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Groundwater Governance: A Tale of Three Participatory Models in Andhra Pradesh, India

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ABSTRACT: This paper explores the possible options for community based groundwater management in India. 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. The paper assesses the operational modalities and the impact of these institutions on access, equity and sustainability of groundwater use using the qualitative and quantitative information from three sample villages representing the institutional models.

Social regulation approach is observed to work 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 benefits like increased area under protective irrigation. 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 contribute to achieving the twin objectives of conservation and improved access with equity. However, community-based groundwater management is neither simple nor easily forthcoming. It requires a lot of effort, working through complex rural dynamics at various levels, since appropriate policies to support or encourage such initiatives are not in place. It is argued that there is need for developing an integrated model drawing from these three models in order to make it more generic and applicable globally. Such a model should integrate scientific, socioeconomic and policy aspects that suit the local conditions.

KEYWORDS: Groundwater, governance, participatory management, social regulation, India

BACKGROUND

While groundwater is studied extensively in terms of its hydro-geology and socio-economic aspects, sustainable management of groundwater has received limited attention. Though the Approach Paper to India's 12th Plan recognises this importance, it fails to provide any plan of action due to the absence of any clear understanding of groundwater management. Recent policies like the model groundwater bill and cabinet approval of making groundwater as a common resource reflect the recognition of managing groundwater in a sustainable manner at the policy level. Sustainable groundwater management (SGM) is critical for food security and poverty alleviation (Shah, 2004). Groundwater irrigation is twice as efficient[1] as surface water irrigation in hydrological terms (m^3/ha) (Llamas and Martínez-Santos, 2005) and requires relatively smaller investment and shorter implementation periods when compared to surface irrigation systems (Valencia, 2004). Besides, it has a large number of inherent services including environmental services (Burke et al., 1999; Polak, 2004).

These virtues of groundwater in the absence of clearly defined property rights[2] have resulted in the sharp increase in groundwater use and over-exploitation (OE) as well as degradation of the resource (Moench, 1992; Bhatia, 1992; Dhawan, 1995). More importantly, there is a clear policy neglect of this important resource over the years. While surface water systems fall under the purview of public policy, groundwater systems are left to the purview of private individuals (Shah, 2009). In the absence of any control or regulation, groundwater has become one of most mismanaged resources globally. The spread of this uncontrolled exploitation has grown beyond public policy management in countries like India where the number of private bore wells has crossed 25 million and is growing, which is termed as 'anarchy' (Shah, 2009). Declining access to groundwater affects not only agricultural production but also education, health, gender, child mortality, poverty and hunger (Sharma, 2009). Overdraft is generally a by-product of population growth, economic expansion, distorting impacts of subsidies and financial incentives, in addition to the spread of energised pumping technologies (Burke et al., 1999). Although groundwater is not a scarce resource in all regions, lack of sustainable management of the resource is the crux of the problem (Burke et al., 1999).

Sustainable management of water 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 out of the public purview. Though the effectiveness and sustainability of canal and tank management institutions are being debated (Reddy and Reddy, 2005), the need for bringing groundwater under a common resource management regime cannot be underestimated. Hitherto groundwater management has been left to private individuals as it is perceived to have high transaction costs of organising individual farmers at a scale to attain the benefits of community management.

As observed in the literature, there appear to be some small-scale institutional innovations that are working towards sustainable management of groundwater in different corners of India (for a detailed review of Indian experiences see Reddy et al., 2012). However, these innovations are confined to small areas. Here we make an attempt to explore the possibilities for scaling up and drawing lessons from Community Based Groundwater Management (CBGM) by comparing three such models that are in operation in the Andhra Pradesh (AP) state in South India.

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

1. The Andhra Pradesh Farmer-Managed Groundwater Systems (APFAMGS), which have their origins in the APWELL Programme.

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[1] Here groundwater irrigation efficiency is defined in terms of reduced non-beneficial and non-recoverable fractions of water withdrawals as elaborated in Perry (2007).

[2] Since property rights on groundwater are linked to land ownership, only land owners benefit from these rights. The landless and even the land owners who are not capable of investing in exploiting groundwater tend to lose. The heterogeneity in the ownership of land as well as financial capabilities result in differences in the perception of the nature of property rights (i.e. private individual based or community based). Hence, there is no agreement on how to design most effective property rights for groundwater (Libecap, 1997; Reddy, 1999).

2. Social Regulations in Water Management (SRWM) by the Centre for World Solidarity (CWS) and its partner NGOs.
3. Collectivisation of bore wells under the Andhra Pradesh Drought Adaptation Initiatives (APDAI) programme being implemented by the Watershed Support Services and Activities Network (WASSAN) with its partner NGOs.

These initiatives have different origins and approaches to CBGM. The basic features of these models are presented in Table 1.

This paper explores the options for groundwater management in India and beyond with the help of the above three community-based groundwater management practices at the village level. The main focus of the study is to understand the functioning and efficacy of groundwater management institutions by comparing and contrasting these three participatory groundwater models in Andhra Pradesh (AP). This paper is organised into five sections. Section two presents the approach of the study in terms of describing the profile of the case study areas. Section three presents the three Community-Based Groundwater Management (CBGM) models in AP, while a comparative analysis of these institutions is taken up in section four. Finally, the last section draws lesson for scaling up.

Table 1. Community-Based Groundwater Management (CBGWM) models/programmes in Andhra Pradesh.

CBGW model	Description
APFAMGS (APWELL)	Dug new bore wells for a group of households (HHs) not having access to water, with clear sharing, groundwater monitoring, and water use efficiency measures. Limited to 'new unexploited' areas. APWELL has been transformed into the largest groundwater awareness programme in the state premised on: i) communities monitoring the groundwater status regularly with knowledge and scientific principles. ii) sharing knowledge of alternative crop systems and evolving *norms* for groundwater management (with facilitation).
SRWM (CWS and Partners Programme)	This programme was initiated on a limited scale and based on regulations: i) the community adopts a *norm* of 'no new bore-wells'. ii) increasing system efficiency through the provision of collective sprinkler irrigation sets. iii) bore-well owners share their water with neighbouring farmers, leading to a substantial reduction of the number of families in the village without water.
Collectivisation of bore wells: APDAI (of CRD, facilitated by WASSAN)	This initiative followed an 'area approach' for groundwater management where the bore well owners pool their individual bore wells 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: i) no new bore wells for at least 10 more years. ii) all the land within the specified area (including those without water) will have a right to supplemental irrigation for kharif rain-fed crops. iii) pipeline network is provided by the project so that water can be taken to any part in the block/area.

Source: Field study using participatory rural appraisal (PRA) /focus group discussion (FGD) methods.

APPROACH

As mentioned earlier, three community-based groundwater management (CBGM) practices have been selected for the purpose of comparative institutional assessment. Three villages, one village representing each of the three institutional models, were selected, where the community groundwater management practices have been adopted under different NGOs (Table 2). These sample villages were selected after visiting a number of villages in the operational areas of these three respective models. While sample of 1 out of 4 villages in the case of Social Regulations in Water Management (SRWM) and 1 out of 6 (first phase villages) in the case of Collectivisation of bore wells under the Andhra Pradesh Drought Adaptation Initiatives (APDAI) are representative, the representativeness of the sample of 1 out of 650 villages in the case of The APFAMGS is questionable. The reason for the small sample is that the APFAMGS has been widely studied though there are no systematic post-project evaluation studies (for instance see AFPRO, 2006; APFAMGS, 2006; FAO, 2010; Verma, et al., 2012; Reddy, 2012; Das and Burke, 2013). The one village sample is used for a systematic evaluation of the model with a focus on household perceptions and cross verification of the large- scale assessments. Care was taken to select a representative village from each of the three models to identify the common and comparable elements in the institutional arrangements and the processes.

Table 2. Details of the sample villages.

Village	Mandal	District	Groundwater model/ project	Implementing agency (NGO)	Year of project initiation	Stage of the project
Thaticherla	Komarolu	Prakasam	APFAMGS	DIPA (BIRDS)	2003-04	1st phase complete; 2nd phase ongoing
Madirepalli	Singanamala	Anantapur	CWS/ SRWM	Rural Integrated Development Society (RIDS) (CWS)	2003-04	Ongoing
Gorantla-varipalle	Nallacheruvu	Anantapur	WASSAN / APDAI	WASSAN/ Mandal Mahila Samakhyas (MMS)	2007-08	Ongoing

Emphasis was given to selected villages with successful implementation so as to assess the operational modalities and the impact of these institutions on access, equity and sustainability of groundwater use, when implemented under best conditions. In other words, the selection was purposive to remove poor implementation as a factor, so that the possible options for community-based groundwater management context can be explored. The selection of villages was informed by observations and qualitative discussions made during the preliminary visits. The opinions of the implementing agencies on appropriate fieldwork sites were also sought. Field research was conducted during February and March 2011.

The villages vary in size and socio-economic composition (Table 3). The geographical area of the villages ranges between 300 and 1900 hectares. Socially, one of the villages is dominated by 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 20% 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 3). Only Madirepalli Village has about 50% of the households from medium and large farmers. These variations help in understanding the dynamics of CBGM in varying socio-economic contexts. About 30 representative sample households were selected from each sample village. Though the sample of 30 allows some generalisations at the village level, the sample is not large enough to draw generic conclusions for the institutional model. Nevertheless, the sample helps to provide insights in terms of household perceptions and impacts.

Table 3. Socio-economic composition of the households in the sample villages.

District/Village/ Farm size	Social categories / No. of households			Total HHs	Sample HHs
	SC/ST	BC	OC		
Prakasam: Thaticherla					
Landless	10	30	5	45	0
Marginal farmers	38	100	3	141	19 (14)
Small-scale farmers	10	40	15	65	8 (12)
Medium-scale farmers	2	0	10	12	3 (25)
Large-scale farmers	0	0	2	2	1 (50)
Total	60[23]	170 [64]	35 [13]	265	31 (12)
Anantapur: Madirepalli					
Landless	2	6	1	9	0 (0)
Marginal farmers	26	8	9	43	5 (14)
Small-scale farmers	3	4	30	37	8 (22)
Medium-scale farmers	0	25	30	55	12 (22)
Large-scale farmers	0	7	22	29	5 (17)
Total	31[18]	50 [29]	92 [53]	173	31 (18)
Anantapur: Gorantlavaripalle					
Landless	7	0	0	7	0 (0)
Marginal farmers	19	20	5	44	8 (18)
Small-scale farmers	2	30	20	52	19 (37)
Medium-scale farmers	0	0	10	10	3 (30)
Large-scale farmers	0	0	0	0	0 (0)
Total	28 [25]	50 [44]	35 [31]	113	30 (27)

Source: Field study using PRA/FGD methods.

Note: SC=Scheduled Caste; ST= Scheduled Tribe; BC= Backward Caste; OC= Other Caste; HHs= Households.

Values within simple brackets indicate the % of sample farmers of HHs taken for the study. Values within square brackets indicate the respective percentages the social groups.

The extent and nature of access across the sample villages would highlight the differences in the functioning and performance of the institutions. All the sample villages depend on groundwater irrigation. The extent of irrigation area ranges between 15% in Gorantlavaripalle to 34% in Madirepalli (Table 4). On the other hand, more than 70% of the households in the sample villages have access to wells. Variations in the extent of irrigation could be due to the groundwater potential in the respective villages. Though only 15% of the households in Thaticherla own wells, 70% of them have access to groundwater through water sharing and community wells. It is observed that the SC/ST farmers and marginal- and small-scale farmers seem to depend more on sharing water, while a large proportion of the OC farmers and large-scale farmers have their own wells (Tables 5 and 6).

Table 4. Household access to groundwater in the sample villages.

Particulars	Thaticherla	Madirepalli	Gorantlavaripalle
No. of households	265	173	113
Average household size	4.4	4.2	4.3
Total geographical area (in ha)	1903	307	1064
Area under irrigation (%)	32	34	15
% of HHs with own wells	15	43	26
% of HHs sharing wells	46	45	40
% HHs depending on community wells	10	0	0
% of HHs with access to wells	71	88	87
Main occupation	Cultivation	Cultivation	Cultivation

Source: Field survey.

Table 5. 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			
	Own well	Water sharing	Community well	All
Prakasam: Thaticherla				
Scheduled Caste/Tribe	7 (1)	27 (4)	6 (1)	40 (6)
Backward caste	26 (4)	79 (13)	15 (2)	120 (19)
Other caste	6 (2)	16 (3)	5 (1)	27 (6)
Total	39 (7)	122 (20)	26 (4)	187 (31)
Anantapur: Madirepalli				
Scheduled caste/Tribe	3 (1)	14 (4)	0 (0)	17 (5)
Backward caste	18 (3)	26 (5)	0 (0)	44 (8)
Other caste	53 (11)	38 (8)	0 (0)	91 (19)
Total	74 (15)	78 (16)	0 (0)	152 (32)
Anantapur: Gorantlavaripalle				
Scheduled caste/tribe	2 (1)	5 (2)	0 (0)	7 (3)
Backward caste	15 (4)	27 (7)	0 (0)	42 (11)
Other caste	40 (12)	10 (4)	0 (0)	50 (16)
Total	57 (17)	42 (13)	0 (0)	99 (30)

Note: Figures in brackets indicate the number of sample groundwater farmer HHs have taken for the study.

Source: Field study using PRA/FGD methods.

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. For the purpose of quantitative household data, a detailed questionnaire was used that covered socio-economic, demographic, agriculture and groundwater management-related issues. In each village 30 households representing the socio-economic categories of the community were selected. The sample was purposively selected representing well owners and those sharing wells or depending on community wells. The sample is representative as the number of sample farmers is in proportion to the actual number of well-owning and well-sharing households. Community wells are present only in one sample village (Thaticherla) under the APWELL/APFAMGS programme.

Table 6. Distribution of the sample HHs across farm size and well ownership status (%).

Village	Status of groundwater user wells	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

Source: Field survey.

Note: MF- Marginal farmers; SF-Small-scale farmers; LMF-Large-scale and medium- scale farmers.

* In this village community a well is also considered as water sharing.

PARTICIPATORY GROUNDWATER MANAGEMENT: THREE APPROACHES

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. Two of the models are funded by external agencies like Food and Agriculture Organisation of the United Nations (FAO) and Aide à l'Enfance de l'Inde (AEI-Luxembourg), and one is supported by the state government (Table 7). All the three models focus on influencing communities through generation of information on groundwater though the degree of using scientific methods used varies. The major differences between the models include: i) two of the models are on a small scale while one (APFAMGS) is on a bigger scale; ii) two of the models use social regulation as a means to achieve sustainable groundwater use, while the other (APFAMGS) depends on awareness building; and iii) contribution of farmers varies between 75% (APDAI) to zero (APFAMGS).

Andhra Pradesh Farmer-Managed Groundwater Systems (APFAMGS)

The origin of the Andhra Pradesh Farmer-Managed Groundwater Systems (APFAMGS) goes back to the APWELL Project initiated by the Government of India in 1987. Community wells were provided with financial support under APWELL programme, which was discontinued in APFAMGS Project. The APFAMGS Project was implemented in the same seven districts, covering 650 habitations in 66 Hydrological Units (HUs) since 2004 with the financial support from FAO. The APFAMGS Project adopted a sub-basin approach for selecting habitations and the focus is demand management with a scientific knowledge-intensive approach. The philosophy of the APFAMGS is 'farmers' understanding of groundwater dynamics makes the difference'. This is achieved through the process of enabling primary stakeholders to involve in participatory hydrology monitoring (PHM) for sustainable use of groundwater resources using hydrological boundaries as an operational unit. The main objective of the project is to "equip groundwater 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

Table 7. Salient features of the community- based groundwater management models.

Features	APFAMGS	SRWM	APDAI
Initiative(funding)	External(FAO)	External(AEI, Luxembourg)	State Government (DoRD)
Implementation	NGOs (BIRDS+Partners)	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 (4 villages)	Small (6 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	No contribution from farmers	20% towards micro irrigation	75%

own demand" (World Bank, 2010: 62-63). 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.

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 learnings 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. 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 where farmer volunteers monitor water levels from 2026 observation wells (one well for every km^2) every fortnight. Daily rainfall measurement is taken from 190 rain gauge stations established for every 5 km^2 in the project area. Discharge measurements are also carried out to understand the pumping capacity in 700 monitoring observation wells by measuring the time taken to fill a drum of known capacity. In addition, farmers also measure the drawdown. Based on these measurements, 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 collected information is shared with the farmers for taking farming decisions.

The success of demystifying science is reflected in the preparation of crop water budgeting (CWB), which is taken up at the village level before the start of each season and aggregated at the HUN level. Using rainfall data and assumed run-off coefficient (10%), 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 be a positive or negative water balance in each season, depending on the recharge and draft. Based on the crop water requirements and the net available groundwater, crop areas are estimated in a collective manner. 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. There were no coercive mechanisms to force the farmers to adopt collective decisions. The data on actual cropping pattern is used to estimate the draft. However, there is always a difference between estimated and actual draft. Though individual farmers' are free to take decisions, 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. More than 4000 farmers are trained to read maps and more than 10,000 farmers can handle hydrological equipment (FAO, 2008). During the field visits, we have observed the farmers presenting CWB 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) 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 are based on this analysis and observations. 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 emerged as trainers to other farmers both under the project and for the government-run farmer schools. Such training and adaptation have demystified hydrology and helped the farmers understand the resource availability and dynamics.

Where the impact of APFAMGS[3] is considered, some of the important achievements include reduction in groundwater pumping in 14 of the 63 HUs; in nine others the reduction was moderate. It is estimated that groundwater pumping was reduced by more than 8% (equivalent to 5 million m^3 per year) over the project area due to water-saving techniques. Overall, the reduction in pumping is not significant enough to have a drainage basin-level impact. In all, except in four HUs, the area under paddy cultivation has come down, ranging from a few to several hundred acres. Crop diversification has taken place in favour of pulses, oil seeds, fruits, vegetables, flowers, etc. Farmers try to offset the losses due to reduction in paddy by growing other high-value crops. Water saving devices such as sprinkler and drip irrigation have been introduced for crops such as groundnut, sunflower, bengal gram, chillies, and horticultural crops. The experience of APFAMGS demonstrates that a comprehensive approach could benefit the farming communities, though in a limited way at present. Several other impacts are reported by the project though some of the claims require technical verification and require systematic post-project evaluation on a scientific basis. Sustainability of the impacts also remains questionable.

[3] This is based on earlier studies with larger sample (AFPRO, 2006; APFAMGS, 2006; FAO, 2008; FAO, 2010; Das and Burke, 2013).

Social Regulations in Water Management at the community level (SRWM)

Social Regulations in Water Management at the community level (SRWM) is an action-research project initiated in 2004 in AP by the Centre for World Solidarity (CWS). 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 prioritising the needs of the community for drinking water, irrigation and other uses, based on the principles of equity.

The project is being implemented in four villages from three districts covering 715 households. Prior to the 1990s, open wells with electrical centrifugal pumps were used to extract groundwater in the programme villages. Farmers started drilling bore wells during the early 1990s – the number of bore wells 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 bore wells and unscientific groundwater exploration many bore wells failed either at the time of drilling or during later years. 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. Growth of groundwater-based irrigation and trends in the groundwater levels were thoroughly discussed and analysed at community meetings, wherein women and men from all households participated. A series of such meetings and interactions helped to better understand frequent failure of bore wells and increasing debts of farmers. For instance, in Madirepalli Village, three neighbouring farmers dug 13 bore wells in an area of 0.5 acre over a period of four years in competition to tap groundwater. The project realised 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, i.e. reducing non-beneficial and non-recoverable losses (Perry, 2007).

A number of training programs, exposure visits and awareness-raising meetings were organised by the grassroots partner NGOs supported by CWS in the project villages. Further public awareness and education were carried out through posters, pamphlets and wall-writings. Monitoring of rainfall and groundwater levels in selected bore wells was done regularly by community volunteers using simple manual rain gauge stations installed in the villages and recording the static water levels in 10 sample bore wells using an electronic water-level indicator. These data were displayed on a village notice board and discussed in the meetings. It took three years (from a total of seven years) of intensive grassroots work and facilitation to make the community realise the ill-effects of indiscriminate drilling of bore wells and use of groundwater. This helped the community to evolve and agree on the following principles for social regulations and interventions in the village:

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

Small groups of farmers were formed in all the project villages between a bore well owner and a group of two to three neighbouring farmers, who did not own bore wells. The bore well owners were motivated to share water, as drilling of new wells in the vicinity of their wells may render theirs dry. Instead, sharing water from his well helps his neighbours, while securing his access to water, i.e. 'win-win' situation. Farmers in the villages are practising sustainable groundwater management by sharing and conserving the resource through micro-irrigation. Most of the farmers reported that huge money was invested and lost when most of the wells failed. Between 2004 (before the intervention) and 2010 (after the intervention), two of the open wells and 16 of the bore wells were revived due to the change in water management practices (Table 8). The area under irrigation also increased substantially, i.e. 31% in the case of *kharif* (first crop: June-October season) and 158% in the case of *rabi* (second crop: November-March season) crops. This was possible mainly due to water sharing, reduction in the cultivation of water-intensive crops like paddy and increase in area under micro-irrigation.

The farmers who were growing paddy and other water-intensive commercial crops have switched over to irrigated dry (ID) crops such as sunflower, groundnut, etc. After the intervention, water is being shared between brothers and neighbouring farmers irrespective of caste and economic status. To augment the bore well yields 28 recharge structures were constructed. 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 bore wells and are presently irrigating about one to three acres per well. Earlier, farmers used to adopt flood irrigation method, but now they are adopting micro-irrigation methods such as drip and sprinkler irrigation for the ID crops.

The key achievements are the following:

- Created access to drinking water to fulfil the needs of the entire community and of the cattle; however, these impacts are local and do not take account of the scale impacts (Syme et al., 2012).

Table 8. Impact of SRWM Project in Madirepalli Village.

Details	Before (2003-04)	After (2010-11)	Change/Impact
Functional open wells (number)	2 (59)	4 (59)	Increased
Functional bore wells (number)	53 (75)	69 (79)	Increased
Observation bore wells (number)	0	10	Increased
Sharing groups formed (number)	01	69	Increased
Farmers sharing water (number)	08	78	Increased
Area under cultivation (acres)	767.5	767.5	---
Area irrigated	Kharif: 213 Rabi: 127	Kharif: 280 Rabi: 328	+ 31% in kharif +158% in rabi
Area under paddy (acres)	Kharif: 74 Rabi: 73	Kharif: 51 Rabi: 0	Kharif: -31% Rabi: – 100%
Area under flood irrigation (acres)	314	51	-84
Area under micro-irrigation (acres)	26	557	Increased
Construction of recharge structures (number)	0	28 (percolation tanks, check dams and recharge pits)	Increased recharge of wells
Cropping pattern	Paddy for regular consumption through very low-yielding bore wells (BWs)	Switched over to irrigated dry (ID) crops like groundnut, green chilli, sunflower, etc.	Better financial returns; conserved resource

Note: Figures in brackets are the total number of wells.

Source: RIDS (2011).

- All 69 individually owned irrigation bore wells came under the water-sharing system providing access to water to 78 new farmers.
- Of the rain-fed lands 268 acres were brought under protected irrigation by sharing water from bore wells using micro-irrigation systems; this corresponds to 44% of the total well irrigated area in the village during 2010-11. Relative extraction of groundwater reduced from 125 to 80% of the annual available groundwater from the year 2004-2005 to 2010-2011.

Andhra Pradesh Drought Adaption Initiative Project (APDAI)

The APDAI pilot project is being implemented by the Society for Elimination of Rural Poverty (SERP) in collaboration with District Collectors and the Department of Rural Development (DoRD). WASSAN is the lead technical agency for this pilot. The aims and objectives include: i) adopting an area-based approach for irrigation; ii) treating groundwater as a common property; iii) checking competitive digging of bore wells; iv) providing access to the groundwater for rain-fed crops for protective/critical irrigation; v) reducing water loss by adopting effective irrigation systems and methods; vi) reducing the cultivation of water-intensive crops (paddy) under bore wells and motivating the farmers for alternative crops to improve water productivity; vii) enabling village-level institutions for groundwater regulation, including monitoring of yields of bore wells; and viii) improving the groundwater recharge, in the long run through convergence.

The project aims 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 sharing, social regulation and controlling competitive digging of bore wells. Further, farmers were provided with pipeline networks for transportation of water to rain-fed farms. Micro-irrigation is promoted to maximise the groundwater use efficiency. Area-based approach involves organising farmers under Common Interest Groups (CIGs) for a rain-fed patch. In each patch, well owners were convinced of the efficacy of sharing their water with the neighbouring farmers. Once consensus was reached on water regulations and sharing the cost of installation of the pipeline, an agreement on groundwater regulation was signed by all the farmers in the patch in the presence of a *Tahsildar* (Revenue official at the sub-district level) on a Rs100 (US$2) bond paper.

As per the agreement, all the bore wells will be pooled through a common pipeline network and water will be shared among all, irrespective of ownership. The bore wells of the farmers willing to share are interconnected to one main pipeline, which is distributed to the identified rain-fed patch of land. No new bore wells 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. One bore well a day will be rested on rotation, thus reducing water pumping by about 20%. While water is shared to protect the kharif (first crop: June-October) crop of non-owners and the acreage of bore well-owning farmers are ensured. A general fund is created for the maintenance of the pipeline, repairs, etc. within the CIG.

As there was no threat of new bore wells coming up in the vicinity that may lead to the drying up of their own bore well, farmers agree to pool their bore wells and share the water. The bore well owners are allowed to continue their earlier cropped area under irrigation but with less water-intensive crops. The water thus saved will provide critical irrigation to a rain-fed patch, which includes lands of both owners and non-owners of bore wells. If any one of the bore wells fails there is a back-up arrangement as they are pooled and one of them is rested for a day on a rotation basis. There was also motivation in terms of getting access to sprinklers/drips at subsidy, through linkage with the Andhra Pradesh Micro-Irrigation Project (APMIP). The APDAI has also extended up to 90% support for pipeline network required for water-sharing.

- Impact of the initiative.
- Able to provide protective irrigation for selected rain-fed patches in the pilot villages.

- Ensured timely sowing, especially during delayed monsoons.
- Increase in cropped area under the pooled bore wells.
- About 25 to 30% of the pumping hours were saved through resting of wells thus saving both the groundwater and electricity.
- Increased water use efficiency through the micro-irrigation system.
- Arresting competitive digging of bore wells.

COMMUNITY-BASED GROUNDWATER MANAGEMENT: A COMPARATIVE ASSESSMENT

Impact of CBGM is carried out using the information collected at the household level for well owners and water-sharing farmers across farm sizes. Three indicators, viz. access to irrigation, access to critical irrigation and shifting to less water-intensive crops was assessed. Besides, awareness and perceptions of the farmers regarding the role and effectiveness of the institutions were also assessed. 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 when compared to the overall sample villages (Table 9). Access to irrigation has gone up in all the sample villages due to sharing and also practising less water-intensive cropping pattern. Across the size classes, increased access to irrigation is greater among marginal and small-scale farmers in two of the sample villages due to sharing of wells (Table 10). On the other hand, large-scale farmers gained more in the case of Thaticherla Village where APFAMGS was working and well sharing was limited to community wells supported under the APWELL programme. While social regulation has benefited the small-scale and marginal farmers, its absence in the other village benefited the large-scale farmers who own the wells. This indicates that social regulation is fairer than APFAMGS. Overall, the new initiatives have resulted in the reduction in the growth of new 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)		
	O	WS	All	O	WS	All	O	WS	All
Before	56	30	49	49	8	31	77	18	59
Present	76	83	78	60	63	62	92	64	83
% Change	36	176	59	22	688	100	19	255	41

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 due not only to increased well-sharing but also to the revival of bore wells.

O= Well owners; WS= Well-sharing households

* In the case of Thaticherla, water sharing is from the community wells.

Source: Field survey.

The number of functional wells and households sharing water has gone up in all the sample villages (Table 11). 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 are almost absent in the sample villages where social regulation is in place (Madirepalli and Gorantlavaripalle), whereas in the case of APFAMGS village (Thaticherla), the number of bore wells has gone up by 20%, as there is no regulation or any restrictions on groundwater exploitation. The informal norms and peer pressure on irrigation practices and crops do not appear to be as effective as formal norms and regulations.

Table 10. Changes in percentage area under well irrigation by farm size.

Status	Thaticherla (APFAMGS)			Madirepalli (SRWM)			Gorantlavaripalle (APDAI)		
	MF	SF	LMF	MF	SF	LMF	MF	SF	LMF
Before	50	62	25	25	39	30	8	66	80
Present	79	79	75	70	58	59	69	85	90
% Change	58	27	200	180	49	97	763	29	13

Source: Field survey.

Note: MF= Marginal farmers; SF= Small-scale farmers; LMF= Large- and medium-scale farmers.

Table 11. Changes in access to wells and access to water.

Name of village	Total No. of HHs (population)	Period	Water-sharing HHs	Area under paddy (acres)	Area under irrigation (acres)	Source of irrigation			
						Dug-wells		Bore wells	
						No.	Area (acres)	No.	Area (acres)
Thaticherla	265	B	45	132	168	24 (0)	0	30 (15)	38 (22)
	(1155)	A	148	55	329	24 (0)	0	36 (31)	159 (48)
Madirepalli	173	B	8	180	254	59 (2)	4	75 (53)	200 (79)
	(725)	A	78	50	491	59 (4)	16	79 (69)	390 (79)
Gorantlavaripalle	113	B	10	128	140	34 (0)	0	82 (40)	90 (64)
	(487)	A	42	80	188	34 (0)	0	84 (46)	138 (73)

Source: Field study using participatory rural appraisal/focus group discussion (PRA/FGD) methods.

Note: Figures in brackets are functional wells and % of area the case of area.

Table 12. Availability of irrigation during critical periods of crop growth by well status (percentage of farmers).

Status	Thaticherla (APFAMGS)			Madirepalli (SRWM)			Gorantlavaripalle (APDAI)		
	O	WS	All	O	WS	All	O	WS	All
Before	23	0	14	0	0	0	60	28	51
Present	36	0	22	10	0	5	77	67	74
% Change	60	-	60	-	-	-	29	140	46

Source: Field survey.

Note: O= Well Owners; WS= Well-sharing households.

Table 13. Availability of irrigation during critical periods of crop growth by farm size (percentage of farmers).

Status	Thaticherla (APFAMGS)			Madirepalli (SRWM)			Gorantlavaripalle (APDAI)		
	MF	SF	LMF	MF	SF	LMF	MF	SF	LMF
Before	18	10	0	0	0	0	0	56	67
Present	27	20	0	17	75	50	50	79	67
% Change	50	100	0	-	-	-	-	41	0

Source: Field survey.

Note: MF = Marginal farmers; SF = Small-scale farmers; LMF = Large- and medium-scale farmers.

Table 14. Changes in area under paddy by well status (% area).

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

Source: Field survey.

Note: O = Well owners; WS = Well-sharing households.

Improved groundwater conditions in the sample villages are also evident from the availability of irrigation in critical periods of crops. The number of farmers reporting availability of groundwater during critical periods has gone up in all the sample villages (Table 12). Though this is limited to well owners in two of the villages, even the well-sharing farmers have reported receiving critical irrigation in Gorantlavaripalle (APDAI). Marginal and small-scale farmers are the main beneficiaries in terms of receiving critical irrigation (Table 13). This indicates that groundwater institutions have improved the source of sustainability and helped in protecting the crops to a large extent. This was possible due to the reduction in the area under paddy in two of the villages (Table 14). On the other hand, area under paddy has gone up in the sample APFAMGS village (Thaticherla). The reduction in area under paddy in these villages is more among large-scale farmers, while the increase in the APFAMGS village is more among marginal and small-scale farmers (Table 15). Of late, small-scale and marginal farmers are investing in bore wells following the drying up of open wells and also due to the availability of affordable technologies (Reddy, 2012). In the absence of any social regulation, farmers do not seem to follow conservation practices, though they tend to reduce their risk of investing in new bore wells as they are now knowledgeable about the groundwater situation. But this risk reduction strategy seems to be limited to large farmers in the APFAMGS village. The better management of groundwater observed in the case of SRWM (Madirepalli) is due to the smallness of the group coupled with intensive efforts towards collective strategies when compared to APDAI (Gorantlavaripalle) village.

Table 15. Changes in area under paddy by farm size (% area).

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

Source: Field survey.

Note: MF= Marginal Farmers; SF= Small-scale farmers; LMF= Large- and medium-scale farmers.

The perceptions of the farmers in the sample villages indicate high awareness about the institutions (Table 16). While the membership is limited to well owners in the case of APFAMGS village, even the well-sharing farmers are members in the other two villages. However, in all the three villages, most of the sample farmers participate in the farmer schools (Table 16). Participation rates range between 73 and 100% among sample villages. On the other hand, participation in crop water budgeting is low at 40% percent in the APDAI village (Gorantlavaripalle). But, 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.

The main benefits perceived in the sample villages are awareness about groundwater followed by crop and irrigation methods (Table 16). Among the reasons for non-participation is the absence of tangible benefits followed by those who say that it is difficult to follow or adopt (non-feasibility). While 70% of the non-participating farmers felt that there are no tangible benefits in the APFAMGS and APDAI villages, only 35% 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% of the sample farmers in the APFAMGS village have endorsed the benefits from groundwater institutions, while 100% agreed about the benefits in the other two villages. Lack of benefits is attributed to not following 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.

Table 16. Farmers' perceptions on community based groundwater management (% of farmers).

APFAMGS/SRWM/ APDAI	Details of perceptions	Thaticherla (APFAMGS)			Madirepalli (SRWM)			Gorantlavaripalle (APDAI)		
		O	WS	All	O	WS	All	O	WS	All
Awareness on groundwater management practices	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 (% of not participating farmers)	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 recommendations	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. Note: O = Well owners; WS = Well-sharing households.

Overall, the performance in terms of physical indicators and farmers' perceptions appears to be better in the 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 fieldwork, 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., 2012) and this is applicable even for the other two initiatives. All the earlier studies on APFAMGS have focused mainly on the capacity-building, cropping pattern changes and sustainability. As far as capacity=building is concerned all the studies are in agreement that the APFAMGS initiative has helped capacitating communities in terms of technical aspects such as participatory hydrology monitoring and crop water budgeting. That is, farmers are now able to estimate recharge and measure groundwater levels. The present conclusions on sustainability are in line with one of the earlier studies (Verma et al., 2012), but differ from those of other studies (FAO, 2010; Das and Burke, 2013). The latest study by Das and Burke (2013) define sustainability[4] differently and argue that APFAMGS initiative is sustainable. On the other hand, Verma et al. (2012) question the FAO claims on sustainability: "what we had read in the FAO reports was very much different when we look at the ground reality in terms of attitude of the community and outcomes of the project". It was observed that most of the APFAGMS initiated practices and activities have been abandoned by the farmers (Verma et al., 2012: 5).

The difference between the other two initiatives is that the APDAI 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. More importantly, the focus was more on well owners as opposed to the entire farming community (the majority of whom are prospective well owners), in the case of APFAMGS and APDAI villages (Table 16). This could be an important reason for the poor performance of APDAI when compared to the SRWM initiative.

LESSONS FOR UP-SCALING

The three models studied 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).

Knowledge-based approach

The APFAMGS focus is on 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. 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

[4] Sustainability of participatory groundwater management has been validated as several other programmes have adopted the model and the technical terms adopted in the model are continuing to be in use (Das and Burke, 2013: 31).

the season is provided (based on the groundwater availability) to the community. These details are shared across the villages within the hydrological unit.

Table 17. Features of the three institutional models.

Features	APFAMGS	SRWM	APDAI
Awareness on groundwater situation	High	High	High
Participation in management	Limited to well-owners	Well-owners as well as well sharing farmers (high)	All the farmers in the well network area (high)
Rules and regulations	Yes (informal and voluntary)	Yes (formal)	Yes (formal and binding)
Extent of well-sharing	Limited	High	High
Cost-sharing	No	Yes	Yes
Practising recommendations	Moderate	High	Low
Additional infrastructure support	Nil	Yes (micro- irrigation)	Yes (pipelines and micro-irrigation)
Key to success	Professional approach	Leadership and incentives (subsidy for micro-irrigation)	Incentives (subsidy for pipelines and micro-irrigation)
Impacts on access to water	Moderate	High	Moderate
Impacts on cropping pattern	Limited	High	High
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.

The 'do-it-yourself' approach with relatively better scientific or technical inputs has clearly improved the awareness of the well owners. While such an awareness has helped in checking further expansion of groundwater development among the existing well owners, it has failed to check the growth of new bore wells. Besides, the focus is mainly on demand management and hence it has also 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 (FAO, 2008, 2010; Das and Burke, 2013). The limited impact is because not only are formal social regulations not imposed but also economic incentives are not provided for adopting such measures. The regulations are informal in the form of peer pressure and voluntary. Economic instruments and incentives that were observed to be more effective in demand management of water (World Bank, 2010) are totally absent. Moreover, the approach is not inclusive of all the farmers. The result is a lot of useful information is generated at the appropriate scale helping only the well-owning farmers. As the membership is limited to well owners, the information-based awareness failed to integrate other farmers into the institutional frame. This has adverse impact on the sustainability of the approach, as the limited membership hinders the collective ownership and commitment to the common good. In some villages, non-members refuse to talk about the initiative, widening the socio-economic divide.

Though farmers are interested in having institutional arrangements in the lines of APFAMGS for managing groundwater, sustainability is a big question mark in the absence of linkages with formal institutions and policy or legislative backing for the movement.[5] 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 year (2009-11) gap 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 continue in the long run (Reddy et al., 2012).

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 back-up they get in the event of well failure, are put in place. Besides, distribution losses are reduced through pipeline supply of water and increased water use efficiency through promotion of micro-irrigation.

Social regulations appear to be effective in terms of stopping new bore wells 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 welfare improvement. However, there are differences between the two models of social regulation in terms of their effectiveness: the SRWM appears to be more inclusive and 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. Though APDAI mostly follows the SRWM approach, it has adopted a broader (area-based) and formal approach involving the department. APDAI focuses more (though not exclusively) on well owners. This, coupled with the difficulties in organising larger groups of farmers, has resulted in relatively less effectiveness of the initiative.

Despite the formal approach, participation and rule following are limited in the APDAI. People indicated that there are no tangible benefits from the initiative and half 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%) from the farmers, which is substantial (total costs are Rs8000 to 10,000 per acre, i.e. UD$135 to 165 per acre). On the other hand, the approach of people's contribution could provide the much needed ownership and sustainability. 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

[5] 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.

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.

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 people's 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.

More importantly, the political economy factors come to the fore as these initiatives expand. While the legislation of making groundwater a common property is good on paper, enforcing it at the village level is a major political challenge. Social regulation is a difficult proposition in politically divided communities. It is difficult to presume that large farmers would give up exclusive control on groundwater due to the awareness created. Given that the scientific basis of this awareness is not good enough to protect the farmers from groundwater-related risks, convincing them for adopting sustainable groundwater management practices is more difficult. India is planning to allocate huge resources during the 12th and 13th five-year plans towards creating a scientific groundwater database, which may take quite some time. Economically, there is a need to look at the costs and benefits to the individual farmers under uncertainties. Moreover, partial participation (fewer well owners) may aggravate the uncertainties, as aquifers are not linearly connected. Nevertheless, these initiatives represent a small starting point to a 'game changing' groundwater management and may take a longer time span to evolve fully. These initiatives need to work through a number of hurdles, technical, socioeconomic and political.

One of the main hurdles for creating generic institutional models is the lack of understanding and interpreting the hydro-geology aspects at an appropriate scale. The knowledge-based approach of the APFAMGS is limited to hard rock areas, and its applicability or adaptation in the alluvial soils needs further testing (World Bank, 2010). Even in the hard rock areas, APFAMGS could really capture the variations in the nature of aquifers, soils, land use, etc. in a more scientific manner, as it assumes a constant 10% recharge factor. In reality the recharge factors vary between 6 to 13% in the hard rock regions of AP (Sridevi et al., 2013). Even the social regulation models need to have a strong scientific basis for designing appropriate models. Besides, none of these models have integrated the economic instruments into the process. While all the three models assessed here have shown that groundwater management is possible at the community level with people's involvement, there is need for developing an integrated model drawing from these three models in order to make it more generic and applicable globally. Such a model should integrate scientific, socioeconomic and policy aspects that suit the local conditions.

REFERENCES

AFPRO (Action for Food Production). 2006. *A systematic assessment of community based groundwater management experiences in Andhra Pradesh*. Hyderabad: Action for Food Production, Field Unit 6, Hyderabad, December.

APFAMGS (Andhra Pradesh Farmer-Managed Irrigation Systems). 2006. *Rebuilding groundwater dependent economy through managed aquifer recharge* (MAR). Hyderabad: Grama Vikas Samstha, Madanapally and APFAMGS, Hyderabad, January.

Bhatia, B. 1992. Lush fields and parched throats, political economy of groundwater in Gujarat. *Economic and Political Weekly* December 27(51-52): 19-26.

Burke, J.; Moench, M. and Sauveplane, C. 1999. Groundwater and society: Problems in variability and points of engagement. In Salman, M. and Salman, A. (Eds), *Groundwater – Legal and policy perspectives*, pp. 31-52. World Bank Technical Paper No. 456. Washington, DC: The World Bank.

Das, S.V.G. and Burke, J. 2013. *Smallholders and sustainable wells – A retrospect: Participatory groundwater management in Andhra Pradesh (India)*. Rome: Food and Agricultural Organisation of the United Nations (FAO).

Dhawan, B.D. 1995. Magnitude of groundwater exploitation. *Economic and Political Weekly* 30(14): 769-775.

FAO (Food and Agriculture Organization of the United Nations). 2008. *Evaluation of FAO, cooperation with India. Andhra Pradesh Farmer Managed Groundwater Systems* (APFAMGS – GCP/IND/175/NET). Evaluation Report. Rome: FAO.

FAO. 2010. *Andhra Pradesh Farmer Managed Groundwater Systems Project: Terminal Report* (GCP/IND/175/NET). Rome: Food and Agriculture Organization of the United Nations. www.solutionsforwater.org/wp-content/uploads/2011/12/APFAMGS-Terminal-Report.pdf (26 December 2013)

Libecap, G.D. 1997. *Contracting for property rights*. Tucson, Arizona: Karl Eller Centre and Department of Economics, University of Arizona; Cambridge, Massachusetts: National Bureau of Economic Research.

Llamas, R. and Martínez-Santos, P. 2005. Intensive groundwater use: Silent revolution and potential source of social conflicts. *Journal of Water Resources Planning and Management* 131(5): 337-341.

Moench, M. 1992. Chasing the water table: Equity and sustainability in groundwater management. *Economic and Political Weekly* 27(51-52): A171-A177.

Perry, C. 2007. Efficient irrigation; inefficient communication; flawed recommendations. *Irrigation and Drainage* 56(4): 367-378.

Polak, P. 2004. *Water and the other three revolutions needed to end rural poverty*. Invited Paper in the World Water Week, Stockholm 15-20 August, Preprint, Stockholm International Water Institute, Stockholm.

Reddy, V.R.; Syme, G.; Ranjan, R.; Pavelic, P.; Reddy, M.S.; Rout, S.K. and Sreedhar, A. 2012. *Scale issues in meso-watershed development: Farmer's perceptions on designing and implementing the common guidelines*. Working Paper No. 2. Hyderabad: Livelihoods and Natural Resource Management Institute.

Reddy, V.R. 1999. User valuation of renewable natural resources: User perspective. *Economic and Political Weekly* 34(23): 1435-1444.

Reddy, V.R. 2012. Hydrological externalities and livelihoods impacts: Informed communities for better resource management. *Journal of Hydrology* 412-413(2012): 279-290.

Reddy, V.R. and Reddy, P.P. 2005. How participatory is participatory irrigation management: A study of water user associations in Andhra Pradesh. *Economic and political Weekly* 40(53): 5587-5595.

RIDS (Rural Integrated Development Society). 2011. Social regulation project of Madirepalli. Power Point Presentation. Garladinne Mandal, Anantapur District: RIDS.

Shah, T. 2004. Groundwater and human development: Challenges and opportunities in livelihoods and environment. Invited Paper in the World Water Week, Stockholm 15-20 August, Preprint, Stockholm International Water Institute, Stockholm.

Shah, T. 2009. *Taming the anarchy: Groundwater governance in South Asia*. Washington, DC: The Resources for the Future Press.

Sharma, K.D. 2009. Groundwater management for food security. *Current Science* 96(11): 1444-1447.

Sreedevi, P.D.; Sarah, S.; Alam, F.; Nazish, R.; Ahmed, S.; Chandra, S. and Pavelic, P. 2013. Investigating geophysical and hydro-geological variability and their impact on water resources in the context of meso-watersheds. Draft Paper, National Geophysical Research Institute, Hyderabad.

Syme, J.G.; Reddy, V.R.; Pavelic, P.; Croke, B. and Ranjan, R. 2012. Confronting scale in watershed development in India. *Hydrogeology Journal* 20(5): 985-993.

Valencia Statement. 2004. In Sahuquillo, A.; Aliaga, R.; Cortina, L.M. and Sanchez Vila, X. (Eds), *Groundwater intensive use,* pp. 399-400. Selected papers of the SINEX conference, Valencia, Spain, 10-14 December 2002. Leiden: A.A. Balkema Publishers.

Verma, S.; Krishnan, S.; Reddy, V.A.; Reddy, K.R. 2012. Andhra Pradesh farmer managed groundwater systems (APFAMGS): A reality check. Water policy research highlight; IWMI-TATA Water Policy Programme. www.iwmi.cgiar.org/iwmi-tata/PDFs/2012_Highlight-37.pdf (26 December 2013)

World Bank. 2010. *Deep wells and prudence: Towards pragmatic action for addressing groundwater overexploitation in India*. Washington, DC.