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# Institutionalising Groundwater Management: A Tale of Three Participatory Models in Andhra Pradesh

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## ABSTRACT

This paper explores the possible options for community based groundwater management in the Indian context. The main focus of the study is to understand the functioning and efficiency of groundwater management institutions by comparing and contrasting three participatory groundwater models in Andhra Pradesh, viz., the APFAMGS, WASSAN and CWS. The paper assesses the operational modalities and the impact of these institutions on access, equity and sustainability of groundwater use at the village and household level using the qualitative and quantitative information.

It is observed that the social regulation approach works better for sustainable groundwater management when compared to the knowledge intensive approach, as the latter is not designed to address equity. Water use and sharing through regulation has increased the area under protective irrigation in an equitable manner. In the absence of any regulations, formal or informal, and in the given policy environment, the farmers do not have any incentive to follow good practices. Thus, encouraging water sharing between well owners and others would result in achieving the twin objectives of conservation and improved access with equity. However, how to attain this on scale needs serious consideration at the policy level. The most important lessons from these models include: i) creation of information at appropriate scale through community involvement; and ii) generating demand for demand management of groundwater with the help of this information.

It is argued that community based groundwater management is neither simple nor easily forthcoming. It calls for a lot of effort, working through complex rural dynamics

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at various levels, since appropriate policies to support or encourage such initiatives are not in place. Often, the existing policies work towards achieving opposite objectives rather than going in tandem with the participatory initiatives. The three approaches have proved that communities are capable of managing groundwater in a sustainable manner.

Communities are capable of understanding and using the technical aspects of hydrogeology. Since groundwater is widely considered as private property, there are no incentives for managing it in a sustainable manner. Unless wide-ranging policy changes are introduced, these initiatives will remain as mere models rather than being adapted on a wider scale. Hence, creating demand for these initiatives is as important as demand management of groundwater. However, the demand management models cannot be effective as long as policy environment is supply-sided.

# I Background

The study of groundwater becomes imperative because:

i) in India, groundwater is the single largest source of water for irrigation as well as drinking;

ii) groundwater, despite being a common resource, is managed privately, resulting in externalities and inequity in access;

iii) negative externalities are widespread, causing distress in most regions, especially the rain-fed; and

iv) of late, policy makers have started making efforts to bring groundwater under the management regime.

While groundwater is studied extensively in terms of its hydro-geology and socio-economic aspects, sustainable management of groundwater has not been dealt with comprehensively either by researchers or policy makers. The increasing groundwater crisis consequent to it's over exploitation and degradation makes groundwater management imperative from the ecological as well as socio-economic point of view. Though the Approach Paper to the 12th Plan recognises this importance, it fails to provide any plan of action due to the absence of any clear understanding of groundwater management. The main bottleneck for bringing groundwater under a management regime is that groundwater is treated as private property by individuals, as a right attached to land ownership. Attempts towards changing this practice are not only perceived to be associated with huge transaction costs, but also resulted in socio-economic conflicts due to the existing inequity in groundwater distribution as well as its economic value.

From the economic point of view, groundwater irrigation is observed to be twice as efficient as surface water irrigation in hydrological terms ($m^3$/ha), and ten times preferable (Llamas and Martínez-Santos, 2005). Besides, it has a large number of *in situ* services including environmental, and is promoted as a plausible option for poverty reduction (Burke *et al.*, 1999; Polak, 2004). Kumar (2007), for instance, mentions that the surplus value product generated from the groundwater in India's irrigated lands (15 major states) contributes nearly 5 per cent of its gross domestic product. A large fraction of the population directly or indirectly relies on groundwater resources for livelihood, as more than 60 per cent of irrigated agriculture is dependent on it (The World Bank, 2010). Groundwater plays a major role in achieving India's food security, besides turning into a net exporter of food, despite a twofold increase in population during the last 50 years (Shah, 2004). Groundwater development requires relatively smaller investment and shorter implementation periods when compared to the traditional surface irrigation system (Valencia Statement, 2004).

These virtues of groundwater in the absence of clearly-defined property rights have resulted in the sharp increase in groundwater use, and over-exploitation as well as degradation of the resource (Dhawan, 1995; Moench 1992; Bhatia, 1992). In India, the declining groundwater table has resulted in increasing the cost of pumping with declining yield. Failure of wells has become a common phenomenon in recent years, and has been causing widespread farmer distress (Reddy and Galab, 2006). Overdraft is generally a by-product of population growth, economic expansion, distorting impacts of subsidies, and financial incentives, in addition to the spread of energized pumping technologies (Burke *et al.*, 1999). According to Shah *et al.*, (2000), groundwater development faces challenges due to three major problems: depletion due to overdraft, insufficient conjunctive use, and pollution due to growing agricultural activities.

About a quarter of India's agricultural production has been at risk due to growing depletion (Shah *et al.* 2000), which results in the persistence of poverty and low growth - a situation that has been further aggravated during recent years. Intensive use of fertilizers and pesticides, leaching from compost pits, animal refuse, dumping grounds for garbage, seepage from septic tanks and sewage, etc., affect groundwater quality (Burke *et al.*, 1999; Sharma, 2009). Another serious issue of groundwater quality is arsenic - approximately 50 million people worldwide are affected by arsenic (Alaerts and Khoury, 2004).

Groundwater over exploitation thus has serious implications for achieving the Millennium Development Goals (MDGs) (The World Bank, 2010). This is because declining access to groundwater not only affects agricultural production, but also education, health, gender, child mortality, poverty and hunger (Sharma, 2009). Although groundwater is not a scarce resource in most regions, sustainable management of the resource is the crux of the problem (Burke *et al.*, 1999). This paper is an attempt to explore the possible options for groundwater management in the Indian context. Specific objectives include:

i) Reviewing the existing groundwater management practices at the policy level across the countries;

ii) Assessing the micro-groundwater management practices at the village level with the help of case studies; and

iii) Critically examining the possibilities for scaling up such practices or drawing lessons for policy at the national level.

The main focus of the study is to understand the functioning and efficacy of groundwater management institutions by comparing and contrasting three participatory groundwater models in Andhra Pradesh (AP). This paper is organized into five sections. The following section reviews the groundwater management practices across countries and their relevance in the Indian context. Section three presents the approach of the study in terms of describing the profile of the case study areas. Section four presents the three Participatory Groundwater Management (PGM) models in AP, while a comparative analysis of these institutions is taken up in section five. Finally, the last section draws lesson for policy.

## II Managing Groundwater: Review of Approaches

Groundwater is a typical resource, as it has the attributes of common resource with greater feasibility for private access and management. In most situations, it is considered as a Common Property Resource (CPR) with extremely high use value (Burke, 1999). At the same time, the linkages between groundwater and land ownership facilitates private access and management. This dichotomy of common as well as private good qualities makes sustainable management of the resource extremely difficult. In some countries like Indonesia, Australia, USA and Peru, it is considered as a public good either through legal tradition or through the suppression of private ownership rights (IRM&ED, 2008). However, in countries like India, groundwater is treated as a *de facto* private property, though other precious resources, such as minerals, lying beneath private lands are treated as state property (Singh, 1995). This often results in over exploitation of groundwater and inequity in access. In order to ensure equity and sustainable use, countries like South Africa have abolished riparian laws through delinking land and water rights (Reddy, 2007).

Lack of clarity regarding property rights on groundwater also results in the poor implementation of sanctioning and enforcing water allocation mechanisms at the policy level. Rigid and static governance structures fail the policy makers to understand the changing groundwater scenario. Lack of information at appropriate scale is a bottleneck at the community level for adopting informed groundwater management practices (Reddy *et al.*, 2011). In the absence of appropriate information coupled with high economic value, the highly heterogeneous nature of groundwater availability in space and time is turning groundwater extraction into a high-risk venture. Therefore, it is necessary to understand the existing groundwater management systems at different levels (national, state and community). Based on a review of existing literature the basic management principles being adopted for groundwater management can be broadly grouped under three approaches, viz. regulatory, economic, and community-based. In what follows, we briefly discuss these approaches.

*i) Regulatory*

Regulation is the most commonly used instrument for managing groundwater use. Regulation mechanisms include restrictions on digging new wells, well depths and the volume pumped, demarcating groundwater protection zones, etc., which are generally enforced by the state administrative process (Shah, 2009). Apart from direct regulation, indirect regulation through restricted supply of electricity for pumping, restrictions on financing, etc., are also used to manage groundwater. These regulations consist of a complex and multilayer framework of a range of constitutional and statutory provisions at the central and state levels. Groundwater management in India falls within the jurisdiction of the State Government that is responsible for the financing, cost recovery and management of all water resources (Saleth, 2005). However, the Central Government has the concurrent power to make laws with respect to any matter for any part of the territory of India.

The Indian Easements Act of 1882, which mentions the private property rights over groundwater use, forms the basis for groundwater regulation in India (Saleth, 2005). It is adopted from the English Common Law, which gives every owner of land "the right … to collect and dispose within his own limits of all water under the land which does not pass in a defined channel" (The World Bank, 2010). Thus, groundwater is treated as an appendage to land because it is an easement connected to land, and persons who own the land also own the groundwater beneath it. They have also the right to transfer rights over groundwater along with the ownership of land.

The Government of India (GoI) introduced a Model Groundwater Bill during 1972 constituting a groundwater management agency at the state level, which is responsible for registrations and control of larger groundwater users. Some of the major elements of this bill include power to notify areas for control and regulation of groundwater development, grant of permission to extract and use water in the notified areas, registration of existing users in the notified areas, prohibition of carrying on sinking wells, etc. The Model Groundwater (Control and Regulation) Bill of 1992 proposes a kind of groundwater permits system. However, it did not set any withdrawal limits (GoI, 1992) and is confined only to the states of Tamil Nadu, Maharashtra, and Karnataka. The National Water Policy of 2002 also makes certain provisions on the control of groundwater extraction.

During the late 1990s, AP, Tamil Nadu, and Maharashtra enacted groundwater legislations. These legislations imposed restrictions on groundwater exploitation by making registration of wells as well as rigging technologies mandatory. The implementation and enforcement of these legislations are yet to bear fruit due to various reasons. For, these legislations have failed to take spatial distribution of the resource into account by putting all the regions together, irrespective of their level of groundwater development. That is, top-down regulations take an aggregate view of the situation, and often fail to capture the local-specific conditions such as geo-hydrology and socio-economic aspects of groundwater use. Hence, they are least likely to be socially and political viable. Similarly, socio-economic equity is not taken into account while enforcing the regulations; i.e., treating those having and those not having wells equally. The doctrine of prior appropriation reinforced the access rights of the existing well owners while curtailing new wells in over-exploited areas. Due to the negligence and conflict of interests of all sections of the society, enforcement has received scant attention (Sharma, 1995). Similarly, the monitoring mechanism to ensure that a particular regulation is enforced is a costly and difficult task in vast and remote regions (Kumar, 2007).

Limiting the power supply and formal credit are the indirect ways of regulating groundwater use. A number of states in India follow power supply regulation for one reason or the other. The main reason, often made explicit for restricted power supply, is supply constraint as well as reducing the burden on the exchequer due to subsidised or free power supplied to the farm sector. The externality of restricted power supply is the regulation of groundwater use. In fact, farmers express, "but for the limited power supply, their borewells would have gone dry", especially during drought years. The power supply restrictions are usually associated with subsidies or free power. The Gujarat Electricity Board (GEB) does not provide new electricity connection for extraction of groundwater in over-exploited, critical and saline areas without the consent of the Central Groundwater Authority (CGWA). It has also launched the *Jyoti Gram Scheme* (JGS), which puts separate feeders for agriculture and domestic services (Lakhina, 2007). Restricted power supply is being followed in a number of states including AP, Gujarat, etc. The power is supplied for only eight hours per day for agricultural purposes; AP has been supplying 7-9 hours a day power supply along with the free power policy for the last 7 years. Restricted power supply policy was observed to have little consequence in the case of large pumps and multiple wells, as the effectiveness of regulations undermines not only the availability of the diesel pump-set option but also by the presence of a 'kink' in the farmers' power demands (Saleth, 2005). As a result, misuse of power as well as groundwater is widespread, as farmers leave their pumps on round the clock. Hence, the combined impact of free but limited power supply for groundwater use needs to be assessed critically.

The National Bank for Agriculture Rural Development (NABARD) has adopted a policy not to provide refinance in critical and over-exploited areas. NABARD has prescribed spacing norms for different types of areas whereby the minimum distance between two groundwater abstraction structures can be indicated (IRM&ED, 2008). According to the NABARD regulation, the farmers do not get credit for a new bore well if it is located within 200 m radius of an existing bore well. Such restrictions are also imposed by other nationalized banks. Field research has shown that credit regulation was not very effective due to the availability of other credit avenues (mainly informal sources) at the village level (Kumar, 2007). This is despite the fact that the cost of credit from informal sources is high. The credit rationing policy of the banks is also trying to curb new power connections to bore-wells and place restrictions on electric power supply. Besides, enforcement is also lax due to the pressure on banks to achieve targets.

The Punjab Government has recently introduced the Punjab Preservation of Sub-Soil Water Ordinance 2008, which prohibits the planting of paddy by the farmers in the state before June 10, in order to conserve groundwater. The ordinance provides for the government agencies to plough the area with the standing crop of such farmers who transplant paddy before the notified date. The effectiveness of this order dissuading farmers from sowing early paddy, thereby conserving groundwater is, however, is yet to be seen.

A model bill to regulate and control development of groundwater has been circulated by the Ministry of Water Resources (MoWR) to all the States / Union Territories (UTs). So far, 11 States/UTs including AP, Goa, Tamil Nadu, Kerala, West Bengal, Bihar, Himachal Pradesh, Chandigarh, Lakshadweep, Pondicherry, and Dadra and Nagar Haveli have enacted and implemented groundwater legislation. However, the effectiveness of their implementation and enforcement is not known.

Some success in reducing groundwater draft through regulatory measures have reportedly been made in a few water-scarce countries such as Jordan, where a quasi-water policy requires measuring withdrawals from the irrigation wells, enforcement of pumping quotas and levy of volumetric groundwater fee (The World Bank, 2000). However, the situation is more complex in countries such as India where millions of individual private tubewell owners, dispersed through the length and breadth of the country with varying groundwater availability and demand conditions, are engaged in groundwater extraction. Putting into effect such an approach and overseeing its implementation in a country of the size of India is nearly impossible. For, the number of groundwater structures in India is estimated at about 23-25 million (The World Bank, 2010). Maharashtra has recently developed a groundwater management model, which involves regulation of more than 1.5 million irrigation wells. It includes a levy on groundwater use and a ban on deep tubewells. The Chinese, with stronger state commitment to groundwater regulation, with a more elaborate reach and local authority structures still find it impossible to regulate groundwater overdraft in North China Plains (Shah, Giordano and Wang, 2004a). Neither have the Americans been able to implement real groundwater demand management, with their elaborate structure or water rights and groundwater districts, nor the Spaniards and Mexicans, with their efforts to promote groundwater user associations.

***ii) Economic***

Pricing of water or a complementary input such as electricity or diesel, water markets, and tradable water rights are some of the important economic instruments that are used in the case of groundwater management. Economic instruments include charges and taxes levied on irrigation wells or volume of water withdrawn such as the 1994 Water Law in China (Wang *et al.*, 2007), Law of the Nation's Water in Mexico (Shah *et al.*, 2004a; Scott and Shah, 2004; Sandoval, 2004), and Israel (Feitelson, 2006). An example of taxes as an economic instrument is found in Chennai (Briscoe, 1999). Municipal water utility is paying the farmers to sell bore well supplies in order to meet the drinking water demand in the urban areas, which created an incentive for the farmers to put water to a higher-value use and reducing mismanagement in groundwater allocation. However, it is very difficult to collect and enforce such a fee in case of large resource users or poor governance environment (Shah, 2009).

Electricity pricing is a more commonly followed instrument in India. Electricity has the potential to regulate the use of groundwater. For instance, it is argued in the context of different regions of India that *pro rata* electricity pricing enhances groundwater use efficiency and sustainability without affecting net returns from farming (Kumar, 2005; Kumar, *et al.*, 2011). The study estimates the levels of pricing at which demand for electricity and groundwater becomes elastic and shows that pricing is socio-economically viable. Further, water productivity impacts of pricing would be highest when water is volumetrically allocated with rationing. Therefore, an effective power tariff policy, followed by the enforcement of volumetric water allocation could address the issue of efficiency, sustainability and equity in groundwater use in India (Kumar, 2005). Similarly, in the context of AP, which is the front-runner in the provision of free power along with supply restrictions, it is argued that pricing of electricity for irrigation is the only option for addressing agrarian distress (Kumar *et al.*, 2011). However, the impact of pricing on groundwater management could also vary, depending on the water productivity (Malik, nd).

In case of diesel pricing, it was found that price rise may not necessarily result in the reduction in groundwater use (Shah, 2007). On the contrary, farmers may opt for highly water-intensive and remunerative crops.

However, the main difficulty with the price mechanism is that of implementation. There is lack of required administrative resources for metering and monitoring groundwater use and collecting user fees. During the 1970s, the GoI had faced difficulty in metering about 2 million wells and thus implemented a flat tariff on electricity used by agriculture. At present, the number of wells is over 20 million, aggravating administrative difficulties and transaction costs. Besides, pricing is a politically sensitive issue, especially when populism has become the norm (Kemper, 2007).

The development of private groundwater market has a long history in rural India (Pant, 2005; Saleth, 1994). Even though selling of water was traced out during the 1920s, it was only in the 1960s that systematic information started flowing (Saleth, 2005). Groundwater markets are widespread in Gujarat, Tamil Nadu, AP, Uttar Pradesh (UP), and West Bengal (IRM&ED, 2008). However, there are no clear-cut statistics about the total area under private groundwater market. Based on his studies from Gujarat and UP, Shah (1993) projected that the area irrigated under groundwater markets was about 50 per cent of the total Gross Irrigated Area (GIA) under private lift irrigation. Whereas Shankar (1992) mentions that the actual GIA ranges from 80 per cent in Gujarat to 60 per cent in UP. A Tamil Nadu study shows that it is not more than 30 per cent (Janakarajan, 1993).

A market is basically formed through a mutual understanding between two adjacent farmers to share water (Mukherji, 2007). It serves two purposes: promoting efficient use, and providing water to poor farmers who are either unable to afford wells or find it uneconomical to do so (Shah, 1989, 1993; IRM&ED, 2008). The markets also increase cropping intensity and demand for agricultural labour, which ultimately benefits the landless and wage labour (Fujita and Hussain, 1995).

The impact of water markets on groundwater demand is not necessarily negative. Though markets encourage groundwater use efficiency, they often expand the area per well due to the incentive to sell water. However, the extent of the impact again may depend on water productivity. Groundwater market in Gujarat, for instance, does not consider the limit of the resources and is thus not sustainable in the long run (Kemper, 2007). Topography and distance between the source and the field also influences sustainability. In hard rock, deep alluvial or scanty rainfall areas, development of market sharing results in over-pumping and over exploitation (Roy, 1989). On the other hand, Shah (2009) mentions that tradable property ownership creates incentives for improving productivity and conservation.

*iii) Community*

Community management of groundwater is very limited in its spread despite the fact that the community management of irrigation (through tanks or canals) is very old. This is mainly because groundwater resource is considered to be private property. Participatory approach to groundwater management in India is based on the Western United States' experience of the communities in aquifer management. This model was also tried in Spain and Mexico where users are registered and organized into associations with a mandate to manage sustainably (Villarroya and Aldwell, 1998; Sandoval, 2004). Thus "community management" implies creation of self-governing water user organisations who take the responsibility of sustainable management of aquifers through collective action (Shah, 2009). The main objectives of the management process are to focus on the demand side through participatory data collection, analysis and dissemination (GoAP, 2007). It can also involve any mix of instruments including regulation, property rights, and pricing (The World Bank, 2010).

The Government of Andhra Pradesh (GoAP) and Punjab for instance started Groundwater Management Projects where farmers are equipped with the necessary data, skills and knowledge, for managing groundwater in a sustainable manner through managing and monitoring their own demand. They measure, and keep a daily track of rainfall, water levels, and well yields, calculating groundwater recharge from monsoonal rainfall, and estimating their annual water use based on the planned cropping pattern. Empirical studies show that in the years when water availability was low either due to low rainfall or high groundwater abstraction during the preceding crop season, the farmers are now able to achieve a combination of crop diversification and water-saving irrigation methods (The World Bank, 2010).

A different type of peoples' participation was observed in Rajasthan. The villagers decided to stop sinking of borewells in order to preserve and judiciously use the water resources at their disposal. As a result, no bore well is found within the 4 km radius of the village (IRM&ED, 2008). In Kerala, two community managed groundwater projects were implemented for proper utilization of water for irrigation. As per the instructions, two persons can irrigate their land at a time. The farmers bear the electrical and Operation and Maintenance (O&M) charges and succeeded to achieve financial and source sustainability. Check Dam Movement was started in Gujarat, where farmers formed village-level local institutions (Gandhi and Sharma, 2009). Under this system, the villagers undertake planning, finance and construction of a system to check dams in and around the village in order to collect and store rainwater, recharge the groundwater aquifers, and thereby recharge the dug wells. As a result, the water table has increased, improving the agricultural income. However, there was no collective action on reducing over extraction. The communities were self-interested and every farmer in the community was free to extract whatever they wanted, rather than focusing on collective targets for crop diversification or water use reduction.

Community based management programmes should be designed with a shared focus on improving agricultural productivity, income and water conservation. Water use reductions should not be explicitly sought, but realized by aligning efficient irrigation interventions with farmer incentives for higher profits. The Planning Commission (2007) also agrees with the fact that community management or control would not work well unless it serves some basic needs of the farmers. According to The World Bank (2010), stakeholders' participation in the management process is necessary because it disseminates understanding of issues that can be the impetus for up-scaling good practices in the sustainable use of groundwater. It also improves the self-regulatory capacity, counteracts corruption, and facilitates the coordination of decisions relating to groundwater, land use, and waste management. According to Burke *et al.*, (1999), socio-economic, political and institutional factors are the main determinants, which incentivise these stakeholders in sustainable groundwater management. As reliability of water supply declines, it poses tremendous risk to the people depending on it. It also influences farmers' decisions about investment in fertilizer, seed, and other inputs; the Government and other institutional investments; and economic returns. Thus, a detailed account about how people are using groundwater, why extraction rate is tremendously increasing, the pricing mechanism and sharing structure, etc., need to be analyzed for a better policy framework that bridges the gap between physical availability to administrative and institutional responses towards a sustainable management process. This calls for proper understanding of the property rights regime under which groundwater development and management falls.

There are a few participatory groundwater management initiatives implemented by different Non-Governmental Organisations (NGOs) in various states (GoI, 2011). These include:

i) The APFAMGS programme in AP aimed at involving farmers in hydrologic data generation, analysis and decision making, particularly around crop-water budgeting (CWB);

ii) groundwater sharing under the Andhra Pradesh Drought Adaptation Initiative (APDAI) involving Watershed Support Services and Activities Network (WASSAN), in parts of AP;

iii) experiences from Barefoot College, Tilonia, with a water budgeting tool known as *Jal Chitra*;

iv) efforts by the Foundation for Ecological Security (FES) at taking a micro-watershed unit for water balance and planning groundwater use along with communities at their sites in Rajasthan, Madhya Pradesh (MP) and AP;

v) experiences of the Advanced Centre for Water Resources Development and Management (ACWADAM) with *Samaj Pragati Sahyog* (SPS) in Bagli, MP, and with the *Pani Panchayats* in Maharashtra on knowledge-based, typology-driven aquifer-management strategies;

vi) the *Hivre Bazar* model of watershed development (WSD) and social regulation to manage water resources; and

vii) social regulation of groundwater use initiated by the Centre for World Solidarity (CWS). The operational modalities and their functioning need to be assessed critically in order to draw lessons for broader policy formulations.

Amidst this backdrop, this paper examines three institutional models that are addressing groundwater management in AP following different approaches. These institutions are assessed in terms of their structure, operational principles, functioning, and effectiveness in managing groundwater at the community level. A comparative assessment of the strengths and weaknesses of these approaches will be taken up in order to arrive at a feasible or acceptable institutional model for scaling up.

## III Approach

For the purpose of comparative institutional assessment, three villages were selected, where the community groundwater management practices have been adopted under different NGOs. Besides, one village where no such management practices were adapted was selected as the control village. The details of the sample villages are presented in Table 1. The sample villages consist of:

i) One village covered under the Andhra Pradesh Farmer Managed Groundwater Systems (APFAMGS) implemented by the NGO, Bharati Integrated Rural Development Society (BIRDS). APFAMGS is a continuation of an earlier programme known as APWELL supported by the Royal Netherlands Government. The APFAMGS was implemented with the support of Food and Agricultural Organisation (FAO).

ii) One village, where the NGO, Centre for World Solidarity (CWS), along with its local partner NGOs, has been implementing the programme named "Social Regulations in Water Management (SRWM)".

iii) One village, where participatory groundwater management is being promoted as part of the Andhra Pradesh Drought Adaptation Initiative (APDAI) of the Department of Rural Development (DoRD). The NGO, WASSAN is the lead technical agency, and the initiative is being implemented by the SERP, through the *Mandal Mahila Samakhyas* (MMS).

iv) One control village with substantial groundwater use, but not having any groundwater management institutions.

**Table 1: Details of the Sample Villages**

| Village | Mandal | District | Ground water Model/ Project | Impleme-nting Agency (NGO) | Year of Initiation of Project | Stage of the Project |
|---|---|---|---|---|---|---|
| Thaticherla | Komarolu | Prakasam | APFAMGS | DIPA (BIRDS) | 2003-04 | Ist phase Complete. 2nd Phase ongoing |
| Madirepalli | Singanamala | Anantapur | CWS/ SRWM | RIDS (CWS) | 2003-04 | Ongoing |
| Gorantlavaripalle | Nallacheruvu | Anantapur | WASSAN/ APDAI | WASSAN/ MMS | 2007-08 | Ongoing |
| Rajupalem | Komarolu | Prakasam | Control Village | NA | NA | NA |

Of these three initiatives, the APFAMGS Project operates at a wider scale, covering 3,000 farmers in seven districts of AP, while the other two are working on an experimental basis on a small scale of a few villages. Though the APFAMGS initiative focuses on rain-fed and semi-arid regions, the socio-economic, agro-climatic and hydro-geological conditions vary widely across the locations and villages. An attempt was made to select a representative village from across the seven districts to identify the common elements in the institutional arrangement and the processes that may be common and relevant for comparison with other initiatives.

***Profile of the Sample Villages:***

The sample villages vary in size (number of households) and socio-economic composition. The control village is the largest, with 374 households (HHs); while the smallest is Gorantlavaripalle, with 113 households (Table 2). The geographical area of the sample villages ranges between 300 and 1900 hectares, and the average family size ranges from 3.8 to 4.4 (Table 3). Socially, two of the sample villages are dominated by

**Table 2: Socio-Economic Composition of the Households in the Sample Villages**

| District/ Farm Size | Village/ Social Categories/ No. of HHs | | | Total HHs | Sample HHs |
|---|---|---|---|---|---|
| **Prakasam** | **Thaticherla** | | | | |
| | **SC/ST** | **BC** | **OC** | | |
| Landless | 10 | 30 | 5 | 45 | 0 |
| Marginal Farmers | 38 | 100 | 3 | 141 | 19 (14) |
| Small Farmers | 10 | 40 | 15 | 65 | 8 (12) |
| Medium Farmers | 2 | 0 | 10 | 12 | 3 (25) |
| Large Farmers | 0 | 0 | 2 | 2 | 1 (50) |
| Total | 60 | 170 | 35 | 265 | 31 (12) |
| **Anantapur** | **Madirepalli** | | | | |
| Landless | 2 | 6 | 1 | 9 | 0 |
| Marginal Farmers | 26 | 8 | 9 | 43 | 5 (14) |
| Small Farmers | 3 | 4 | 30 | 37 | 8 (22) |
| Medium Farmers | 0 | 25 | 30 | 55 | 12 (22) |
| Large Farmers | 0 | 7 | 22 | 29 | 5 (17) |
| Total | 31 | 50 | 92 | 173 | 31 (18) |
| **Anantapur** | **Gorantlavaripalle** | | | | |
| Landless | 7 | 0 | 0 | 7 | 0 |
| Marginal Farmers | 19 | 20 | 5 | 44 | 8 (18) |
| Small Farmers | 2 | 30 | 20 | 52 | 19 (37) |
| Medium Farmers | 0 | 0 | 10 | 10 | 3 (30) |
| Large Farmers | 0 | 0 | 0 | 0 | 0 |
| Total | 28 | 50 | 35 | 113 | 30 (27) |
| **Prakasam** | **Rajupalem** | | | | |
| Landless | 28 | 0 | 4 | 32 | 0 |
| Marginal Farmers | 1 | 60 | 100 | 161 | 12 (8) |
| Small Farmers | 1 | 10 | 150 | 161 | 13 (8) |
| Medium Farmers | 0 | 0 | 10 | 10 | 3 (30) |
| Large Farmers | 0 | 0 | 10 | 10 | 3 (30) |
| Total | 30 | 70 | 274 | 374 | 31 (8) |

*Source:* Field Survey (PRA/FGD Methods).

*Note:* Figures in the brackets indicate the per cent of sample farmer HHs taken for the study.

the Other Caste (OC) households, while two of them have a higher proportion of Backward Caste (BC) households. Two of the sample villages have more than 25 per cent of the
households belonging to the Scheduled Caste/Tribe (SC/ST) households. In terms of economic composition, most of the sample villages are dominated by marginal and small farmers (Table 2). Only Madirepalli Village has about 50 per cent of the households from medium and large farmers. These variations help in understanding the dynamics of Community Based Groundwater Management (CBGM) in varying socio-economic contexts. The proportion of the sample from these villages ranges between 8 and 27 per cent. This is due to the size of the sample village, as the number of sample households chosen are 30 from each sample village.

*Access to Groundwater:*
Access to groundwater and irrigation is at the core of groundwater management. The extent and nature of access across the sample villages would highlight the differences in the functioning and performance of the PGM. All the sample villages depend on groundwater irrigation. The extent of irrigation ranges between 15 per cent in Gorantlavaripalle to 34 per cent in Madirepalli (Table 3). On the other hand, more than 70 per cent of the households in the three villages, where groundwater institutions are present, have access to wells, as against 29 per cent in the control village. Variations in the extent of irrigation (percentage of area under irrigation) could be due to the groundwater potential in the respective villages. However, the contrast in the access to wells in one form or the other, explains the role of groundwater institutions. For instance, though only 15 per cent of the households in Thaticherla own wells, 70 per cent of them have access to groundwater through water sharing and community wells. On the contrary Rajupalem (control village) has only 29 per cent of the households reporting access to well water for irrigation, despite 17 per cent of them owning wells. In the control village, only 12 per cent of the households share water with others as against 37 to 46 per cent of the households in the villages with groundwater institutions (Table 3).

There is a clear pattern in the access to groundwater across socio-economic groups of farmers. It is observed that the SC/ST farmers and marginal and small farmers seem to depend more on sharing water, while a large proportion of the OC farmers and large farmers have their own wells (Tables 4 and 5). The landholding pattern is more or less similar in all the sample villages, though we do not have specific information the hydro-geology of the villages. These two factors are critical in influencing the access and quality of groundwater.

**Table 3: Groundwater Access to Households in the Sample Villages**

| Particulars | Thaticherla | Madirepalli | Gorantlavaripalle | Rajupalem |
|---|---|---|---|---|
| No. of Households | 265 | 173 | 113 | 374 |
| Average Household Size | 4.4 | 4.2 | 4.3 | 3.8 |
| Total Geographical Area (in ha) | 1903 | 307 | 1064 | 1676 |
| Area under Irrigation (%) | 32 | 34 | 15 | 22 |
| % of HHs with Own Wells | 15 | 43 | 26 | 17 |
| % of HHs Sharing Wells | 46 | 45 | 40 | 12 |
| % HHs depending on Community Wells | 10 | 0 | 0 | 0 |
| % of HHs with Access to Wells | 71 | 88 | 87 | 29 |
| Main Occupation | Cultivation | Cultivation | Cultivation | Cultivation |

*Source:* Field Survey.

**Methodology:**

Qualitative as well as quantitative research methods have been used for the study. Primarily, Focus Group Discussions (FGDs) and household questionnaires were used to elicit the required information. Besides, basic secondary data about the villages were collected from the village secretary, elders, and key informants. Field research was conducted during the months of February and March, 2011. The study team collected information and held discussions with key professionals involved in APWELL/ APFAMGS, CWS, and APDAI/WASSAN projects for a broader understanding on the objectives and processes involved in the design and implementation of the respective initiatives. The study team also interacted with the officers and consultants of the State Irrigation and Command Area Development (I&CAD) and the Groundwater Department both at the state and district levels. During the field visits, the team had discussions with the staff of local NGOs implementing the respective programmes. Important issues covered include communication and awareness strategy, community participation, groundwater management by community, impact on cropping pattern and yields, etc.

For the purpose of quantitative household data collection, a detailed questionnaire was prepared, covering socio-economic, demographic, agriculture and groundwater management. In each village, about 30 households representing the socio-economic categories of the community were selected. The sample is divided into two groups, viz. well owners and those sharing wells or depending on community wells. The sample is divided in proportion to the actual number of well-owning and well-sharing households.

At the end of the field visit, the gist of the information collected was shared with the villagers for the purpose of triangulation. Community wells are present only in one sample village (Thaticherla) under the APWELL/APFAMGS programme.

**Table 4: Details of Well Status of Groundwater Farmers across Social Categories and Farm Sizes in Sample Villages**

| District/Village/ Caste Category | Well Status of Groundwater Farmers | | | |
|---|---|---|---|---|
| | OW | WS | CW | All |
| **Prakasam: Thaticherla** | | | | |
| SC/ST | 7 (1) | 27 (4) | 6 (1) | 40 (6) |
| BC | 26 (4) | 79 (13) | 15 (2) | 120 (19) |
| OC | 6 (2) | 16 (3) | 5 (1) | 27 (6) |
| Total | 39 (7) | 122 (20) | 26 (4) | 187 (31) |
| **Anantapur: Madirepalli** | | | | |
| SC/ST | 3 (1) | 14 (4) | 0 | 17 (5) |
| BC | 18 (3) | 26 (5) | 0 | 44 (8) |
| OC | 53 (11) | 38 (8) | 0 | 91 (19) |
| Total | 74 (15) | 78 (16) | 0 | 152 (32) |
| **z Anantapur: Gorantlavaripalle** | | | | |
| SC/ST | 2 (1) | 5 (2) | 0 | 7 (3) |
| BC | 15 (4) | 27 (7) | 0 | 42 (11) |
| OC | 40 (12) | 10 (4) | 0 | 50 (16) |
| Total | 57 (17) | 42 (13) | 0 | 99 (30) |
| **Prakasam: Rajupalem** | | | | |
| SC/ST | 0 (0) | 0 (0) | 0 (0) | 0 (0) |
| BC | 7 (2) | 9 (3) | 0 (0) | 16 (5) |
| OC | 55 (16) | 35 (10) | 0 (0) | 90 (26) |
| Total | 62 (18) | 44 (13) | 0 (0) | 106 (31) |

*Note:* OW-Own Well; WS-Water Sharing; CW-Community Well. Figures in the brackets indicate the No. of sample groundwater farmer HHs taken for the study.

*Source*: Field Survey (PRA/FGD Methods).

Table 5: Distribution of the Sample HHs across Farm Size and Well Ownership Status

| Village | Groundwater User Well Status | Economic Class | | | Overall |
|---|---|---|---|---|---|
| | | MF | SF | LMF | |
| Thaticherla | Owned | 47 | 29 | 24 | 55 |
| | Water Sharing | 79 | 21 | 0 | 45 |
| | Total | 61 | 26 | 13 | 100 |
| Madirepalli | Owned | 7 | 40 | 53 | 48 |
| | Water Sharing | 31 | 13 | 56 | 52 |
| | Total | 19 | 26 | 55 | 100 |
| Gorantlavaripalle | Owned | 6 | 76 | 18 | 57 |
| | Water Sharing | 54 | 46 | 0 | 43 |
| | Total | 27 | 63 | 10 | 100 |
| Rajupalem | Owned | 22 | 44 | 33 | 58 |
| | Water Sharing | 62 | 38 | 0 | 42 |
| | Total | 39 | 42 | 19 | 100 |
| Overall | Owned | 21 | 48 | 31 | 54 |
| | Water Sharing | 55 | 29 | 16 | 46 |
| | Total | 37 | 39 | 24 | 100 |

*Source:* Field Survey.
*Note:* MF- Marginal Farmers; SF-Small Farmers; LMF-Large and Medium Farmers.

## IV. Participatory Groundwater Management: Three Approaches

Water is a State Subject and so is its development, utilization and monitoring. The Government of AP is responsible for water resource planning, storage as well as use. Several Government Departments/Agencies, Non-Governmental Organizations (NGOs) and people's institutions are involved in water development, use, monitoring and regulation. Water management is encouraged through institutional arrangements such as Water User Associations (WUAs) and Tank Management Committees (TMCs). These state promoted institutional arrangements are limited to surface water resources such as canals and tanks leaving groundwater development and management to private individuals. Though effectiveness and sustainability of canal and tank management institutions are being debated (Reddy and Reddy, 2005), the need for bringing groundwater under common resource management cannot be undermined. Hitherto groundwater management is left to private individuals, as it is perceived to have high transaction cost of organizing individual farmers at a scale to attain the benefits of community management.

On the other hand, as observed in the earlier section on review, there appear to be some small-scale institutional innovations that are working towards sustainable management of groundwater in different corners of the country. However, these innovations are confined to small areas in the absence of policy support in bringing groundwater under the management regime, and the possibilities for scaling up these models have not been explored. Here we make an attempt to explore the possibilities for scaling up and drawing lessons from PGM by comparing three such models that are in operation in AP.

The State of AP has a long history of community groundwater management, and is one of the first states to initiate a joint well programme way back in 1987. The three models selected are:

i) The Andhra Pradesh Farmer Managed Irrigation Systems (APFAMGS), which has its origins in APWELL programme;

ii) Social regulations in Water Management (SRWM) by the CWS (NGO) and its partners; and

iii) Collectivization of borewells under the Andhra Pradesh Drought Adaptation Initiatives (APDAI) programme being implemented by WASSAN with its partner NGOs. These initiatives have different origins and approaches to PGM (Table 6).

All the three models have been initiated in the arid and semi-arid districts of AP, where the extent of groundwater development is quite high. In what follows we discuss these three models in detail.

**i) APFAMGS**

The Andhra Pradesh Farmer Managed Groundwater Systems (APFAMGS) has its origin in the APWELL Project initiated by the GoI in 1987. The APWELL Project was conceived in collaboration with the Netherlands Government, which funded a number of minor irrigation schemes in AP. The APWELL Project was approved for financing by the Netherlands Government in June 1994. From April 1995 to March 2003, the APWELL Project was implemented in seven districts of AP, viz. Prakasam, Mahbubnagar, Nalgonda, Anantapur, Kurnool, Chittoor and Cuddapah. The project was co-financed with 15 per cent (of total cost excluding establishment costs) contribution from the farmers, and the rest as a grant from the Royal Netherlands Government. The establishment costs and part of the cost of electricity infrastructure were borne by the GoI/GoAP[4] . Physical activities such as groundwater prospecting, drilling, yield testing,

[4] For details on funding pattern, see APWELL Final Report. ARCADIS Euroconsult, 2003, pp. 45-50.

**Table 6: Groundwater Management Programmes / Project Models in Andhra Pradesh**

| CBGWM Model | Description |
|---|---|
| APFAMGS<br>(AP WELL) | (a Dug new borewells for a group of HHs not having access to water, with clear sharing, groundwater monitoring, and water use efficiency measures.<br>(b) Limited to "new un-exploited" areas.<br>APWELL has been transformed into the largest groundwater awareness programme in the state premised on:<br>i) communities monitoring the groundwater status regularly with knowledge and scientific principles;<br>ii) sharing the knowledge of various alternate crop systems and evolving norms for groundwater management (with facilitation); this process will lead to lesser groundwater depletion and better management. |
| Social Regulations in Water Management (CWS &Partners Programme) | This programme was initiated on a limited scale and based on regulations:<br>(i ) the community adopts a norm of "no new borewells ";<br>(ii) increasing system efficiency through the provision of collective sprinkler irrigation sets; and<br>(iii) borewell owners share their water with neighboring farmers leading to substantial reduction of the number of water-less families in the village. |
| Collectivisation of borewells : APDAI<br>(of CRD, facilitated by WASSAN) | This initiative followed an "area approach" for groundwater management where the borewell owners pool their individual borewells to provide supplemental/critical irrigation to a larger rain-fed area (entire block) for survival of rain-fed crops. The community has to abide by the following rules:<br>(i) no new borewells for at least 10 years;<br>(ii) all the land within the specified area (including water-less) will have a right for supplemental irrigation for Kharif rain-fed crops; and<br>(iii) pipeline network is provided by the project so that water can be taken to any part in the block/area. |

*Source:* Field Observation (PRA/FGD methods)

**Table 7: APWELL Project Coverage on Completion (up to March 2003)**

| District | Villages | No. of Wells / WUGs | Total No. of HHs | HHs / WUGs | Total Ayacut (acres) | Ayacut per WUG (acres) | Ayacut per HHs (acres) | Avg. Yield (kg/ha) | Avg. Cost per Bore well (Rs.) | WUG Contribu tion / Well (Rs.) |
|---|---|---|---|---|---|---|---|---|---|---|
| Anantapur | 39 | 415 | 1396 | 3.4 | 4410 | 10.6 | 3.2 | 4009 | 131724 | 16159 |
| Chittoor | 110 | 419 | 2076 | 5 | 3481 | 8.3 | 1.7 | 3109 | 141242 | 17171 |
| Cuddapah | 59 | 415 | 2160 | 5.2 | 3978 | 9.6 | 1.8 | 2995 | 150625 | 18167 |
| Kurnool | 78 | 518 | 2013 | 3.9 | 5299 | 10.2 | 2.6 | 4557 | 143036 | 16765 |
| Mahbubnagar | 55 | 821 | 2741 | 3.3 | 8605 | 10.5 | 3.1 | 2604 | 129987 | 15610 |
| Nalgonda | 42 | 299 | 1439 | 4.8 | 3018 | 10.1 | 2.1 | 3569 | 153300 | 18796 |
| Prakasam | 87 | 575 | 2053 | 3.6 | 5698 | 9.9 | 2.8 | 3523 | 142660 | 16635 |
| Total | 470 | 3462 | 13878 | 4 | 34489 | 10 | 2.5 | 3523 | 140102 | 19790 |

*Source:* APWELL Project: Final Report, ARCADIS Euroconsult, 2003, pp.76-77.

and construction of the distribution systems, were done through the Andhra Pradesh State Irrigation Development Corporation (APSIDC), with its technical staff under the Executive Engineer in each district[5] .

Under this programme, a total of 4,480 borewells were drilled. Of these, 3,462 were successful with yield above 1,500 gph, at 77 per cent success rate[6] in 470 villages, covering about 14,000 households across seven districts (Table 7). In the APWELL Project, farmers own and maintain the bore well irrigation systems constructed as part of the project. Under each well, the farmers formed Water User Groups (WUGs) for construction, operation, and maintenance of the bore well systems. Women WUG members formed Self-Help Groups (SHGs) for thrift and credit activities, and gradually initiated land and water-based agriculture and other supplementary income-generating activities. On an average each well/WUG has four households covering 10 acres of land, i.e., an average of 2.5 acres. The average cost of a well was about Rs.1.4 lakhs of which about 14 per cent was contributed by the farmers (Table 7). Clusters of WUGs were formed into Bore Well User Associations (BUAs), which in due course were legally

[5] A technical assistance team, consisting of national and international experts on various disciplines, based in Hyderabad, advised and coordinated project activities in the field. In each district, local NGOs were contracted to implement the social, institutional, gender, agricultural, and watershed aspects of the project. For this the NGOs appointed a dedicated team consisting of Agricultural Production Trainers (APTs), Gender Development Organisers (GDOs), Watershed Development Facilitators (WDFs), and Community Organisers (COs). A District Field Coordinator (DFC), who was part of the consultant's team, supervised the work in each district.

[6] 75 per cent is the acceptable success rate.

registered, for training, conflict resolution, procuring agricultural inputs, marketing, agro-processing, and groundwater management. Important components of the project included: groundwater resources development where feasible, land-and-water management by the users, extension and training, activities for gender integration, environment management, and monitoring and evaluation.

The project clearly demonstrated that PGM is a viable concept if introduced in conjunction with groundwater development, agricultural production, institutional development, and capacity building of farming communities. The implementation process followed by the APWELL Project achieved certain important results, which are good lessons for future projects:

- The intense community organization efforts to form and nurture WUGs assured the involvement of the farmers from the very inception of the project activities within the village.
- Compulsory inclusion of women as members of WUGs and forming SHGs helped to mainstream women farmers into the management of groundwater systems.
- At the end of project implementation, the assets created were handed over to the WUGs. Thus, the project had a distinct exit policy woven into its concept.
- The WUGs contributed 15 per cent of the cost (excluding administrative charges). This ensured greater sense of ownership among them.
- Every member of the WUG was given a pipe outlet on his/her land, assuring equity in water distribution and reducing water conveyance loss.
- Intensive capacity building through training, exposure visits, and demonstrations assured quick adoption of sustainable water management and agricultural practices.
- Well-trained and strongly-motivated staff of the Government and NGOs working closely with farmers is necessary for the successful implementation of PGM.

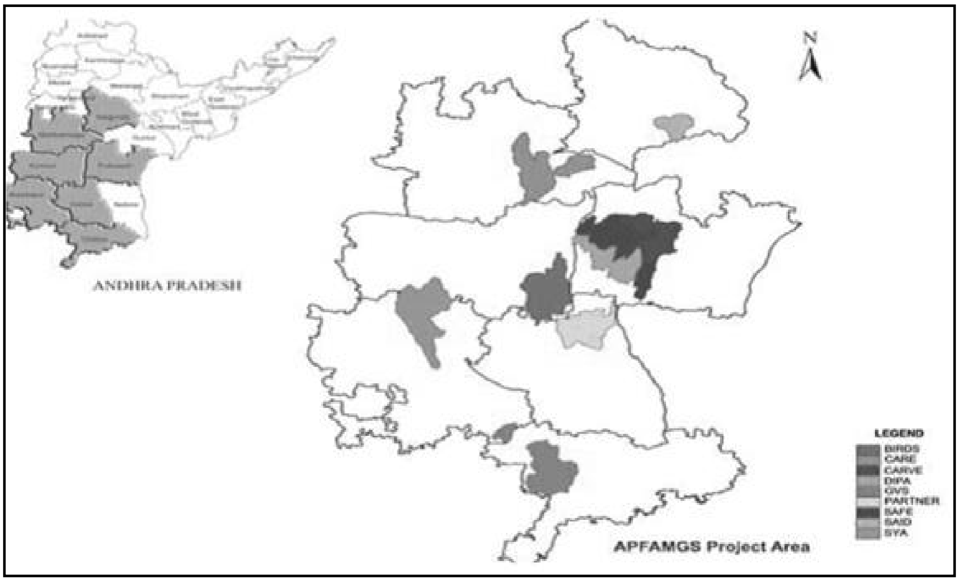
APWELL to APFAMGS

On the recommendation of the Mid-Term Review Mission[7], the APWELL gradually initiated a number of pilot activities related to water conservation, including WSD in two villages, Participatory Hydrological Monitoring (PHM) in all clusters with more

[7] AP Groundwater Bore Well Irrigation Schemes (APWELL): Mid-term review mission report, Netherlands Economic Institute, 1997

than 10 successful groundwater irrigation systems, an experiment with people-controlled groundwater system in upper Gundlakamma sub-basin in Prakasam District; artificial recharge measures in two watersheds (with technical inputs from the National Geographical Research Institute (NGRI)), and introduction of drip and sprinkler irrigation, and eco-farming through application of low-cost bio-fertilizers and bio-pesticides. The APWELL Project also conducted water quality testing in fluoride-endemic areas. During the final year of the APWELL Project, it was decided that the Indo-Dutch development assistance agreements were not to be extended to new projects. Instead, the Dutch Government approved a far smaller capacity building initiative to support farmer-managed groundwater systems for implementation through a network of NGOs in the seven APWELL districts. This was called the APFAMGS, for which funding was provided directly by the Royal Netherlands Embassy (RNE) till June 2004, after which it was transferred to the FAO.

**Fig 1: Location Map of the Operational Area under the APFAMGS (APWELL) Project**




The APFAMGS Project was implemented in the same seven districts (Fig/Map:1) as that of the APWELL, covering 650 habitations in 66 Hydrological Units (HUNs). It works in partnership with groundwater-dependent farmers, and empowers farmers with the knowledge and skills to monitor the groundwater system and take up appropriate interventions towards its management. The APFAMGS Project adopted a sub-basin approach for selecting habitations, unlike the APWELL which selected villages with exploitable surplus of groundwater. Thus, the approach to groundwater management shifted from water sharing to water management. Moreover, its infrastructure and incentive-centred approach has transformed it into a scientific knowledge-intensive approach.

The philosophy of the APFAMGS Project is: "farmers' understanding of groundwater dynamics makes the difference". This is achieved through the process of enabling primary stakeholders to involve in PHM for sustainable use of groundwater resources using hydrological boundaries as an operational unit. The APFAMGS Project is implemented through a network of Community Based Organizations (CBOs) including nine field level partner NGOs and two international resource agencies. The main objective of the project is to "equip groundwater farmer users with the necessary data, skills and knowledge to manage groundwater resources available to them in a sustainable manner, mainly through managing and monitoring their own demand". The basic premise is that self-generated scientific data and knowledge will enable farmers to make appropriate farming choices using groundwater. The farming communities make informed decisions using hydrological data developed on the Geological Information System (GIS) platform.

Elaborate institutional arrangements with equal representation of men and women were made to implement the programme. The main activities taken up include:

- Awareness generation on the emerging groundwater crisis, and treating groundwater as a "common good" at the habitation and hydrologic unit level.
- Demystifying the science of hydrology through participatory learning, practising and establishing a new relationship between farmers and groundwater.
- Participatory planning and sharing of information through Crop Water Budgeting (CWB) workshops for evolving common strategies that limit damage to the groundwater system without sacrificing individual interest.

Additional steps include:

- improving crop water efficiency,
- reducing chemical pollution,
- groundwater governance transcending individual holdings and habitations without being coercive through voluntary choices such as reduced pumping, preventing construction of new wells, crop diversification, reduced application of chemical fertilizers/pesticides, etc.

A comprehensive institutional structure integrating technical and social components was established. At the village level a Groundwater Management Committee (GMC) is the key institution of the farmers - both men and women. A network of GMCs is formed at the hydrological unit level, viz. the Hydrological Unit Network (HUN). These two are critical for providing a "demonstration effect" of the learning's from the project to the larger community of farmers beyond the project area. The HUNs have a legal status, allowing them to receive funds as well as carry out business activities. Making the farmers water literate is the core of the approach. The first step in this direction is to enhance the farmer's capacities to collect and analyse data on their own.

Capacity building and training activities are part of project components. Formal and informal techniques such as technical training related to recording rainfall, measuring draft from observation wells, cultural shows, practical training, exposure visits, exchange visits, and workshops are included. These capacities are used in the PHM exercise. In PHM, the farmers volunteer to monitor water levels from 2,026 observation wells (one well for every sq km) every fortnight. Daily rainfall measurement is collected from rain gauge stations from 190 rain gauge stations established for every 5 sq km in the project area. The collected information is shared with the farmers for taking farming decisions. Discharge measurements are also carried out to understand the pumping capacity in 700 monitoring observation wells. This is accomplished by measuring the time taken to fill a drum of known capacity; additionally, the discharge farmers also measure the drawdown. Based on these measurements, the farmers have a good understanding of the pumping capacity of the wells, well performance, water requirement for different crops, and the ways and means to increase water use efficiency.

The success of demystifying science is reflected in the CWB, which helps farmers to collectively make land use plans, depending upon water availability. The CWB is taken up at the village level before the starting of each season and aggregated at the HUN level. Using rainfall data and assumed run-off coefficient (10 per cent), the contribution of rainfall to groundwater recharge is estimated. The net availability of groundwater is estimated by adding or deducting the previous season's balance. There may either be positive or negative water balance in each season, depending on the recharge and draft. Based on the crop's water requirements and the net available groundwater, crop areas are decided in a collective manner. By following local measures, the volunteers explain the area under each crop with the available groundwater. They estimate the area that can be devoted to paddy if the entire water is used for paddy crop or other crops, or a combination of different crops. The estimates show that in 59 of the 63 HUNs, groundwater balance is deficit. The CWB also identified over-exploited aquifers, and water-harvesting measures such as injection wells were taken up in these aquifers. In some areas, abandoned open wells were also used to trap the flood flows and transfer them to the aquifers. Though there is no coercive mechanism to force the farmers to adopt collective decisions, a survey was conducted after every season on the extent to which collective decisions were made and discussed in the GMC. The data on actual cropping pattern is used to arrive at the actual draft; however, there is always a difference between estimated and actual draft. Though individual farmers' decisions are respected, the GMCs and HUNs are able to act as pressure groups to advocate change in cropping patterns, use of sustainable agricultural practices, and water saving technologies in some places.

A hydrological database has been generated and is used for managing groundwater in 559 out of 650 habitations. In fact, the data generated is the property of the GMC and is being sold to outside agencies for the purpose of research. More than 4,000 farmers are trained to read maps and more than 10,000 farmers can handle hydrological equipment. It is assessed that some of the achievements have surpassed the targets (FAO, 2008). During the field visits, we have observed the farmers presenting crop water budget estimates and taking the water table measurements. However, the farmers are yet to be trained on using the GIS. About 300 Farmer Water Schools (FWS)9 have been established to train the farmers and equip them with technical and non-technical aspects of groundwater management. Hydro-Ecosystem Analysis (HESA), a decision-making tool for groundwater management, is being adopted and supported by recharge and discharge factors. Crop plans and management of groundwater is based on this analysis and observations. This is the same sequence used for Agro-Ecosystem Analysis in the classical FFS approach (FAO, 2008). The focus of FWS is on the active and lead farmers who can apply them directly on farm and also share them with a larger audience. The FWS has successfully created the first batch of over 10,000 farmers who have already emerged as trainers to other farmers both under the project as well as for the Government-run Farmer Field Schools (FFS). Such a training and adaptation has demystified hydrology, which is a hidden source, and helped the farmers in understanding the resource availability and dynamics. Sharing of information across HUs resulted in evolving common strategies, limiting the depletion of the groundwater table. Some of the important achievements include reduction in groundwater pumping in a number of HUs. In 14 of the 63 HUs, groundwater pumping has been reduced significantly, while in nine others the reduction was moderate.

Overall, despite the reduction in pumping in a number of HUs, it is not significant enough to have a drainage basin-level impact. Reduced water pumping has a direct bearing on area under paddy, as paddy is water-intensive and the most preferred crop. In all, except in four HUs, the area under paddy cultivation has come down ranging from a few acres to several hundred acres. The farmers' experience showed that they incur crop losses whenever they do not follow the collective advice due to water scarcity.

Crop diversification has taken place in favour of pulses, oil seeds, fruits, vegetables, flowers, etc. The farmers try to offset the losses due to reduction in paddy by growing other high value crops. The risks associated with commercial crops such as monoculture, reduced area under food crops, and loss in soil fertility, are also being addressed simultaneously. Water saving devices such as sprinkler and drip irrigation have been introduced for crops such as groundnut, sunflower, Bengal gram, chillies, and horticultural crops. It is estimated that groundwater pumping was reduced by more than 8 per cent (equivalent to 5 MCM per year) over the project area due to water-saving techniques. The experience of APFAMGS proves that a comprehensive approach could benefit the farming communities, though in a limited way at present.

*Impact of APFAMGS:*

Several impacts, on expected lines, are reported by the Project. Though some of the claims require technical verification, these impacts are:

- Empowerment of the community to collect, analyse and use data and knowledge related to water,
- Change in perception of groundwater from private property to that of a common good,
- Shift from cultivation of irrigated water intensive crops to less water intensive Irrigable Dry (ID) crops,
- Reduced losses from irrigated crops and increased profits from rain-fed or less water-intensive cash crops,
- Reduced groundwater draft,
- Increased groundwater recharge,
- Reduced use of chemical inputs,
- Increased use of organic methods of farming, and
- Reduced migration.

***ii) Social Regulations in Water Management at the Community Level (SRWM)***

An action research project called "Social Regulations in Water Management at the Community Level" (SRWM) was initiated in 2004 in three villages in AP by the Centre for World Solidarity (CWS), in partnership with local grass-root NGOs. Another village in Warangal was added during 2007. The project aims to promote local regulation and management of groundwater resources with equitable access to all families in the communities. The project is expected to develop models to equip the community with drought mitigation preparedness strategies through better water management and regulations at the community level; and to support Community Based Organisations (CBOs) and *Panchayat Raj* Institutions (PRIs) in prioritizing the needs of the community for drinking water, irrigation, and other uses, based on the principles of equity. Specific objectives of the project include:

- To develop the capacity of the community and NGOs on CWB, water supply and demand, and water balance assessments.
- To strengthen the role of PRIs and water communities, to decentralise decision making, and creating the authority to enforce the rules, regulations and norms.
- To regulate water demand to ensure that everyone has access to at least the basic minimum of water for drinking and household purposes.
- To ensure regulatory mechanisms in irrigation practices that fit/relate with organisational structures such as NRM committees of *Gram Panchayats*, Watershed Committees (WSC), etc., and develop appropriate linkages to other Natural Resources Management (NRM) sectors.
- To crystallize facilitating mechanisms for social regulation of water resources and advocate the Government for wider replication and policy change.

The project is being implemented in four villages from three districts covering 715 households at an estimated cost of about Rs.2.5 million per year over three years from AEI, Luxembourg). The four project villages include Madirepalli and CR Pally in Anantapur District, Mylaram in Medak District and Enabavi in Warangal District. In all the four villages, rain-fed agriculture is the norm, but groundwater is an important contributor to irrigation on 6 to 42 per cent of the land. Groundwater provides the much needed life-saving irrigation during prolonged dry spells. Since 2009, as many as 15 more villages, which are spread in Anantapur, Chittoor and Nellore districts, were added in the project.

Prior to the 1990s, open wells with electrical centrifugal pumps were used to extract groundwater in the programme villages. Farmers started drilling borewells during early 1990s - the number of borewells grew rapidly in these villages over the last 15 years - and the shallow open wells gradually dried up due to declining groundwater levels. Due to indiscriminate drilling of borewells and unscientific groundwater exploration, many borewells failed either at the time of drilling or during later years. Furthermore, drilling borewells as deep as 300 ft at a closer spacing resulted in the drying up of the shallow, open dug wells, and shallow borewells due to well interference. This phenomenon resulted in huge loss of investments to farmers and seriously affected the livelihoods of farmers dependent on irrigation.

The project interventions began with a participatory assessment of water resources in the project villages. Participatory Rural Appraisal (PRA) methods were used to map the resource status and the existing water utilization pattern for different purposes, such as drinking, domestic, and for irrigation. Growth of groundwater-based irrigation and trends in the groundwater levels over a period of time were thoroughly discussed and analysed in community level meetings, wherein women and men from all households participated. A series of such meetings and interactions helped to arrive at the crux of the issues, i.e., frequent failure of borewells and increasing debts of farmers due to investment on new borewells.

Competition between neighbouring farmers often leads them to drill borewells as close as two meters apart. For instance, in Madirepalli Village, three neighbouring farmers dug 13 borewells in an area of 0.5 acres over a period of four years in competition to tap groundwater. The project realized that there is need for changing the mind-set of the farmers from "competition" to "cooperation" and to increase the "water literacy" among the farmers for efficient use of water.

**Map 2: Location Map of SRWM Project Sample Villages**

A number of training programmes, exposure visits and awareness-raising meetings were organized by the grass-root partner NGOs supported by CWS in the project villages. Further public awareness and education was carried out through posters, pamphlets and wall-writings. PHM of rainfall and groundwater levels in selected borewells was done regularly and shared and discussed at village meetings in order to increase the understanding of farmers on the behaviour of groundwater in relation to rainfall. A volunteer from the community measured rainfall from a simple manual rain gauge station installed in the villages and recorded the static water levels in 10 sample borewells using an electronic water level indicator. This data was displayed on a village notice board and updated periodically.

The first three years (from a total of seven years) of intensive grass-root work and facilitation has resulted in the community realizing the ill-effects of indiscriminate drilling of borewells and use of groundwater. The community evolved and agreed on the following "social regulations" and interventions in the village:

- No new borewells to be drilled in the village;
- Equitable access to groundwater for all the families through well sharing;
- Increasing the groundwater resources by conservation and recharge; and
- Efficient use of irrigation water through demand-side management.

Small groups of farmers were formed in all the project villages between a borewell owner and a set of about two to three neighbouring farmers, who did not own borewells. The bore well owners were motivated to share water by explaining that drilling new wells in the vicinity of their wells may render theirs dry due to competitive extraction. Instead, sharing a portion of water from his well helps his neighbours, while securing his access to water and thus livelihood. Sharing water with neighbours is a "win-win" situation, benefiting both the bore well owners and water receivers.

*Sharing the Resource at the Village Level*

Sharing of groundwater resource by well owners with other farmers is the prominent feature of the PGM in villages. The practice is of significance in an over-exploited area like Anantapur. For instance, Madirepalli Village of Singanamala Mandal has basically granitic terrain. The dug wells are very deep - sometimes more than 35 feet - and dry. The farmers in the village are practicing groundwater management by sharing and conserving the resource through micro-irrigation and its augmentation through construction of recharge structures. Before the interventions, the farmers were given training on PHM, and are provided with the required equipment. However, there was slackness in practicing it.

The villagers express gratefulness to the local NGO (RIDS) which created enough awareness among them about the futility of drilling new bores and the advantages of sharing water. Most of the farmers reported that earlier, they drilled numerous borewells of various depths. Most of these were drilled without scientific investigation, and huge money was invested in the hope of getting enough water. They believe that the efforts of the NGOs would ultimately pave the way for changing the groundwater scenario in their village. This change of practices occurred over a period of time, and also with the cost attached to the lessons learnt. Between 2004 (before the intervention) and 2010 (after the intervention), there was significant change in the attitude of the farmers, with substantial physical gains (Table 8). For instance, two of the open wells and 16 of the borewells were revived after the intervention. The area under irrigation also increasedsubstantially, i.e., 31 per cent in the case of Kharif and 158 per cent in the case of Rabi crops. This was possible mainly due to water sharing, reduction in the cultivation of water-intensive crops (paddy), and increase in area under micro-irrigation. Groundwater recharge has been enhanced through renovation of recharge structures

**Table 8: Impact of SRWM Project in Madirepalli Village**

| Details | Before (2003-04) | After (2010-11) | Change/ Impact |
|---|---|---|---|
| Area under cultivation (acres) | 767.5 | 767.5 | --- |
| No. of functional open wells | 2 (59) | 4 (59) | Increased |
| No. of functional borewells | 53 (75) | 69 (79) | Increased |
| Area irrigated (acres) | Kharif: 213<br>Rabi: 127 | Kharif: 280<br>Rabi: 328 | Increased by 31% in Kharif and 158% in Rabi |
| Number of observation borewells | 0 | 10 | Increased |
| Number of sharing groups formed | 01 | 69 | Increased |
| Number of farmers sharing water | 08 | 78 | Increased |
| Area under paddy (acres) | Kharif: 74<br>Rabi: 73 | Kharif: 51<br>Rabi: 0 | Kharif: -31%<br>Rabi: -100% |
| Area under direct irrigation (acres) | 314 | 51 | -84 |
| Area under micro-irrigation (acres) | 26 | 557 | Increased |
| Construction of recharge structures | 0 | 28 (percolation tanks, check dams and recharge pits) | Increased recharge of wells |
| Cropping pattern | Paddy for regular consumption through very low-yielding BWs | Switched over to ID crops like groundnut, green chilli, sunflower, etc. | Better financial returns; conserved resource . |

*Note:* Figures in brackets are the total number of wells.
*Source:* Rural Integrated Development Society (RIDS) (2011).

such as percolation ponds, check dams, etc. A notable achievement is that 78 farmers are sharing water with well owners and getting critical irrigation for their irrigated dry crops. The area under Kharif paddy has declined by 31 per cent, while Rabi paddy is totally stopped; direct irrigation is used only in the case of paddy.

Earlier, the villagers drilled a large number of bores individually in their lands in the hope of having an irrigation source. For instance, a farmer, K. *Subbanna*, drilled 26 bores but only one was successful and is functioning to this day. Most of the bores went dry or were low-yielding. The farmers earlier resorted to growing paddy and other water-intensive commercial crops but subsequently switched over to Irrigable Dry (ID) crops such as sunflower, groundnut, etc. After the intervention, the farmers decided not to drill new borewells and share the water from the successful bores with other farmers. Water is being shared between brothers, among farmers irrespective of caste and between small and big farmers in the village. The villagers constructed 28 recharge structures and helped to augment the yields of the successful bores. The number of farmers sharing bores increased from eight in 2004 to 78 in 2010-11. The recharge structures constructed during the past 2-3 years reportedly revived/rejuvenated some of the defunct borewells and are presently irrigating about one to three acres per well. Earlier, farmers used the flood irrigation method, but now they are adopting micro-irrigation methods such as drip and sprinkler irrigation for the ID crops.

*Key Achievements of the Project in Madirepalli Village:*

- Gradual change in thinking among the community, recognizing groundwater as a scarce and CPR,
- Enhanced resource availability through rejuvenating and taking up new water harvesting activities,
- Created drinking water access to fulfil the entire community's and cattle's needs; however, these impacts are local and do not take the scale impacts (Syme et al., 2011),
- All 69 individually-owned irrigation borewells came under the water-sharing system providing water access to 78 new farmers,
- 268 acres of rain-fed lands brought under protected irrigation by sharing water from borewells using micro-irrigation systems; this corresponds to 44 per cent of the total well irrigated area in the village during 2010-11,
- Relative extraction of groundwater reduced from 125 to 80 per cent of the annual available groundwater from the year 2004-2005 to 2010-2011, and
- Farmers changed from water-intensive crops to water-saving crops.

Though there was a deeper crisis in agriculture in Madirepalli Village due to higher groundwater dependency, the existence of traditional regulatory practices in *Gonchi* seepage channels and motivated village leadership contributed to better results of the project in Madirepalli compared to the other project villages. While Madirepalli was successful in expanding the water-sharing system to many borewells, there was a significant change in cropping pattern (from water-intensive crops to water-saving crops) in Mylaram Village. The project was also successful in building a community level institution, called Water Resources Committee, in CR Pally, which took up the agenda of groundwater management and regulation. From 2009, electricity efficiency measures such as formation of Distribution Transformer (DT) level farmers groups; installing capacitors on all pump-sets; and regularizing unauthorized electric connections to agricultural pump-sets helped to reduce low voltages at pump-sets, and contributed to reduction in motor burnouts in project villages.

***iii) Andhra Pradesh Drought Adaption Initiative Project (APDAI)***

The APDAI pilot project is being implemented in two phases due to different modes of financing. Phase I of the pilot program (April 2006 - June 2007), financed by a World Bank-executed trust fund, initiated activities in six villages in three Mandals of Mahbubnagar District. Phase II of the pilot implementation was started in November 2007 and the project was expanded into an additional nine villages in Mahbubnagar District and initiated activities in 10 new villages in Anantapur District. In addition, there is an option to pursue pilot initiatives outside the 10 selected villages in Anantapur. The implementation of the APDAI Phase II is being supported by the Japan Policy and Human Resources Development (JPHRD), the Climate Change Initiative Grant (CCIG), and the World Bank. The pilot activities are implemented by the Society for Elimination of Rural Poverty (SERP) in collaboration with District Collectors in the pilot districts, and under the oversight of the Principal Secretary, Department of Rural Development (DoRD) through the Office of the Commissioner, Rural Development.

The drought adaptation pilot is rooted in the strength of the CBOs and is implemented by the federation of women SHGs (*Mandal Mahila Samakhyas* - MMSs) in convergence with various Government departments. The pilot initiative relies on pooling existing experience and expertise of NGOs, research institutes, and CBOs into a consortium of supporting agencies led by WASSAN to facilitate the action research on the ground. As part of APDAI initiatives, a new approach was introduced to secure rain-fed crops through sharing groundwater for critical irrigation, and involving communities for management by developing social regulations. WASSAN is the lead technical agency for this pilot.

The APDAI approach of community groundwater management aimed at two shifts:

1. From individual farmer approach to area-based approach for irrigation; and
2. From groundwater as private property to groundwater as common property.

It aimed at building a case for enabling policy support and investments on critical/ protective irrigation and water sharing, focusing on rain-fed farmers. The envisaged model included an approach to facilitate a common understanding between owners and non-owners of borewells, to share the groundwater. It also provided for incentivising for sharing and initiating social regulation for controlling the competitive digging of borewells. Further, farmers were supported with pipeline networks for transportation of water to rain-fed farms and linkage with micro-irrigation systems that contribute to maximize the groundwater use efficiency. The pilot was taken up during 2006-07, initially in Chellapur Village of Mahbubnagar District. Later it was extended to eight villages in Mahbubnagar, Anantapur and Ranga Reddy districts. The main objectives of the initiative include:

- Stopping the competitive digging of borewells ;
- Providing access to the groundwater for rain-fed crops for protective/critical irrigation, which improves their productivity;
- Reducing water loss by adopting effective irrigation systems and methods;
- Reducing the cultivation of water-intensive crops (paddy) under borewells and motivating the farmers for alternative crops to improve water productivity;
- Enabling village level institutions for Community Managed Groundwater Regulations, including monitoring of groundwater level and bore well yields;
- Improving the groundwater recharge, in the long run through convergence; and
- Ensuring food and fodder security for household needs.

*Implementation Process*

The process is initiated with participatory analysis of agriculture under rain-fed conditions and the need for protective irrigation in order to make crop production viable. These exercises are usually carried out with the entire village and also with farmers in small groups. Area-based approach involves organising farmers under Common Interest Groups (CIGs) for a rain-fed patch. In each patch, well owners are convinced to share their water with the surrounding farmers. Once consensus is reached on water regulations and sharing the cost of pipeline installation, an agreement on groundwater regulation is signed by all the farmers in the patch in the presence of a *Tahsildar* on a bond paper for Rs.100.

As per the agreement, all the borewells will be pooled through a common pipeline network and water will be shared among all, irrespective of ownership. No new borewells will be dug for at least the next 10 years. The cropping pattern will be decided on the basis of crop plans linked to the availability of water in agreement with members of the CIG while giving priority to food and fodder crops and a reduction in the area under paddy. One bore well a day will be rested on rotation, thus reducing water pumping by about 20 per cent. While water is shared to protect the Kharif crop of non-owners, the acreage of bore well-owning farmers is ensured; and a general fund is created for the maintenance of pipeline, repairs, etc., within the CIG.

The water from the borewells of the farmers willing to share is interconnected to one main pipeline, which is distributed to the identified rain-fed patch of land. This involves:

- Preparation of a pipeline network plan:
  - o Identification of bore well points;
  - o Levelling survey using hydrometer for main pipeline, sub-lines and outlets;
  - o Plot-wise area measurement and location of pipeline on the field; and
  - o Preparation of a detailed map showing the individual plot and total patch area boundaries and the pipeline network.
- Preparation of pipeline design and detailed estimation of the pipeline network
- Work Execution:
  - o Calling quotations from reputed PVC companies;
  - o Placing a work order to the short-listed company; and
  - o Execution of work by CIGs and *Grama Samakhyas*, with the support of WASSAN.
- Evolving crop planning and regulation mechanisms:
  - o Restriction of water-intensive crop area for each farmer owning borewells;
  - o Forming outlet-wise groups for water use;
  - o Appointment of one or two persons for water distribution;
  - o Formation of water regulation committee at village level;
  - o Outlet-wise scheduling of water distribution at the time of critical irrigation; and
  - o Developing a common fund for pipeline maintenance by collecting water charges from the water users of the pipeline network.

As there was no threat of new borewells in the vicinity that may lead to the drying of their own bore well, the farmers agree to pool their borewells and share the water. This would avoid competitive bore well digging, unnecessary investments, and loss of capital. The bore well owner is assured of earlier cropped area but with less water-requiring crops. The water thus saved will provide critical irrigation to a rain-fed patch, which includes lands of both bore well owners as well as others. If any one of the borewells fails, there is a back up arrangement as they are pooled. There was also motivation in terms of getting access to micro-irrigation system (sprinklers and drips) at subsidy, through linkage with the Andhra Pradesh Micro-Irrigation Project (APMIP). This was intended to increase the groundwater use efficiency. The APDAI has also extended up to 90 per cent support for pipeline network required for water sharing.

*Impact of the Pilot*

- Able to provide protective irrigation for selected rain-fed patches in the pilot villages;
- Ensured timely sowing, especially during delayed monsoons (because of assured water supply);
- Increase in cropped area under the pooled borewells ;
- Incremental returns on crop yield;
- On an average, about 25 to 30 per cent of the pumping hours were saved through resting of wells, resulting in saving both the groundwater and power consumption;
- Micro-irrigation system and pipelines have reduced the labour time for irrigating the crop (seven hours to one hour). It also increased water use efficiency;
- Arresting competitive digging of borewells.

*Experience in Gorantlavaripalle:*

Gorantlavaripalle in Nallacheruvu Mandal has 113 families and the total cultivated area is 270 acres. There are 26 borewells, 60 families having irrigated lands, and 40 families without any source of irrigation. Normally, paddy is cultivated under bore well irrigation. Farmers with borewells also have dry-lands, which are at a distance of more than one kilometre from the borewells, while farmers without any water source have lands nearer to the borewells.

To facilitate groundwater sharing, all the farmers in the village were organized into five groups, based on the contiguity of the land. Thus, the village area was divided into five blocks. Each block consists of farmers with and without wells. All the groups passed a resolution agreeing to network the 26 borewells through a single pipeline. The farmers in their groups identified those with water and without water and came to an agreement regarding who would share water with whom. A committee was formed with two representatives from each group (one with water source and the other without water source) and a representative from the Village Organisation (VO). Based on the agreement, WASSAN facilitated the MMS to undertake the following surveys:

i. Ground levelling survey - This was completed in October, 2008;

ii. Pumping water level - This was completed in November, 2008;

iii. Static water level survey, and

iv. Discharge measurement

The last two surveys should be done once in a month. After the above surveys, a plan and a budget estimate were prepared for networking the borewells and distribution pipes. They also framed norms and regulations and signed the agreement, with the *Tahsildar* as a witness, on a Rs.100 stamp paper. The plan and estimates were discussed in a meeting organized by the MMS. It was estimated that the cost of networking and distributing water to dry-land crops would cost about Rs.8 to 12 thousands per acre. Based on the discussions in the MMS, it was proposed that the cost should be shared in the following proportion: 25 per cent as initial farmer's share; 25 per cent as subsidy from the programme; and 50 per cent as loan to the farmer (either from bank or the VO).

However, farmers conveyed their inability to bear these costs due to frequent droughts in the recent years. A meeting was organized in the village in June, 2009 with the farmers, staff of MMS, WASSAN, and the Project Directors of District Water Management Agency (DWMA) and District Rural Development Agency (DRDA). It was agreed that farmers would first pay a membership fee of Rs.1000 per acre and another Rs.1000 per acre after obtaining the crop yields. The canal digging work was initiated in July, 2009, and was completed in December, 2009.

All the farmers under the bore well network prepared a crop plan for *Kharif*, 2010. They agreed to decrease the area under paddy and other water-intensive crops, such as sugarcane, under the borewells. For efficient functioning of the networking system they agreed to appoint one *Neerugatti* (waterman) with the following responsibilities:

1. Encourage every farmer to take up crop cultivation;
2. Inform the farmers about their turns for water sharing;

3. Collect annual fees of Rs.1000 per acre after the yields are obtained;
4. Out of the amounts collected the share of the waterman is 20 per cent and the remaining 80 per cent is allocated for repairs and maintenance - this amount is deposited into the bank account of the committee; and
5. Bring at once to the notice of the committee members regarding leakages and repairs.

## V Community Based Groundwater Management: A Comparative Assessment

In this section we assess the impact of the CBGM institutions at the household level. This is based on the quantitative and qualitative data collected from the sample households from the sample villages. Impact assessment is carried out at the two levels, viz. well owners and water-sharing farmers across farm sizes. Impacts are assessed not only between different types of institutions but also with and without institutions, i.e., using the control village. Three indicators, viz. access to irrigation, access to critical irrigation, and moving towards less water-intensive crops are assessed. Besides, awareness and perceptions of the farmers regarding the role and effectiveness of the institutions is also gauged.

Access to irrigation has gone up in all the sample villages, including the control village. It may be noted that the sample households include only those farmers having wells or those sharing water from well owners and hence, the proportion of area irrigated is on the higher side. The increase is the highest in the control village at 213 per cent (Table 9). The difference between the control and other sample villages is that the increase in area under irrigation is mainly through sharing of wells in the villages with institutional arrangements while in the control village, irrigation under own wells has gone up substantially. Across the size classes, increased access to irrigation is more among marginal and small farmers in three of the sample villages, including the control village (Table 10). On the other hand, the large farmers gained more in the case of Thaticherla Village where APFAMGS is working. It may be noted that water sharing is neither new nor attributed to the groundwater institutions alone, and sharing has been practiced in all the sample villages prior to the advent of these institutions. Even in the control village, well sharing has been practiced, though on a limited scale between relatives, in the recent years. The role of institutions becomes clear in terms of other impacts such as reduction in individual wells, availability of critical irrigation and reduction in the cultivation of water-intensive crops.

**Table 9: Changes in Percentage Area under Well Irrigation by Well Status**

| Status | Thaticherla (APFAMGS) | | | Madirepalli (SRWM) | | | Gorantlavaripalle (APDAI) | | | Rajupalem (Control) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | O | WS | All | O | WS | All | O | WS | All | O | WS | All |
| Before | 56 | 30 | 49 | 49 | 8 | 31 | 77 | 18 | 59 | 32 | 0* | 22 |
| Present | 76 | 83 | 78 | 60 | 63 | 62 | 92 | 64 | 83 | 66 | 77 | 69 |
| % Change | 36 | 176 | 59 | 22 | 688 | 100 | 19 | 255 | 41 | 138 | --- | 213 |

*Note:* *Though there was the practice of sharing wells before 2004, there was no area covered as the groups became defunct, consequent to the drying up of wells. Hence, the changes are not entirely due to increased well-sharing activity; instead it is due to the revival of borewells under water sharing.

*Source:* Field Survey.

**Table 10: Changes in Percentage Area under Well irrigation by Farm Size**

| Status | Thaticherla (APFAMGS) | | | Madirepalli (SRWM) | | | Gorantlavaripalle (APDAI) | | | Rajupalem (Control) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | MF | SF | LMF | MF | SF | LMF | MF | SF | LMF | MF | SF | LMF |
| Before | 50 | 62 | 25 | 25 | 39 | 30 | 8 | 66 | 80 | 17 | 14 | 41 |
| Present | 79 | 79 | 75 | 70 | 58 | 59 | 69 | 85 | 90 | 73 | 69 | 66 |
| %Change | 58 | 27 | 200 | 180 | 49 | 97 | 763 | 29 | 13 | 329 | 393 | 61 |

*Source:* Field Survey.

The number of households sharing water has gone up in all the sample villages (Table 11), and the increase is substantially higher among the villages with groundwater institutions than in the control village. On the other hand, the number of wells almost doubled in the control village as against the moderate increase in the institutional villages. The number of functional wells has also gone up in all the sample villages. This could be due to the better rainfall conditions after 2004 when compared to severe drought conditions (three successive droughts) between 2001 and 2004. Most of the dug wells dried up during this period and a few of them revived after 2004. More importantly, investments in new wells is marginal in the sample villages where social regulation is in place (Madirepalli and Gorantlavaripalle), whereas in the case of APFAMGS village (Thaticherla), the number of borewells has gone up by 20 per cent, as there is no regulation.

Table 11: Changes in Access to Wells and Access to Water

| Village | Total No. of HHs (Population) | Period | Water Sharing HHs | Area under Paddy (acres) | Area under Irrigation (Acres) | Source of Irrigation | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Dug Wells | | Borewells | |
| | | | | | | No. | Area (acre) | No. (acre) | Area |
| Thaticherla | 265 (1155) | B | 45 | 132 | 168 | 24 (0) | 0 | 30 (15) | 38 (22) |
| | | A | 148 | 55 | 329 | 24 (0) | 0 | 36 (31) | 159 (48) |
| Madirepalli | 173 (725) | B | 8 | 180 | 254 | 59 (2) | 4 | 75 (53) | 200 (79) |
| | | A | 78 | 50 | 491 | 59 (4) | 16 | 79 (69) | 390 (79) |
| Gorantlavaripalle | 113 (487) | B | 10 | 128 | 140 | 34 (0) | 0 | 82 (40) | 90 (64) |
| | | A | 42 | 80 | 188 | 34 (0) | 0 | 84 (46) | 138 (73) |
| Rajupalem | 374 (1414) | B | 25 | 150 | 199 | 9 (6) | 14 | 40 (35) | 95 (48) |
| | | A | 44 | 150 | 249 | 9 (4) | 8 | 79 (62) | 150 (60) |

*Note:* Figures in brackets are functional wells and percentage of area in the case of area.
*Source:* Field Survey (PRA/FGD Methods).

Improved groundwater conditions in the sample villages under groundwater institutions are also evident from the availability of irrigation during critical periods. The number of farmers reporting availability of groundwater during critical periods has gone up in all the institutional villages, while the number has gone down in the control village (Table 12). However, this is limited to well owners in two of the villages. In the case of Gorantlavaripalle (APDAI), even the well-sharing farmers have reported that they have received critical irrigation. The marginal and small farmers are the main beneficiaries in terms of receiving critical irrigation in the institutional villages (Table 13), whereas in the control village, the proportion of marginal and small farmers receiving critical irrigation has come down. This indicates that groundwater institutions have improved the source sustainability and helped in protecting the crops to a large extent. This would have been possible due to the reduction in the area under water-intensive crops (paddy) in two of the institutional villages (Table 14). However, the APFAMGS village, along with the control village, reported an increased area under paddy. The reduction in area under paddy in the institutional villages is more among large farmers, while the increase in area under paddy is more among marginal and small farmers (Table 15). This is mostly compensated by groundnut crop. In all the sample villages, no crop area has declined substantially. The decline is more in the villages with social regulation. This reflects the improved access to critical irrigation. In the absence of any social regulation, the farmers do not seem to follow conservation methods, though they tend to reduce their risk of investing in new borewells as they are familiar with the groundwater situation due to the interventions of the APFAMGS.

**Table 12: Availability of Irrigation during Critical Periods of Crop Growth by Well Status**

**(Percentage of Farmers)**

| Availability/ Status | Thaticherla (APFAMGS) | | | Madirepalli (SRWM) | | | Gorantlavaripalle (APDAI) | | | Rajupalem (Control) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | O | WS | All | O | WS | All | O | WS | All | O | WS | All |
| Before | 23 | 0 | 14 | 0 | 0 | 0 | 60 | 28 | 51 | 34 | 0 | 23 |
| Present | 36 | 0 | 22 | 10 | 0 | 50 | 77 | 67 | 74 | 20 | 0 | 13 |
| % Change | 60 | - | 60 | - | - | - | 29 | 140 | 46 | -43 | - | -43 |

*Source:* Field Survey.

**Table 13: Availability of Irrigation during Critical Periods of Crop Growth by Farm Size**

**(Percentage of Farmers)**

| Availability/ Status | Thaticherla (APFAMGS) | | | Madirepalli (SRWM) | | | Gorantlavaripalle (APDAI) | | | Rajupalem (Control) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | MF | SF | LMF | MF | SF | LMF | MF | SF | LMF | MF | SF | LMF |
| Before | 18 | 10 | 0 | 0 | 0 | 0 | 0 | 56 | 67 | 27 | 32 | 0 |
| Present | 27 | 20 | 0 | 17 | 75 | 50 | 50 | 79 | 67 | 5 | 16 | 21 |
| % Change | 50 | 100 | 0 | - | - | - | - | 41 | 0 | -83 | -50 | - |

*Source:* Field Survey.

The perceptions of the farmers in the institutional villages indicate high awareness about the institutions (Table 16). While the membership is limited to well owners in the case of APFAMGS villages, even the well-sharing farmers are members in the other two villages. As a result, institutional membership is quite low in the APFAMGS village. However, in all the villages, most of the sample farmers participate in the field or farmer schools (Table 16) - participation rates range between 73 and 100 per cent among sample villages. On the other hand, participation in crop water budgeting is as low as 40 per cent in the APDAI village (Gorantlavaripalle). It was observed that all the farmers who participated in crop water budgeting exercise followed the recommendations in the social regulation villages while fewer farmers followed the recommendations in the APFAMGS village.

Table 14: Shifting away from Paddy Crop by Well Status (% Area)

| Crops/ Status | Thaticherla (APFAMGS) | | | Madirepalli (SRWM) | | | Gorantlavaripalle (APDAI) | | | Rajupalem (Control) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | O | WS | All | O | WS | All | O | WS | All | O | WS | All |
| **Before** | | | | | | | | | | | | |
| No Crop | 11 | 9 | 10 | 13 | 61 | 34 | 13 | 29 | 18 | 13 | 32 | 19 |
| Paddy | 11 | 4 | 9 | 63 | 4 | 38 | 23 | 4 | 17 | 14 | 0 | 10 |
| Groundnut | 7 | 4 | 6 | 24 | 35 | 29 | 29 | 46 | 34 | 11 | 0 | 8 |
| **After** | | | | | | | | | | | | |
| No Crop | 9 | 9 | 9 | 5 | 2 | 4 | 3 | 0 | 2 | 14 | 12 | 13 |
| Paddy | 16 | 22 | 18 | 17 | 4 | 12 | 21 | 4 | 16 | 19 | 6 | 15 |
| Groundnut | 7 | 0 | 5 | 65 | 94 | 78 | 37 | 71 | 48 | 4 | 3 | 4 |
| **% Change** | | | | | | | | | | | | |
| No Crop | -17 | 0 | -12 | -63 | -97 | -89 | -75 | -100 | -88 | 10 | -64 | -29 |
| Paddy | 50 | 400 | 100 | -73 | 0 | -69 | -7 | 0 | -7 | 36 | 0 | 55 |
| Groundnut | 0 | -100 | -20 | 173 | 171 | 172 | 28 | 54 | 39 | -67 | 0 | -56 |

*Source:* Field Survey

Table 15: Shifting away from Paddy Crop by Farm Size (% Area)

| Crops/ Status | Thaticherla (APFAMGS) | | | Madirepalli (SRWM) | | | Gorantlavaripalle (APDAI) | | | Rajupalem (Control) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | MF | SF | LMF | MF | SF | LMF | MF | SF | LMF | MF | SF | LMF |
| **Before** | | | | | | | | | | | | |
| No Crop | 13 | 4 | 13 | 50 | 19 | 36 | 38 | 15 | 10 | 30 | 18 | 9 |
| Paddy | 8 | 13 | 6 | 15 | 55 | 36 | 0 | 16 | 40 | 3 | 12 | 13 |
| Groundnut | 13 | 0 | 0 | 35 | 26 | 28 | 62 | 31 | 20 | 3 | 6 | 16 |
| **After** | | | | | | | | | | | | |
| No Crop | 11 | 13 | 0 | 5 | 10 | 0 | 0 | 3 | 0 | 13 | 14 | 13 |
| Paddy | 24 | 17 | 6 | 10 | 16 | 10 | 0 | 16 | 30 | 10 | 14 | 22 |
| Groundnut | 8 | 0 | 6 | 75 | 68 | 84 | 92 | 40 | 40 | 3 | 4 | 3 |
| **% Change** | | | | | | | | | | | | |
| No Crop | -20 | 200 | -100 | -90 | -50 | -100 | -100 | -80 | -100 | -56 | -22 | 33 |
| Paddy | 200 | 33 | 0 | -33 | -71 | -73 | 0 | 0 | -25 | 200 | 17 | 75 |
| Groundnut | -40 | 0 | 0 | 114 | 162 | 200 | 50 | 29 | 100 | 0 | -33 | -80 |

*Source:* Field Survey

Table 16: Farmers' Perceptions on Community Based Groundwater Management

| Awareness on Groundwater Management Practices | Details of Perceptions | Thaticherla (APFAMGS) | | | Madirepalli (SRWM) | | | Gorantlavaripalle (APDAI) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | O | WS | All | O | WS | All | O | WS | All |
| APFAMGS/ SRWM/APDAI | Awareness | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| Membership | Yes | 35 | 0 | 19 | 93 | 94 | 94 | 76 | 92 | 83 |
| Participated in FFS | Yes | 100 | 79 | 90 | 100 | 100 | 100 | 82 | 62 | 73 |
| Benefits derived | Awareness on crops | 100 | 71 | 87 | 100 | 100 | 100 | 82 | 77 | 80 |
| | Groundwater methods | 71 | 71 | 71 | 100 | 100 | 100 | 82 | 69 | 77 |
| | Groundwater awareness | 100 | 100 | 100 | 100 | 100 | 100 | 94 | 77 | 87 |
| | All of the above | 90 | 81 | 86 | 100 | 100 | 100 | 86 | 74 | 81 |
| Reasons for not participating | No tangible benefit | 59 | 86 | 71 | 33 | 38 | 35 | 59 | 85 | 70 |
| | Not feasible | 41 | 36 | 39 | 7 | 6 | 6 | 41 | 62 | 50 |
| | Personal reasons | 6 | 7 | 6 | 0 | 0 | 0 | 12 | 15 | 0 |
| Participated in crop-water budgeting | Yes | 100 | 43 | 74 | 100 | 100 | 100 | 65 | 8 | 40 |
| Followed recommenda-tions | Yes | 82 | 29 | 58 | 100 | 100 | 100 | 65 | 8 | 40 |
| Benefits from groundwater management | Yes | 100 | 57 | 81 | 100 | 100 | 100 | 100 | 100 | 100 |
| | Conduct of FSS/ FWS/CWB | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| | Management of groundwater | 88 | 86 | 87 | 100 | 100 | 100 | 82 | 85 | 83 |
| | All of the above | 96 | 95 | 96 | 100 | 100 | 100 | 94 | 95 | 94 |
| Reasons for lack of benefits | Institutions play only advisory role | 18 | 29 | 23 | 100 | 94 | 97 | 18 | 77 | 43 |
| | Farmers not followed GMC's suggestions | 82 | 71 | 77 | 0 | 6 | 3 | 82 | 23 | 57 |

*Source:* Field Survey

Hence, the number of farmers growing paddy has increased in some cases, while in others, a decline was noticed. It is observed that a large number of farmers have started growing groundnut in Madirepalli.

The main benefits perceived due to the institutions are awareness about groundwater, followed by crop methods, and groundwater irrigation methods (Table 16). Among the reasons for non-participation is the absence of tangible benefits followed by non-feasibility. While 70 per cent of the non-participating farmers felt that there are no tangible benefits in the APFAMGS and APDAI villages, only 35 per cent of the farmers perceived this reason in the case of SRWM village (Madirepalli). This perception is greater among the well-sharing farmers when compared to the well owners. Similarly, 81 per cent of the sample farmers in the APFAMGS village have endorsed the benefits from groundwater institutions, while 100 per cent agreed about the benefits in the other two villages. Lack of benefits is attributed to the reason that farmers do not follow the suggestions of the management committee, as the institutions play only an advisory role. However, the sample farmers in APFAMGS and APDAI villages perceive that the advisories are being followed or adopted.

Overall, the performance in terms of physical indicators and farmers' perceptions appears to be better in case of Madirepalli Village (SRWM) where social regulation is in place; while the performance of APFAMGS where there is no regulation seems to be poor. The APFAMGS initiative is the oldest among the three models. In fact, during the field work, the APFAMGS interventions were terminated, as the NGOs were waiting for the extension of the project. Hence, the poor performance of APFAMGS raises the issue of institutional sustainability (Reddy *et al.*, 2011), and this is applicable even for the other two initiatives. The difference between the other two initiatives is that the APDAI initiative is backed by the DoRD, while the SRWM is NGO-driven. The better performance of SRWM could be due to the intensive approach it has adopted in promoting water sharing - it has taken almost three years to organise the farmers and build awareness before initiating the well-sharing process. Besides, the SRWM worked with small groups of well-owning and well-sharing farmers, whereas the groups were bigger in the area-based approach followed by the APDAI.

## VI Lessons for Up-Scaling

AP, arguably, has more experience in promoting community-based water management than any other Indian state. Even in the case of groundwater management, AP is the first state in the country to introduce community-based management way back in the 1990s. Unlike in the case of surface water, canals or tanks, there is no evidence of in situ institutional innovations in the case of groundwater. This is mainly due to the existing private (*de facto*) property rights on groundwater. Though these initiatives under study are still at a pilot stage, they can provide valuable insights for designing appropriate policies. However, the potential for up-scaling is linked to the specific hydro-geological and socio-economic settings and hence needs region-specific or flexible approach. Here we assess the strengths and weaknesses of the three institutional approaches and explore the possibilities for scaling up or policy lessons for bringing groundwater under community management.

The three models considered here have the common goal and objective of sustainable groundwater management. All the three institutions are led by NGOs with support from different agencies including the State Government. However, the approaches followed and the implementation modalities are different and can be grouped as: i) knowledge intensive; and ii) social regulation. These approaches have their advantages as well as disadvantages in terms of achieving their objectives and the sustainability of the initiatives (Table 17).

*i) Knowledge-based Approach*

The APFAMGS initiative is based on the principle of demystifying science through enhancing the capacities of the communities in terms of their skills and scientific knowledge. The focus is on facilitating or making communities assess the groundwater potential at the village level and estimating the available water before each crop season. These estimates are integrated at the hydrological unit level, providing the much needed scientific scale for assessing the groundwater. At the same time, the scale at which observation wells are monitored (village level) is more appropriate to the communities. For, official groundwater assessment is made based on the observation wells located at the Mandal (more than 30 villages) level and does not reflect the situation at the village level. Crop water budgets are prepared by the communities at the village level and the suggested cropping pattern for the season is provided (based on the groundwater availability) to the community. These details are shared across the villages within the hydrological unit.

The "do-it-yourself" approach with relatively better scientific or technical inputs has clearly improved the awareness of the well owners. The initiative is highly successful in demystifying science and needs to be considered at the policy level to promote institutional linkages for generating such information at the village level. While such an awareness has helped in checking further expansion of groundwater development, i.e., new wells, it has failed to encourage other conservation practices such as increased investments in recharge structures or equity by sharing the water with un-irrigated farmers. Though our sample village does not provide any evidence on the reduction in water-intensive crops (paddy), it has been achieved in other places (Reddy, 2012). The limited impact is mainly due to the reason that neither social regulations are imposed, nor economic incentives are provided, for adopting such measures. In fact, the farmers feel that the APFAMGS merely plays an advisory role without any incentives or disincentives to follow the advisories. The result is a lot of useful information generated at the appropriate scale, helping only the well-owning farmers while the farmers hitherto not having wells are dissuaded from digging new wells (through information-based awareness)-there is no incentive for them to support the initiative; in fact, they are not even members of the committee.

**Table 17: Features of the Three Institutional Models**

| Features | APFAMGS | SRWM | APDAI |
|---|---|---|---|
| Initiative (funding) | External (FAO) | External (AEI, Luxembourg) | State Government (DoRD) |
| Implementation | NGOs (BIRDS) | NGOs (CWS+Partners) | Govt.+NGO (WASSAN+Partners) (*Mahila Samkhyas*) |
| Years of existence | 8 | 7 | 2 |
| Groundwater situation | Scarce | Scarce | Scarce |
| Project scale | Big (650 villages) | Small (19 villages) | Small (8 villages) |
| Key features | Information | Informal regulation | Formal regulation |
| Scale of operation | Hydrological unit | Vicinity of wells (within a village) | Area based on the wells (within a village) |
| Institutional approach | Influencing community through generation of intensive scientific information | Regulating community through awareness and incentives | Regulating community through semi-scientific information-based awareness and incentives |
| Operational modalities | All well owners with focus on information. Followed an extensive approach | Small groups of well owners and dry land farmers. Followed an intensive approach | Larger group of well owners and dry land farmers covering specific location. Focus on incentives |
| Farmers' contribution | NIL | 20 per cent towards micro irrigation | 75 per cent |
| Awareness on groundwater situation | High | High | High |
| Participation in management | Limited to well owners | High | High |

Contd..

Contd.. **Table 17**

| | | | |
|---|---|---|---|
| Practicing recommendations | Moderate | High | Low |
| Key to success | Professional approach | Leadership and incentives | Incentives |
| Impacts on access to water | Moderate | High | Moderate |
| Nature of key impact | Reduction in over exploitation of groundwater | Conservation of water and sharing of water | Conservation and sharing of water |
| Impact on equity | No | Yes | Yes |
| Scalability | Good | Poor | Moderate |
| Sustainability | ? | ? | ? |

*Source:* Field Survey (PRA/FGD Methods) and Reports

Our qualitative research indicated that farmers are very much interested in having institutional arrangements in the lines of APFAMGS for managing groundwater. However, sustainability of the APFAMGS initiative is a big question mark in the absence of linkages with formal institutions, and policy or legislative backing of the movement[8]. Moreover, the exit protocol is not clearly defined. In a number of villages, the activities of the APFAMGS came to a standstill during the two years' gap (2009-11), due to the delay in the extension of the project. One suggestion made by the farmers in this regard is to bring the initiative under the groundwater department's purview so that the process would go on in the long run (Reddy *et al.*, 2011).

***ii) Social Regulation Approach***

The other two models, viz. the SRWM and APDAI, have adopted social regulation to manage groundwater. Though awareness building and data generation by the village communities are important components, the process is not so systematic. The most important aspect of these two models is to bring consensus among the communities to share water between well owners and others. Incentives such as reduced risk of well failure as no new wells are allowed, subsidies for micro irrigation, provision for protective irrigation to the dry plots of the well owners, and the irrigation backup they get in the event of well failure, are put in place. Besides, there is provision for water harvesting structures to increase recharge, and distribution losses are reduced through pipeline supply of water and increased water use efficiency through promotion of micro irrigation (subsidies).

[8] Though HUNs are registered bodies and can take up activities like input procurement, output marketing, etc., they are yet to be functional in these activities.

Social regulation appears to be effective in terms of stopping new borewells as well as a larger number of households, especially the marginal and small, benefiting from sharing water with well owners. This not only helped in increasing the cropped area, but also provided protective irrigation to a number of plots during critical periods, thus saving the crops. This also resulted in equity in the distribution of water and overall improvement in welfare. However, there are differences between the two models of social regulation in terms of their effectiveness: the SRWM appears to be more effective when compared to APDAI. One reason could be that the SRWM is older, followed an intensive approach, and worked with smaller groups of farmers compared to the APDAI initiative. Though APDAI mostly follows the SRWM approach, it has adopted a broader (area-based) and formal approach involving the department. Besides, groundwater management is one of the pilots under the APDAI and hence, there are chances of dilution as far as the departmental involvement is concerned.

Despite the formal approach, participation and rule following is limited in the APDAI. People indicated that there are no tangible benefits from the initiative, and 50 per cent of the farmers felt that the institutional arrangements are not feasible. This view is more conspicuous among those sharing wells. This sceptical nature could be due to the larger contribution (75 per cent) from the farmers, which is substantial (total costs are Rs.8 to 10 thousand per acre). On the other hand, the approach of peoples' contribution could provide the much needed ownership and sustainability[9]. It is observed that the formal process of entering an agreement with the witness of the *Tahsildar* has also discouraged some villages from joining the initiative.

The formal approach of APDAI appears good on paper, as it follows an integrated approach of drought adaptation. The integration also involves various departments such as rural development, groundwater, agriculture, etc., but the feasibility of such integration is doubtful. The approach involves the existing institutions such as the *Mahila Samakhyas*, which provide the assurance of sustenance in the medium run at least. However, at the same time, there is also a danger of acquiring the stamp of a Government programme where people look for freebies rather than regulation and contribution.

On the whole, the social regulation approach seems to work better for sustainable groundwater management when compared to the knowledge intensive approach. Water use and sharing through regulation has increased the area under protective irrigation in an equitable manner.

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[9] Of late people's contribution in Government programmes has lost its importance, as people are increasingly considering Government programmes as welfare measures rather than developmental. Hence, their contribution is treated as negative rather than as ownership

The knowledge intensive approach is not designed to address equity. In the absence of any regulations, formal or informal, the farmers do not have any incentive to follow the good practices in the given policy environment. Encouraging sharing of water between well owners and others would result in achieving the twin objectives of conservation and improved access with equity. How to attain this on scale needs serious consideration at the policy level.

Sustainability of these initiatives is a major concern in all the approaches. None of the approaches have a well-defined exit protocol, while the APDAI appears to be well placed in this regard as its process involves a number of departments and formal institutions. At the same time, it requires strong leadership at the village level to implement and take the initiative forward, especially in the context of peoples' contribution. In the case of SRWM, its present success is mainly due to the commitment of NGO partners in the absence of any contribution from the farmers. Besides, in the absence of contribution, the financial sustainability of the initiatives would be a big concern, especially once the external funding stops. The weak sustainability of APFAMGS initiative was already evident during the no fund phase. Hence, fund flows appear to be critical for the success of the initiatives. The initiatives may continue in some of the villages due to strong leadership and commitment of the local NGOs even beyond the present funding, as they are at a smaller scale. Thus, scaling up these initiatives requires much more planning and designing.

***Limitations of these Models***

All these models suffer from limited scientific knowledge application at the ground level. The APFAMGS, which focuses on "demystifying" science, does not follow a rigorous scientific approach towards groundwater recharge and balance estimation, water budgeting based on crop water requirement, etc. Similarly, the well-sharing and social regulation models do not integrate technical inputs for estimating the groundwater availability. Moreover, they do not consider scale impacts at a watershed or basin scale, as the positive impacts observed in the study locations may be causing negative impacts downstream. Unless the impacts are considered at a scale of a hydrological unit, it is difficult to assess the real impacts.

Due to the short duration of these interventions, we are not able to provide hard core evidence to support some of the impacts that are measured in terms of farmers' perceptions. In the absence of long term data, the issue of attribution is also a problem. The changes in groundwater balance could be due to rainfall and other climatic fluctuations. Therefore, it is necessary to keep these limitations in view while considering scaling up of these initiatives.

*Policy Directions for Scaling Up*

The assessment of the three models indicates that CBGM is neither simple nor easily forthcoming. It calls for a lot of effort, working through complex rural dynamics at various levels. The reason is that appropriate policies to support or encourage such initiatives are not in place. Often, the existing policies work towards achieving opposite objectives rather than going in tandem with the participatory initiatives. The three approaches have proved that communities are capable of managing groundwater in a sustainable manner. The communities are also capable of understanding and using the technical aspects of hydro-geology. However, since groundwater is widely considered as a private property, there are no incentives for managing it at the community level. Furthermore, there are no economic incentives or disincentives for managing groundwater in a sustainable manner. Hence, unless wide-ranging policy changes are brought in, these initiatives remain as models rather than being adapted at a wider scale. Creating demand for these initiatives is as important as demand management of groundwater, and the demand management models cannot be effective as long as policy environment is supply-sided.

Some of the important policy interventions for promoting CBGM on a wider scale include:

- Need for dispelling the notion of groundwater as private property and making it a common property in the real sense. This calls for wide-ranging legislations and legal support.
- Establishing or moving towards community-based property rights on groundwater.
- Moving towards aquifer planning at the hydrological unit level to start with and then to watershed or river basin scale.
- Creating hydrological information at a much smaller scale appropriate for short-term farming decisions. This could be attained through creating low cost infrastructure at the village level and providing training at the local level to take up the responsibilities on a regular basis with the necessary economic incentives.
- Water sharing at the village level needs to be promoted as a first step in this direction. Existing wells could be linked and termed as common property.
- Incentives to conserve and manage water resources rather than exploit the resources such as free power and support prices for water-intensive crops like paddy.

- The present policy distortions of free power, and the input and output pricing policies need to be rationalised to match conservation objectives.
- Regulation through pricing is the most effective instrument, but is hardly adopted at the policy level. In the absence of realistic pricing, water use efficiency remains a dream.
- As long as water rights are linked to land, water sharing is the best option to achieve equity. Encouraging and strengthening the existing traditional group wells in AP through differential and higher incentives in electricity tariffs, subsidies for micro-irrigation kits, etc., would help improve the equity and sustainability of groundwater.
- Andhra Pradesh Water Land and Trees Act (APAPWALTA) bans drilling new wells in villages notified as over-exploited. The Government may encourage only new wells on group sharing basis in villages/micro-basins that are identified as critical and semi-critical with respect to groundwater development. Strengthening and enforcing the existing regulations like APWALTA could be a starting point in this direction.
- Delinking land and water rights need to be treated as an important policy goal, at least in the long run.

Thus, the experience of the three models reveals that wide ranging policy changes are required to scale up the achievements of these small scale initiatives. Replication of these models could be possible with high transaction costs, but the sustainability of these initiatives remains uncertain in the present policy environment.

The most important lessons from these models include:

i) creation of information at the appropriate scale through community involvement, and

ii) generating demand for demand management of groundwater with the help of this information.

However, the conclusions drawn here are based on the experience of a few villages and hence cannot be generalised. While these findings provide some insights, there is a need for better understanding of such initiatives through a large scale systematic research covering the existing initiatives across the country.

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