Ramachandrula, 2008; Shah et al., 2003; Menon, 2007).

In Andhra Pradesh as much as 7 hours per day of free electricity is supplied to farmers for agricultural purposes such as the running of tube wells. This has led to vast increases in the energy requirements of the state, and subsequently contributed to the demise in both quality and quantity of the groundwater resource, as well as the ‘bleeding’ of the electricity industry (Ramachandrula, 2008; Shah et al., 2003). Some authors put forward the notion of effective pricing regimes that will mean less economically viable wells will not be constructed. Strong farmer lobby groups have opposed this, and in many cases would signal political suicide for those that promoted such strategies (Shah et al., 2003).

2.3.1 Changing this incentive regime

If the government provides the means and incentives to check overexploitation, such as the withdrawal of subsidies for agricultural electricity, the costs of extraction will be passed onto those who extract groundwater (Vaidyanathan, 1999). Likewise, several authors advocate for the need for metered rates as opposed to the current flat tariff based on pump size, stating this would result in a more water efficient agrarian industry (Vaidyanathan, 1999; Shah et al., 2003). However, the impact on rural economies needs to be taken into account, as farmers might turn to other sources such as diesel generators or initiate unregistered wells. Previously, the government was acclaimed for these subsidy initiatives, as they fostered growth in the agricultural industry and provided measures towards self-sufficiency in food production (Mukherji and Shah, 2005). However, there is a growing realization that equally, this may have contributed to the overexploitation of the groundwater resource (Vaidyanathan, 1999). Whatever the case, it seems that if the current regime is to
prevail, then similarly, there needs to be incentives and education that promote the conservative use of water.

### 2.4 Regulation

State regulation of the groundwater resource is viewed as necessary by numerous authors. The debate between authors concerns the extent to which this regulation should extend. For some, the most effective and efficient way to achieve sustainability is to simply “make it more expensive to pump water” (Vaidyanathan, 1999, p.103). However, the consensus among authors is that there needs to be state directed incentives among other initiatives to discourage the over exploitation of the groundwater resource (Menon, 2007). For instance, Khanna (2002) states that it would not be efficient enough for centralised ‘bureaucracy’ to be able to manage the complex task. Instead “the priority should be to loosen the tight control of bureaucracy and give a significant say to farmers in water management” (Khanna, 2002, p.3). This is illustrated by Mukherji and Shah (2005) in Figure 2, through which the existing and desirable groundwater governance scenarios are debated. It can be seen that the current central government role is high, with the desired level being substantially reduced. The role of civil society, regional policies and markets are desired to be substantially increased, with global lessons having less of an influence on policy formations; a reflection of the local specificities and conditions when it comes to groundwater governance.
This management scenario or approach is effectively placing the management and essentially control of groundwater into the hands of those who use the resource (Khanna, 2002). As such this local or ‘community’ based management of groundwater, where users effectively impose self-restrictions to achieve the sustainability of the resource is gaining more of a footing in management regimes in India (Steenbergen, 2006). This of course highlights the need for adequate education of users concerning the resource and is further discussed in subsequent sections of this review.
2.5 Focus of development over management

Currently, throughout much of India there is a focus on development as opposed to management. Vaidyanathan (1999, p.114) states that a substantial “prerequisite for improving water management lies in many cases in organizational and managerial reform”. This relates strongly to where funds are placed and where investments are made. There is a significant emphasis on the development of new schemes, which has for a substantial period been to the detriment of existing schemes (Shah et al., 2001).

The Green Revolution and subsequent groundwater boom has meant that many people that traditionally relied on rainwater, and ‘rainwater harvesting’ for their water needs have now turned to wells and tube wells (Narain, 2003). There needs to be a reversion and encouragement to “renewing and improving traditional local systems” (Vaidyanathan, 1999, p.115). In comparison to the amount of investment into new irrigation schemes and structures, the “magnitude of investment is relatively small” to meet the requirements of maintaining those already existing, (Vaidyanathan, 1999, p.113). There is a distinct need for a change from the resource development stance concerning groundwater to that of resource management (Batchelor et al., 2003; Shah et al., 2003).

2.6 Catchment wide approach

To improve the overall quality of the groundwater resource it is important that a catchment wide approach is undertaken in the management of the resource. This includes such things as the reforestation of the catchment areas of tanks, and restoring the capacity of irrigation distribution networks and tanks (Vaidyanathan, 1999). To establish such initiatives may require the restricted use of common pool resources. For instance, in the past there may have been use of timber from common property. However, effective basin management means that upper catchment areas also needs to be managed, through afforestation, which will decrease hortonian overland flow (runoff) and increase infiltration, thus replenishing the aquifer and the sustainability of the groundwater resource (Vaidyanathan, 1999). This decreases the velocity of runoff, allowing for recharge to occur (Shah et al., 2003). In terms of community based management such catchment wide approaches may be necessary to gain cohesion in the management of the resource.
2.6.1 Lack of scientific data

A major limitation to the effective management of groundwater in India is the lack of scientific data concerning the state of the resource and extraction rates (Romani, 2007; Shah et al., 2003; Menon, 2007). The importance of knowledge of the resource such as the boundaries of the aquifer is crucial in determining the sustainable level of the resource (Vaidyanathan, 1999). If effective management of the resource is to occur there needs to be such information available. Even information about the proportion of wells that are drying up may provide a crucial indication of the state of the resource (Menon, 2007). This lack of basic knowledge and scientific data concerning the groundwater resources is a fundamental difference when comparisons are made to the management of surface water.

Government personnel have a more significant and managerial role in major and medium sized surface works compared to the private sector orientated groundwater industry. Meaningful information can be extracted and collaborated at a state level which in turn leads to management of the surface water resource at more of a regional and potentially catchment scale (Vaidyanathan, 1999). Although, numerous sources suggest the need for a catchment or regional based approach to the management of groundwater, in most areas of India this is not occurring (Romani, 2007). Vaidyanathan (1999, p.69) states that estimates associated with the development and usage levels of groundwater are based more on “norms and assumptions rather than direct measurements of actual extraction”. Hence, this does not address the variations in the groundwater resource, as discussed in section 2.7.

The government needs to increase the collection of data and the status of the resource, and learn from the areas in which mistakes have already been made, not only to address those mistakes but to also apply them to other scenarios (Shah et al., 2003). The changing nature of the groundwater scenario necessitates this assessment and reassessment of the state of the resource (Chatterjee & Purohit, 2009). The involvement of communities through community-based initiatives can provide a cost effective means whereby such monitoring and data collection can be achieved (Hooja et al., 2002). However, as stated, the appropriate management regime will be largely dictated through where the irrigation water is sourced (Vaidyanathan, 1999).
2.7 Spatial differences influencing groundwater extraction

Overall, in South Asia there is an abundance of groundwater to be tapped; far in excess of that which is already utilised. Only about an estimated third of the annual recharge that India receives is utilised (Shah et al., 2001). Therefore, it is the spatial imbalance of groundwater usage that is the issue, with some areas at levels greatly in excess of sustainable levels, and with others that have the capacity for further development (Vaidyanathan, 1999). For some areas such as the Ganga-Meghna-Brahmaputra basin, it is highlighted that there is a distinct need for development of the groundwater resources to combat the effects water logging and flood-proneness (Shah et al., 2001). This could involve a planned draw-down of the water table prior to the monsoon, thus allowing for enhanced recharge from the monsoon rains and alleviating flooding (Shah et al., 2001). Numerous authors highlight the advantages associated with conjunctive use of surface and groundwater resources. Romani et al. (2007) discussed how the development of groundwater extraction in canal command areas could reduce the occurrence of water logging and the corresponding salinization as well as providing a distribution means of ‘canal waters’.

The difference between the productivity of irrigated areas and non-irrigated areas varies greatly throughout India, which is hence reflected on the pressures exerted on the groundwater resource. The extent of the issue and the level of exploitation of the resource highlights the need for an effective management regime that delivers management that is specific enough so as to deal with the various local conditions throughout India and South Asia. For groundwater management in India, one of the main differentiating factors in comparison to management regimes in the developed world is both sheer size of the population affected as well as the size of landholdings (Shah et al., 2003). This imposes limitations as to the sort of management regime that is likely to be met with success.

There are huge variations in holding sizes throughout the nation and also the rate of irrigation development. Thus, figures looked at on a national scale may not be applicable to specific regions due to this variation (Vaidyanathan, 1999). This reinforces the need for a regional approach to the management of groundwater. The sheer size of an aquifer is a limitation to its effective management (Menon, 2007).
Therefore, purely locally based approaches are unlikely to have significant enough influence to induce any real change into the groundwater system.

### 2.7.1 Numbers of people involved in the management of the resource

The sheer number of people that the management of groundwater in India has to coordinate with is a limiting factor to the effective management of the resource. This mainly relates to the number of users being high but the land holding sizes being small. This poses major issues concerning the implementation of management regimes. For instance, India has had a draft model groundwater bill for the previous 20 years. Issues over both the implementation and enforcement of such a bill has led to the stagnant nature in which nothing concerning the bill is being done (Shah et al., 2003). The applicability of lessons learnt in other regions of the world is limited as scenarios such as those found in Australia and California have far fewer landowners for a comparable area. In areas of South Asia the number of groundwater users may be well over 1,000 times greater than that of the US or Australian examples (Shah et al., 2003).

Some initiatives such as permits used for irrigation in Australia would not be feasible in the Andhra Pradesh or Indian context, as the permits are only necessary if the irrigated area is to be greater than 2 ha; a factor which obviously would not succeed in South Asia due to small land holding sizes (Shah et al., 2003). Therefore, in India the complexity that this imposes on the situation means that collective action of the groundwater users may be harder to obtain and ultimately that effective management of the resource may be hindered.

### 2.7.2 Artificial recharge

South Asia is largely characterised as having a monsoon climate (Vani, 2009). This has relevance for South Asia as the majority of the rainfall that the region experiences occur in some 100 hours of heavy downpour (Narain, 2003; Chetty, 2001; Shah et al., 2003). For groundwater management to occur effectively there needs to be not only demand side management but also supply side management, augmenting further recharge of the groundwater resource. For community-based approaches as devolved in the following section this requires high participation and education concerning the benefits and need for artificial recharge, especially if extraction rates are substantial.
High emphasis is being placed on rainwater harvesting, with the aim of maximising the amount of recharge that can occur through slowing the movement of water via artificial means, allowing for infiltration (Narain, 2003). South India states of Andhra Pradesh, Karnataka and Tamil Nadu have a large quantity of tanks of which a “strategy that has been widely recommended is that of transforming these into recharge tanks by filling them with canal water” (Shah et al., 2001, p.4146). In many areas this has already been undertaken. In western India, community members as well as local NGOs have collaborated to modify many aspects that assist in rainwater harvesting, as well as structures to encourage recharging of groundwater (Shah et al., 2001). Two NGOs, Tarun Bharat Sangh and Pradan located in western Rajasthan have been working with local communities to rehabilitate tanks that in some cases are centuries old. These aim to increase groundwater recharge and have had a significant impact, reviving springs and rivulets that had previously dried up (Shah et al., 2001).

The combined use of both small and large water harvesting techniques may provide flexibility as well as user involvement in the management of the resource through the initiation of the structure and the subsequent maintenance required (Menon, 2007). This community involvement might include the construction of small-scale dams or bunds designed to capture rainwater in the area and ‘feed’ the underground water resource (Vaidyanathan, 1999). Some authors state that it would be good to reduce the restrictions placed on waterways that limit small-scale development of the watershed as this limits the community’s ability to implement local level initiatives and take control of the management of the water resource (Vaidyanathan, 1999). This may greatly increase the number of artificial recharge structures in a short amount of time and correspondingly influence groundwater levels.

### 2.8 Community based management theory

Community based management operates on the notion of combining local peoples knowledge, experience and sense of priorities with available scientific and technical knowledge (Vaidyanathan, 1999). There exists wide consensus over the desirability of community participation, but in reality, this does not occur with seemingly entrenched focuses on state regulation (Ramachandrula, 2008; Shah et al., 2001). As a result some authors cite that community management of groundwater is rare. Vaidyanathan (1999) does put forward an approach that vests the “right to exploit and allocate
groundwater with local communities, with the state confining itself to defining the framework of principles and procedures for community management and facilitating their functioning” (Vaidyanathan, 1999, p.167). This highlights a supportive role for the state emphasising the education needed concerning groundwater management.

The importance of education concerning the benefits of the collective and collaborative management of groundwater is discussed by multiple authors (Pangare, 2002; Vani, 2009; Khanna, 2002). Those that are most sceptical of the process of participation largely cite two factors. Firstly, that villagers are often illiterate or lack the technical expertise in terms of how the groundwater system works and therefore how it should be managed. Secondly, that communities are often so divided that to obtain consensus over the best management regime would be near impossible (Vaidyanathan, 1999). It is therefore important that the state as well as other support organisations play a facilitator role in which education is disseminated throughout the community (Datta, 2005). The lack of knowledge concerning the specific local environment concerned is a limitation to collective management both at the state and community levels. Conditions under which this community based groundwater management is more likely to work are discussed on in the following sections. The principle merit of involving user communities is to “decentralize the task of monitoring the levels and patterns of use of available supplies as well as changes in water yields of wells and to evolve mechanisms for ‘fair’ distribution in the light of local circumstances” (Vaidyanathan, 1999, p.167).

2.9 Conditions under which community based groundwater management might work

A significant aspect to this research is the situations in which community based management of groundwater is more likely to be successful. Groundwater is a resource that can be and has largely been developed within the private industry (Ramachandrula, 2008). This largely influences the sort of management that is appropriate. For many of the scenarios in the Indian context, sustainable growth may be achieved through the inclusion of the community in effective participatory management. This section will provide discussion as to the conditions which promote or allow for effective common property resource management.
2.9.1 Common pool resource management

Ostrom (1990) in her book ‘Governing the Commons’ states that the mis-management of common resources often comes about because the people involved are making individually rational, but collectively irrational decisions. Perhaps the most apt way that Ostrom (1990) describes this concept is where, when people act only in what is best for themselves, then at a larger scale, there is a loss for everyone as the resource gets used to beyond sustainable limits. With common pool resources it is hard to “control the tendency to over-exploit the resource in the interests of short-term private profit without any concern for the long-term sustainability” (Vaidyanathan, 1999, p. 166). Such depletion is inevitably linked to an inability to coordinate the efforts of individuals (Deshpande & Jyotishi, 2002). As for many common pool resources, this can be applied to the groundwater situation, particularly in the Indian and wider South Asian context. Furthermore, in changing environments, through factors such as; “population growth, technological change, and climate changes… coordinated action [is] more difficult than in more static settings” (Deshpande & Jyotishi, 2002, p.286).

The over-extraction of groundwater illustrates these concepts. The continued lowering of groundwater levels inevitably requires that further investment be put into new wells or that existing wells be deepened to allow for extraction to continue. Thus, further investments are made, and correspondingly, the profits associated with the extraction decreases, due to both the monetary requirements of the modifications as well as the increased costs of lifting from a greater depth (E. A. S. Sarma, 2004). “One would have thought that under these conditions, there would be a strong economic incentive, both for individuals and society, to explore arrangements to contain the tendency for competitive deepening” (Vaidyanathan, 1999, p.163). However, in numerous cases this is not occurring. Furthermore, for the poorer members of society, the lowering of the water table may in fact ultimately may result in limited access to the groundwater resource (Datta, 2005). This therefore highlights further social implications associated with the overexploitation of groundwater which is further discussed in section 2.10.

2.9.2 Theories concerning the use of common pool resources

There are numerous approaches that depict how the downfall of common pool resources occurs, such as the tragedy of the commons. All of these have a similar
theme whereby each person as an individual receives the most benefit by using the resource as much as they can, or conversely about the trust associated with how others are going to use the resource (Ostrom, 1990). For collective action to occur there needs to be cooperation from all those involved in the use of the resource, otherwise those that do become involved in collective management will be disadvantaged (Ostrom, 1990). The management of groundwater is therefore a pareto-inferior system, because if looked at purely from an individual’s perspective they will not gain the most benefit from the resource through collective action (Vaidyanathan, 1999). Furthermore if complete collective action is not present the individual will be less likely to invest time or funds into the common pool resource in comparison to if sole property rights were existent (Ostrom, 1990).

Deshpande and Jyotishi (2002) however, state that when dealing with private property regimes such as groundwater there is a lack of assurance of action therefore influencing the effectiveness of collective approaches. The Pani Panchayat system incorporates the management of water at the local level through management committees and operates on a basis of such assurance where correlation of expectation occurs so as such assurances are met and there is little incentive to defect (Deshpande & Jyotishi, 2002). The problem in the Indian context is therefore how to engage the vast numbers of people involved in such a collective management initiative and how to educate them on the necessity of such an initiative. This in combination with caste and other social structures existent in the village system will inevitably have a significant impact on the level of success achieved (Sen, 2008). This aspect is further discussed in section 2.10.

Ostrom (1990) also discusses the notion of the logic behind collective action. Three broad notions are put forward as contributing to whether or not collective action can occur:

- If the individual gains the greatest by the group succeeding then collective action may occur effectively
- Works on the assumption that if what is best for the group is also best for the individual then collective action may occur
• Unless group is small, or coercion or something of the like is present to make individuals act in their common interest, rational self interested individuals will not act
  
  (Ostrom et al., 1994; Ostrom, 1990)

Therefore, these notions suggest the requirement to not only illustrate the need for collective management of groundwater resources, but also to provide education that addresses such needs. This may provide a means through which ‘coercion’ is established by providing the knowledge of what some of the costs and consequences that may occur if the resource is not managed effectively (Vaidyanathan, 1999). Vaidyanathan (1999, p. 158) builds on these notions put forward by Ostrom in which people will agree to cooperate for the collective good when:

• “Such action is expected to bring substantial benefits to the group as a whole both in relation with size of the group and the costs involved
• The sharing of costs and extra benefits resulting from such collective action is seen by the group to be ‘fair’; and
• There are credible arrangements for ensuring that the agreed sharing of costs and benefits will be effectively enforced”.

2.9.3 Mechanisms of sharing common resources

Mechanisms by which the sharing of the common pool resource can be enforced are important, ensuring an equitable sharing of the costs and benefits associated with the development and use of the resource (Vaidyanathan, 1999). It is important that the participants view the programme as fair. The burden associated with the sharing of the resource must be less than that of the benefits of sharing the resource and that ‘freeriders’ of the system are discouraged (Ostrom, 1990). This egalitarian thinking, sharing the benefits arising from the development of common land is “not only desirable but essential to generate peoples’ participation and contribution” (Vaidyanathan, 1999, p. 160).

The *Pani Panchayat* approach to water entitlement described by Vaidyanathan (1999) gives everyone in a community an equal share of a water resource irrespective of whether the are land owners or not. This along with Participatory Irrigation
Management (PIM) and Water User Associations (WUAs) forms other aspects of participatory irrigation management. WUAs constitute farmers’ organisations through which the management of groundwater is undertaken at the local level (Pangare, 2002). However, some authors state that these approaches are too idealistic in nature and as a result have not delivered adequate results (Mahapatra, 2007).

2.9.4 Cooperative ownership and social structures

Cooperative ownership of wells is put forward as a viable tool to achieve the maximum benefits from the groundwater resource (Menon, 2007). Firstly, the point that lowering of the water table does not benefit anyone reiterated. It weakens the productivity of the investment as it dries up, requiring further investment and risk for the farmer (Ramachandrula, 2008). Education of the benefits of effective collaborative management is a major factor influencing the effectiveness of collaborative-based approaches (Vaidyanathan, 1999). It needs to be emphasised that in the long run, such an approach would contribute to sustainability and improve the productivity of the land.

Some authors state the fact that there is a preference for individual ownership of wells suggests that it is still economically viable for the wells to be owned and operated in this manner (Vaidyanathan, 1999). However, this could be linked to a perception of access as there are still many cases of farmers getting heavily into debt as a result of bores going dry (Datta, 2005). This provides an opportunity whereby adequate education concerning the potential of the groundwater resource and the benefits of a collaborative approach may be able to change the thinking surrounding individually owned wells.

Ownership of wells is typically lower for smaller landholders. However, they tend to have a higher irrigation ratio than larger ones, especially in areas that are serviced via surface irrigation schemes. As stated, groundwater extraction through wells and tube wells are largely in the hands of the private sector and requires substantial investment to be able to tap the resource (Ramachandrula, 2008). Thus, access to groundwater resources for smaller landholders is limited, as they may not have appropriate funds to meet the associated costs of implementation (Vaidyanathan, 1999). This there for has implications of equity and is further discussed in section 2.10.
Larger landholders generally have the means to gain groundwater through bore wells and pump sets. They then often become the source for others (Vaidyanathan, 1999). This can lead to a possible ‘waterlord’ situation where “farmers who don’t have access to water resources and pumpsets… have to buy water from those who do” (Sainath, 1996, p.339). When people have the rights to water through land ownership and others don’t due to various factors this ‘Panidar’ or water lord class can emerge (Deshpande & Jyotishi, 2002). Through groundwater development the larger farmers get a disproportionate benefit from the irrigation (Datta, 2005; Vaidyanathan, 1999). Some of the poorest irrigators in South Asia buy water from pump irrigation owners for as much as 10 – 14 cents per cubic metre of water, substantially higher than if the water was to be bought through canal irrigators (Shah et al., 2001). This highlights the dominance that ‘water lords’ have over the situation. The social inequalities within the structures of communities may however be a limitation of this approach, as the benefits of such an initiative would not be equitably spread (Datta, 2005).

2.9.5 Local leadership

The quality of local leadership is a crucial factor in persuading the new community that participation in the management of the common resource will be best for all, and consequently make for a collectively improved situation for the area (Vaidyanathan, 1999). This can be in the form of local civic leaders or for instance NGO involvement in the implementation of management regimes. External agencies play a critical role in the community participation process, acting as a conveyor of knowledge and a facilitator of management initiatives (Vani, 2009). However, it is important that the state plays a supportive role and works with the agency to create a complimentary and supportive relationship (Vaidyanathan, 1999).

A research project called the “social regulation of groundwater management at community level” was initiated in 2004 in three villages in AP by the non-government organisation Centre for World Solidarity in partnership with other local NGOs (Ramachandrula, 2008, p.10). This program aimed at promoting the local community based regulation of the groundwater resource, as well as aiming to address many of the equity issues associated with groundwater development and use. The main findings of the project included that there was a realisation for a “real need for changing the mind set of farmer from ‘competition’ to ‘cooperation’ and to increase
the ‘water literacy’ among the farmers for efficient use of water” (Ramachandrula, 2008, p.11). Local leadership was identified as a crucial element for the project to be met with success. Such studies also highlight the sort of education that is needed to raise awareness concerning the major issues.

2.10 Intra village inequality

Many of the benefits of groundwater development have been highlighted throughout this literature review. However, authors also highlight some of the negatives associated with groundwater development such as widening the gap between the rich and the poor, which often reinforces pre existing inequalities (Datta, 2005; Hill, 2009). Some of the consequences associated with groundwater over exploitation can equally have negative effects on equality and the very benefits that were delivered through the development of groundwater. The following sections will discuss these viewpoints further.

2.10.1 Focussing management regimes

For common property resource management to work it is important that resource management regimes are aimed at the people who actually have the power over the use of the resource (Shah et al., 2001). Shah et al. (2001) outlined how in some instances, management programs were aimed at all users of groundwater, when in fact it was only a few people that held the real power over the management of the resource. Thus, without the cooperation of these people, sustainability of the resource would be unattainable. Therefore, this effectively acknowledges the ‘de facto rights’ of those individuals and incentives maintaining management of the resource may have to be undertaken, otherwise they may not be supportive of an initiative in which they see the rights they have enjoyed being diminished (Shah et al., 2001).

Furthermore, if certain people are to gain from the current situation they may block attempts by the less powerful to change the distribution of such power throughout the community (Ostrom, 1990). Such is the case of the water lords of Ramnad as discussed by Sainath (1996) whereby the water lords hold all the power. The establishment for instance of a community bore well would immediately affect the potential profits that the water lord would be able to attain, so they may sabotage or
damage it. This illustrates some of the power issues that affect the situation in which management of groundwater as a common pool resource can occur.

2.10.2 Widening the gap between the rich and the poor through bore well development

As stated, groundwater development exists predominantly within the private sector. This development also has significant social influences for the surrounding areas. There are a range of factors that influence farmers wanting or needing to increase their production. These include; increasing sizes of the families dependent on the agricultural output and pressures associated with being able to compete with markets that have experienced increased production associated with the Green Revolution. However, the amount of monetary input that is required for the development, for instance, of a tube well can be substantial enough to trap smaller less-well-off farmers in a debt circle (Vakulabharanam, 2004). This is even more severe if the initial drilling of the well fails, or if the well dries up over time (Vakulabharanam, 2004). For many farmers in Andhra Pradesh this has led them to a debt trap in which the only way that they can see their escape is suicide (E. A. S. Sarma, 2004). Hence, this is important to control the over exploitation of the resource, to minimize the failure of the resource and to be able to provide security for such investments.

Although poverty issues can be addressed through groundwater development, the challenge put forward is to put the pump in the hands of the poor (Hooja et al., 2002). This could provide the catalyst in which poor people could change their livelihoods through expansion of their farming via irrigation techniques. However, often they are too poor to afford a pump, or their land holdings are not substantial enough to make the purchasing of a pump a viable investment (Shah et al., 2001). So groundwater development can in fact increase the existing inequalities between on the one hand, the powerful and wealthy irrigation pumpers, and on the other hand, the people that rely on them for their water supply. As mentioned earlier the associated technology is continually advancing; meaning pumping technology is more readily accessible to a wider range of people through both automated mechanical pumps as well as manual pumps (Shah et al., 2001). The advent of such accessible pumping has, for many regions of South Asia, generated prosperity and to an extent alleviated poverty.
The advent of tube wells that can tap water at depths of up to 400-450 m have not only substantially lowered the water table to beyond levels where traditional manual water lifting techniques can be used, but it has effectively ‘priced out’ many farmers (Shah et al., 2001). Through the competitive deepening and extraction of groundwater, the cost of irrigation for the entire community is increased. To minimise these costs many of these farmers form irrigation societies to not only share to costs of establishing such wells, but to also share the risks if the endeavour was to fail (Khanna, 2002).

2.10.3 Representation in management programs

Ideally management projects and the benefits associated with them are distributed throughout society equally. However, there is debate that they can at times, widen the gap between the rich and the poor even more. In some projects or Pani Panchayat systems there exists higher representation in management committees towards the upper class (Deshpande & Jyotishi, 2002). Thus, at times, such community-based initiatives can also reinforce existing inequalities throughout society. There needs to be mechanisms in place to address these issues. Datta (2005) highlights that at times these are well entrenched, creating various ethical dilemmas for any management approach. More powerful people within a community undoubtedly have the influence to determine whether such projects are met with success. It therefore important to get them on board, as was discussed in section 2.9.5.

2.11 Water market development

Numerous sources highlight the emergence and significance of groundwater markets throughout South Asia in the development of groundwater resources (Adiseshu, 2008; Vaidyanathan, 1999; Hill, 2009). This involves the selling of water, pumping and irrigation services. Water is increasingly being thought of as a commodity in India (Lahiri-Dutt, 2008). It is argued by some authors that this is a mechanism that should be encouraged as it may be able to deliver the sort of self regulation that is necessary for a common pool resource such as groundwater, as it would be in the users best interest to sustain the capacity of the resource into the future (Vaidyanathan, 1999). Furthermore, groundwater markets are at times, seen as a means through which agricultural areas can be modified to that of a modern economy (Adiseshu, 2008).
However, there are also equity issues with such a market. Those that have the control over the extraction of the groundwater are in a position of power, a position that only becomes more entrenched as others in the community become reliant on them for irrigation needs, as discussed earlier.

The population increases in cities that have been witnessed throughout many areas of South Asia also play an important role in demand for groundwater (Datta, 2005). Many of these centres utilise groundwater far beyond the natural recharge volumes. This demand gives landowners in the nearby rural areas a huge market for selling groundwater (Datta, 2005). Currently, people have a common right to tap the same aquifer, but it is the owner of a piece of land that also has the right to exploit the water beneath it. This means that groundwater development can increase the gap between the rich and the poor, as it is the landowners who have access the resource (E. A. S. Sarma, 2004). This may reinforce the equity issues that were discussed in the previous sections, such as power structures within a community and reliance that can lead to debt entrapment. Furthermore, when these social factors are combined with the cast structure of the village system, what constitutes a workable or ideal situation will be influenced and at times have to be compromised (Vaidyanathan, 1999).

Through the effective and equitable development of groundwater markets, access to water for irrigation may be more widely available and the number of bores through which this is sourced is minimised. For the farmer that owns the bore well this maintains the economic viability of the water extraction device, as the number of other bores tapping the same aquifer is also limited. However, inevitably it is the owner of the bore that would place priority on their own crops during times of drought or water shortages, thus it would be the buyer that would feel the brunt of the losses associated with such events (Ramachandrula, 2008).

### 2.12 NGO involvement

Non-government organisations (NGOs) can play a significant role in the participatory management process. Primarily this is seen as a research and advocacy role through which education is disseminated through to participants (Vani, 2009). In India, NGOs “have had a long and significant… role in implementing programmes and projects related to natural resource management” (Vani, 2009, p.207). This role forms an
Chapter two: Literature Review

integral part of this research, as it constitutes factors that may influence the success of participatory projects such as APFAMGS. Throughout India, both government and NGOs are “investing heavily in participatory watershed development” and management (Ahluwalia, 1997, p.23). This section will therefore elaborate further on the role that NGOs play in community based management approaches to common pool resources.

2.12.1 Cooperation from all sectors of community

As stated earlier, for effective management to occur there needs to be collaboration from all sectors of a community (Ostrom, 1990). For a resource like groundwater, it is not only at this community level, but also at a wider regional or catchment level. NGOs can therefore play a significant role in creating continuity in the management of common pool resources such as groundwater (Vani, 2009). For such continuity to be possible, rapport must be built with all of the communities involved. This creation of awareness, social mobilisation and capacity concerning the management of natural resources is a fundamental role that the NGO plays in programs.

Groundwater is a resource that for a large part is out of view, thus the state of the resource is hard to define without the proper equipment. This provides a barrier to the effective management of the resource when compared to surface water projects (Vaidyanathan, 1999). This also highlights the need for education of the consequences that can come out through the over exploitation of the groundwater resource. The use of multifarious ways of disseminating this information is key to involving a wider range of users in the collaborative management of the water resource (Vani, 2009). In management programmes there needs to be a process throughout the implementation that reflects this range in knowledge, so that an appropriate level of rapport can be established (Ahluwalia, 1997).

2.12.2 Providing links between communities and others

NGOs “constitute a vital link between citizens and government, working for the transfer and development of information, funds, capacities, skills, institutions and processes” (Vani, 2009, p.208). They strengthen the engagement of those involved in the use of common pool resources for collaborative management. This means that NGOs can, through management programmes and other initiatives, provide
connections with the relevant personnel so that the highest benefits can be delivered to the community. Lele et al. (2002) highlighted the fact that NGOs can for a large part mobilise experts in specific fields, and thus enable management programmes to be tailored to specifically address the local issues. This is an important aspect, because often, crucial support for users associations is not delivered through the irrigation or agricultural departments of government (Lele et al., 2002). Furthermore, it is the semi-arid or rain fed areas that often get neglected through the development process (Sen, 2008). Therefore it is even more important that these areas are exposed to the sorts of scientific and technical information that is available and consequently may impact on them greatly through effective development and management initiatives.

2.12.3 Necessity of NGO involvement

There has been, for some time, speculation that water users associations could increase their role in the management of water, and in effect negate much of the need for NGO involvement. However, there are conflicting views concerning this matter. Lele et al., (2002) states that bureaucratic channels alone cannot provide the support functions for user associations to operate adequately and effectively. NGO support may provide adequate guidance for such user authorities to scale up their contribution in the effective management of the groundwater resource (Lele et al., 2002). By maintaining the involvement of NGOs in the management of resources, a resulting indirect approach may provide a favourable method for the management of groundwater (Mukherji & Shah, 2005). This therefore addresses the logistical challenges that would be associated with wholly central regulation whilst providing a support network for local governing bodies and the projects themselves. The complex nature of managing resources such as groundwater consequently means that varying approaches will be more appropriate depending on the specificities of each scenario (Mukherji & Shah, 2005).

2.13 Adoption of water saving technologies

A range of environmental issues including water depletion, salination, contamination and water logging highlight the need for increased use of water efficient technologies (Feder & Umali, 1993). Along with conserved use of water, such technologies can potentially save on the amount of labour needed to irrigate the fields, thus having
indirect benefits associated with their use (Steenbergen, 2006). Steenbergen (2006) discusses how the adoption of water saving technologies does not necessarily mean that farmers are being more conservative with their water use. Farmers are consequently more efficient with their use of groundwater. Therefore this can mean that irrigation can go further and farmers may extend their agricultural production (Steenbergen, 2006).

(D. Kumar M, 2007) highlights the benefits that incentives can offer in the adoption of water saving technologies. These are mainly based on two factors:

- “The parameters that the farmers think are economic and can be affected by saving technologies; and
- The perceptions farmers have about the physical and economic aspects of the technologies, which are governed by their educational background, knowledge base and exposure”

(D. Kumar M, 2007, p.234)

The importance of education and awareness is therefore emphasised. Even if farmers are aware of these water saving technologies, a range of factors may influence whether or not the farmer uses them. The various factors that contribute to this technological adoption have received high scholarly attention (Feder & Umali, 1993; Knowler & Bradshaw, 2007; Rauniyar & Goode, 1992). For instance, the high initial capital investment may serve as a deterrent, which is even more so if an adequate independent water supply is not available or there is insufficient water pressure to run such systems (D. Kumar M, 2007). Even factors such as the availability of credit, risk association and the size of farmers can heavily influence whether or not irrigation technologies are adopted (Feder & Umali, 1993). It is therefore important that further education and knowledge dissemination is undertaken so that the benefits of water conservation are understood more widely. Feder and Umali (1993, p.222) argue that in deciding whether or not to use irrigation systems farmers must “first choose the optimal amount of water for each irrigation technology and then choose the irrigation technology yielding the highest operational profit”. Farmers therefore are more likely to utilise such technology when irrigation effectiveness is high, a combination of the amount of water used by the crop and the overall water applied (Feder & Umali, 1993).
Water saving technologies can provide substantial increases in yield in most conditions (D. Kumar M, 2007). However, when farmers do use these technologies and they fail through for instance; improper utilisation, word can be spread very quickly and efficiently concerning the failure, thus deterring people from adopting them (D. Kumar M, 2007). For a large part it is realised that in many cases the approach taken in promoting agricultural efficient technologies needs to be tailored to be in alignment with the specific needs of different areas (Knowler & Bradshaw, 2007).

2.14 Conclusion

Groundwater is an important resource in India and the wider South Asian context. This is predominantly due to the significant reliance people have on the resource for maintaining their livelihoods. Groundwater development has had a substantial impact on the food production capacity of many parts of India. This has been largely influenced through the advent of the Green revolution. Although many of the benefits associated with the Green Revolution have received high scholarly attention, so too have the negative effects that have resulted. The main point that is made concerning the Green Revolution is that it has vastly changed the environment in which the farmer in rural India operates. Traditional farming techniques and methods to an extent have become redundant or their applicability reduced. This is mainly through Green Revolution technologies such as groundwater extraction devices and high yielding seeds, fertilisers and pesticides. Thus inputs into the agrarian system have been altered drastically.

Policy influences such as the highly subsidised electricity for agricultural purposes have been a key factor in the expansion of the groundwater industry in India. However, equally this is also identified as contributing to the overexploitation of the resource as indiscriminate pumping can occur at relatively low cost to the farmer. The development of the groundwater industry in India has been largely attributed for alleviating poverty and enhancing the livelihoods of the poor. However, there are also downsides to this argument, as groundwater development can also increase inequality between the rich and the poor through access to the resource being limited. This access regime can occur due to a variety of factors. Furthermore, decreasing groundwater levels due to over extraction can effectively price out sectors of society
through competitive deepening and the associated costs needed to maintain irrigation. Thus, for many scenarios in the groundwater debate there are many, sometimes contrasting arguments as to the effects.

As stated, community based groundwater management is the focus of this thesis. It is identified as a management approach which operates and relies on the effective participation of all those involved in the use of the groundwater resource. The conditions under which collective management of resource occurs has been put forward as well as the associated theories. Private property rights play a crucial role in the management of groundwater resources as it is mainly in the private realm that the development of this resource has occurred. It is the coordination between individuals and assurances of intended action that provide the basis for effective community based management.

Groundwater markets are cited by some authors as a means through which the initiation of further wells can be minimised and access to the groundwater can be achieved for a wide range of people. However, once again equity issues come into play, as the farmers who own the bores and sell the water are inevitably in a position of power. NGOs can play a significant role in the management of groundwater resources and the promotion of collective management of common pool resources, a point of which is a focus of this research. Water saving technologies can vastly improve the efficiency of water use and accordingly have benefits for communities who adopt these. There are however factors that influence the adoption levels, and such adoption does not always mean that there is higher conservation of water, just that it goes further.

Management projects can play a crucial role in promoting the management of resources such as groundwater. Just as the factors of a community in which community management are important, so too are the factors of management projects that could help deliver increased success. These points therefore form the focus of this thesis, identifying many of these factors through the use of a case study; the Andhra Pradesh Farmer Managed Groundwater Systems (APFAMGS) project. A brief outline of the project is given in section the methodology.
3.1 Introduction

This chapter is predominantly aimed at the state and district level in which research was undertaken, further specifying the study areas. The literature review outlined groundwater management in a wider context, identifying the various factors at play such as the impact of the Green Revolution and those relating to the collaborative management of common pool resources that have influenced the groundwater resource. The context section then builds on these, identifying and justifying why the various areas were chosen to conduct research. The focuses of previous management programs that have been implemented throughout the state are briefly discussed. The locations of the study areas are put forward, highlighting specific districts in which the APFAMGS project has been implemented and those that formed the basis of this research.

Legislation relevant to groundwater management both at the national and state levels is put forward. Legislation plays an integral role in the management of the resource and underpins the regulatory environment through which participatory approaches such as the focus of this research are situated. It is therefore important to outline in the context of this research.

3.2 The context of groundwater management at the Andhra Pradesh state level

This section looks at groundwater use and management at the state level. Agriculture is still a significant land use in the state although its contribution to GDP has declined from about 60% in the 1950s to around 22% at present. However, it is still the dominant source of income and livelihoods for about 60% of the people living in the state (Centre for Economic and Social Studies, 2008). Groundwater and the management of groundwater is therefore a significant resource for a vast majority of
people residing within the state. The Central Groundwater Board (2006) states that
groundwater development, based on the annual groundwater draft and the net annual
groundwater is at around 45% overall in the state. This suggests that there is
substantial room for further groundwater development. However, there are several
districts in which a significant number of mandals (sub-districts) are considered to be
over-exploited, critical or semi-critical. Of these, as many as 300 of the 1,277 throughout the state are classified as critical or over-exploited (World Bank, 2010).
The combination of these two factors highlight the spatial distribution of groundwater overexploitation throughout the state, with some mandals having room for further
development and others having a need for conservation and augmented aquifer replenishment. Uncertainty and unreliability of the groundwater resource in many
areas of the state has resulted in many farmers being unprepared for failure which has contributed to a low agricultural growth (Dev, 2007).

3.2.1 Expansion of groundwater use

High expansion of wells has intensified the agricultural crisis in the state; with farmers incurring heavy losses that are largely attributed to the drying up of wells and bore wells. Losses have been the highest in the areas in which rainfall was low and surface irrigation was high (Centre for Economic and Social Studies, 2008). This therefore highlights the need for conjunctive surface and groundwater use throughout the state. This is particularly important in arid areas of the state that receive little rainfall where there should be increased focus on surface water irrigation, as this would facilitate recharge of the groundwater resource (Planning Department, GoAP, 2011). This would require high expenditure on surface irrigation infrastructures. However, currently state governments are not generally increasing the public investment in irrigation and irrigation infrastructure and those areas which are deemed to be arid, in many cases, are not perceived as the most economic of areas to invest in such infrastructure (Centre for Economic and Social Studies, 2008).

Groundwater use in Andhra Pradesh has undergone substantial increases since the 1970s, predominantly through irrigation requirements (Ramachandrula, 2008). Similar to the national trend of groundwater use throughout India that was put forward in the initial introduction, the amount serviced through wells has substantially increased, whereas the other two main sources of irrigation waters, particularly tanks,
have been consistently decreasing (see Figure 3). However, the rate at which wells have been getting installed has somewhat levelled off since approximately the year 2000. The number of bore wells registered as being connected to the power grid within the state was somewhere in the region of 2.35 million (Steenbergen, 2006) although other sources place estimation at 1.74 million (World Bank, 2010). This highlights the extent to which people within the state rely on groundwater for their livelihoods.

Figure 3: Net Area Irrigated from different sources in Andhra Pradesh. Source: (Ramachandrula, 2008)

The increase of groundwater expansion is not slowing. Within the space of 2008-2010, the amount of irrigation water sourced through tube wells increased from 35.1% to 43.3% (Directorate of Economics & Statistics, 2010). So, although various sources dispute the extent, the trend in dominance of irrigation sourced through groundwater development is by no means something that has come to a stand still. The level to which farmers rely on tanks and dug wells has significantly decreased with many areas “witnessing a period of institutional and physical decline” as tube wells became more popular and water levels decreasing to below that where many dug wells could access it (Steenbergen, 2006, p.388).

3.2.2 Management programs

This thesis takes a similar viewpoint to that of Steenbergen (2006) who highlights that community based groundwater management should not be advocated as the only way in to approach the management of the resource. But that it provides an “important
cornerstone in promoting groundwater management, alongside legislation, registration, the development of aquifer associations and the rationalisation of related energy pricing” (Steenbergen, 2006, p.387).

Throughout Andhra Pradesh there has been several initiations of management programs (Hooja et al., 2002). Many of these in the past have focused on augmenting the supply side through initiation of water harvesting structures such as check dams and farm ponds (Hassan, 2002). However, there is a growing realization that for effective groundwater management there needs to both supply and demand side initiations otherwise farmers may be inclined to merely put in more wells (Steenbergen, 2006). Through similar approaches to that of the APFAMGS project there have been motions to increase the awareness of groundwater issues, through capacity building. The building of awareness throughout the farmer community, as well as explaining the reasons behind some of the policies mentioned in the Andhra Pradesh Water, Land and Trees Act (APWALTA) 2002 discussed later, farmers then had an understanding of the groundwater resource and the need for effective management. Based on this, local gram panchayats could initiate various measures to implement micro-groundwater management, as well as enact and comply with many of the policies in APWALTA (Steenbergen, 2006). Management projects throughout the state, which have a high participatory focus, have the potential to deliver substantial results. In combination with regulatory aspects such as those under the National Water Policy 2002 (NWP) and APWALTA, this may contribute to effective management of the groundwater resource. Both these acts are considered further in section 3.5.

3.2.3 Land usage

Land usage in Andhra Pradesh is varied as shown in Table 1. Net sown area makes up a substantial portion with forest and fallow also featuring strongly. It is also noticeable that land-holding size per household is decreasing. During 2000-01 it was 1.25 hectares, it has now decreased to 1.2 hectares (Planning Department, GoAP, 2010).
Table 1: Land utilisation in Andhra Pradesh. Adapted from: (Planning Department, GoAP, 2011)

<table>
<thead>
<tr>
<th>Land use</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net area sown</td>
<td>37%</td>
</tr>
<tr>
<td>Forrest</td>
<td>23%</td>
</tr>
<tr>
<td>Current fallow</td>
<td>12%</td>
</tr>
<tr>
<td>Land put into non agricultural uses</td>
<td>10%</td>
</tr>
<tr>
<td>Barren and uncultivable land</td>
<td>7%</td>
</tr>
<tr>
<td>Other fallow lands</td>
<td>6%</td>
</tr>
<tr>
<td>Culturable waste</td>
<td>2%</td>
</tr>
<tr>
<td>Permanent pastures</td>
<td>2%</td>
</tr>
<tr>
<td>Misc. Tree crops</td>
<td>1%</td>
</tr>
</tbody>
</table>

3.2.4 Rainfall and drought

Rainfall throughout Andhra Pradesh can vary greatly with substantially less generally received in the west of the state in comparison to the coastal east as shown through Figure 4 (Centre for Economic and Social Studies, 2008). This variability has an impact on recharge rates of groundwater and when this recharge occurs, especially when as much as 50% of the rainfall can occur within 5-7 days of a year (Chetty, 2001). Therefore, runoff levels can have a significant impact on the level of infiltration and corresponding replenishment of groundwater. If extraction rates are in excess of these levels then inevitably there will be decreases in the water level.
For much of Andhra Pradesh, drought has highlighted the overexploited nature of much of the groundwater resources. This is further given a high profile when the media shows the effects that the drying up of wells is having, particularly on the rate of farmer suicides as a result of indebtedness and loss of crops (Steenbergen, 2006). The rate of suicide is exacerbated through other indirect influences such as informal private sector credit organisations that have exorbitant interest rates. Through lack of formal institutions farmers in the state are forced to utilise these avenues if they want to expand their agricultural production (Centre for Economic and Social Studies, 2008). For far too many farmers in the state, the expansion of their agricultural regime through groundwater irrigation is not being met with the fruition that they expected.

3.3 Location

Andhra Pradesh is located in the South East of peninsular India. The locations in which the APFAMGS project was implemented are shown in Figure 5 and Figure 6, signalling with arrows those in which research for this thesis was undertaken. The total geographic area of the state is 275,040km² and it is the 5th most populous state of India with 84,655,550 people. As much as 85% of the state has underlying hard rock aquifers from which groundwater is extracted (World Bank, 2010). These underlying
rock formations contributing to confined aquifers are shown in both Figure 7 and Figure 8. It can be seen that the majority of Andhra Pradesh is underlain by hard rock. Such formations contribute to there being less storage capacity in the underlying aquifers and they are significantly more affected by extraction and recharge rates (World Bank, 2010). Throughout the state there is increasing pressures on groundwater resources to meet requirements. These aspects relating to the groundwater and agro-climatic regimes of the data have been put forward in the previous sections.

Figure 5: Left: India, with the state of Andhra Pradesh in blue. Right: The 7 Districts of Andhra Pradesh where the APFAMGS project was implemented – arrows indicate the districts in which this research focussed. Source: (APFAMGS Brochure, 2008).
Figure 6: Location of the project areas within the Districts with those in which this thesis concentrated on shown by arrows. Source: (APFAMGS Brochure, 2008).
Figure 7: Hydrogeological map of India, note Andhra Pradesh is mainly of a Granite Basement Complex signalling the presence of hard-rock aquifers. Source: World Bank (2010).
Figure 8: Hydrogeological map of India, note that all of the study areas outlined in Figure 6 are seen to have underlying consolidated/semi consolidated formations. Source: Central Groundwater Board (2006).
3.4 Districts in which research was undertaken

The role of this section is to provide background concerning the various factors of the study areas and thus provide insight into why they were considered appropriate for situating this research. As stated earlier, these districts were Kurnool, Prakasam and Anantapur. The focus is predominantly on the groundwater status of these three districts. The overall defining features are that all are considered to be arid with low rainfall and high incidence of drought, thus necessitating the need for effective groundwater management.

3.4.1 Kurnool

Kurnool is a district in the Rayalseema region located in the South East of the state of Andhra Pradesh. Approximately 75% of all occupations and the associated people within the district have direct or indirect reliance on agriculture for their livelihoods (Chhotray, 2004). Annual rainfall is typically low and inconsistent and as a result many farmers historically relied on rain fed agriculture. The Rayalseema region is “distinctive on account of its rugged, dry upland terrain” (Chhotray, 2004, p.335). Most of the villages throughout Kurnool District are of a mixed class with a wide range in the land holding sizes of farmers. The tapping of groundwater for drinking and irrigation purposes varies greatly and is reflected in the extent to which groundwater resources are overexploited within the district.

There are 54 mandals in Kurnool District, with a total area of 17,700 sq. km and an estimated population of 4,046,600. Figure 9 depicts the state of the groundwater resource over these mandals. Although approximately 69% of the mandals are classified as ‘safe’ (as of 2004), 22% are over-exploited. It was noticeable that almost all (8/12) of the over-exploited mandals were in non-command areas (Central Groundwater Board, 2006). This ratio highlights the link between surface and groundwater irrigation resources within the district.
3.4.2 Prakasam

The area of Prakasam District is 17,625 sq. km with a population of approximately 3,059,423. Prakasam is located in the Coastal Andhra region, which encompasses all districts on the eastern coastline of the state that border the Bay of Bengal (Ramanaiah et al., 2006). Like Kurnool District, Prakasam has a high reliance on agriculture with only 15% of the population being classed as urban. Around 36% of the total area of the district is considered to be under irrigation, with implications for groundwater over-exploitation and the other issues associated (Ramanaiah et al., 2006). There are 56 mandals in Prakasam District. Of these it can be seen through Figure 10 that there are 64% in which the groundwater resource is classified as ‘safe’ compared with 20% that are considered over-exploited. The level of groundwater development is considered to be higher than that of Kurnool at 57% (Central Groundwater Board, 2006).
3.4.3 Anantapur

Anantapur District is located in the South East of Andhra Pradesh with an area of 19,135 sq km and a population of 3,183,814. The average precipitation of the districts varies greatly, with the eastern side receiving around 700 mm per annum and the western side receiving as little as 250 mm (Bhagavan & Raghu, 2005). This therefore induces high variability in the water available for replenishment of the groundwater resource. Like Kurnool District, Anantapur is largely located in a rain shadow area, thus influencing rainfall and drought (Chetty, 2001). For instance, in the period 1995-2005 as many as 7 years were affected by drought (Bhagavan & Raghu, 2005). Such occurrences of consecutive droughts over an extended period of time have meant that overexploitation is far greater in this district compared to many others in the state (see Figure 11).

There are 63 mandals in Anantapur. Of these 45% are considered to be at the stage of over-exploitation as seen in Figure 11. This is significantly higher than the other two districts mentioned above, especially when it is seen that only 22% of the mandals are considered to be at a safe level of exploitation. However, groundwater development is still considered to be less than that of both Kurnool and Prakasam Districts at only 33% (Central Groundwater Board, 2006).

![Categorisation of mandals in Anantapur District. Adapted from: (Central Groundwater Board, 2006)](image)

3.5 Legislative context

It is important to acknowledge the legislation that exists within and influences the field. Various Acts at both national and state levels highlight the importance of
groundwater and the impact that it has on development. Many of these also highlight the role that communities need to play in the management of these resources with the Centre for Economic and Social Studies (2008, p.6) in a human development report stating “development means the capacity of a society to participate and enable the people to have a vision of their future”. Thus the notion of public participation is present in many levels of legislation. This section focuses on two key pieces of legislation that influence groundwater management in Andhra Pradesh, these being: the National Water Policy 2002 (NWP) and the Andhra Pradesh Water Land and Trees Act 2002 (APWALTA). The relevant sections of both are now put forward and discussed.

3.5.1 National Water Policy 2002

The National Water Policy 2002 (NWP) highlights the over-exploited nature of the groundwater resource in many regions of India. A broad range of measures for addressing development of groundwater were put forward in the NWP as shown Table 2. The use of scientific data in the analysis and reassessment of groundwater potential is reiterated in section 7.1. The outcomes that may be associated with the over exploitation are put forward, highlighting those actions that might mitigate against them such as; augmenting recharge (through artificial recharge structures), not exceeding such levels and conjunctive use of both surface and groundwater resources.

Table 2: Section 7 of the National Water Policy 2002 relating to ‘Ground Water Development’

<table>
<thead>
<tr>
<th>Section</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.1</td>
<td>There should be a periodical reassessment of the ground water potential on a scientific basis, taking into consideration the quality of the water available and economic viability of its extraction.</td>
</tr>
<tr>
<td>7.2</td>
<td>Exploitation of ground water resources should be so regulated as not to exceed the recharging possibilities, as also to ensure social equity. The detrimental environmental consequences of overexploitation of ground water need to be effectively prevented by the Central and State Governments. Ground water recharge projects should be developed and implemented for improving both the quality and availability of ground water resource.</td>
</tr>
<tr>
<td>7.3</td>
<td>Integrated and coordinated development of surface water and ground water resources and their conjunctive use, should be envisaged right from the project planning stage and should form an integral part of the project implementation.</td>
</tr>
<tr>
<td>7.4</td>
<td>Over exploitation of ground water should be avoided especially near the coast to prevent ingress of seawater into sweet water aquifers.</td>
</tr>
</tbody>
</table>
Section 5 of the NWP highlighted the priority placed on irrigation; below drinking water, but above many others such as, hydropower, ecology, agro-industries and non-agro industries, navigation and other uses. The priority placed on irrigation above many other uses highlights the activity’s importance, which is inexplicably linked to the livelihoods of farmers. This is reinforced through section 7.2, which mentions and ensures the idea of ‘social equity’ with and through irrigation.

Other policies that are important in considering the management of groundwater that the NWP refers to revolve around issues such as:

- **Groundwater exploitation has to be severely restricted.**
- **Flood and drought are normal parts of the hydrology of some regions and therefore water resources planning should be carried out accordingly.**
- **Saving power and reducing groundwater irrigation and carbon footprint should be major focus are in the new water policy.**
- **There is a need for effective groundwater regulation programs to sustain groundwater dependent communities for long term and to protect associated surface water.**
- **Water can be managed progressively more and more at the panchayat level**
- **Rainwater and groundwater harvesting should be promoted**
- **Subsidies and incentives should be given to those who have water saving measures.**

Many of these are in alignment with the issues outlined in the earlier literature review. However, as stated a purely regulatory approach to groundwater management is not desirable in the Indian context (Mukherji & Shah, 2005). Noticeably, there is a linking between the electricity and irrigation sectors, acknowledgement that there is interdependence and cooperation between the two industries if either is to gain efficiency and near sustainability. However, this is an aspect of groundwater management that is highly politicised in the context of Andhra Pradesh. The 2004 government was elected on the basis of free electricity for farmers; with a combined total of some 2,100,000 bore wells (Steenbergen, 2006). This then puts considerable pressure on both energy supply and groundwater. Therefore political policies are perhaps to be blamed for the exacerbation of the groundwater issue in many parts of the state and India as a whole. The mention of regulation programs and the
management of resources at the *panchayat* levels also puts forward the question of how this is to be achieved. This relates strongly to the management programs such as the focus of this thesis.

Section 12 (page 5) of the NWP highlights the significance placed on the participatory approach to the management of resources. It incorporates the range of stakeholders at various levels that should be involved in the management approach taken, with the aim of local bodies taking a more dominant role in the management approach in the long run. Section 12 is outlined below:

“Section 12: Management of the water resources for diverse uses should incorporate a participatory approach; by involving not only the various governmental agencies but also the users and other stakeholders, in an effective and decisive manner, in various aspects of planning, design, development and management of the water resources schemes. Necessary legal and institutional changes should be made at various levels for the purpose, duly ensuring appropriate role for women. Water Users’ Associations and the local bodies such as municipalities and gram panchayats should particularly be involved in the operation, maintenance and management of water infrastructures / facilities at appropriate levels progressively, with a view to eventually transfer the management of such facilities to the user groups / local bodies”.

It can be seen that a participatory approach is viewed as necessary in the management of groundwater resources, is properly recognised through formal channels and is even viewed as essential through the eventual transfer of the management to local bodies. The issue is then how best to carry out this inclusive participatory approach and whether management projects/programs such as the focus of this thesis are an appropriate means for meeting these deliverables.

Section 6.8 (page 4) of the NWP reinforces some of these notions in other sections stating, “The involvement and participation of beneficiaries and other stakeholders should be encouraged right from the project planning stage itself.” Furthermore, the Ministry of Water Resources (2010) in a brainstorming report involving academia, experts and professionals highlighted numerous factors relating of the NWP in which improvements could be made, making special reference to section 6.8 as outlined
The inclusion and participation of various stakeholders in the management of groundwater is therefore viewed as an important factor by policy makers.

“Participation management of water resources should be practiced by all means. Governmental agencies and all stakeholders should be involved, the word ‘encouraged’ in section 6.8 of National Water Policy 2002, may be replaced by “ensured” (Ministry of Water Resources, Gov of Ind, 2010, p.25).

Section 9.5 (page 5) of the NWP states that with “irrigation being the largest consumer of fresh water, the aim should be to get optimal productivity per unit of water. Scientific water management, farm practices and sprinkler and drip system of irrigation should be adopted wherever feasible”. Through the use of management programs such adoption might be encouraged. One aspect of this thesis looks at the role that management projects take, in the adoption of water saving technologies.

Section 19 (page 7) also gives weight to the development of drought prone areas, citing that they “should be made less vulnerable to drought-associated problems”. All three areas in which research has been undertaken are considered to be drought prone. The project is thus in line with these policies and provides insight into their effectiveness.

The Act also highlights the need for periodical assessments of the state of groundwater throughout India, particularly as the issues faced vary significantly when comparing different regions of the country. This notion of monitoring is reiterated by the Central Groundwater Board (2006) who highlights the need for the exploitable quantity of groundwater to be limited to the amount that is recharged annually, a factor of which varies spatially.

### 3.5.2 Andhra Pradesh Water, Land and Trees Act, 2002

The Andhra Pradesh Water, Land and Trees Act 2002 (APWALTA), is the predominant act through which water management in Andhra Pradesh is undertaken. It repealed predeceasing legislation, encompassing all facets of water management, as well as those relating to land and trees (Ramachandrula, 2008). The main focus of the act is to “promote water conservation, enhance tree cover, and regulate the exploitation and use of ground and surface water” (Ramachandrula, 2008, p.6).
The Act outlines the role of the government in the regulation of water, land and trees. Primarily this is through an Authority called the “Andhra Pradesh State Water, Land and Trees Authority” (the Authority) as stated in Section 2 (1) of the Act. Some authors state that the role of government is too high for the effective management of a resource such as groundwater (Steenbergen, 2006). The specific role that the Authority has is outlined in Section 6 of the Act and is reiterated below:

6. Subject to any special or general directions by the Government in this behalf, the authority shall perform the following functions, namely:

(a) Promote water conservation and enhancement of tree cover in the State;
(b) Regulate the exploitation of ground and surface water in the State;
(c) Make regulations for the functioning of the authorities at District and Mandal level constituted under the Act;
(d) Advise the Government on the legislative and administrative measures to be taken from time to time for the conservation of natural resources;
(e) Advise on economic measures to be taken by the Government as incentives or disincentives relating to taxes, levies, fees or other charges to promote conservation of natural resources;
(f) Advise on strengthening public participation in conservation of natural resources from time to time in such a way that equity in access to water in different basins, sub-basins and regions in the State is maintained;
(g) Advise on any other matter that may be referred to it by the Government; and
(h) Advise the Government on the constitution and functions of the District level and Mandal level Authorities.

(GoAP, 2002, p.4)

As it can be seen this is predominantly a regulative role in the management of groundwater, however sub point ‘f’ highlights the promotion of participatory approaches. They therefore play a significant role in the management of groundwater, a point of which needs to be acknowledged through this research. However, as highlighted by many authors, a regulatory approach to management in the context of highly populated countries such as India has exorbitant administrative costs associated but also limitations concerning the ability of the state to effectively reach down and interact with the lower levels.

Chapter 3 of the APWALTA outlines “Ground Water Protection Measures”. It provides a framework through a regulatory means in which the groundwater of
Andhra Pradesh is to be regulated by the Authority. Subsection 8 (2) outlines that “the owners of all the wells… shall register their wells/water bodies with the Authority” (GoAP, 2002, p.4). This signifies a highly regulatory approach. Much of the development within the groundwater industry is within the informal sector, thus presenting issues in the implementation and administration of such a rule. Section 9 (1) outlines that “the Authority may prohibit water pumping by individuals, groups of individuals or private organisations in any particular area” (GoAP, 2002, p.5). Other sections of Chapter 3 of the Act relate to:

- **Section 10 (1)** Requiring permission for the sinking of a well near a drinking water source.
- **Section 11 (1)** The Authority may declare particular areas as over exploited.
- **Section 12 (1)** Prohibit the extraction of water if it is found to be adversely affecting drinking water sources.
- **Section 13** Regulate the distance and depth of wells being sunk.
- **Section 14** Registration of drilling rigs.
- **Section 15** The Authority has the power to close any wells.
- **Section 16** Compensation for closed wells.
- **Section 17** Guidelines for constructing rain water-harvesting structures.
- **Section 18** Re-use of water, recycling.
- **Section 19** Prohibition of water contamination.

All of these initiatives although desirable, highlight the significant administrative commitment and cost if they are to be effectively enforced, as mentioned earlier. This, in combination with the nature of the groundwater resource, results in laws that are also not easily implemented. So, to an extent Andhra Pradesh has “enacted groundwater laws, but [they] are yet to be implemented in any significant way” (Mukherji & Shah, 2005, p.337). This focus on state regulation over the previous decades has missed the community level elements necessary for the management of groundwater. For this reason the Act has had limited success is keeping groundwater extraction within sustainable limits (Ramachandru, 2008). However, by 2005, no more than a year after the Act was implemented it was claimed that 65% of official wells in the state had been registered (Steenbergen, 2006). This highlights a significant achievement in itself but also raises issues concerning bore wells that exist.
outside of the legal legislative channels of which there are few accurate estimates (Steenbergen, 2006).

3.6 Conclusion

This section has further justified the need for management of the groundwater resource in Andhra Pradesh and the specific districts chosen for research, as well as providing insight into the physical and climatic reasons behind this. Factors outside of these physical aspects are further discussed in the following methodology chapter. Although the focus of the research is and remains on community based approaches, it is important to reflect on the legislative provisions in which these approaches exist. Thus, this section has discussed some of those policies given in the National Water Policy 2002 and the Andhra Pradesh Water, Land and Trees Act 2002. It was identified how they might influence community based groundwater initiatives in the state. It was acknowledged in section 3.4 that the research districts have varying levels of groundwater development and exploitation and thus varying necessities of management. However, effective management is crucial for those that have been categorised as over-exploited and to minimise the implications for areas that have been identified as semi-critical and critical.
4.1 Introduction

This chapter outlines the theoretical basis through which research has been undertaken, defining the methodological framework that guides the research process (Sarantakos, 1993). The methodology used has incorporated predominantly qualitative approaches in the data collection stages but also quantitative aspects in parts of data analysing. Secondary resource gathering and analysis through the literature review was used to frame the issue at hand. Primary research methods utilised in the field included the interviewing of farmers and key informants. The methods used for data analysis are also put forward and a justification given. Both the limitations and positionality of the research form an integral aspect of consideration. This is of particular importance when considering research in a cross-cultural setting and inevitably induces additional considerations that must be made when conducting research. Ethical considerations therefore are of increased importance as cultural practices and structures may be very different to that of which the researcher is accustomed to. The aim of this chapter is to establish a link between what has been outlined in the preceding literature review and context chapters, the objectives of this thesis and the results and discussion chapters yet to come.

4.2 Objectives/ context of research

The central objective of this thesis is that of community management of groundwater. Primarily this concerns the factors that influence the way in which groundwater is managed, and getting to the crux of why these issues have eventuated. As outlined in the literature review, these outline a range of factors from agro-climatic conditions, political factors, roles of institutions consisting of local, central and non-government organisation as well as interactions between surface and ground water sources. NGOs are having a greater role in participatory regimes for the management of groundwater resources that are aimed at the community level.
4.3 Research / methodological approach

In developing research it is important to choose a methodological approach or combination of approaches that best addresses the research questions (Singleton Jr & Straits, 2010). Each approach to social sciences and qualitative research is based on assumptions as to what factors have the greatest influence on the subject (Neuman, 2003). However, through having a greater understanding of these assumptions the researcher can gain increased insight about the choices made and the findings obtained (Neuman, 2003). Different systems of thinking known as paradigms are useful in defining the research at hand. This has influences on the way in which the research is perceived and the techniques utilised in carrying it out.

A critical framework with interpretative underpinnings was used as the theoretical approach through which the research was conceptualised. By undertaking my research in a way that incorporated elements of both these paradigms, a more meaningful understanding of the different aspects present both physically and socially constructed could be gained. This allowed the research to be broken down into the basic assumptions, issues to be overcome and the questions over which this research was to be orientated (Neuman, 2003).

Nueman (2003, p.108) defines a critical approach as a “process of inquiry that goes beyond surface illusions to uncover the real structures in the material world in order to help people change conditions and build a better world for themselves”. In analysing the debates surrounding community based groundwater management, a critical approach was undertaken to understand the factors that might influence why varying levels of success existed spatially. This also relates to the varying levels of benefits and impacts that the farmers received through the case study project: APFAMGS.

A critical approach to research highlights the fact that social change and conflict are not necessarily seen easily, as many factors influence what a community or individual says and projects (Neuman, 2003). This is particularly useful when identifying limitations of the research as discussed in section 4.9, and how the responses of participants might be objectified. Therefore, this addresses some of the various factors that might be at play throughout the research.
In a broad sense the interpretive paradigm looks at how people interact with each other (Neuman, 2003). In applying this approach to the research context it is important to consider the factors that might influence the sharing of groundwater resources. As outlined in the literature review, these can also have social impacts relating to power distribution throughout a community. Through taking an interpretive approach the research can look at these various factors and how perceptions of the community relate to the sharing of groundwater, a crucial factor for the effectiveness of community based management approaches. The identification of these social links within a community and the prevalence of water sharing networks such as community bores is therefore an important aspect.

### 4.3.1 Qualitative or quantitative approach

Qualitative researchers tend to define the research topic loosely and in more general terms to allow flexibility (Sarantakos, 1993). Dooley (2001) defines qualitative research as that which is based on field observations without the use of statistics in analysing. The approach used was incorporated both qualitative in and quantitative aspects throughout the research process. Both were utilised in the fieldwork, where statistical information was then extracted from the data collected. The strengths of this approach in the field were that of flexibility and the ability of interacting with participants in their local setting (Dooley, 2001). However, these were stringent enough that themes could be extracted and the aforementioned statistical quantitative data extracted.

In the context of this research this quantitative aspect was useful as in allowed for the analysis of the responses of many subjects, with reliability being a key factor (Neuman, 2003). This therefore puts forward triangulation of the results through the utilisation of both aspects as well as observations whilst carrying out fieldwork (Cargan, 2007). Interviews based largely on questionnaires formed the foundations of this research, which was decided on due to the nature and context of the research undertaken. There are multiple players in community-based management of groundwater. Qualitative research enables insight into the opinions and lived experiences of participants. Quantitative inducing empirical through which objective facts are measured (Neuman, 2003). Thus the approach utilising a combination of both draws on these strengths and increases the vigour of the results.
The players in which this research focussed on were firstly, the NGOs involved in the community based management project studied, and secondly, the farmers that have participated in the project. Both these groups provide differing insights and perceptions concerning the dynamics within and the results that had been obtained through the project. Key informant interviews were undertaken with representatives of the NGOs to gain insight into what NGOs view their role to be and how they perceive this role. Farmers are the recipients of any benefits that are delivered through the project, so their opinion concerning the project and the deliverables is crucial to understanding the success and factors that influence the ability to replicate this elsewhere.

The number of farmers interviewed allowed responses to be grouped and statistical representations extracted providing a quantitative aspect to the research. This provided results that were easily comparable between different areas that might have had different experiences of the project for a variety of reasons. An overall grounding in sound theoretical knowledge should be the underpinning basis for all research (Silverman, 2001).

4.4 Secondary research

Secondary research in the form of a literature review provided the theoretical basis for the research, outlining community based groundwater management through information that had already been published in some form (Sarantakos, 1993). The different factors that have influenced changes in the agricultural system and exacerbated the pressures placed on the groundwater system were put forward and an analysis of legislative context was undertaken. The review provided background research as to the situation of groundwater as well as community based initiatives to address the issue. The literature review considered previous research and linked and applied it to the study at hand (Sarantakos, 1993). This provided insight into the debates that surround groundwater management and what provides the best results. This is particularly relevant when considering the context in which the groundwater is utilised in India with large numbers of users with small land holdings.
4.5 Case study and location of research

A case study approach is typical of qualitative research and can provide value through the many aspects of a specific case that are investigated, providing a more intensive study (Neuman, 2003). The research looked at the things that were delivered though the Andhra Pradesh Farmer Managed Groundwater Systems (APFAMGS) project. The project aimed at promoting community based groundwater management.

The context outlined the three specific districts in which research was undertaken. These were Kurnool, Prakasam and Anantapur, all of which are located in Southern Andhra Pradesh, India. In all of these areas the APFAMGS project had been implemented, and were chosen on the basis of availability of NGO staff to assist with the research and the climatic regimes. As the context has outlined, although all districts are considered to be arid, the extremity of this is varied. Therefore these locations were also chosen so as to gain insight into how the project operates or may differ when considered in different agro-climatic conditions. The APFAMGS project is now outlined, followed by the NGOs that were worked with.

4.5.1 The APFAMGS project

The Andhra Pradesh Farmer Managed Groundwater Systems (APFAMGS) project was implemented in 2004. The United Nations Food and Agricultural Organisation (FAO) was the donor agency with funds accepted mainly from the Embassy of the Kingdom of the Netherlands in India. The funds were then appropriated through 9 NGOs spread over 7 drought-prone districts of Andhra Pradesh with one nodal NGO: Bharati Integrated Rural Development Society (BIRDS) acting as the implementing agency. This section aims to briefly outline the project through which the research was based.

The main objectives of the APFAMGS project were to (APFAMGS Brochure, 2008):

1. Get both men and women farmers in a position where they understand the groundwater systems in which they are operating. Overall project areas consisting of about 650 habitations.
2. Development of hydrological databases through which groundwater management committees can base their decisions
3. Adoption of alternative agricultural practices that suit the availability of groundwater
4. Establishing of community based institutions for the alternative management of groundwater resources, with equal representation of men and women over the projects areas.

The overarching theme of the project is ‘demystifying the science of hydrology’ and to change the perceptions surrounding the groundwater resource. The Participatory Hydrological Monitoring (PHM) approach utilised aims to overcome the lack of knowledge that farmers have concerning the groundwater resource, empowering them to be able to effectively manage the groundwater resource and make the calls required.

A unique aspect of the project is that there are no material incentives such as cash or subsidies to the farmers. Instead, the project firmly aims to offer a means through which increased knowledge concerning groundwater use is gained. Equipment and skills for them to be able to manage these are given along with facilitating the access to information about water saving techniques and improved agricultural practices. Main aspects of the training offered encompass groundwater and rainwater measurement, creating increased knowledge of the resource and the agricultural practices that groundwater can sustain. Thus farmers are able to grow crops accordingly.

Four NGOs were chosen in collaboration with and including the nodal NGO BIRDS. These are outlined in Table 3 along with the corresponding districts they are located in.

Table 3: NGOs that the research cooperated with and the corresponding districts they are located in

<table>
<thead>
<tr>
<th>NGO</th>
<th>Abbreviation</th>
<th>District</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bharati Integrated Rural Development Society</td>
<td>BIRDS</td>
<td>Kurnool</td>
</tr>
<tr>
<td>Development Initiatives and People’s Action</td>
<td>DIPA</td>
<td>Prakasam</td>
</tr>
<tr>
<td>Society for Sustainable Agriculture and Forest Ecology</td>
<td>SAFE</td>
<td>Prakasam</td>
</tr>
<tr>
<td>Star Youth Association</td>
<td>SYA</td>
<td>Anantapur</td>
</tr>
</tbody>
</table>
4.5.1.1 APWELL project

It is important to note the Andhra Pradesh Groundwater Bore Well Irrigation Schemes Project (APWELL) that was a prior project to that of APFAMGS. This project utilised many of the same NGOs. The project was implemented between 1995 and 2003 with the aim of increasing the agricultural production of small and marginal farmers through the provision of groundwater irrigation facilities (Steenbergen, 2006). Thus the APWELL project had a different focus to that of the APFAMGS project. It did however mean that the local NGOs used in the implementation of the APFAMGS project had in many cases already built up somewhat of a rapport with the farmers, which is important in the implementing stages of a project.

4.6 Field research methods

Field research was conducted in February and March of 2011. The methods consisted of a qualitative approach that incorporated interviews with key informants and farmers as well as observations through interaction with participants. The discourse through which research is undertaken will inevitably influence the results obtained, so the project was looked at from both the farmer’s perspective as well as NGO representatives. Initially it proved difficult to arrange interviews with the NGO representatives and to work with them and the farmers they are involved with. However, upon arriving to India, the snowballing technique was used both in the arranging of the research schedule with the various NGOs and also when in the field and interviewing farmers.

4.6.1 Interviewing techniques

Interviews formed the basis of the field component of this research. Semi structured interviews were followed for both interviews with farmers and key informants although the level varied between the two. Semi structured interviews contain elements of both structured and unstructured interviews (Sarantakos, 1993). By interacting through these informal interviews, insight into the situation was possible. Flexibility is outlined as one of the major benefits associated with interviews as they can then be adjusted to diverse situations (Dooley, 2001). Increased motivation for answering all questions in an interview was viewed as a major advantage when comparing to, for instance: questionnaires, which do not require the same amount of
participation (Sarantakos, 1993). All interviews were recorded, with the participant’s permission, so that the maximum extraction of information would be possible. The information given to participants regarding this research is attached in Appendix A.

4.6.2 Key informant interviews

Key informant interviews were undertaken with four representatives from NGOs. These were more substantial than the interviews with farmers and comparatively less formal. An exemplar of the key informant questionnaire is attached in Appendix C. The basis of the interviews was a questionnaire of which had been derived from the research questions outlined earlier. However, the emphasis and direction of the questions could be altered based on strengths coming through in the discussion (Cargan, 2007). Thus, interviewees were given the reign to be able to elaborate on the factors that they viewed as most important. As a result, some key informant interviews were comparatively longer than others and all were substantially longer than the interviews carried out with the farmers.

Through the use of such open-ended interview techniques more complex and comprehensive answers could be attained. The presence of the interviewer can clarify or elaborate on the question, ensuring the respondent understands what is being asked, could even provide scope outside of the question (Sarantakos, 1993). In such a situation it is important that the researcher realises and reacts accordingly if the discussion strays too far outside of the scope of the research. The permissible length of the interview and response is also influenced by the presence of the interviewer (Neuman, 2003). This was evident as one of the Key informants had to cancel due to a change in schedule, the interview was then carried out via email and questionnaire. The responses from this key informant were substantially less in-depth when compared to those in which direct interviews had been carried out.

4.6.3 Farmer interviews

The interviews undertaken with farmers were comparatively more structured than the key informant interviews. Approximately 140 farmers were interviewed over the three districts and four NGOs. Although the interviews were still deemed to be semi-structured, varying situations between farmers meant that some questions could not be answered and the interview had to be adjusted accordingly. For instance, if a farmer
did not have a bore well, a raft of questions would be excluded. However, if that same farmer had for instance; further insight into less water intensive cropping regimes, the interview could be altered to gain the maximum benefit from this aspect of the farmers knowledge. Therefore a semi structured questionnaire approach to these field interviews was adopted. An exemplar of a farmer interview questionnaire is attached in Appendix D, through which the semi structured nature of the interviews is highlighted. This then allowed for comparison and collation of the data gained through the farmer interviews as the questions generally followed the same format and themes. Interviews were deemed to be the most appropriate approach to gaining information and insight from the farmer. The literacy rate in rural Andhra Pradesh is 65.4% for males and 43.5% for females (Government of India, 2001). In fact Govinda and Biswal (2005) highlight that Andhra Pradesh has some of the highest illiteracy rates in India. This would have provided a significant obstacle if, for instance, a questionnaire approach had been taken (Sarantakos, 1993).

The selection of farmers to participate was based largely on the contacts of the NGOs, but also invariably on who was willing to be interviewed. From this, the farmers interviewed also snowballed. The sort of criteria for farmer participants was described to the NGO representatives. This incorporated farmers from a wide range of land holding sizes as well as classes. This also highlighted the need for explaining the purpose of the research with the NGO staff. Upon outlining the sorts of parameters that were desired to gain the appropriate participants the NGO representatives did not try to limit the people I talked to. Although initially contact would be made to a few members that had, for instance, been involved in management committees. At times this would mean that meetings with overall committees would occur and then individually after. Furthermore, some of these farmers would suggest more people for me to talk to that met the criteria.

Rather than stating outright that farmers from a range of castes were desired as participants, selection was sought through indirect means, such as ranges in landholding sizes mentioned earlier. Involvement in the project gave insight into what was delivered, however, this was not necessitated as there were farmers interviewed that stated that they had not had any involvement with the APFAMGS project. NGO representatives were generally receptive to the research approach adopted, although at
times did emphasise that it would be good to talk to certain farmers. However, it is acknowledged that often such farmers had an in-depth understanding of the project and groundwater management and therefore provided valuable input into this research.

4.6.4 **Snowballing**

The snowballing method was used extensively throughout the fieldwork component of this research. Snowball sampling refers to when respondents subsequently are asked or recommend others who would be useful interviewees for the study (Sarantakos, 1993). Snowball sampling is based on the notion of networks among individuals or organisations through which, via multiple stages, the study can incorporate numerous participants (Neuman, 2003). Often the challenge is in finding the initial contact. Contact was first made with the nodal NGO BIRDS, and from this initial meeting the study was further expanded to include the NGOs of DIPA, SAFE and SYA. This was a key point as once the nodal NGO agreed to participate and assist with the research then the subsequent partner NGOs were more eager and willing to help and participate. Prior to the fieldwork, many of these organisations had been hard to contact or get a response from, so ‘getting an in’ was a crucial step in the research process.

4.6.5 **Observations**

Observations in the field provided a means through which I could actively see the effect of the management project. For instance, on numerous occasions the farmers would demonstrate the measuring of their groundwater level or the method in which rainwater is measured and recorded. Being able to see how water saving technologies, such as sprinklers or drips were used and implemented, provided a greater insight into the management process than if only interviews had been undertaken. This further interaction often also served to build up further rapport with the farmers, highlighting the interest that I had in their agricultural regimes and the ways in which they were further improving them. Having a translator with me made such observation more meaningful as I was able to ask further questions whilst being shown, or my translator could clarify specific points at a later stage. The use of a translator is further discussed in section 4.9.2. The use of photographs throughout this thesis aims to illustrate some
of these observations so the reader also gains further insight into groundwater management that is undertaken in the research areas.

### 4.7 Ethics

Ethical considerations are an important aspect when undertaking research. This is important when deliberating whether or not there will be any negative effects for participants (Neuman, 2003). Nueman (2003, p.145) outlines clear prohibitions that are recognised in a code of ethics:

“Never cause unnecessary or irreversible harm to participants, secure voluntary consent when possible and never unnecessarily humiliate, degrade, or release harmful information about specific individuals that was collected for research purposes.”

The University of Otago’s ethics approval, Category A, for research involving human participants was gained prior to the commencement of fieldwork (code for the approval by Ethics Committee: 11/012). Measures were taken to ensure that participants were contributing of their own free will. This was applied for both key informant and farmer interviews. At the beginning of interviews farmers were told that they didn’t have to answer questions that they didn’t want to. Informing participants verbally at the beginning of the interview was deemed the most appropriate due to the illiteracy rate in rural India. Farmers generally gave a response along the lines of “I don’t want to talk about that” (translated from the local language of Telugu) if they did not want to answer. Although this was infrequent it shows that participants only answered what they were comfortable with.

### 4.8 Data analysis

Data analysis is a process through which data is organized, integrated and examined, whilst “searching for patterns and relationships among the specific details” (Neuman, 2003, p.507). As such, data analysis was roughly split into four categories - data collection, data reduction, data organisation and data interpretation.
4.8.1 Data collection and analysis

Data collection consisted of the field research as outlined in section 4.6 involving interviews with key informants and farmers as well as observations. Secondary research outlined in section 4.4 also contributes to this stage of the research process.

Data reduction involved reducing the data to a manageable form through transcribing the recorded interviews. Transcription of all interviews was completed before leaving India. This was predominantly to utilise the translator services and for further clarification of the points made by the interviewees.

The transcripts of interviews were coded into conceptual categories that result in the information being organized into themes or categories (Neuman, 2003). These were based on what showed through from the interviews themselves as well as being based on the research questions. This therefore reflects the flexible nature of qualitative research (Cargan, 2007). This stage of the analysis process was undertaken upon my return to New Zealand. For the interviews with farmers this was achieved through entering the transcript information into spread sheets with columns based the aforementioned themes.

4.8.2 Data interpretation

The interpretation stage of the analysis is important as it links the research back to objectives and utilises information available to justify what has been obtained or observed (Silverman, 2001). A number of tools were used to assist in conveying these interpretations. Both Nueman (2003) and Cargan (2007) discuss the benefits associated with the use of matrices. They are easily produced and allow for the “summarisation of a substantial amount of information” (Cargan, 2007, p.264). Matrices were used extensively to sort large amounts of data, especially relating to key quotations extracted from the interviews.

Pie charts were chosen due to the ease of visual interpretation offered (Cargan, 2007). This visual representation was only used for information derived from the farmer interviews as the volume meant that statistical data such as percentages regarding a topic could be extracted. Photographs were used to illustrate some of the relevant features witnessed whilst fieldwork was being carried out.
4.9 Limitations

The nature of qualitative research means that limitations to the research are often present in some way, shape or form (Sarantakos, 1993). Through the identification of these limitations, measures can be taken to minimise their influence through effective research design. It also needs to be acknowledged that the results only represent a ‘slice’ of time in an ever-changing social and physical situation. This of course has implications for the applicability of results in the long run.

Often limitations may be identified prior to the commencement of fieldwork through reading literature that might outline some of the issues as well as talking with people that have experienced research in similar areas (Neuman, 2003). For this research, talking with my supervisor about what to expect and the challenges I would face in the field proved invaluable in developing my research design and preparing myself for the time to be spent within a very different culture to that of my own. The major limitations identified were that of the language barrier, a translator and the role of the NGOs in the research. These are now discussed in more depth.

4.9.1 Language barrier

The language barrier is invariably the greatest limitation to conducting research in a country in which the predominant language is different to that of your own. This was discovered in the very first instance of arriving in India and persisted throughout my time there. Although as time progressed I got more accustomed to dealing with situations in which this was an issue. Prior to the commencement of my time in India I attempted to learn basic phrases of Telugu, the local language. However, for the most part this was ineffective as my ‘New Zealand’ accent proved difficult to understand in the initial stages of meeting someone that was fluent in English, let alone with me attempting to speak a new language.

Of the four key informant interviews that took place, two spoke fluent English so the interview could take place without the need of the translator. Although particularly to begin with, much repetition and clarification was required. The other two spoke English to a limited degree so the use of a translator was necessary for them to be able to further explain their response or to increase their understanding of questions. Of the
140 farmers interviewed, only one spoke fluent English so the use of the translator was extensive.

Responses during the interviews shaped what further questions were asked. Therefore it was important that I was aware of these, but also the interview was not too disjointed due to the stop-start nature of translation. Particularly for the interviews with the farmers, the knowledge that the translator had of what the research goals were and the specificities of the questions asked became important. Often this meant that my further questions were pre-empted by the translator, minimising pauses between questions and vastly increasing the efficiency of the interview process.

4.9.2 Translator/ interpreter

The need of an interpreter was determined prior to field research, during the initial stages of planning. As expected, English was spoken very little, if at all, in the research areas. Thus it was essential that a translator of some degree was present. Bringing someone else in to assist in the data collection and interpretation process inevitably induces various limitations into the research (Rayner, 2000). Contrastingly, there were also numerous advantages associated with having a translator, such as further insight into cultural practices to be adhered to, or arranging transport.

Numerous options for interpreters were explored. Getting a separate translator through a few of the NGOs was offered. However, the availability of them could have influenced the amount of field research that could be undertaken, as well as the areas in which I could have gone. I therefore decided to hire a translator to travel with me during my fieldwork. As it turned out, Raj, the son of a professor I was staying with during my initial time in India offered to accompany me and act as my interpreter. The relationship between the researcher and translator is one of utmost importance and can greatly shape and influence the results obtained (Rayner, 2000). Being roughly the same age (a few years out of university) Raj, an engineering student, was ideal for the role and furthermore provided comparatively less bias in terms of the topic, of which would have been a limitation to some degree had interpreters from the NGOs been utilised.

This does not mean to say that Raj may not have had any preconceived ideas about farmers, or the different sectors of society. These individual aspects inevitably may
influence the results gathered, or for instance, the weighting on specific questions. This was mitigated through firstly explaining the various aspects of the research and the focus or key points of interest. However, it is acknowledged that with research such as this there are limitations. Through the identification of these, the effects can be recognised and action taken accordingly.

The use of one interpreter throughout the research meant that there was consistency throughout the entirety of my research. It also meant that the translator became very familiar with what was of interest in the specific questions, so he could ask further questions so as to get the desired depth of response without having to relay each answer in full to me. We also became very used to each other’s ‘accents’ lending advantages to this aspect. After interviews we would often discuss what was said, and this was furthered during the transcribing of the interviews. Therefore, reinforcing what was required through the interviews.

4.9.3 Influence of the NGOs

The research was possible largely due to the cooperation and assistance of the NGOs that had worked on the APFAMGS project. The influence that they had on the research therefore needs to be addressed. Although the range of farmers desired for the research was explained, the NGOs played a part in contacting and arranging the participants. At times this would just mean contacting local management committees to arrange for farmers to come in at a specified time to meet with me from which they would be individually interviewed. However, farmers that were highly involved in the project were often sought out by the NGOs to participate as would be expected in such project-focused research. Although this research was about what the project delivered, it needs to be acknowledged that potentially many of the farmers interviewed were those that had experienced considerable success. However, many of the farmers also stated how successful the program had been overall in their village, providing wider insight as to the extent of the project. To a degree it can therefore be said that the ‘randomness’ of farmer participation was influenced, as is the case for much qualitative research through which participants are sourced from a contact base (Neuman, 2003). Qualitative theory often involves sampling that does not follow non-probability procedures and for this reason it is claimed by some that it cannot be viewed as representative (Sarantakos, 1993).
The NGO staff were often present while interviews were occurring. This may have influenced what the farmers were comfortable saying as many of them identified that they had become friends with the staff, and hence may not have wanted to point out any failures or shortcomings of the project. Nevertheless, the assistance of the NGOs provided an ‘in’ with the communities that was invaluable as farmers could have been comparatively less inclined to participate had I been merely an outsider coming into their village. However, the motivations of the NGOs for me doing research also need to be considered, as too do the possible motivations behind farmers’ responses. For instance, many stated that they wanted free bores, or various subsidies. With this in mind the positionality I had in my research also needs to be considered.

4.10 Positionality

The positionality of the researcher is important when contemplating study design and methodology (Cargan, 2007; Chacko, 2004). This relates to the perspective that the researcher might take due to a variety of factors such as ethnicity, gender, age and other elements of their identity. Contemplation of these aspects and how they might influence preconceived perceptions of my research was even more important with the research being situated in a vastly different country to that of my own.

My ethnicity inevitably influenced the research. Being a white, male student in rural parts of India proved to be both positive and negative in some aspects. For many of the villages it was a complete novelty for farmers to talk with a white, blonde haired, green-eyed student. Many of the remote villages had not seen a white person in their area before, so many were keen to talk with me. This often meant that there was no shortage of villagers around me, and at times listening in on interviews, such as depicted in Figure 12. This may have had an influence on results as subsequent farmers being interviewed may have overheard responses that farmers before them had given.
Figure 12: At numerous times throughout the field work there were crowds of people interested in what was going on and wanting to participate. Author’s collection

However, although this ‘excitement’ or ‘novelty’ factor was present, this does not take away from the fact that I was an ‘outsider’ in their village. This cross-cultural research does introduce limitations, as the researcher cannot understand the cultural complexities due to the unfamiliarity of the setting (Chacko, 2004). Thus the link with the NGOs and having Raj as a translator was important. Being a foreign person showing an interest in what villagers of remote areas of rural India in itself may have been advantageous (Herod, 1999). Farmers were eager to demonstrate the skills, knowledge and processes that they had learnt through the project to someone from so far away. This may well have been an aspect that an ‘insider’ may not have been so privy to. This could even be applied to the level of hospitality that I experienced when visiting numerous villages, with many farmers insisting on giving some of their produce or roasting up some groundnuts. This provided me with further insight into the way that farmers and villages as a whole operated. However, the time restraints on my research have to been acknowledged as a limiting factor to this aspect.

Social stratification in India is linked to age among other factors such as caste, religion, gender and education (Chacko, 2004). My age of 22 may also have influenced the sort of perceptions others may have had regarding my research capabilities. However, my ethnicity might have countered this due to the curiosity...
Chapter four: Methodology

about my culture and the obvious differences between the research participants and myself. Other factors concerning positionality regarding my background therefore need to be addressed.

Gender is an issue that numerous academics state can influence the sorts of information made available (Sarantakos, 1993; Herod, 1999). Although in the context of research in India there is comparatively more literature relating to women conducting research in the country (Chacko, 2004). However, this is not to say that there are not issues, just that they are different. Being a male researcher may have influenced whether or not female farmers were made available for interviews, and thus impacted on this sector of my research.

4.10.1 Background factors influencing perceptions

I come from a farming as well as scientific geography background. This influenced my perceptions about how farming and the management of groundwater should be undertaken. It took some time to adjust to the vastly different contexts in which farming exists in India in comparison to New Zealand. Reading before the commencement of fieldwork provided background into what was expected, but in the context of this research first-hand experience was invaluable.

My background in combination with ethnicity may have meant that participants viewed me as someone from high socio-economic class (Chacko, 2004). This was especially relevant when I told them the size of the farm I grew up on – which I soon learnt to avoid. This made me feel uncomfortable, as it gave an impression of dominance. However, equally this may have meant that more people were willing to participate in the research and influenced thoughts concerning my seemingly young age (Chacko, 2004).

Herod (1999) highlight that the researcher’s positionality is not necessarily fixed and that at times it may be advantageous to present oneself in different ways depending on the participant. This might be applied to how I approached interviews with farmers as opposed to NGO representatives. In talking with farmers the idea was to not intimidate them, so keeping the questions simple and to the point, however still adapting this level depending on the individual. The fundamental idea behind this is to gain the most benefit from the interview (Herod, 1999). This notion was still
applied when interviewing NGO representatives, however their knowledge base was often very different compared to that of the farmers, meaning that aspects of the interview could stray to topics applicable to the project.

4.10.2 Differentiation from the NGO

As I was visiting the various villages with NGO staff many of the farmers thought I was part of the organisation. Although introductory information such as where I was from and why I was researching in India was given to them, this association was hard for some farmers to eliminate. Some asked what I would do for them or if I would stay. This may potentially influence the sorts of results that were gathered, as farmers might have said what they thought I wanted to hear. By having individual interviews with each of the farmers the influence of this may have been minimised (Sarantakos, 1993).

4.10.3 Cultural practices and structures

In India the caste structure is still present throughout society (Seabrook, 2002). This inevitably has an impact on research being undertaken due to the power structures associated with “class, caste, gender, religious affiliation, and education” (Chacko, 2004, p.58). This research hinged on a management project and the farmers that were involved, meaning that having a farm was a crucial criterion for participants. Therefore, it can be ascertained that certain sectors of society were not included in the research such as the landless, which may be, but not always, linked to these power structures. However, this research aimed at obtaining a representative cross section of the farmers within a society and gain insights into how the project affected farmers with differing land holding sizes and statuses.

Cultural practices also dictated the positionality that I had concerning my research. Effort was made to adhere with these such as always removing shoes when entering a temple or house and wearing long pants as opposed to shorts. Such efforts in combination with my attempts at greeting participants in their local language gave an image of me attempting to fit in and learn ways of Indian culture, even if these greetings for the most part required Raj to relay them to the farmers.
4.11 Conclusion

This chapter has outlined the methodology employed throughout the research process. This aimed at providing results through the use of effective research techniques that address and build on the research questions. Qualitative research methods of semi-structured interviews of varying degree were utilised as the predominant means of data collection. The flexibility of qualitative research was viewed as the main advantage of the adopted research approach, through which interviews could be adapted to various situations and to gain the most efficient and valuable results (Neuman, 2003).

The major limitations surrounding the research were that of the language barrier, translator and the role of the NGOs in the research process. Some of these were pre-empted and expected prior to the research being conducted, but likewise, there were cases where the design had to be adapted whilst in the field. Having a consistent translator throughout the field component and transcribing aspects of the research process affected many of these identified limitations.

The positionality of the researcher inevitably influences the research. Being a white student in India meant there was very much a physical difference between the interviewees and myself. These positions and the influence that they may have had on the research need to be considered and appreciated in the context of legitimate research. Using these methodologies information was gathered regarding, and at times going beyond the research questions. The following chapter now outlines and discusses the results gathered through this research.
5

A Community-Based Groundwater Management approach: APFAMGS

Results and Discussion

5.1 Introduction

This chapter will outline and discuss the results obtained throughout this research. The aim of this study; providing insight into community based groundwater management, forms the basis of this chapter with the research questions assisting in framing the aspect concerned. To reiterate what was first put forward in the introduction, the research questions are as follows:

- To what extent do management projects promote collaborative management of groundwater and the sharing of the resource?
- What are the main roles that NGOs play?
- How effective/successful are such projects?
- What are the conditions in which such projects are more likely to be met with success?

Due to the nature of the topic researched, the structure of this section does not directly reflect these questions, as portions of each aspect of the research are applicable to multiple questions. Instead, through discussion, linkages are made whereby the research questions and overall aim are addressed. This chapter covers a range of results relating to research undertaken with the APFAMGS project. The ideas and issues that were brought up in the literature review are applied to the studied project and discussed accordingly. This incorporates inputs sourced from both the farmers themselves as well as the NGO representatives. However there are, of course, sections in which the perspective of one holds more relevance over the other.
As stated, the structure of this chapter is largely shaped by the main themes that have become evident through the research. Sharing of groundwater and the communities involved in the APFAMGS project are outlined, identifying factors that influence this aspect. The prevalence of groundwater markets within the research areas are discussed in relation to those issues outlined in the earlier literature review. The role of NGOs in the project is discussed, outlining the main functions and how these vary over different stages of the management process. Local leadership within the research areas is discussed and the implications that it has for management projects. The success level, training received and teaching through the APFAMGS project is put forward, outlining the associated importance. The impact that the project has had in particular on farmer’s ability to manage, analyse and apply the knowledge of the groundwater resource that they have gained through the project is discussed. Finally, the prevalence of irrigation system use throughout the research areas is presented, outlining differences between the different districts. Conclusions are drawn throughout with key ones being collated and briefly summarised at the end. The main conclusions are covered in more depth in the final conclusion chapter of this thesis.

### 5.2 Sharing of groundwater resources and the communities involved in the project

One of the main aims of this research is to determine the sort of things that can make this sort of community based groundwater management project and approach successful. This was done through looking at the situations, people and places that are involved from both the farmer’s perspectives and the NGOs involved. As stated, groundwater development is largely within the private sector. Therefore, the conditions under which effective management can occur is an important aspect when considering management regimes, as collaboration in the management of resources largely rests on the ability of individuals being able to coordinate their efforts (Deshpande & Jyotishi, 2002). This section of the chapter therefore relates strongly to both research questions one and four:

- The extent to which management projects promote collaborative management of groundwater and the sharing of the resource, and;
- The conditions under which this can occur.
Firstly, this section therefore investigated some of the factors that contribute towards the sharing and collaboration of groundwater management, such as land holding size and various aspects of the communities involved. How this is done and the level to which this sharing of groundwater is carried out is put forward as well as the methods employed. Issues of gender in the management of groundwater are then briefly discussed.

5.2.1 Collaboration in the management of groundwater

Effective groundwater management requires wide reaching collaboration between a range of different stakeholders (Ostrom, 1990). In many villages in Andhra Pradesh and elsewhere in India there is a raft of issues that makes this collaboration potentially difficult. The numbers of people from different social and economic backgrounds involved in a collaborative initiative provides a significant obstacle to engaging with the majority needed for an effective management regime (Saravanan, 2008). Key Informant 2 built on this, stating; “there are socio-economic issues, there are political issues and there are the caste issues… it is tough to bring all these groups to one platform and to think in one way” (Key Informant 2). It is therefore important that management projects reflect these factors, and does so in way that is conscious of the fact that in India, caste and social structures play a significant role at the local level in the management of water resources (Saravanan, 2008). The APFAMGS aims of equality and inclusivity, demonstrate that this is an underlying theme of the project. Key Informant 2 further noted that:

“All the groups of the village have to be involved. It is not that there are only backward people or the higher community. All the community is involved and [has to] come together to take up this issue, because it is a common issue. A water related problem is a common problem. If only one sector of a community is participating or only one farmer is doing it, then problem will not be solved. It needs to be addressed as a unit” (Key Informant 2).

Power structures, the nature of villages in rural India and the high range of landholding sizes all play a part in influencing participation and collective action concerning the management of groundwater (Hassan, 2002). Although this provides an obstacle in the implementation of a project such as APFAMGS the results show
some instances where collective management has been occurring beyond these constrictions. A quote from a farmer below detailed a situation in which inter-caste sharing occurred effectively:

“Individually we could not have installed a bore. The three partners belong to three different castes. We are the only community bore well belonging to three different castes in my village. Others are generally brothers or cousins. We share the water equally, and we do not have any fights” (Farmer Interview 8).

Although this sort of response only featured a few times throughout the farmer interviews undertaken, it does show that there are examples where the stratified nature of villages does not work in opposition to the effective collaboration in the management of groundwater resources. Although many farmers did state that it only really works when all the farmers involved have the same landholding size. Therefore, it should not be taken that collective management can always occur inter caste, but just that in a few cases it can work where equality is a strong factor in the arrangement. In some cases cooperation across caste can occur but only in those instances where there is some commonality of class (as taken by landholding size). Approximately half of the farmers who had community bores stated that it was shared between family members. For instance, “[we] have a community well that is shared between 3 brothers” (Farmer Interview 103). In many cases of community bore wells, the family unit is used as the basis for sharing of groundwater resources, through which many of the social structures of the village are avoided. This does however put forward a peculiar notion of ‘community’. An example of a shared bore well in Kurnool District is shown in Figure 13.

Figure 13: left: Farmers / GMC members stand next to and discuss a shared/community bore well, right: A farmer is interviewed about his community bore well. Author’s collection
Chapter five: Results and Discussion

Figure 14 shows the incidence of bore well ownership over the four study areas and over the study as a whole. Community/shared bores had the highest incidence in Kurnool District with 37% of the farmers interviewed. The highest incidence of individual ownership was in Prakasam District where 71% of the farmers had individual bore wells – with both study areas in this district reporting the same value for this aspect. It is important to note that some farmers also stated that they had both individually owned bores as well as access to community bores for a portion of their land. Overall, individually owned bores accounted for 60% of farmers and community owned or ‘shared’ bore wells made up 25% of farmers.

It is also important to note the effect that previous projects might have had such as the APWELLS project described in section 4.5.1.1 of the previous chapter. “Before the APFAMGS project there was the APWELLS project, where for every ten acres bore wells were installed” (Key Informant 3). The APWELLS project aimed at initiating community bore wells for irrigation. The distribution of this was project was not as extensive as the APFAMGS project, thus some portions of the study areas may not have received the mentioned community bores. Many of the farmers who had community bore wells stated that they had got them through the project.

Figure 14: Bore well and well ownership over each of the four study areas, with the lower right graph showing these values combined
5.2.2 Land holding size of farmers interviewed

The differences in the land holding sizes of the farmers interviewed over all study areas can be seen in Figure 15. The most common size was between 2.5 and 5 acres with 47 out of the 140 farmers. Thirty farmers had 7.5 -10 acres. Eighteen farmers had between 5 and 7.5 acres and 13 had between 1 and 2.5 acres. The remaining defined farm sizes all had below 10. The largest farm size was 95 acres, however this was a joint farm with about two thirds of it being leased out. The next largest was 40 acres. Some of the influence that these larger farmers have is discussed at a later stage in this thesis. The smallest farm was one acre.

![Figure 15: Land holding sizes of farmers interviewed over all four study areas](image)

This shows that there was high variance in the size of landholding throughout the three districts. If family was not the binding point for community wells it was apparent that the majority of community wells serviced similar amounts of land for each of the involved farmers. For instance, for a bore well that serviced 10 acres and three farmers used it, all would irrigate between 3-4 acres. For equity purposes it appears that for the majority of farmers the use of the bore well is “dependent on the size of the landholding” (Farmer Interview 19).

This equality in the use of community bore wells was cited as an important aspect. For larger farmers this might mean that only a few acres of their farm would be irrigated through the community bore well, thus all stakeholders would receive the same irrigation benefit. This of course is easier to implement when all farmers have
the same sized farms – “three of us use the bore for a total of 10 acres” (Farmer Interview 4). Therefore, when the size of the landholding is equal this translates to equal use of the bore.

The majority of farms were 10 acres or less. Combined with the high rate of individual bore well ownership seen in Figure 14, it is suggested that there is still room for initiating community bore wells, as a portion of each of the farms involved could then benefit from further irrigation. Ideally this would focus on greater use of the wells that are already existent, and therefore minimise the demand for more wells and thus making the bore more efficient (Vaidyanathan, 1999). However, it is likely that such an initiative would be met with resistance from those who have the ownership of bore wells. Initiation of any further bores should only occur if there is sufficient water, for example in the command areas of canals where recharge is enhanced (Chatterjee & Purohit, 2009).

It was apparent that almost all of the farmers that had more than 10 acres had an individually owned bore well. Many of these larger farmers also cited that they had community/shared bores with very few having no bore well at all. For instance, only one larger farmer in the Kurnool District stated that they did not have a bore. A representation of this from the Kurnool District study area is shown in Table 4. However, it was clear upon further analysis of these responses that although it appears to be evenly spread between individual bore ownership, community/shared ownership, the number of wells owned varied greatly between the smaller and larger farmers. Of the smaller scale farmers (for this scenario 0-7.5 acres) that stated that they had an individually owned bore well, only one had more than one (which was only two).

In comparison, the farmers at the other end of the scale had multiple bore wells with examples of these responses from the Kurnool District given in Table 5. This shows that a disproportionate number of bore wells were controlled by the larger landowners in the area, with some having as many as 11. As emphasised in the literature review, it is important that a management project for groundwater involves those that have high control over the resource (Shah et al., 2001). As stated by Shah et al. (2001) this perhaps places more importance on the involvement of such farmers as opposed to the smaller farmers who do not have the same capacity to extract groundwater.
of these farmers have such high numbers of wells, if they were not to participate in a management initiative it could undermine the efforts others nearby.

**Table 4: Disaggregation of bore well ownership of farmers interviewed in Kurnool District based on land holding size using the same intervals as in Figure 15.**

<table>
<thead>
<tr>
<th>Land holding size in acres</th>
<th>0-2.5</th>
<th>2.5-5</th>
<th>5-7.5</th>
<th>7.5-10</th>
<th>10-12.5</th>
<th>12.5-15</th>
<th>15-17.5</th>
<th>17.5-20</th>
<th>20+</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individually owned bore</td>
<td>II</td>
<td>III</td>
<td>II</td>
<td>II</td>
<td>II</td>
<td>II</td>
<td>II</td>
<td>II</td>
<td>II</td>
</tr>
<tr>
<td>Community/shared bore</td>
<td>III</td>
<td>II</td>
<td>II</td>
<td>II</td>
<td>II</td>
<td>II</td>
<td>II</td>
<td>II</td>
<td>II</td>
</tr>
<tr>
<td>No bore</td>
<td>III</td>
<td>II</td>
<td>II</td>
<td>II</td>
<td>II</td>
<td>II</td>
<td>II</td>
<td>II</td>
<td>II</td>
</tr>
</tbody>
</table>

**Table 5: Quotes from farmers of the Kurnool District study area with larger land holdings in regard to the number of bores they have**

<table>
<thead>
<tr>
<th>Quote</th>
<th>Size of farm in acres</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes, I have 11 bores, one I got from the project (Farmer Interview 38)</td>
<td>95</td>
</tr>
<tr>
<td>Yes, 5 individually owned. No community wells (Farmer Interview 31)</td>
<td>30</td>
</tr>
<tr>
<td>I have 3 bores (Farmer Interview 36)</td>
<td>20</td>
</tr>
<tr>
<td>No, I do not have a bore (Farmer Interview 25)</td>
<td>20</td>
</tr>
<tr>
<td>Yes, I have 2 bores. They are individually owned (Farmer Interview 28)</td>
<td>16</td>
</tr>
<tr>
<td>Yes, I have 8 bores, one of which is sponsored (Farmer Interview 40)</td>
<td>20</td>
</tr>
</tbody>
</table>

Many villages have initiated a ‘no more bores policy’. However, this does not take away from the fact that in several areas bores had gone dry due to what many of the farmers put down to there “being too many bores being installed nearby” (Farmer Interview 22). In such areas effective management and collaboration is necessary if any sort of community irrigation system is going to work, and as such, further initiation of bore wells would only further detract from the issue.

### 5.2.3 Gender issues in the APFAMGS project

Gender issues have an important impact and influence in the management of resources such as groundwater. Although gender is not a focus of this research, the APFAMGS project does have goals that address the inclusion of women in the management process. It is therefore important to mention. Exclusions of women from management programmes are often on the basis of accepted perceptions that the women’s role is confined to roles such as caring, family and child bearing (Lahiri-Dutt, 2007). This deviates from the fact that in many cases, particularly when it comes to small-scale farmers and irrigators, women are the primary managers and educators (Lahiri-Dutt, 2007). This highlights the importance of community-based schemes.
being inclusive and addressing of gender issues. Figure 16 shows some of the women that were seen working in the fields throughout the research area. Although it was not determined whether or not they were the owners of the farm, it illustrates part of the role that they have in the agricultural system.

![Figure 16: Women working in the field, harvesting groundnut. Author’s collection](image)

Over the four study areas, as seen in Figure 17, the farmers interviewed constituted 81% male and 19% female. In the FAO (2008) evaluation report, women participation in the project was stated to be as high as 50%. This does not mean that women do not participate or that the results of this research dispute the levels reported by the FAO, just that perhaps there are other factors that might influence the number of female farmers being interviewed. It was highlighted in the methodology that being a male researcher in rural India might influence whether or not women would participate in the research. It could also be that males were more likely to participate in the formal aspects associated with the project. For sustained community based interventions there needs to equality and inclusion of all sectors of a community for there to be ultimate success through which the needs of both men and women should be addressed (Lahiri-Dutt, 2007).

![Figure 17: Gender make-up of farmers interviewed](image)
5.3 Groundwater markets and the associated issues

In areas where there is sufficient groundwater, the establishment of water markets has been identified as a means through which water can effectively be shared throughout a community. Adiseshu (2008) states that groundwater markets can be a means whereby the agricultural production of rural areas can be completely transformed to that of a modern agricultural economy. Increased access to the groundwater resource means that more people can gain agricultural intensification through irrigation. This access is therefore reliant on the sharing of the groundwater resource, linking to the promotion of collaborative management and the sharing of groundwater – research question one. With such access regimes in mind, prior to this research it was thought that water markets would play a significant role in groundwater usage. Throughout the three districts it was apparent that the selling of groundwater varied greatly, as too did the opinions and statuses concerning groundwater.

In Kurnool more than half the farmers interviewed were either involved in the selling or buying of water for irrigation purposes. Representations of these are given in Table 6. Prior to this research it was thought that it would be the larger farmers that would predominantly be involved in the selling of groundwater, especially when information considered, such as Table 5, highlighted that larger farmers generally had multiple bores. However, as seen in Table 6 the farm size with the highest number of farmers who sold water was the 5-7.5 acres category. It is proposed that these farmers had irrigation capacity beyond that of their own farms and therefore had water available to sell. Steenbergen (2006) argued that farmers will irrigate to the level that will deliver the highest benefit and as irrigation capacity increases, a higher proportion of the farm will come under irrigation. These notions are further discussed in relation to the use of irrigation systems as discussed in section 5.10. For larger farmers they may have brought more of their land under irrigation. Some of the larger farmers also cited that “everybody around [their] land had bores” (Farmer Interview 38) thus there was no market for them to sell water, even if they wanted to. This highlights different scenarios in the demand of groundwater, which is largely a reflection of the extent of development within a community.
Table 6: The selling of groundwater in Kurnool District study area: a disaggregation of the farmers interviewed based on the size of farm

<table>
<thead>
<tr>
<th>Land holding size in acres</th>
<th>0-2.5</th>
<th>2.5-5</th>
<th>5-7.5</th>
<th>7.5-10</th>
<th>10-12.5</th>
<th>12.5-15</th>
<th>15-17.5</th>
<th>17.5-20</th>
<th>20+</th>
</tr>
</thead>
<tbody>
<tr>
<td>No, do not sell water</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes, do sell water</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Buy water from others</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

No response: ||

It was noted that farmers who had community/shared bore wells did not generally sell water. This is attributed to the combined 10 acres of land that was promoted as the ideal size for a community/shared bore well. This meant that each person could get an adequate amount of water.

For those that did sell or buy water the price varied substantially. A selection of responses concerning prices given for buying and selling of water from farmers within the Kurnool study area is given in Table 7. Water was predominantly bought or sold on a per day, per crop or per acre basis, with the highest given at 3000 rupees per crop/ per acre and the lowest at 150 per day. This highlights that there is no official water markets, with much of the buying and selling of water being negotiated on an individual basis between farmers. It also suggests that the farmers involved in the selling of water have a high degree of power over what they can charge for their groundwater. The amount of water required will be influenced by the sorts of crops grown, the use of any irrigation systems and individual farmer preferences, thus it is hard to ascertain how much water is required or how long it might take to irrigate one acre for instance.

Table 7: Quotes from farmers in Kurnool District regarding the selling and buying of water for irrigation

<table>
<thead>
<tr>
<th>Quote from farmer – <strong>selling</strong> of water</th>
<th>Quote from farmer – <strong>buying</strong> of water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sells water for 300 rupees for 7 hours a day (Farmer Interview 10)</td>
<td>Yes. For 250 rupees for 7 hours a day. About 8 days a month (Farmer Interview 14)</td>
</tr>
<tr>
<td>Sells for 250 rupees for 6 hours (Farmer Interview 12)</td>
<td>Yes I buy for 250 rupees- 7 hours a day (Farmer Interview 15)</td>
</tr>
<tr>
<td>When we have a lot of water we sell it to two or three farmers for 1000-1200 rupees per acre (Farmer Interview 21)</td>
<td>Yes, we buy from our neighbours. 1,000 rupees per acre. So I spend about 4000 per crop per acre (Farmer Interview 23)</td>
</tr>
<tr>
<td>800 per acre (Farmer Interview 27)</td>
<td>Yes 450 per acre (Farmer Interview 25)</td>
</tr>
<tr>
<td>Sell it for 2000 rupees per acre (Farmer Interview 30)</td>
<td>Yes I buy water from others From another bore for about 3000 per crop for the whole thing (Farmer Interview 26)</td>
</tr>
<tr>
<td>2500 rupees for one crop (Farmer Interview 35)</td>
<td>I buy water. I spend about 5000 per acre per crop (Farmer Interview 29)</td>
</tr>
<tr>
<td>If the neighbour doesn’t have a bore then I sell it at 500-2000 rupees per crop, depending on the crop (Farmer Interview 36)</td>
<td>Yes. 2,000 per acre for paddy (Farmer Interview 32)</td>
</tr>
<tr>
<td>About 3000 per crop per acre (Farmer Interview 37)</td>
<td>I buy for 300 rupees per day (Farmer Interview 33)</td>
</tr>
<tr>
<td>I sell it for about 1500 per crop (Farmer Interview 39)</td>
<td>From the teluguganga canal we draw water, and in the absence of that we buy water from our neighbours bore – at 400 per day (Farmer Interview 34)</td>
</tr>
<tr>
<td>I sell I for 150 per day (Farmer Interview 40)</td>
<td></td>
</tr>
<tr>
<td>For about 2000 per crop, per acre (Farmer Interview 41)</td>
<td></td>
</tr>
</tbody>
</table>

In Kurnool District many of the farmers that did not currently sell water stated that they would do so if they got the opportunity. In contrast, in both Prakasam and Anantapur Districts most farmers said that they would not undertake the selling of groundwater. Many of these farmers stated that the water from the bore wells was adequate to only “meet [their] own needs” (Farmer Interview 113). However, many of these farmers also took the view that they “would give water for free if anybody really needed some” (Farmer Interview 105) and especially if it is needed for “animals or for drinking” (Farmer Interview 114). This is perhaps a result of social expectation, meaning that it may not be socially acceptable to sell water, or perhaps due to differing levels of physical limitations.

In section 5.10 (irrigation systems) discussed later in this chapter, it is shown that particularly in Prakasam District there was room for a greater use of water efficient irrigation systems such as drips and sprinklers. Although many of the farmers, as shown above, stated that they only had enough water for themselves, the use of such irrigation technologies may free up water so as to enable the establishment of a groundwater market. The volatile nature and unpredictability of rainfall events and drought throughout the region may also highlight some of the downsides of a groundwater market.
The establishment of groundwater markets during times when there is adequate water levels may have the capacity to meet requirements due to availability and the low cost associated with pumping. However, times of drought or even water shortage would mean that irrigation requirements might outweigh supply (Adiseshu, 2008). It is the non-owners of the bore that would feel the brunt of the shortfall as owners of the bore-well would place priority on their own crops (Adiseshu, 2008). This may mean that well owners have a high level of control over the resource with others utterly dependent on them to be able to grow their crops and maintain their livelihoods (Sainath, 1996). Therefore the farmers selling the water have greater security over their investment and gain a disproportional benefit from the groundwater resource (Datta, 2005). For the purchasers of groundwater, profitability would be less, due to increased cost of extraction, decreased water pressure and the associated costs of pumping water further from the source (Adiseshu, 2008).

It is important to note both positives as well as negatives that are associated with the establishment of a groundwater market. The costs of installing a bore well is substantial, with some of the farmers stating that it was “upwards of 70,000 rupees” (Farmer Interview 18). Therefore, it is in that farmers best interests to ensure that the bore does not go dry and thus renders the investment useless (Ramachandrula, 2008). There were a few cases where farmers interviewed stated that their bores had gone dry. Some even asserted that they had multiple bores installed, which had all been met with failure, “twice we have had bores installed, and both have dried up - we spent more than 60,000 [rupees] on each” (Farmer Interview 23). This highlights a substantial cost for the farmer, a cost that cannot easily be regained if the benefits of the bore ‘dry up’. Under these circumstances, it is apparent why farmer suicides have been a significant issue in parts of Andhra Pradesh (E. A. S. Sarma, 2004).

Such investment and/or failures can lead to farmers becoming caught in a debt trap whereby they view the only route of escape as ending their own life (E. A. S. Sarma, 2004). Other farmers highlighted that they needed to deepen their bores to maintain access to water, thus incurring additional costs to that of the original installation of the bore; “at first it was 150 ft and then it had to be re-bored to 350 ft to get sufficient water” (Farmer Interview 97). Some situations reflected the “immiserisation of small and marginal peasantry” associated with the rapid development of well irrigation.
through which the gap between the rich and the poor is widened (Vakulabharanam, 2004, p.1426). Similar to required deepening of bore wells, farmers which had relied on dug wells for their water needs began to find themselves without water, “first we had wells and then these went completely dry so we had to get bores” (Farmer Interview 44). So in many areas there was a continuing need for investment through the deepening of bore wells associated with the groundwater levels being driven further downward (Vani, 2009).

The effects of groundwater depletion are felt through many levels of water users in a community and some are effectively ‘priced out’ of groundwater extraction all together (Vakulabharanam, 2004). All of these scenarios highlight increased costs for farmers that are associated with the lowering of the groundwater table and the high rate of bore well installation. Many farmers, as highlighted earlier, have now “stopped the installation of bores after the project came” (Farmer Interview 36). So through the project, increased understanding of the groundwater resource is being gained, along with knowledge concerning the capacity of extraction that it can sustain.

The selling of water in combination with water efficient technologies does however offer an opportunity to minimise the demand for further bore wells as it provides a means where a larger number of farmers can obtain access to water for their irrigation requirements. Further education concerning the benefits of sharing groundwater resources needs to be applied. This could incorporate things such as the deterring of further bore wells being installed. For the farmer this maintains the economic viability of extraction as other potential bore wells would not be extracting groundwater from the same source (Adiseshu, 2008). This also minimises the risk of the farmer’s bore well going dry. However, this needs to be set up in a way that is equitable and does not feed into power relationships that further widen the gap between the rich and poor, as described in the water lord situations by (Sainath, 1996). The prospect of this in combination with the stratified caste structure present in many villages poses issues concerning a compromise between what an ideal situation would be and one which is workable (Vaidyanathan, 1999). Hill (2009) identified that such markets often reinforce inequalities existing in rural communities. For this reason community owned bore wells are perhaps a preferable option to the establishment of a water market as the cost of investment is shared but also the cost of failure (Adiseshu,
Chapter five: Results and Discussion

2008). Under such variable conditions effective collaborative management of the resource is even more critical, but also reiterates the need for monitoring of the resource so that farmers can make an informed decision about the merits of installing a bore (Chatterjee & Purohit, 2009).

5.4 Role of NGOs in community based groundwater management projects

This section outlines the results concerning the role that NGOs play in the APFAMGS project, providing discussion regarding methods used, support offered and the necessity of involvement. This therefore figures strongly in addressing research question two – What are the main roles that NGOs play? The presence and role of NGOs in management projects is well documented, with Vani (2009, p.207) highlighting how in India NGOs “have had a long and significant legacy in implementing programmes and projects related natural resource management”. Many of these organisations are also involved in research and advocacy roles where education is an underlying theme of interaction with participants.

Participatory watershed development is an area of water management that is receiving particular attention, thus highlighting the need for assessing the role and contribution that are made to such initiatives (Ahluwalia, 1997). To a large extent the NGOs involved in projects such as APFAMGS are combining local people knowledge, experience and sense of priorities with scientific and technical knowledge. External agencies play a critical role in the community participation process, acting as a conveyor of knowledge and a facilitator of management initiatives (Vaidyanathan, 1999). It is the effectiveness and necessity of this role that form the main focus of this section.

5.4.1 Rapport building for implementation

Key Informant 1 stated “people have identified water as issues in their daily agriculture work, so it was easy to highlight the importance of the issue and the project”. However, is clear that just because people are aware of water being a major issue, it does not mean that they are then immediately accepting of new ideas about how they should manage their farm or their extraction of water. A key point made by Key Informant 2 was that “it needs to be addressed as a unit [as a whole]… if the problem is to be solved”. As stated earlier, for a common pool resource such as
groundwater, there needs to be cooperation from all sectors of a community (Ostrom, 1990). Rapport building was therefore a crucial part in the implementation of the APFAMGS project. Primarily this was so that information given to the farmers was more readily accepted as a key informant stated:

“For farmers in a community, if some stranger is coming in with a new idea, it will not be accepted just like that. There are steps and stages through which the farmers are being convinced and then the scientific program is implemented. So you are not directly going to them with scientific, big and complex ideas” (Key Informant 2).

“Community mobilisation and organisation” was highlighted by Key Informant 1 as being a significant role of the NGO and contributed “greatly to the success of the project”. There are however “steps to gain this mobilisation effectively as well as convincing [farmers] of the involved principles” (Key Informant 2). It is clear that there was a need for gradual steps leading to the introduction of the scientific basis in which the APFAMGS program was grounded and to build up a rapport and relationship with the farmers.

“First we go to the farmer and try to get acquainted with them about who we are, why we are here and what the solutions are. Slowly we meet with individual farmers… we will organise evening meetings when the workers are available. Then we will sit with them at a common place and slowly discuss [the issue] with them. Next we will have cultural group nights, an act with a local play or drama that highlights the problem and issue, so that it will get into their mind easily... We will try with more non-formal ways of teaching them, telling them about the problem by various pictures and showing them some models and drawings. Slowly the issue and problem that [they] are facing will be imparted on them” (Key Informant 2).

This shows that there is very much a method of interaction with a community, one that does not go “straight in there with all scientific information” and that has definite “steps and stages with which the farmers are being convinced” (Key Informant 2). It is about setting the issue in a way that is understandable for the farmer. “Generally we had to work a little harder in a few villages, which mostly contained people who were...
less educated and less open to the project” (Key Informant 4). Groundwater is a resource that is ‘out of view’ which in itself provides a barrier for its effective management when compared with surface water projects (Vaidyanathan, 1999). For effective NGO intervention and promotion of groundwater management, the need for an approach through which farmers gain an effective understanding is even more significant. The use of non-formal interaction is one such method whereby a range of approaches are used to gain farmer involvement:

“They tried to attract everybody in many different ways to the extent of serving breakfast, tea and distributing sweets during the meetings. Soon when the farmers got used to attending the meetings they didn’t need much motivation or coaxing. All of us became very good friends with them” (Farmer Interview 44).

These “non-formal education methods [such as] art festivals” builds rapport and understanding with the farmers (Key Informant 4). Field trips are another component where farmers “may be taken through some fields where they have faced a lot of problems due to overexploitation” (Key Informant 2). Through involvement in the project it eventually got to a stage where the farmers had ownership of the issues and “believed the APFAMGS project was theirs” (Key Informant 4). This ownership of the resource and the associated management is crucial in initiating effective collaborative management (Vani, 2009).

The results of this research, particularly relating to the uptake of the program initially, show that there were a substantial number of people within the communities who readily took up the project. This is apparent in Table 8 with just over 50 per cent of the farmers that partook in this research stating that they had been attending the project from the beginning. Some of the interviewees at this point even suggested that others had followed them into the project through responses such as “I was one of the first people to go and I led others in to follow” (Farmer Interview 27). Farmers that gradually started attending the meetings and participating made up 13.9% of those interviewed. Those that gave responses along the lines of “I took a bit of convincing” or “I followed others into the project” constituted 28% of the farmers. Some were more stubborn, and it was not until bore wells started to go dry that some farmers realised that “whatever they were telling [us] was important and useful, and then like a chain everybody started realising” (Farmer Interview 59).
“Some of the farmers did not follow. An important reason being that when a farmer has sufficient water he does not follow. He does not follow until he realises the importance of mismanagement” (Farmer Interview 51).

These comments highlight the value in field trips that enable farmers to see first hand the effects of groundwater over-exploitation and then bring these lessons back to their community. In far too many cases - such as those in Gujarat mentioned in the earlier literature review - it is not until the resource gets to unsustainable levels that the need for effective management is realised (Shah et al., 2001). Through such projects as APFAMGS, there is a need to emphasise the importance of conservative water management in drought-prone areas, even during times when water shortages are not as dire.

Table 8: The level of uptake and the initial response to the APFAMGS project

<table>
<thead>
<tr>
<th>Response</th>
<th>Number of farmers</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attended the program from the beginning</td>
<td>70</td>
<td>51.1%</td>
</tr>
<tr>
<td>Attended from between/ gradually started</td>
<td>19</td>
<td>13.9%</td>
</tr>
<tr>
<td>attending</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Took quite a bit of convincing</td>
<td>28</td>
<td>20.4%</td>
</tr>
<tr>
<td>Did not attend APFAMGS</td>
<td>8</td>
<td>5.8%</td>
</tr>
<tr>
<td>Did not respond to question or the answer</td>
<td>15</td>
<td>10.7%</td>
</tr>
<tr>
<td>was not applicable</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>140</td>
<td>100%</td>
</tr>
</tbody>
</table>

The APWELLS project was identified as a crucial point through which the involved NGOs had already established a rapport with many of the farmers that were then subsequently involved with the APFAMGS project. Had this not already been present, Key Informant 3 argues that the “initial stages of building a relationship with the farmers would have been significantly longer” (Key Informant 3). So differing levels of rapport with farmers consequently means a slightly different approach needs to be taken (Vani, 2009). The NGO therefore has to be able to implement the project through a process which first focuses on building a relationship before full implementation of the project initiatives (Vani, 2009). It was evident that NGO staff in some places had “a tough time convincing [the farmers] that water is a resource which cannot be [over] exploited” (Key Informant 2). However, “first they would use media and cultural programs to get a relationship before trying to convince them” (Key Informant 2). In some areas, where the APWELLS project had been present
NGO interaction had already occurred. This highlights the benefits associated with using local NGOs for the implementation of such projects, because through previous interactions a relationship is already built and established with the local community.

NGOs are often identified as the pace setters, imparting motivation to participants to effectively manage water resources (Lele et al., 2002). However, for this motivation to be followed through there needs to be respect for the NGOs as well as for what they are prescribing. It was found that many farmers still took some convincing of the benefits, and at times it was not until the wells dried up or water shortages occurred that active following and participating in the project was undertaken. This may be largely attributed to the fact that the APFAMGS project encompassed a larger number of villages and farmers than the earlier APWELLS project, so there were farmers that previously had not had any interaction with the NGOs.

This shows that there were differing levels of rapport and trust between the farmers and the NGOs during the initial stages of the project. It is therefore important that the NGO be able to adjust the project to not only fit social, economic and environmental status but also the level to which rapport has already been built up.

5.4.2 Expert input and the ability to adjust

NGO involvement in projects such as APFAMGS can offer a range of benefits. This can include the “ability to mobilise suitable and experienced experts” and to be able to modify the management approach taken quickly and in accordance with the situation (Lele et al., 2002, p.309). A key informant highlighted that “subject experts were available at the head office, including [those that specialised in] water, agriculture, gender and the project” (Key Informant 3). If the village coordinators had any problems “they could consult the project expert and if they couldn’t solve the problem the project expert would consult the subject expert” (Key Informant 3). This shows that NGOs involved in the project have the ability to adapt the process to fit the situation and provide guidance (Vani, 2009). For instance, one farmer said that a geology expert had come and told them that groundwater usage was uneconomical in their area, shedding light on why so many wells were drying up and thus allowing farmers to plan their cropping patterns according to the limited irrigation. One
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respondent suggested that “they have helped us a lot and they also got foreign scientists to come and guide us” (Farmer Interview 37).

Through the input of experts and the suggestions given, “the village coordinators go about their work… interacting with the farmers and telling them about the meetings” (Key Informant 3). By providing experts the NGO provides a knowledge resource for which the farmers would otherwise have no access. This is an important aspect for farmers as it is something that is not effectively given through irrigation and agricultural departments as per the current situation (Lele et al., 2002). Some farmers highlighted this as an important difference between the NGOs and government organisations, with the “[NGOs] coming near to the people and interacting… [whereas] government organisations do not come near the people” (Farmer Interview 49). This level of interaction that the NGO has with the community is further divulged by a farmer’s response outlined below:

“Before DIPA [the NGO] gave us awareness, before the project there were different programs that gave wells etc. But now DIPA comes to the village, sits with the village and cooperates. They tell us about the water, how to use the water and how water is wasted. They told [us] again and again and the people eventually understood the value of water” (Farmer Interview 49).

5.4.3 Providing links between the farmers and other organisations/services

NGOs can provide links to other organisations to deliver further benefit to farmers. An example of this seen throughout the research was the organising of subsidies for irrigation systems such as drips and sprinklers. Although the project itself did not offer subsidies on such items to farmers, NGO workers were able to connect and in some cases organise subsidies through the appropriate government department. It is reasonable to say that in many cases the farmers may have remained isolated from such organisations and the benefits offered if it was not for the NGO involvement. This is an example of the NGOs working with state organisations, which is an important aspect as long as it remains in a “complementary and supportive relationship” (Vaidyanathan, 1999, p.157). This is a key differentiating point between NGOs and many user groups such as WUAs (Water User Associations) as highlighted by Lele et al. (2002). As in many cases NGOs can “have better access, ranging from
farmers to highest levels in government and other agencies and have better social background to work with farmers” (Lele et al., 2002, p.309). However, Lele et al. (2002), Hooja et al. (2002) and Vani (2009) all highlight the supporting role that NGOs can play for users organisations whereby they provide a crucial support service.

5.4.4 Necessity of NGO involvement

Some government initiatives have suggested that WUAs (Water User Associations) could essentially take over the role that NGOs have in the management process. However, Lele et al. (2002) disagrees stating that the bureaucratic channels alone cannot provide sufficient support for WUAs to function effectively. As stated in previous sections, education is an important aspect of APFAMGS. “NGOs play a vital role in the compilation of data and the training [of farmers] in how to use and interpret it themselves” (Key Informant 1). Although the NGOs are not directly involved in the collection of data they play a role in maintaining the books, records and assets. This shows that the NGOs educate farmers concerning groundwater measurement but they still play a large role in the collation and analysing of data. Information is then disseminated through display boards as seen in Figure 18 as well as through community meetings in Figure 21 located further through this chapter:

“We disseminate the data at the village level through display boards and we also maintain the records at our office and we also forward it to the head office. This information forms the platform for the next CWB (crop water budget) meeting” (Key Informant 4).
Just over 80% of farmers interviewed over the three districts stated that it “was good to work with the NGO”. This shows that farmers generally viewed the relationship that they had with the NGO in a positive light. Approximately 60% of farmers viewed the role that the NGO played in the management of groundwater as crucial, with comments such as; “if it were not for BIRDS [NGO] we would not have had this much improvement, any that we have had is because of BIRDS” (Farmer Interview 25). Table 9 showcases a representative sample of similar quotes on the role of NGOs.

Table 9: A selection of quotes from farmers that highlight NGO involvement as important or crucial

<table>
<thead>
<tr>
<th>Quotes from farmers regarding NGO involvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>“I think NGOs such as BIRDS play a crucial role and that they should stay” (Farmer Interview 9)</td>
</tr>
<tr>
<td>“No it would not have been successful without them” (Farmer Interview 37)</td>
</tr>
<tr>
<td>“This sort of management would not be possible without them” (Farmer Interview 42)</td>
</tr>
<tr>
<td>“Without DIPA [the NGO] the project would not have been successful” (Farmer Interview 47)</td>
</tr>
<tr>
<td>“It is very necessary to have them” (Farmer Interview 51)</td>
</tr>
<tr>
<td>“Yes they are very crucial” (Farmer Interview 86)</td>
</tr>
<tr>
<td>“I think that 75% of the credit goes to them for the success of the project” (Farmer Interview 129)</td>
</tr>
<tr>
<td>“I think that they play a very important role and we have a lot of new things to learn from the project” (Farmer Interview 132)</td>
</tr>
</tbody>
</table>
Approximately 22% of all farmers interviewed stated that success in the project was very much based on collaboration between the NGOs and farmers as opposed to NGOs being explicitly crucial to the management process. It was noted that this ratio was significantly higher in Anantapur though, with approximately 45% of farmers taking this viewpoint. This perhaps shows a stronger viewpoint “that the project was successful because of a collaborative effort from everyone” (Farmer Interview 105) where “[the NGO] has worked hard… but the farmer has worked very hard” (Farmer Interview 117). As stated earlier, farmers may view the project as ‘theirs’ after some time. This suggests that perhaps farmers in Anantapur have a higher ‘sense of ownership’ and the associated results of the project compared to farmers from the other districts. This level of ownership may be attributed to the comparatively higher pressure on the groundwater resource in Anantapur, which may place the effects of groundwater depletion at higher importance and necessitate collaborative management of the resource (Hassan, 2002).

A few farmers put the success of the project purely down to the role of the farmer. “[NGO involvement] was crucial to the extent of giving awareness but not success. The success is mainly contributed by the farmers” (Farmer Interview 59). However, this only constituted approximately 2% of the farmers interviewed.

Many farmers also pointed to the continual need for NGO support and involvement in the management of the groundwater resource. One such farmer put forward the analogy:

“In the presence of the teacher the student behaves but when the exams are over the student stops doing what he learnt. So after [the teaching] the teacher is still useful and important. The new students are coming… and it is very important to teach them” (Farmer Interview 49).

From this it is gathered that throughout the duration of the project farmers engaged in the good practice water management promoted through the project, but upon its termination commitment started to weaken. The continued presence of the NGO staff at and beyond the community meeting meant that groundwater management and the initiatives taught throughout the project were continued at the same level. Primarily it
was seen through the project that NGOs played a significant role in the dissemination of expert advice, the education of farmers concerning the management of groundwater resources and for a large part, play a role in support of users associations.

5.5 The presence of local leadership within a community and the potential for a successful project

Overexploitation of many resources occurs due to people making decisions that are individually rational, but are collectively irrational (Ostrom, 1990). This highlights the need for overall cohesion in the management of a common pool resource such as groundwater. Local leadership is cited as an essential factor in which communities can be persuaded that participation and cooperation is the best way in which the common pool resource will be able to deliver the most benefits for all those involved (Vaidyanathan, 1999). This aspect of the research relates strongly to the conditions under which management projects are more likely to be met with success – research question four.

Success through NGO involvement or state intervention is far less likely if the community is not ‘on board’ (Vani, 2009). Therefore getting local leadership enthusiastic and committed is important because this will increase the uptake and likelihood of success for projects such as APFAMGS. This section puts forward results related to this aspect and discusses the application and implication that they have for the project. Methods used to engage with the public from the perspective of the NGO are investigated. As previously stated, the APFAMGS program is primarily a knowledge-dissemination medium through which the science surrounding groundwater and groundwater management is ‘demystified’. Therefore, an important aspect is the extent to which people initially took up the project, and hence how accepting they were of the information and cooperation that was asked of them. The extent of initial participation impacted on the level to which NGO involvement had to overcome any predisposed or engrained notions concerning the management of groundwater. Finally, the importance of local leadership from both the perspectives of the NGO as well as the end users of the groundwater is discussed.
5.5.1 Local leadership importance

Local leadership has been identified throughout the literature review as being of high importance for the success of local level resource management programs such as APFAMGS. The quality of such leadership can greatly influence community opinion concerning collective management of common pool resources (Vaidyanathan, 1999). One key informant stated that getting such local leaders on board was:

“Essential for the success of this program as we cannot isolate and avoid them. Certain policy decisions at the government level are passed through these local leaders, local panchayat and local administrators. So without the coordination between these actors it cannot be successful. So we involve these leaders in our activities regularly” (Key Informant 2).

The acknowledgement of the status that local leaders have, as well as their influence, suggests that gaining the participation of such people early on in a project such as AMFAMGS is viewed as highly important by the NGOs.

The impact of local leadership not only influences opinion but also attracts more people into participating in programs such as APFAMGS. In the earlier APWELLS project, free bores were given to farmers. Contrastingly, in the APFAMGS project there were no material outputs, except for giving information and awareness to the farmers. This provided a barrier for the uptake of the project but “the farmers who benefitted from the APWELLS project helped in gathering the other farmers” (Key Informant 3) meaning that the APFAMGS project was further reaching.

In some cases people would be ‘model farmers’ for their village and run an experiment comparing both the APFAMGS method and the method used prior to the project and farmers could “ask about stuff that they don’t know” (Farmer Interview 67). Experiments such as these provide a visual representation of some of the benefits and improvements that management of groundwater and agriculture can deliver. Otherwise, in some cases, “people did not believe them at first as [they] thought there was unlimited water supplies” (Farmer Interview 59). Local leadership was viewed as highly important by 45% of the farmers interviewed, with many stating that it is essential for the success of such projects. Whereas 32% of farmers asserted that the success was not so reliant on the influence of local leadership and that such success
was based more on purely a collaborative approach where everyone participating was responsible.

The literature review discussed ideas of power and how for management programs to be successful there needs to be the incorporation of those people that hold the power, much like the ‘waterlord’ situation discussed by Sainath (1996). Influence is a factor that can greatly affect the success of a management project. This does not only relate to the level of control that an individual may have over a resource such as ground water, but also the degree to which they can convince others to follow a particular management program (Vani, 2009). The importance of this influence of local leaders was found to be coherent with the viewpoints of all NGO representatives that were interviewed. The influence local leadership can have on management projects is viewed as significant and for a large part, may be the determining factor between that of success or failure.

5.6 The success level of the APFAMGS project

The success level as perceived by the farmers and NGO is seen as an indication of how effective the project has been at addressing groundwater management and the other associated goals of the project and is therefore significant in addressing research question number three. Approximately 77% of farmers interviewed stated that they viewed the project as being ‘successful’. A selection of these responses is put forward in Table 10. These show that a significant number of the farmers valued the project and the things that they had learnt through it. The final quote listed suggests that, “there is more potential in the project” (Farmer Interview 117), which is a response that was mirrored by many of the farmers who want the project to continue. At the point at which fieldwork was carried out, the project had been completed for approximately one year. This was a point that a few farmers highlighted, with one farmer stating, “they have given the farmer community a lot of information and helped them a lot and then they totally stopped coming” (Farmer Interview 44). Even once the management principles and methods have been taught, the farmers still view the NGOs as having an important role.
Table 10: Sample of quotes from farmers that viewed the project as being 'highly successful'

<table>
<thead>
<tr>
<th>Quotes from farmers</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Yes I think that the project is successful” (Farmer Interview 6)</td>
</tr>
<tr>
<td>“Yes, it is 100% successful” (Farmer Interview 17)</td>
</tr>
<tr>
<td>“Yes and it would be better if it went further ahead” (Farmer Interview 26)</td>
</tr>
<tr>
<td>“Yes to a great extent” (Farmer Interview 42)</td>
</tr>
<tr>
<td>“Yes very successful at least to the extent of our area (Farmer Interview 57)</td>
</tr>
<tr>
<td>“Yes it is 99% successful” (Farmer Interview 66)</td>
</tr>
<tr>
<td>“Yes to a great extent, we have learnt a lot” (Farmer Interview 91)</td>
</tr>
<tr>
<td>“Yes it has been very successful and we have learnt a lot” (Farmer Interview 112)</td>
</tr>
<tr>
<td>“Yes I think that the project is very successful and I also think that there is more potential in the project” (Farmer Interview 117)</td>
</tr>
</tbody>
</table>

Approximately 11% of farmers suggested that the project was a partial success. Once again, a sample of quotes outlining such a viewpoint can be seen in Table 11. Some highlight that the project had not been uniformly met with success for all of those that participated, emphasising potential for further impacts. The first quote argued that, “some people failed after following the method” (Farmer Interview 15). This highlights the fact that projects such as APFAMGS will not always deliver the same results to all people due to influences such as climate variation, physical characteristics such as soil type or even the farmers themselves (R. Kumar et al., 2005). Key Informant 1 highlighted these factors and identified how the project may not be as applicable over varying areas:

“The APFAMGS project is not answer to the all areas, it depends on formations, rainfall and aquifer. Some of the methods and model can be replicable with small changes according to the groundwater estimations and norms of the committees in that country. [The project] needs to be redesigned [and adapted to meet] local conditions” (Key Informant 1).

Some farmers suggested that although the methods promoted through the project were good, some people were not following them correctly. The final quote listed highlights an important aspect when considering the results of this research: “people might say that the project is fully successful but that is not fully true” (Farmer Interview 130). This suggests that in some cases people are perhaps saying what it is
that they think researchers want to here, or perhaps what they think will deliver the most benefit to them; i.e. the continuation of the project and the associated benefits. Such limitations and implications were previously discussed in the methodology chapter. Some farmers asserted that “a lot of farmers had gotten free bores through the project” (Farmer Interview 27) or “I wish that they [would] help us more, and I wish they installed more bores and also gave us sprinklers and drip pipes” (Farmer Interview 26). Although as stated earlier it was not the APFAMGS project that gave free (community) bore wells but the APWELLS project, its predecessor. This perhaps gives insight into how farmers view projects like these and how they perceive that they can get further benefits.

Table 11: Sample of quotes from farmers that viewed the project as ‘partly successful’

<table>
<thead>
<tr>
<th>Quotes from farmers</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Yes it is successful but some of the people failed after following the method that was told” (Farmer Interview 15)</td>
</tr>
<tr>
<td>“Yes it is successful to some extent” (Farmer Interview 18)</td>
</tr>
<tr>
<td>“Successful to about 70%” (Farmer Interview 51)</td>
</tr>
<tr>
<td>“There is more scope for more success in the project” (Farmer Interview 123)</td>
</tr>
<tr>
<td>“The methods that were showed to us showed signs of increased productivity to whoever followed them. But most people are not following it” (Farmer Interview 25)</td>
</tr>
<tr>
<td>“For some people the project is successful but for some it is not. People might say that the project is fully successful, but that is not fully true” (Farmer Interview 130)</td>
</tr>
</tbody>
</table>

5.6.1 The reasons attributed for the success of the project

The reasons or factors for which both farmers and NGO representatives attribute the success of the project to inevitably constitutes a crucial point in addressing both how successful the project has been and the conditions which allow for any successes, a point that this research seeks to understand - in questions three and four. These reasons varied greatly and a range of them are outlined in Table 12, with the major ones briefly discussed as follows. Water issues, including the need for water management, conservation and creating awareness were the most prevalent reasons with approximately 50% of farmers citing them as reasons for the success of the project. Groundwater knowledge and water recharge was attributed as an important reason behind the success of the project by 30% of farmers. Knowledge concerning different sorts of crops and cropping patterns was cited by 34% of farmers.
The methods/approach promoted through the project and the associated decrease in investment and increase in productivity were both cited by approximately 20% of farmers interviewed. Many of these reasons are now put forward and discussed further concerning the sort of training that is received through the project.

Table 12: The reasons attributed for the level of success of the project by farmers interviewed

<table>
<thead>
<tr>
<th>Reason cited for success by farmers</th>
<th>Number of farmers</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Created a lot of awareness/ helped a lot of people</td>
<td>47</td>
<td>33.6%</td>
</tr>
<tr>
<td>Methods taught/ approach taken</td>
<td>22</td>
<td>15.7%</td>
</tr>
<tr>
<td>Decreased investment / increased productivity</td>
<td>18</td>
<td>12.9%</td>
</tr>
<tr>
<td>Groundwater knowledge/ water recharge</td>
<td>30</td>
<td>21.4%</td>
</tr>
<tr>
<td>Water issues/ management/ conservation</td>
<td>50</td>
<td>35.7%</td>
</tr>
<tr>
<td>Learnt about crops/ increased the amount of crops</td>
<td>34</td>
<td>24.3%</td>
</tr>
<tr>
<td>Gave free bores</td>
<td>7</td>
<td>5.0%</td>
</tr>
<tr>
<td>Learnt about pesticides</td>
<td>5</td>
<td>3.6%</td>
</tr>
<tr>
<td>Learnt about fertilisers</td>
<td>9</td>
<td>6.4%</td>
</tr>
<tr>
<td>Reasons for not being successful</td>
<td>3</td>
<td>2.1%</td>
</tr>
</tbody>
</table>

Many of these reasons are now put forward and discussed further concerning the sort of training that is received through the project.

5.7 The training received through the APFAMGS project

The training that farmers received through the project is an indicative aspect of the success level of the project, building on the previous section and feeding into research question four: how effective sucSsful are these projects. As one key informant pointed out, training of farmers is essential for effective management of groundwater resources. “Before the APFAGMS project people would use water however they wanted, but then we formed GMCs and HUNs and through farmer field schools where we taught them to manage groundwater” (Key Informant 4). Key Informant 2 highlighted that “as a responsible group or NGO we play a vital role in training…”
[and] bringing awareness to the farmer. These natural resources can be optimally utilised can be utilised sustainably” (Key Informant 2). Key Informant 1 also stated that the “FFS [Farmer Field School] as well and CWB [Crop Water Budget] and FWS [Farmer Water School] meetings were among the most significant results” that have been delivered through the project.

The following quote from a farmer that was interviewed illustrates the breadth to which training and awareness through the project extended. However, as stated in the previous section regarding the variation in success there were also differences in what farmers viewed as the main training associated with the project.

“They came at the beginning and we didn’t have much awareness about agriculture. We have learnt about groundwater, how groundwater can be utilised, not mismanaged and its importance. The project was very effective and even reached the uneducated or the illiterate and taught them. We have learnt how to measure rain with the help of a rain gauge installed in our village. By knowing how much it has rained we can grow crops and also we will know how much more water we would require per crop. We also know how much water seeps in for different kinds of soils. This sort of information has been taught to every person of the village so obviously the project is successful” (Farmer Interview 72).

Rain gauges such as those described by this farmer are shown in Figure 19. This section will further investigate the training of farmers through the APFAMGS project.

Figure 19: Rain gauge use. Left: Members of a Groundwater Management Committee demonstrate how to use the equipment. Author’s collection
5.7.1 Farmer Field Schools as a means of disseminating information

The Farmer Field Schools (FFS) were found to be a good platform for interaction with the participants of the APFAMGS project and for building rapport, with Key Informant 2 stating, “they [the FFS] are used as a platform to run these projects and go to the people directly”. The Farmer Field Schools thus contribute to the promotion of collaborative groundwater management. Participation in the FFS was found to be high in all four of the study areas. As seen in Figure 20, of the 140 farmers interviewed 81% mentioned that they had attended and participated in the FFS, 8% did not attend, with 1% sometimes attending. The remaining 10% did not give answers or the answer was not applicable. This shows that there is high uptake of the project, as identified in section 5.4.1 previously. One such community meeting relating to the current state of groundwater in the area is shown in Figure 21 in which a range of information is given over the broad issue.

Figure 20: Participation in the FFS of the farmers interviewed over the four research areas
5.7.2 Training as a whole

During the interview process farmers talked at length about the training that they received and returned to the theme at different points rather than just when specifically asked about it. The farmers did not suggest that training was confined to FFS and therefore it is hard to ascertain what was learnt specifically through the Farmer Field School (FFS) and what was learnt through other aspects of the project. This may be attributed to the fact that different farmers may place differing levels of importance on the various aspects that they learnt about through the training and thus influence the answers given in this research. For a large part it can be assumed through the training of NGO staff that information and training disseminated through the project to the farmers was very similar over all the project areas.

This next section hence concentrates on the overall training and things that participants have learnt through the program as opposed to what was specifically learnt through the FFS or FWS (Farmer Water School) and CWB (Crop Water Budget) meetings. This will provide insight into the outcomes and the successes that have been delivered through the project. However, at this point it is also important to reiterate that farmers receive information through a variety of means, not just through avenues such as FFS. For example, the community display boards, as mentioned earlier in section 5.4.4,
provide easily accessible information for farmers. Further examples of these are given in Figure 22.

![Figure 22: A series of village display boards from the study areas. They show a variety of information for the farmers within the area. Author’s collection](image)

The sort of training that is offered or disseminated through a management program such as APFAGMS is viewed as indicative of success. However, it is important to note that it is through the initiating of these lessons by farmers and whether or not groundwater is managed sustainably in the future that is the real signal of success. The results shown in Table 13 represent the answers that farmers gave when asked what the main things, if any, were that they had learnt through the project. It is also important to note that some people responded with multiple answers whilst others limited themselves to one single main point. Nevertheless, Table 13 provides insight into the various training outcomes that were evident through this research. These responses are perhaps more relative to what each farmer took away as the most important. The main aspects of Table 13 are now further broken down and discussed.

**Table 13: Training received / outcomes of the APFAMGS project**

<table>
<thead>
<tr>
<th>No</th>
<th>Training received / outcome</th>
<th>Number of farmers (out of 140)</th>
<th>Percentage of farmers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>How groundwater is used, conserved and managed</td>
<td>72</td>
<td>51.4%</td>
</tr>
<tr>
<td>2</td>
<td>Efficient irrigation techniques/methods</td>
<td>24</td>
<td>17.1%</td>
</tr>
<tr>
<td>3</td>
<td>Groundwater level measurement</td>
<td>54</td>
<td>38.6%</td>
</tr>
<tr>
<td>4</td>
<td>Water discharge measurement</td>
<td>15</td>
<td>10.7%</td>
</tr>
<tr>
<td>5</td>
<td>Rainwater measurement</td>
<td>15</td>
<td>10.7%</td>
</tr>
<tr>
<td>6</td>
<td>Irrigation depending on the amount of water available or the amount required by the crop</td>
<td>33</td>
<td>23.6%</td>
</tr>
<tr>
<td>7</td>
<td>Learnt about different crops, seeds and growing according to water levels</td>
<td>65</td>
<td>46.4%</td>
</tr>
<tr>
<td>8</td>
<td>Changed the sorts of crops that were grown</td>
<td>21</td>
<td>15.0%</td>
</tr>
<tr>
<td>9</td>
<td>Now grows less water intensive crops</td>
<td>53</td>
<td>37.9%</td>
</tr>
</tbody>
</table>
Chapter five: Results and Discussion

<table>
<thead>
<tr>
<th></th>
<th>Learnt about crop rotations and cropping patterns</th>
<th>41</th>
<th>29.3%</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>Just stated what crops they grew/answer was not applicable</td>
<td>51</td>
<td>36.4%</td>
</tr>
<tr>
<td>12</td>
<td>Used more/increased organic fertilisers and lessened inorganic fertilisers</td>
<td>90</td>
<td>64.3%</td>
</tr>
<tr>
<td>13</td>
<td>Uses roughly the same amounts of organic and inorganic fertilisers</td>
<td>10</td>
<td>7.1%</td>
</tr>
<tr>
<td>14</td>
<td>Has decreased the use of fertilisers and pesticides</td>
<td>43</td>
<td>30.7%</td>
</tr>
<tr>
<td>15</td>
<td>No change to the use of fertilisers and pesticides/still mainly using inorganic fertilisers</td>
<td>25</td>
<td>17.9%</td>
</tr>
<tr>
<td>16</td>
<td>Pesticide use/training</td>
<td>14</td>
<td>10.0%</td>
</tr>
<tr>
<td>17</td>
<td>Used more organic pesticides</td>
<td>17</td>
<td>12.1%</td>
</tr>
<tr>
<td>18</td>
<td>Farmer harmful and farmer helpful insects</td>
<td>10</td>
<td>7.1%</td>
</tr>
</tbody>
</table>

### 5.7.2.1 Water conservation and management

The main and most apparent things that were learnt through the APFAMGS project were related to water conservation and management. Many suggested that they had learnt about different sorts of crops, cropping patterns and rotations. The awareness of growing less water intensive crops was particularly evident and applied to approximately 40% of farmers for which a selection of responses can be seen in Table 14. Through the use of scientific data encouraged in the program, many of the farmers have “learnt what sorts of crops to grow, depending on how much water [they] have in [their] bores” (Farmer Interview 80). This influences the security over crops as a farmer highlights that “we have learnt how to measure the groundwater level and depending on that we grow crops... because of this our crops have never gone dry” (Farmer Interview 131). Many stated that highly water intensive crops such as paddy (as seen in Figure 23) had been greatly reduced and “crops that require less water like grams and sunflower” (Farmer Interview 71) or “groundnut” (Farmer Interview 109) were now grown (such as those seen in Figure 24). Figure 24 also shows an innovation used by some farmers: the planting of maize between crops, which was identified as minimising the spread of disease.
Figure 23: Irrigation running straight onto paddy fields from the bore well (left). Transplanting of paddy (right). The growing of paddy is very water intensive. Author’s collection

Figure 24: Growing of groundnut (left) and chilli (right), which are less water intensive compared to paddy. Author’s collection

Table 14: A selection of quotes from farmers regarding low water-intensive crops

<table>
<thead>
<tr>
<th>Quote from farmer regarding the growing of less water intensive crops:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>“Now I grow crops that require less water, like chilli and grams” (Farmer Interview 3)</td>
<td></td>
</tr>
<tr>
<td>“Before the program I would grow paddy. Now I grow less water intensive crops. With the amount of water required for paddy we could grow greater volumes of less water intensive crops” (Farmer Interview 16)</td>
<td></td>
</tr>
<tr>
<td>“We’ve also learnt about less water intensive crops like sugar cane, grams, banana and tumeric, of which we are now growing” (Farmer Interview 18)</td>
<td></td>
</tr>
<tr>
<td>“When we are short of water we mostly grow chilli and cotton and when there is sufficient water we grow paddy” (Farmer Interview 52)</td>
<td></td>
</tr>
<tr>
<td>First we would grow paddy. When the project asked us not to grow much paddy, we didn’t listen to them and then the drought hit us and we realised our mistakes. Now we have decreases the growing of paddy by at least 50 % and we also grow other stuff like sunflower, tomato and other low water intense crops (Farmer Interview 59)</td>
<td></td>
</tr>
<tr>
<td>To grow less water intense crops… like grams and sunflower unlike paddy (Farmer Interview 71)</td>
<td></td>
</tr>
<tr>
<td>“Before we didn’t know how much water we had in our bore so we would grow whatever</td>
<td></td>
</tr>
</tbody>
</table>
crop we felt like and when we would fall short of water the crops would go dry. Now, because we know how to measure the water level we grow crops according to the water level to meet those requirements” (Farmer Interview 94)

“Since we have learnt about groundwater measurement, when we have enough water we grow paddy and when there is less water we grow sunflower and groundnut” (Farmer Interview 100)

“We have learnt what sort of crops to grow depending on how much water we have and how much crop to grow. We have learnt about less water intense crops” (Farmer Interview 117)

Many farmers also highlighted that “greater volumes of less water intensive crops” (Farmer Interview 16) could be grown with the amount of water required for growing paddy, therefore increasing productivity and profits. Some farmers mentioned the changing of cropping patterns that the project had induced into their cropping regimes as “when [they] fall short of water [they] mostly grow chilli and cotton and when there is sufficient water [they] grow paddy” (Farmer Interview 52). This changing of cropping patterns is fundamental is gaining the most efficiency out of water extracted (Steenbergen, 2006). This aspect is especially important in arid areas (Chetty, 2001), such as that which is depicted in Figure 25 where highly water intensive paddy was grown in arid Anantapur District. However Figure 25 also shows the growing of groundnut in an area not far from the vast expanses of paddy.

Figure 25: The lush paddy fields in stark contrast to the surrounding arid landscape (left) and less water-intensive growing of groundnut (right). Both photos were taken in Anantapur study area. Author’s collection

However, in line with the findings of World Bank (2010), generally speaking the results show that farmers are increasingly in tune with the current state of the groundwater in their area and can thus plan their cropping regimes accordingly.
Building on this, 5% of farmers stated that they now paid more attention to the seasonal growing of crops and thus adhered to things such as not growing paddy outside of the rainy season such as that outlined by Farmer Interview 100 in Table 14. However, it must be noted that some of the quotes noted in Table 14 have contradictions. Sugar cane mentioned by Farmer Interview 18 is not generally considered to be water efficient, predominantly being referred to as a cash crop that requires high inputs.

### 5.7.2.2 Crop rotation

The initiation of crop rotation was an important aspect of the training that was identified by approximately 30% of the farmers interviewed (Table 13). A selection of farmers responses regarding these are outlined in Table 15. Methods of crop patterns such as “maintaining distance between each sapling” (Farmer Interview 42) were cited as being important aspects of crop patterns learnt through the project. The notion of not growing the same crop over and over again so as to avoid a reduction in productivity was highlighted by Farmer Interview 84. Furthermore, Farmer Interview 84 identified that land fertility increases by utilising crop rotation. An area in which there were multiple cropping types was depicted in Farmer Interview 90 stating, “we knew about [crop rotation] even before the project but now we make it compulsory”.

**Table 15: A selection of quotes form farmers regarding crop rotation and cropping patterns**

<table>
<thead>
<tr>
<th>Quotes from farmers regarding crop rotation and crop patterns</th>
</tr>
</thead>
<tbody>
<tr>
<td>“After the farmer field schools we learnt that it is very important to rotate crops” (Farmer Interview 41)</td>
</tr>
<tr>
<td>“To grow crops like sunflower and grams and to maintain distance between each sapling” (Farmer Interview 42)</td>
</tr>
<tr>
<td>“Yes. Before we had sweet lime, now I grow; cotton, sunflower, chilli and tomato” (Farmer Interview 79)</td>
</tr>
<tr>
<td>“Putting the same crop in over and over again will give you less productivity. Earlier we would grow paddy and soda. Now we grow chilli sunflower, cotton and noogu” (Farmer Interview 81)</td>
</tr>
<tr>
<td>“I have learnt about crop rotation… and what sort of crops to grow. Earlier I would grow the same type of crop for a long period of time, but now I grow grams, chilli and tomato. So that the land fertility increases” (Farmer Interview 82)</td>
</tr>
<tr>
<td>“Earlier I would grow the same type of crop for a long period of time, but now I grow grams, chilli and tomato. So that the land fertility increases” (Farmer Interview 84)</td>
</tr>
<tr>
<td>“Yes we knew about [crop rotation] even before the project, but now we make it compulsory. Before we would grow grams, oats, paddy, chilli, and tomato. Even now I grow the same thing” (Farmer Interview 90)</td>
</tr>
</tbody>
</table>

115
The project may have reinforced farmer awareness concerning some of the issues that can arise through mono cropping and therefore encouraged further the adoption of crop rotation. This aspect therefore also needs to acknowledge the existing skill base of the farmer. As outlined in the literature review, the environment within which farming in India exists has changed drastically over the previous decades, due to shifting agricultural practices such as those associated with the Green Revolution (Evenson & Gollin, 2003). It is therefore fair to say that some consequences associated with these changes in the agricultural environment will be more extreme than others. Although the Green Revolution did introduce new varieties of crops, pre-existing knowledge concerning cropping patterns and changes was evident.

5.7.2.3 Fertilisers

The most apparent result as seen in Table 13 is that of increased usage of organic fertilisers with almost 65% of farmers citing this as a major thing that they had learnt through the APFAMGS project. Many also stated that they had “learnt to decrease inorganic fertilisers because [when used] excessively it damages the fertility of the soil” (Farmer Interview 98). The influence on fertility is important when considering fertiliser regimes (Tilman, 1998). One farmer outlined that “before the project [he] would use a lot of fertilisers and pesticides for cotton, chilli and paddy. After the extensive use of fertilisers and pesticides [he] got good productivity once or twice but later on the soil went bad and [he] got losses” (Farmer Interview 51).

“I have learnt about fertilisers and pesticides, groundwater, the disadvantages of inorganic fertilisers, and that it is better to use organic fertilisers. By following their method we get good productivity, with low investment. Because of the use of a lot of inorganic fertilisers the fertility of the soil is going down so we should use more organic fertilisers. We have followed to some extent and decreased the amount of fertilisers that we use. We were spending a lot of money on it but now because of the project we have decreased it” (Farmer Interview 37).
This “bringing of awareness [concerning] low external inputs to the crop” was identified by Key Informant 2 as one of the main functions of the NGO. “Now, because of these new methods our investment has decreased and our productivity has increased” (Farmer Interview 134). Some farmers appeared to have taken ownership of certain aspects of the project, particularly in regard to fertiliser use:

“In this project [fertilisers] is my part. I have learnt about 20-30 types of fertilisers. I was made the president for the fact that I can help a lot of people and also that a farmer listens to a farmer and not to a stranger. We did an experiment and then the farmer community understood then that whatever [the NGO] is telling us is correct. I was using a lot of inorganic fertilisers and pesticides, the highest in my village. I would use about 50 bags of fertilisers per acre for chilli, whereas now I use only 4 bags. Then I constructed my own shed for making vermicompost from dung from the cattle I own. People wanted to buy from me but whatever I made was just enough for me” (Farmer Interview 36).

Table 16 shows a selection of responses farmers gave when asked about the types of fertilisers they use. Several outline how they have come to make their own vermicompost as a result of the project. This utilises organic matter that is largely available to the farmer, thus lowering the cost of fertilisation and the associated costs that would accompany the contrasting inorganic fertilisers. Steenbergen (2006) also highlights how organic fertilisers such as vermicompost can increase the moisture capacity of soil, and therefore lowers the required degree of irrigation. This increases the efficiency in the use of the groundwater extracted.

In general, the consensus was that use of organic fertiliser was one of the most significant results delivered through the APFAMGS project, with the majority of the farmers mentioning it. Some farmers stated that the ratio was as high as a “90% organic and 10% inorganic [mix]” (Farmer Interview 41). Other farmers listed in Table 16 reported a “50/50” (Farmer Interview 63) and an interesting “25/50” (Farmer Interview 91) mix of organic to inorganic fertilisers. Whatever the true usage is over the communities in which research took place, it is evident that there are differences and as one farmer remarked, “after they have told us we are slowly
changing. Not everybody is changing, but it will take some time” (Farmer Interview 88).

Table 16: A selection of quotes from farmers regarding fertiliser use

<table>
<thead>
<tr>
<th>Quotes from farmers regarding fertiliser use</th>
</tr>
</thead>
<tbody>
<tr>
<td>“We use organic fertilisers, which I have learnt to make through the APFAMGS project” (Farmer Interview 13)</td>
</tr>
<tr>
<td>“I have learnt how to make vermicompost through the project so I mostly use that” (Farmer Interview 21)</td>
</tr>
<tr>
<td>“I learnt how to make vermicompost and that I should not use a lot of inorganic fertilisers… because it would cause infertility of the soil” (Farmer Interview 27)</td>
</tr>
<tr>
<td>“We have cattle whose dung we use as fertilisers” (Farmer Interview 35)</td>
</tr>
<tr>
<td>“I have decreased the use of fertilisers and pesticides. Now we are mostly using organic fertilisers. 90% organic and 10% inorganic.” (Farmer Interview 41)</td>
</tr>
<tr>
<td>“Before the project I would use a lot of fertilisers and pesticides for cotton and chill and paddy. After the extensive use of fertilisers and pesticides I got good productivity once or twice but later on the soil went bad and I got losses. After that I take precautions when I use fertilisers or pesticides” (Farmer Interview 51)</td>
</tr>
<tr>
<td>“Earlier we would only use inorganic fertilisers but now after the project we are using organic fertilisers – 50/50 of both” (Farmer Interview 63)</td>
</tr>
<tr>
<td>“After the project we have got a lot of awareness on organic fertilisers. We have learnt the importance of decreasing inorganic fertilisers and the increase of organic fertilisers. Inorganic fertilisers also require more water as compared to organic fertilisers, almost three times more water” (Farmer Interview 76)</td>
</tr>
<tr>
<td>“We have decreased the use of inorganic fertilisers. On using organic fertilisers the investment is low and the productivity is high” (Farmer Interview 85)</td>
</tr>
<tr>
<td>“Earlier we would mostly use inorganic fertilisers but now after they have told us we are slowly changing. Not everybody is changing, but it will take some time” (Farmer Interview 88)</td>
</tr>
<tr>
<td>“Use of inorganic fertilisers is about 25% and organic fertilisers is about 50%” (Farmer Interview 91)</td>
</tr>
<tr>
<td>“We are mostly using organic fertilisers. I learnt about fields, using organic fertilisers and using dried up leaves and organic waste as manure” (Farmer Interview 94)</td>
</tr>
<tr>
<td>“We have learnt to decrease inorganic fertilisers because on excessive use it damages the fertility of the soil. We are mostly using organic fertilisers and decreasing chemicals to a great extent” (Farmer Interview 98)</td>
</tr>
<tr>
<td>“Earlier we would use Urea and DAP which we have decreased. Now I mostly use organic fertilisers” (Farmer Interview 104)</td>
</tr>
<tr>
<td>“We are mostly using organic fertilisers like vermicompost and we have decreased the use of inorganic fertilisers. We also use cow dung” (Farmer Interview 117)</td>
</tr>
<tr>
<td>“Earlier we would use a lot of inorganic fertilisers, but now we are mostly using organic fertilisers” (Farmer Interview 125)</td>
</tr>
<tr>
<td>“I mostly use organic fertilisers and we have decreased the use of inorganic fertilisers. We use zinc, magnesium, borate and mostly use cow dung” (Farmer Interview 129)</td>
</tr>
<tr>
<td>“I mostly use organic fertilisers. I make my own vermicompost and use it. I recently started making it so I don’t sell it to anybody” (Farmer Interview 131)</td>
</tr>
</tbody>
</table>
This shows that farmers have a higher understanding of the consequences that may transpire if adequate management of inputs such as fertilisers is not undertaken. This may provide a means through which people are further convinced of the merits of continued collective management of the resource (Vaidyanathan, 1999). As stated by Ostrom (1990), people will agree to cooperate for the common good when the individual also gains by the group succeeding, when what is best for the group is also best for the individual and when coercion exists, as reinforced by Vaidyanathan (1999). Through the training disseminated via the APFAMGS project, farmers are becoming more aware of the need for management of both the natural resources and the farming techniques employed if sustainability of their livelihoods is to occur.

5.8 The prevalence of teaching between farmers of what has been learnt through the APFAMGS project

The further teaching and dissemination of information learnt through the APFAMGS program to others was prevalent in the farmers interviewed. This is a general factor of the research that feeds into many aspects of the research questions. Overall, teaching in the project was viewed favourably, with one enthusiastic farmer stating “there is no project that has spread or given so much awareness to farmers” (Farmer Interview 59). Over 84% of the farmers interviewed stated that they were involved with teaching at the very least at an advisory level. Table 17 shows the level in which teaching was prevalent in the research participants. For the most part responses consisted of either advising others when asked or simply that they were involved in the teaching. It was not divulged what level this teaching was. However, in some cases it was clear that there was a degree to which this varied ranging from “yes, I have taught all of my children what I have learnt” (Farmer Interview 08) to “We have village meetings where we discuss water and all of these issues” (Farmer Interview 36). This shows that throughout communities people engage in the roles of education and teaching one another at different levels.

“Whatever they have told has been helpful to us, it has been helpful to every farmer. About 60% of the village took part. But the remaining 40% have learnt from others who have attended. 100% of the village have benefitted from the project” (Farmer Interview 57).
This is of course the view of one participant. As stated in earlier sections there are some cases where desired results had not eventuated for farmers after following the prescribed method or where farmers were perhaps not as involved with aspects such as teaching as they said they are. However, for the most part, the majority of the farmers appeared to be genuinely appreciative of what the project had taught them and were keen to pass on the skills and the knowledge that they had learnt.

Table 17: The prevalence of teaching throughout the farmers that participated

<table>
<thead>
<tr>
<th>Response</th>
<th>Number of farmers</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Involved with actively teaching others</td>
<td>78</td>
<td>56%</td>
</tr>
<tr>
<td>Involved with teaching purely at an advisory level</td>
<td>39</td>
<td>28%</td>
</tr>
<tr>
<td>Not involved with teaching</td>
<td>6</td>
<td>4%</td>
</tr>
<tr>
<td>Did not respond to question or answer was not applicable</td>
<td>17</td>
<td>12%</td>
</tr>
<tr>
<td>Total</td>
<td>140</td>
<td>100</td>
</tr>
</tbody>
</table>

5.9 **Groundwater monitoring and the variations in the resource**

This section further scrutinises the results relating to research question number one, surrounding the collaborative management of the groundwater resource. As groundwater is the focus of this research, application of the skills and knowledge that farmers have learnt through the project is of importance. This section further discusses these points.

5.9.1 **Monitoring of groundwater levels throughout the four study areas**

Groundwater management is the focus of this research and warrants particular scrutiny in this discussion. This is largely seen to fit into both research question one and three that respectively examine the extent to which management projects promote collaborative management of groundwater and the sharing of the resource and how effective/successful such projects are. Figure 26 shows the range of responses surrounding the measurement of groundwater by the farmers interviewed. For those farmers that did measure the groundwater levels these ranged from between once a week and once every 1-2 months. Measurements of twice a month were most
prevalent with 42% of the 140 farmers interviewed denoting measurements at such intervals. Measurements of once a month and three times a month were found to be 16% and 7% respectively. Both measurements of once every 1-2 months and once a week were undertaken by 1% of farmers. The remaining 33% consisted firstly of those that had no bore – 11%, those that didn’t measure groundwater levels or that others measured it for them – 18%, and finally those that did not respond to the question – 4%. This shows that the majority of farmers have an understanding of the water levels specific to where they are situated, and as discussed in previous chapters, they can then grow crops according to that level (World Bank, 2010). With the addition of rainfall data farmers can develop cropping plans in accordance with available water resources (Steenbergen, 2006). In the project, such information is discussed at Crop Water Budgeting (CBW) meetings.

![Figure 26: Groundwater monitoring among farmers interviewed](image)

Through the farmers themselves taking ownership of the measurement of groundwater levels they also have a higher understanding of the resource and the capacity for irrigation. Steenbergen (2006) states that this can act as a trigger for action concerning the adequate management of the groundwater resource, something that is not easily achieved through non-participatory means. Groundwater levels are, at times, undulating and are reliant or react heavily to rainfall inputs (R. Kumar et al., 2005).
This undulating aspect of the groundwater resource as stated in the context chapter, is particularly prevalent in Andhra Pradesh, which is predominantly underlain by hard-rock aquifers (World Bank, 2010). In some areas it is therefore more necessary to have frequent measurements than in other areas. Furthermore, to be able to accurately equate the current state of the groundwater level for an area it is important that regular and accurate data is attained.

5.9.2 Trends in groundwater levels

The trends in groundwater levels reported by farmers throughout the three research districts were relatively evenly spread. Responses can be seen in Figure 27. Most prevalent was that there had been an increase in the groundwater level. Reasons attributed for this rise in the groundwater level varied. These reasons included the fact that there had been sufficient rains, that water recharge through surface works such as canals had substantially affected the water levels and lastly, the increased conservation of water mainly associated with the project.

Firstly, many farmers put the rise down to there “being sufficient rains” (Farmer Interview 55). In this sense, the presence of ‘high rains’ signifies a divergence to previous years in which consecutive droughts occurred over an extended period of time, which Chetty (2001) states as being not uncommon for the region. Some farmers even remarked that there had been too much rain, which also has implications for their farms. It is evident through the literature that the region does experience variation in rainfall from year to year, but the overall semi-arid nature necessitates the need for management regimes to be in place should the region come under the stress of drought once again. This is especially relevant when considered in the context that much of the groundwater is not replenished by consistent rainfall but short bursts with much of the annual rainfall falling in as little as 5-7 days (Chetty, 2001; Vani, 2009; Narain, 2003). Furthermore, Vani (2009) highlighted that any significant variations are likely to be random in nature. Therefore, it is important that indiscriminate development of groundwater resources does not occur, only to be met with disaster upon the next advent of drought. A key aspect of the project is to limit the number of new bores being installed and to promote the sharing of groundwater resources through things such as community bore wells which we discussed in section 5.2.
Other respondents cited that surface water irrigation such as the Teluguganga Canal, pictured in Figure 28, had drastically increased water levels in some areas of Kurnool. One such farmer stated, “once they had a water level of 120 ft, but now it is at 15 ft due to water seeping in from the canal” (Farmer Interview 17). Where surface water irrigation was prevalent groundwater problems of shortage were relatively non-existent. This can be largely attributed to the effect of water logging, which in itself has significant issues for farmers (Shah et al., 2003). As a result numerous authors highlight the need for mixed source irrigation that utilises both surface water irrigation through such things as canals which provides recharge for aquifers, and then groundwater use for counteracting water logging in the command areas of canals (Shah et al., 2003; Vaidyanathan, 1999). The fact that the water level has risen over 100 ft as stated by Farmer Interview 17 and other farmers of the same village, suggests that the rise is attributed to the canal development. However, farmers in this village recognised this aspect of their land, with many of them stating that their land was only suitable for the growing of paddy. Therefore the growing of paddy maximises groundwater extraction and minimises the influence of water logging.
Many farmers also argued that the project had increased groundwater levels through “conservative and efficient use of groundwater” (Farmer Interview 110). This was largely attributed to the role that the project had played by encouraging and educating farmers about conserving groundwater. Increased knowledge concerning the amount of water that is required for growing a specific crop meant that farmers could apply water accordingly (World Bank, 2010). In many cases this also meant increased yields as a result of optimal application. This also reflects the uptake of irrigation systems for more efficient use of groundwater and is further discussed in the following section.

Just below 20% of farmers interviewed stated that the groundwater levels were further decreasing. Many suggested that this was because of a “lack of rains” (Farmer Interview 118). However, substantial increases in the number of bore wells were attributed by many as a leading cause in the continued decrease in groundwater levels (Farmer Interview 113). This suggests that there is scope and necessity for improving water conservation measures in some areas. Groundwater level decreases were identified by more farmers in Anantapur district in comparison to the other two districts of Kurnool and Prakasam. This suggests that differences in groundwater use as well as other hydrogeological and climatic factors have an influence on the current state of groundwater levels. The climatic differences may be a factor for this as mentioned earlier in this section or it may be a result of increased stress placed on the resource through high demand.
“Earlier we thought that there was a lot of water that we could get from bores and whenever we would run out of water we would have financial losses. But after the project we came to know about how the groundwater system works and we have also learnt the importance of water recharge structures” (Farmer Interview 51).

However, this is also reflected through the measures of groundwater conservation such as the use of irrigation systems, of which farmers in Anantapur were more likely to use as discussed in the following section. The fact that within each of the study areas there exists such varying opinion concerning the state of the groundwater suggests that spatially the issues relating to groundwater levels might be different from village to village and certainly between districts. This variance in the changing state of groundwater levels highlights the need for a specific groundwater management regime that reflects the level of stress that the groundwater resource is under. Key Informant 1 further verified some of the trends seen in Figure 27, stating that in “some areas water levels were favourable, whereas others were negative and no change in others”.

“Crop Water Budgeting and Farmer Water School attendance” were among the most significant results that the project had produced (Key Informant 1). This provides a medium for which water budgeting can occur at the local level that is specific to the hydrological and even village unit. Thus, any differences in the level of groundwater exploitation or the changes in groundwater levels can be addressed accordingly at the local level. The quote from Key Informant 4 below identified that in such community based management, it is the farmers or the groundwater management committees that would deal with the enforcing of the rules concerning the use of the groundwater.

“Before the APFAGMS project people would use water however they wanted, but then we formed GMCs and HUNs and also through farmer field schools where we taught them to manage groundwater. Mostly the GMCs would administrate [police the] misuse of groundwater” (Key Informant 4).

This ‘self regulation’ is a means by which the stratified nature of communities can be overcome and effective participation of all those involved in the extraction of groundwater is incorporated (Hassan, 2002). With groundwater being a community
resource it requires active public participation in all levels of the management (Romani, 2007). This in effect creates ownership of the problem by the farmers themselves whereby enforcement of rules such as ‘no more bores’ and encouragement of water conservation measures such as the irrigation systems discussed in the next section are undertaken by the community.

5.10 The use of irrigation systems throughout the four study areas

The use of irrigation systems conserves water and can potentially save the farmer substantial labour costs associated with irrigation (Steenbergen, 2006). Table 18 shows the use of irrigation systems over the three districts combined. Nearly 50% of farmers used either drip irrigation or sprinklers such as those seen in Figure 29. Over 42% of farmers used no irrigation systems at all, and just “let the water flow” (Farmer Interview 6). As mentioned earlier, the range in the use of irrigation systems may be attributed to differing agro-ecological conditions prevalent in each of the districts, or within the districts. The differences in the use of irrigation systems may also be attributed to the role that NGOs play in promoting their use through programs such as APFAMGS. These are now discussed in the context of the results gathered.

![Figure 29: Irrigation systems in use. Left: Micro-irrigation system. Middle: Drip irrigation system. Right: Sprinkler system. Author’s collection](image)

<table>
<thead>
<tr>
<th>Irrigation Method/type</th>
<th>Number of farmers</th>
<th>% Of farmers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does not irrigate</td>
<td>16</td>
<td>11.42%</td>
</tr>
<tr>
<td>No irrigation system used (just runs the water onto the field)</td>
<td>59</td>
<td>42.14%</td>
</tr>
<tr>
<td>Drips</td>
<td>29</td>
<td>20.71%</td>
</tr>
<tr>
<td>Sprinklers</td>
<td>40</td>
<td>28.57%</td>
</tr>
<tr>
<td>Micro sprinklers</td>
<td>1</td>
<td>0.71%</td>
</tr>
<tr>
<td>Identified the importance of pipes in the transfer of water</td>
<td>7</td>
<td>5%</td>
</tr>
</tbody>
</table>
Areas that were close to canals had no shortage of groundwater for irrigation, with water levels as high as “15 ft” (Farmer Interview 39). Therefore such farmers felt that there was no need for irrigation systems to be utilised. The irrigation regime of these farmers was also influenced by the sort of crops that they could grow, with Farmer Interview 39 stating, “paddy is the only thing [he] can grow and [he] got it checked with the same result”. The influence on changing cropping patterns was further discussed in section 5.7.2.2. It may also be attributed to the level of encouragement or support that is given for the use of such irrigation systems both within a community and from outside influences.

Figure 30 shows a comparison of the irrigation systems over the four NGO areas. It can be seen that in Prakasam (NGOs: DIPA and SAFE) the use of irrigation systems were least evident, with 22% and 34% of farmers respectively stating that they utilised any form of irrigation system in their farming regime. This may be attributed to the physical conditions of Prakasam, which is comparatively less arid than Kurnool and Anantapur districts whom Chetty (2001) identifies as being in a rain shadow area. In Anantapur (NGO- SYA) the use of irrigation systems was substantially higher than the other two districts, with over 70% of farmers utilising drips, sprinklers or micro sprinklers. Table 19 disaggregates this figure further, based on the land holding size of farmers interviewed. It can be seen that all farmers in the Anantapur District with farms over the size of 10 acres utilise irrigation systems in their farming regime. It appears that smaller farmers are less likely to utilise irrigation systems. High initial investment may serve as a deterrent for smaller farmers (D. Kumar M, 2007).

Table 19: The use of irrigation systems in the Anantapur District study area in relation to size of farm

<table>
<thead>
<tr>
<th>Land holding size in acres</th>
<th>0-2.5</th>
<th>2.5-5</th>
<th>5-7.5</th>
<th>7.5-10</th>
<th>10-12.5</th>
<th>12.5-15</th>
<th>15-17.5</th>
<th>17.5-20</th>
<th>20+</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drip</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sprinkler</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Micro-sprinkler</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Does not irrigate or does not use irrigation systems</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
</tbody>
</table>
This may be attributed to a push for getting subsidised systems to farmers by the NGO. Although the APFAMGS project itself does not supply such things, NGOs in some cases “got the farmers sprinklers and drips at a subsidy from other government organisations” (Key Informant 3). This was apparent from many of the interviewed farmers in the Anantapur District, as many stated something along the lines of taking the sprinklers or drips “at a subsidy” (Farmer Interview 125). “Earlier there was nobody to tell us about water conservation” (Farmer Interview 97). This ties into the role that NGOs have through the project as discussed in section 5.4.

![Figure 30: Series of pie charts comparing the use of irrigation systems over the four NGOs in which research was conducted, with top left: Kurnool District study area, top middle and top right: the two Prakasam study areas, and bottom: Anantapur District study area. Clear differences between the districts can be seen.](image)

Although all study areas were considered to be drought prone, Anantapur was noticeably more arid in comparison to both Kurnool and Prakasam. Thus, a physical difference was prevalent in which water resources may be scarcer and therefore require more stringent conservation through means such as irrigation systems.

Steenbergen (2006) highlights that the promotion of and use of irrigation systems such as drips and sprinklers does not necessarily mean that there is more conservative
use of water. This is mainly attributed to the fact that farmers just view the water as going further and thus can irrigate an expanded area compared to what was previously achievable when no systems were used (Steenbergen, 2006). Many farmers did note the minimised amount of time taken to irrigate through the use of irrigation systems. “Irrigation which would take 4 days now only takes two days because of sprinklers” (Farmer Interview 93).

In Anantapur over 50% of the farmers interviewed said that they only irrigated a proportion of their land ranging from between a quarter to three quarters of their land. The breakdown of this in relation to the size of farm is shown in Table 20. It can be seen that irrigation ratio is generally higher for smaller farms with only a few farmers (Vaidyanathan, 1999). Comparatively there are few farmers with land holdings of over 10 acres stating that they irrigated the ‘whole thing’ (Ramachandrula, 2008). All of the farmers with land holdings above 7 acres irrigated a portion of their land, however this ratio varied. There were a few farmers that highlighted that they did not irrigate any of their land. However, the majority of these were less than 5 acres. For smaller farmers it can therefore, for a large part, be said that there is either complete irrigation of the farm or none at all. It is likely that this is strongly linked to the access that the farmer has to an irrigation source.

Table 20: The proportion of the farm irrigated in the Anantapur District study area in relation to size of farm

<table>
<thead>
<tr>
<th>Land holding size in acres</th>
<th>0-2.5</th>
<th>2.5-5</th>
<th>5-7.5</th>
<th>7.5-10</th>
<th>10-12.5</th>
<th>12.5-15</th>
<th>15-17.5</th>
<th>17.5-20</th>
<th>20+</th>
</tr>
</thead>
<tbody>
<tr>
<td>The whole farm</td>
<td>Ill</td>
<td>I</td>
<td>II</td>
<td>I</td>
<td>II</td>
<td>I</td>
<td></td>
<td></td>
<td>I</td>
</tr>
<tr>
<td>Two thirds of farm</td>
<td></td>
<td></td>
<td>I</td>
<td>I</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Half of farm</td>
<td></td>
<td></td>
<td></td>
<td>I</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>I</td>
</tr>
<tr>
<td>One third of farm</td>
<td>I</td>
<td></td>
<td>I</td>
<td>I</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>One quarter of farm</td>
<td></td>
<td></td>
<td></td>
<td>I</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>Ill</td>
<td>I</td>
<td>I</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Through the responses of many farmers it was noted that many still stated that they drew water from their bore wells for the 7 hours a day that there was electricity available and every day of the drier months of the year:

“Except for a lake we do not have any water bodies nearby and groundwater levels were all drying up. At that time the project was started for us. After the
project everybody got drips and sprinklers and earlier when they used to only irrigate one acres, now they are irrigating three acres” (Farmer Interview 131).

This shows that although many of the farmers stated that they are taking measures for the conservation of water, the actual amount of water drawn has not decreased. This therefore is in alignment with the observation of Steenbergen (2006) described above. Table 20 showed that almost none of the larger farmers irrigated their entire land holding. This suggests that there is further room for irrigation expansion, which may be enabled through the use of water conservative techniques such as irrigation systems.

In Prakasam it was evident that farmers irrigated a higher proportion of their land in comparison to other districts. As seen in Figure 30, irrigation systems were not in high use at this location. In the Cumbum area of Prakasam, particularly, where the NGO SAFE operated, farmers generally did not extract water from their bores at the same frequency as others, instead the majority only extracted water for about 15 days a month. This indicates that there is room for further conservative use of groundwater through the use of irrigation systems. However, some farmers in the area did state “[they] have decreased the wastage of water due to transmission from the bore to the crop because of use of drip, sprinklers and pipes” (Farmer Interview 48). So there is evidence of some farmers utilising these water efficient techniques. This may further reduce the amount of water that needs to be extracted or could be used to increase the irrigation potential of the land.

5.11 Summary

This chapter has put forward the main findings of this thesis within the context of the research questions and thus contributed to the overall aim of providing insight and discussion into the merits of community based groundwater management and the conditions under which it is effective. The interrelated nature of the topic has meant that it was not appropriate to address each question individually. Instead the results have been put forward and discussed in a manner through which the questions can be addressed as a whole. At this stage of the thesis these results are briefly summarised, with further depth and reflection occurring in the following chapter.
The sharing of groundwater provides a means through which management projects promote the collaborative management of groundwater. Various factors were found to influence the likelihood of effective sharing occurring such as structure and equality. This was viewed as important, with community bores existing outside of these parameters being largely constituted within families. Discussion concerning groundwater markets also impacts on the sharing of the resource. This presence of such markets varied greatly over the four study areas for which there were a multitude of reasons cited. Farmers that were involved in community bore well did not generally sell water. For those areas in which the selling of groundwater was occurring there were substantial differences in the prices charged and paid, thus highlighting the control that the owner of the bore well asserts over the resource. Some authors identify groundwater markets as a way in which access to the benefits of irrigation can be spread over a wider range of people. Although this may be true in some instances, equally, it can widen the gaps between the wealthy and poor sectors of society.

The role of NGOs in the management project forms a significant aspect of the results discussed. For the purpose of this, the role was split up into four sections. Firstly, NGOs play an important role in the building of rapport with communities. This can be particularly important when considering the steps taken in the implementation of a project like APFAMGS. The ability of NGOs to bring in experts in a variety of fields to provide insight into various issues is valuable, as is the linking of communities with other organisations through which further benefits such as various subsidies can be gained. The necessity of NGO involvement is put forward as being highly important in the initial implementation stages, but later the role is one more of support and education, continuing these linkages.

Local leadership is identified as a crucial condition that influences the potential success of a project such as APFAMGS. Due to the level of influence that they have this is particularly important in the initial stages of a project. This was a point reiterated by both NGO representatives and farmers.

The success level of the APFAMGS project was looked at from both the NGO and farmer perspectives. A majority of the farmers stated that the project had been very successful, citing numerous reasons. Most of the reasons related to what had been
learnt through the project and the impact that it had delivered, particularly on groundwater regimes and on their farming practices such as the sorts of crops grown and the use of fertilisers. The level at which farmers are teaching others about what they have learnt from the project can be viewed as an indication of how entrenched the lessons are, and therefore an indication of success in the long run.

Groundwater management is the focus of this research and is an indication of both the success of the project and the level to which groundwater is being effectively managed. Over the four study areas it was seen that a high number of farmers monitored the groundwater levels of their bore wells and were aware of the current state of groundwater levels in their area. This suggests that there is an increased awareness of the variables within the groundwater resource through which farmers can effectively based their irrigation and farming regimes. The following conclusion chapter builds on the summaries put forward in this section.
Chapter six: Conclusion

6 Conclusion

This research has focused on community based groundwater management and utilised the Andhra Pradesh Farmer Managed Groundwater Systems (APFAMGS) project as the basis of discussing this approach and concept. The literature identified the main reasons that have contributed to the need for effective groundwater management. These included factors such as overexploitation and the extent to which people throughout India have come to rely on groundwater for their livelihoods. The Green Revolution was recognised as a major factor in the increasing demand for groundwater, enhancing the irrigation capacity for farmers that has occurred over the previous decades. Green Revolution technologies, such as low cost groundwater extraction devices have meant that the resource is accessible to a wider range of people. The associated development of high yielding crop varieties has greatly increased the productive capacity of farmers in many areas of India, but has also altered the inputs required for effective and maximum growth. These high yielding varieties often require greater application of irrigation and fertilisers in comparison to traditional varieties of crops that have at times been grown for centuries. For some areas, this has delivered prosperity and agricultural growth. However, through over-exploitation of groundwater various unforeseen consequences have occurred. For some areas this has meant continued lowering of the groundwater table, or contamination of the groundwater resource. It is these alterations to the environment in which farmers in India cultivate that have necessitated the need for effective management. The issue is therefore how best to approach this complex set of issues.

Community based management of groundwater has been discussed as a means through which this effective management can occur. A participatory focus is the underlying principle of the approach through which farmers gain the ability and skills to manage the resource themselves. The shared or common pool nature of groundwater resources necessitates that for management to be effective there needs to be cooperation and collaboration in the management effort from all those involved in the use of the resource. If this is not the case, then those who do participate will
inevitably be at a disadvantage, as the resource may continue to be over-exploited by those who do not participate, thus undermining the efforts of the initiative. The APFAMGS project is discussed as a means through which this collaborative approach can be undertaken and forms the basis of this research.

The APFAMGS project was implemented in seven drought prone districts of Andhra Pradesh and involved nine NGOs. This research looked at four areas in which this project was implemented spread over three districts and involving four of the involved NGOs. The main conclusions that have been drawn from this research are now given below.

### 6.1 The conditions under which community based groundwater management might work

The conditions under which community management might work is an important aspect to this research as it presents the major factors that influence the ability for the successes and learning from the APFAMGS project to be replicated elsewhere. These include such things as the presence of local leadership and the influence of private property rights on the management of groundwater. It is the coordination of efforts between individuals that provides the important basis for effective community based management. These aspects were largely covered in the literature review and then reflected and applied through findings based on the APFAMGS project.

The characteristics of communities form a fundamental basis for the implementation of projects such as APFAMGS. The incidence of bore well ownership within a community highlights the extent to which management initiatives need to address. It was found that bore well ownership varied greatly throughout the 4 research areas. Individual bore well ownership was found to be as high as 71% of farmers in some areas and as low as 44% in other areas. The extent of community/shared bore wells highlights an important aspect as to the management approach. The results showed that sharing of groundwater is most effective where each partner gets equal benefit, for instance, the same amount of irrigation. Other arrangements included the amount of irrigation being based on the overall size of the land holding. Arrangements between family members were also quite prevalent and cited as addressing many of the equality issues.
Farmers with shared or community bore wells were not generally involved in the selling of water. However, in some areas the selling of water was undertaken by farmers who had individually owned bore wells. This presence of groundwater markets to varying degrees highlights a situation through which, in some cases, access to the groundwater resource can be increased for those who might not otherwise have the means to irrigate. It also demonstrates notions of equality with such markets often increasing the gap between the rich and the poor sectors of society, reinforcing existing inequalities. However, for management projects such as APFAMGS to be successful it is essential in some cases that the larger farmers are involved. These larger farmers were often found to have more than one bore well, with one farmer having as many as 11. Therefore, the larger farmers frequently had a disproportionate level of influence and control over the groundwater resource. If they did not participate then the efforts of the initiative may be severely undermined.

Many sources as identified in the literature highlighted the importance of local leadership when it comes to effective groundwater management. The results of this research support this notion. This is particularly important in the early stages of a project’s implementation as getting the participation of local leaders can have a significant influence on whether or not others follow. Both the farmers and the NGO representatives interviewed attributed high importance to such local leadership. Nearly 51% of the farmers interviewed stated that they had attended the project from the beginning, indicating there was a high initial uptake. However, the role of local leadership in encouraging others to join the project was highlighted when others stated that they took some time and convincing to participate. Cooperation from all users of the groundwater resource was identified as an essential element in an effective management regime, emphasising the importance that this research then places on this aspect.

The success of the APWELLS project, which was a precursor to the APFAMGS project, was also identified by participants as having a significant role in this initial uptake. It meant that many of the NGOs had already built up a relationship with some of the communities involved, effectively providing an ‘in’ through which farmers then had greater trust in the information that was given to them through the APFAMGS project. This then leads onto the results relating to the involvement of
NGOs in the APFAMGS project. This same aspect is also demonstrated by the crucial role of utilising existing local NGOs in the implementation of such projects.

6.2 Role that NGOs have, and that of the state

There are three aspects of the role that NGOs identified as important for the success of this project; rapport building, providing expert input, initiating links between communities and other organisations. Rapport building was identified as a crucial stage of the process of project implementation. This meant that NGOs did not go straight in with complex ideas about the management process. Instead, they focused on building a relationship and furthering trust. Informal methods were used to illustrate the issue of groundwater to the participants. In many areas the effects of groundwater over-exploitation had been experienced making the notions easier to understand. However, as authors such as Vaidyanathan (1999) or Shah et al. (2001) highlight, the nature of groundwater provides an obstacle to management in that it is out of view, and so in many cases it is not until the effects of mismanagement are felt that the need is realised. Education is the primary focus of the APFAMGS project through which the empowering of farmers to manage their own resources occurs. The role of the NGO is therefore to largely facilitate this process of education.

Lele et al. (2002) argue that one advantage of NGO involvement is that experts in various fields can be mobilized quickly. This research found that a range of experts were available including those with specialist knowledge in water, agriculture, geological and gender. NGO involvement thus provides a resource through which extended value can be added to the project and is a major benefit of the approach. It is suggested that participation of farmers remain a focus, ensuring that they understand the reasons behind the approach taken and the specificities of their location. Even a basic understanding by the farmers of the reasons expert input may be required, in instances such as hydrogeological investigation, is important. This understanding is significant, as it remains a crucial aspect of the management approach with the farmers themselves choosing to manage groundwater accordingly.

Links to other organisations was another role that NGOs executed. This facilitative role that NGOs performed was most evident when farmers described how they had received subsidies through the project for items such as irrigation systems. As the
APFAMGS project did not offer such things itself this shows that farmers were put in contact with the organisations or government departments that did have the ability to provide these resources. Vani (2009), Hooja et al. (2002) and Lele et al. (2002) all highlight this facilitative role that NGOs can play in the management of groundwater. State organisations also may increase this aspect of their role in the management process. This would be in line with legislation such as the National Water Policy 2002 and Andhra Pradesh Water, Land and Trees Act 2002, both of which highlight the significance of a participatory approach as discussed in the context chapter. Projects such as APFAMGS offer insights into the success rates of such approaches and the benefits of a highly participatory approach to the management of groundwater. This research suggests that state support for such projects will increase capacity and decrease the likelihood of failure.

The necessity of NGO involvement was also explored. The necessity of NGO involvement in the initiation of such projects is perhaps best illustrated through the number of farmers who highlighted the importance of the role that they play in the management process. Approximately 60% of farmers interviewed stated that this was crucial to the success of the project, with 80% of the farmers highlighting that it was good to work with the NGOs. The continual requirement of NGO involvement is also demonstrated to a degree. Many of the farmers highlighted that after the ending of the project (approximately one year prior to this study) some of the practices promoted through the project were decreasing in their communities. The continued presence of the NGO staff at and beyond the community meeting meant that groundwater management and the initiatives taught throughout the project were continued at the same level. The project demonstrates that NGOs played a significant role in the dissemination of expert advice, the education of farmers concerning the management of groundwater resources and for a large part play a role in support of users associations.

### 6.3 Empowering people

The overarching goal of the APFAMGS project is to empower people to have the skills so that they can then effectively manage the resource themselves. It is this emphasis on education and empowerment that separates it from other community based initiatives. This is a difference to many other community based management
pilot schemes, through which information regarding the state of the groundwater resource is gathered by experts and then given to the communities (World Bank, 2010). In the APFAMGS project it is the farmers themselves that collect and disseminate the information throughout the community and hydrological unit. They therefore have a higher understanding of the groundwater resource in comparison to someone that has merely been given the figures. The APFAMGS project refers to this as ‘demystifying the science of hydrology’.

Through the monitoring of groundwater levels farmers had an indication first hand of the state of the groundwater in their area, which directly affects them. As many as 67% of farmers reported that they measured the water levels of their bore well, with 42% of them conducting this twice a month. It was also evident from interviews that farmers had developed an understanding of the trends in groundwater levels. Although the results show that these varied greatly due to the various physical attributes of area including factors that influence recharge rates and storage capacity such as hydrogeological and rainfall aspects. By having knowledge about the groundwater status of their area farmers could then plan their cropping regimes accordingly as highlighted by many other aspects of the training.

This research is in agreement with the World Bank (2010) report in that the APFAMGS project not only promotes good water management but also that good farming techniques. There is particular emphasis on ways of lowering investments and maximising profits, many of which correspond to good water management approaches. More water efficient techniques reduced pumping while many of the farmers now favoured the use of organic fertilisers as opposed to more expensive inorganic fertilisers that were previously used. The benefits of organic fertiliser use also includes increased soil fertility and moisture retention.

An increased number of people were aware of the potential impacts of growing the same crop over and over again such as reduction in soil fertility. This was shown through many farmers increased adoption of crop rotation and diversification policies. Although some farmers highlighted that they already knew about crop rotations prior to the APFAMGS, the project has increased awareness of the dimensions of the issue and has ensured a greater divergence away from crops such as paddy and sugar cane. This change in the cropping regimes away from the ‘cash crops’, many of which
require high-level inputs, has therefore also reduced the use of water through the growing off less water intensive crops such as groundnut, chilli or sunflower.

Through management committees, cooperation between farmers is sought and these farmers decide the appropriate levels of extraction based on the measurements collated by the community. These skills concern both an understanding of groundwater levels and knowledge of the water requirements of the various crops. It is this linking between water availability and the types of crops that are grown that is a key finding of the research, one of which signals that effective community based management of the resource is occurring.

6.4 Overall success level

For a large part the successes of the APFAMGS project is shown through the training received and benefits that have been delivered through the project as concluded above. This is also illustrated by the opinions of the farmers that have been involved with the project. Approximately 77% of all farmers held the view that the project was very successful. Although it was acknowledged that successes associated with the project were not always equally experienced by all who participated, arguably to an extent this is unavoidable. Farmers will inevitably follow the promoted methods to varying degrees and factors outside of control such as climate variables will further influence success levels. Many farmers argued that because of the project they now have enough water to grow their crops, have greater security of their investments, and as mentioned, have the ability and capacity to grow crops accordingly.

6.5 Opportunities for further research

This research has investigated and discussed results from the APFAMGS project. The success of this project suggests that community-based initiatives of groundwater management can be a means through which effective management of the resource can occur. It has been seen that the highly participatory approach adopted through the project has delivered significant results through the empowering of farmers to undertake the management of the resource themselves. This has meant that farmers can adjust their farming and cropping regimes accordingly, so as to coincide with the availability of the groundwater resource for irrigation purposes. This approach is one that incorporates high levels of cooperation and collaboration between farmers. As it
is the farmers themselves who undertake the measuring of groundwater and inputs such as rain, they have an enhanced understanding and knowledge of the resource, particularly in comparison to someone who has merely been told the state of the groundwater.

The research also demonstrated that state involvement was important in initiatives such as APFAMGS, providing a guidance and support role similar to and perhaps going beyond that of implementing NGOs due to the scale at which the state may operate. This, in combination with analysis of current legislation such as those discussed in the context chapter is an avenue that may warrant further research. Through researching the policies present in such legislation and linking them to current state spending on water management and development this could provide guidance as to the placement and future expenditure of the state. The associated success of projects such as APFAMGS may provide a basis through which effective groundwater management can occur, an avenue such that increased government support and funding could enhance. Further research is important to ascertain the most appropriate and applicable management approach for the Indian context.
References


References


Appendix A: Participant Information and Consent Form

COMMUNITY BASED GROUNDWATER MANAGEMENT IN ANDHRA PRADESH, INDIA

INFORMATION SHEET FOR PARTICIPANTS

Thank you for showing an interest in this project. Please read this information sheet carefully before deciding whether or not to participate. If you decide to participate we thank you. If you decide not to take part there will be no disadvantage to you of any kind and we thank you for considering our request.

What is the Aim of the Project?

Groundwater management is an area of increasing concern throughout South Asia, but particularly in those areas where the Green Revolution has led to increased intensity of agriculture. In Andhra Pradesh, in south India, the United Nations agency FAO has been cooperating with a number of local NGOs to develop community based monitoring and management of groundwater through a scheme called the Andhra Pradesh Farmer Managed Groundwater Systems (APFAMGS) project. Although the FAO has widely hailed this collaboration as successful, there has been little academic or independent research on the veracity of these claims. This research aims to undertake a comparison of four different sites in Andhra Pradesh that are involved in the APFAMGS in order to understand some of the reasons behind the success and challenges of this project. The research is towards a Masters of Planning degree at the University of Otago, Dunedin, New Zealand.

What Type of Participants are being sought?

The research will involve interviews with representatives of two NGOs involved with the APFAMGS programme. This will include participants that are deemed experts in groundwater management, but also those that have experience in community based management of resources. Further participant will be the users of the groundwater resource; this will largely comprise individual or groups of farmers. Where practicable, participants will be contacted prior to the student departing for India via phone or email. Through this initial contact further informants may be identified and contacted in the same manner. The participant may request a copy of the results of the research.
What will Participants be Asked to Do?

Should you agree to take part in this project, you will be asked to meet with the researcher and discuss the role that the organisation plays in the APFAMGS programme, how effective the programme has been and the stance the organisation has on community based management of groundwater resources. The participants will be asked to take part in a semi-structured and open ended interview in which the focus will be on these themes. The interviews are not expected to take more than an hour. The interviews may take place at a location of the participant’s choice, but where possible may be asked to fit in with the researcher’s schedule referring to when they will be in the applicable area. If the participant so wishes, the interview may be conducted in the participants native language. In this instance a translator will be used.

Please be aware that you may decide not to take part in the project without any disadvantage to yourself of any kind.

What Data or Information will be Collected and What Use will be Made of it?

Audio tapes of the interviews will be taken for transcribing purposes at a later date, but only if the participant agrees that such recording may be undertaken. The data collected will be securely stored in such a way that only those mentioned below will be able to gain access to it. At the end of the project any personal information will be destroyed immediately except that, as required by the University's research policy, any raw data on which the results of the project depend will be retained in secure storage for five years, after which it will be destroyed.

The results of the project may be published and will be available in the University of Otago Library (Dunedin, New Zealand) but every attempt will be made to preserve your anonymity.

On the Consent Form you will be given options regarding your anonymity. Please be aware that should you wish we will make every attempt to preserve your anonymity. It is expected that through the audio recording of the interviews that there will be limited personal information obtained. Such details will primarily be used to outline the group/organisation that the participant affiliates with as well as other key factors of the research. It is expected that these interviews will form the basis of the research. However, with your consent, there are some cases where it would be preferable to attribute contributions made to individual participants. It is absolutely up to you which of these options you prefer.

This project involves an open-questioning technique. The general line of questioning includes community based groundwater management and may largely relate to the APFAMGS programme. The precise nature of the questions which will be asked have not been determined in advance, but will depend on the way in which the interview develops. Consequently, although the University of Otago Human Ethics Committee is aware of the
general areas to be explored in the interview, the Committee has not been able to review the precise questions to be used.

In the event that the line of questioning does develop in such a way that you feel hesitant or uncomfortable you are reminded of your right to decline to answer any particular question(s) and also that you may withdraw from the project at any stage without any disadvantage to yourself of any kind.

**Can Participants Change their Mind and Withdraw from the Project?**

You may withdraw from participation in the project at any time and without any disadvantage to yourself of any kind.

**What if Participants have any Questions?**

If you have any questions about our project, either now or in the future, please feel free to contact either:

Shaun Hamilton  
Department of Geography  
University Telephone Number: N/A

Dr Doug Hill  
Department of Geography  
University Telephone Number: (643) 479 8775

This study has been approved by the University of Otago Human Ethics Committee. If you have any concerns about the ethical conduct of the research you may contact the Committee through the Human Ethics Committee Administrator (ph 03 479 8256). Any issues you raise will be treated in confidence and investigated and you will be informed of the outcome.
COMMUNITY BASED GROUNDWATER MANAGEMENT IN ANDHRA PRADESH, INDIA

CONSENT FORM FOR PARTICIPANTS

I have read the Information Sheet concerning this project and understand what it is about. All my questions have been answered to my satisfaction. I understand that I am free to request further information at any stage.

I know that:-
1. My participation in the project is entirely voluntary;
2. I am free to withdraw from the project at any time without any disadvantage;
3. Personal identifying information (audio-tapes) will be destroyed at the conclusion of the project but any raw data on which the results of the project depend will be retained in secure storage for at least five years;
4. This project involves an open-questioning technique. The general line of questioning includes community based groundwater management and may largely relate to the APFAMGS programme. The precise nature of the questions which will be asked have not been determined in advance, but will depend on the way in which the interview develops. Consequently, although the University of Otago Human Ethics Committee is aware of the general areas to be explored in the interview, the Committee has not been able to review the precise questions to be used.
5. I will not face any risks through my participation in this project.
6. The results of the project may be published and will be available in the University of Otago Library (Dunedin, New Zealand) but every attempt will be made to preserve your anonymity. A copy of the results may be requested.
6. 7. I understand that reasonable precautions will be taken to provide security for email and phone correspondence, but I am also aware that such security cannot be guaranteed.
7. 8. I am aware that a translator may also be present at the interview and have access to the information obtained.

I agree to take part in this project.

.................................................................
..............................
(Signature of participant) (Date)

This study has been approved by the University of Otago Human Ethics Committee. If you have any concerns about the ethical conduct of the research you may contact the Committee through the Human Ethics Committee Administrator (ph 03 479 8256). Any issues you raise will be treated in confidence and investigated and you will be informed of the outcome.
Appendix B: List of Key Informants

Key Informant 1: Representative of BIRDS

Key Informant 2: Representative of SAFE

Key Informant 3: Staff member BIRDS

Key Informant 4: Staff member SYA
Appendix C: Example questionnaire for Key Informants

Questionnaire for NGO representatives:

1. What is your name?
2. What is the position that you hold within the organisation?
3. What does the position entail for you? I.e. what is the role that you play?
4. What would say is the main role that NGOs such as yours takes in community based groundwater management such as APFAMGS?
5. Does the role that the NGO plays differ in the implementing stage compared to after the project has been implemented? Does it change to a facilitator sort of role?
6. What are the main issues involved in designing and implementing these schemes?
7. What sort of problems do you face during the implementation of these sorts of programs?
   a. What are the main challenges?
8. How successful do you think your NGO has been in addressing these issues?
9. When the program first began did you generally find that there were farmers that were very accepting of the project? Or did you really have to push the information on them?
   a. Does this change over time?
10. What sorts of methods are used in the implementation of the program?
11. How has large scale fertiliser and pesticide use changed the cropping patterns in the area?
12. Are there some instances where they are more successful in some villages and less successful in others?
13. What are the main factors of villages that make for a successful implementation of the program?
14. How important do you think getting local leaders on board of the program is for the success of the program?
Appendices

15. According to you is community-based management the best way to manage common resources such as groundwater?
   a. If so. What are the factors that make it more preferable to other alternatives?

16. How are the community representatives of GMCs and HUNs elected? Does your NGO have much of a say in who has leadership roles within the committees?

17. Are they generally the most prominent leaders of the community?

18. Do they generally correspond to the wealthier farmers?

19. Has the program brought members of the community together?

20. With the information that is collected by the groundwater management committees and similar groups, what is the role that the NGO plays with that information?

21. What are the main factors that give need for this project?? i.e. in the area chosen?

22. How do you think groundwater levels have been influenced as a result of this project?

23. What sort of training does the NGO provide? One, for the people who are working for the NGO, and two, for the groundwater users/farmers?

24. Has the program induced any level of change into the cropping patterns adopted by farmers?

25. How many villages does your NGO deal with?

26. In your opinion has the APFAMGS project been successful in your area?

27. In your opinion what are the most significant results that the program has produced?

28. If a project like the APFAMGS project were to be implemented somewhere else what recommendations would you give to improve this model or approach that you have learnt through your involvement?

29. Are you involved in the monitoring of groundwater levels? Have there been any changes in recent trends since the implementation of the program?

30. Are there any ways that you think that these projects could be improved into the future?

31. Do you have any further comments about the project or the role of NGOs?
Appendix D: Example questionnaire for Farmer Interviews

For example purpose, sourced from farmer interview 31

Interview Number:

Introductions:

What is your name?

What is your village?

1. How big is your farm?
2. Do you irrigate much on that farm?
3. Do you have a bore well?
4. How many? Ie more than one?
5. For how many hours a day and for how many day a month do you draw water from your bore well?
6. You’ve got 5 pumps. Are any of them community wells? *(example of open-ended format of question – leading on to further questions)*
7. How long have you had these pumps?
8. What sort of depth do you bore wells go to?
9. Do you sell any excess water?
10. What type of irrigation methods/systmms, if any, do you use?
11. Have you had much involvement with the APFAMGS project??
12. When the program first started did you know/understand the reasons behind the program or did you take quite a bit of convincing??
13. So from that have you played a teaching role? Teaching others in the community? *(example of open-ended format of question – leading on to further questions)*
14. What sort of training did you receive from the APFAMGS program?
15. Did you attend the farmer field school?
16. Have you found that the stuff you learnt from the program was useful?
17. With your wells, if the opportunity came to have a sharing of bore water supply, community bore well, would you take it?
18. How often do you measure the groundwater?
19. What sort of trends, if any, do you see in the groundwater level?
20. Did any/has any of your borewells ever gone dry?
21. How did you find BIRDS the NGO that’s involved with the implementation of the program?
22. Do you view that the APFAMGS project is successful in your area?
23. What factors do you think are attributed to that success?
24. How crucial do you view the role of NGOs such as BIRDs in making these sorts of programs successful?
25. Do you think that this sort of management would be able to occur without their help?
26. How important do you think that people setting an example is for the success of this kind of project?
27. Say people like you didn’t take up the project initially, do you think that it would eventually take off? (example of open-ended format of question – leading on to further questions)
28. Have you had experience with other management approaches?
29. Has the APFAMGS project changed the type of crops that you use, and the season that you grow those crops?
30. What sort of crops do you grow?
31. Have you changed your crops to less water intensive crops?
32. In what ways do you think that these kinds of programs can be improved so as to better meet your needs?
33. Even though the project has already been implemented, do you still see that BIRDS have a crucial role? (example of open-ended format of question – leading on to further questions)
34. Do you have anything in the way of water recharge structures on your property?
35. Do you attribute the rising of groundwater levels only to lots of rains recently or also to the knowledge you have gained through the APFAMGS project? (example of open-ended format of question – leading on to further questions)
36. Does the farm pond often have water in it? *(example of open-ended format of question – leading on to further questions)*

37. How do you feel about losing part of your land to the canal? *(example of open-ended format of question – leading on to further questions)*

38. How has the program influenced what sort of fertilisers you use?

39. Form the project ahş your productivity gone up much on your farm?

40. What level of mechanisation do you have on your farm?

41. Are there any other comments that you have about the project?