APWELL Project

Judicious Management of Groundwater through Participatory Hydrological Monitoring

A Manual

ARCADIS
EUROCONSULT

Andhra Pradesh – APWELL Project Area

BIRDS

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Abbreviations

APSGWD	Andhra Pradesh State Ground Water Board
APSIDC	Andhra Pradesh State Irrigation Development Corporation
APWELL Project	Andhra Pradesh Borewell Irrigation Programme
BUA	Borewell User Association
CGWB	Central Ground Water Board
CWB	Crop-Water Budgeting
DFC	District Field Coordinator
DTU	District Training Unit
EPHM	Extensive Participatory Hydrological Monitoring
EVA	Environmental Viability Assessment
FTT	Farmer Training Team
GEC	Groundwater Estimation Committee
GMC	Groundwater Management Committee
GoAP	Government of Andhra Pradesh
HMR	Hydrological Monitoring Record
IPHM	Intensive Participatory Hydrological Monitoring
IPM	Integrated Pest Management
NGO	Non Governmental Organisation
PCWB	Participatory Crop-Water Budgeting
PWL	Pumping Water Level
PHM	Participatory Hydrological Monitoring
PRM	Participatory Resource Mapping
SHG	Self Help Groups
SWL	Static Water Level
WUG	Water User Group

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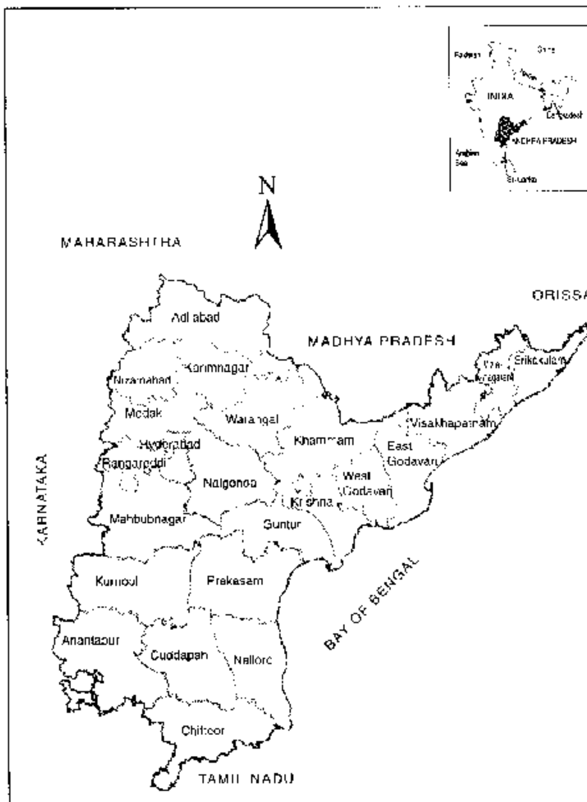
The APWELL Project was conceived in the late 1980s to improve the living conditions of small and marginal farmers through sustainable and environmentally sound interventions. This objective was to be achieved through increased agricultural production through groundwater development, ie, by providing borewell irrigation facilities to the groups of small and marginal farmers in seven drought prone districts in the State of Andhra Pradesh. By the time the Project was completed in March 2003, 3,462 successful wells and related irrigation systems had established. Each well serves an *ayacut* (irrigated area) of about 10 acres, normally owned by around 5 families. The total area irrigated by wells established under the Project amounts to 35,000 acres, directly benefiting about 14,000 small and marginal farming families. The irrigation system are owned and managed by water user groups (WUGs) formed by the families served by one well.



Andhra Pradesh - APWELL Project Area

From the start of the Project it was recognized that groundwater depletion by excess pumping formed one of the main project risks. In view of the project's emphasis on sustainability and environmentally sound interventions, measures were taken to mitigate the problem of groundwater depletion. Foremost, the Project has ensured that drilling is limited to the most potential areas (in many cases virgin areas with assured recharge). To this end it conducted groundwater resource estimations at micro-catchment level. Data collected during hydrological surveys and from other sources are fed into the Environmental Viability Assessment (EVA), a model developed by APWELL to identify sustainable clusters for groundwater development. The EVA approach is documented in a separate manual which is available on the project website at http://www.apwelll.org. The various efforts of the Project to ensure proper planning of groundwater utilization can be summed up under the following headings:

- Limiting groundwater development to areas (administrative units) listed as safe and qualifying for groundwater abstraction by government agencies (CGWB & Andhra Pradesh State Groundwater Department) and where groundwater quality falls under potable standards for human/animal consumption.
- Selecting potential clusters within the prioritized areas based on systematic scientific desk studies using secondary data and maps.
- Groundwater resource estimations for micro-catchments using EVA norms developed by APWELL.

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Acknowledgement

This manual is the result of continuous guidance and support I received from several individuals and organizations during the past few years. I therefore, acknowledge the contribution made by many colleagues, friends, external mission members, senior professionals and farmers. Their inspiring words and positive criticism helped me to shape the manual in an easily comprehendible and neatly presentable manner.

My special thanks are to all those people, within the APWELL Project and outside, especially to:

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S. V. Govardhan Das

March 2003

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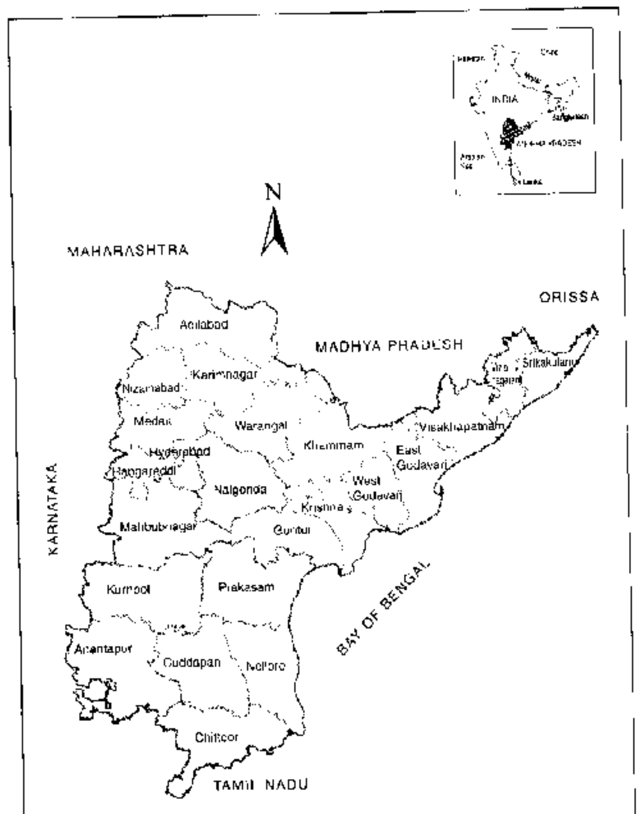

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- Strict adherence to government prescribed spacing norms (a distance of 300 m between two borewells) to prevent interference between two pumping wells.
- Artificial recharge of groundwater to deeper aquifers being developed.
- Monitoring of groundwater quality.
- Regular people-scientist interaction to bring awareness on sustainable groundwater development and characteristics of potable groundwater.
- A range of extension interventions aimed at promoting judicious irrigation practices, ranging from the cultivation irrigated dry crops, the use of sprinkler and drip irrigation technologies, joint crop planning by WUG members, and water and land management techniques.

The box on the next page provides further details on the APWELL site selection procedures.

The sustainability of borewells is governed by many factors beyond the control of a project like APWELL. Indiscriminate drilling by individual farmers is one example. In spite of this, it was felt that APWELL should develop instruments contributing to the long-term sustainability of groundwater resources in locations where borewell irrigation was practiced. In absence of legislation to control drilling (except for drinking water borewells), the Project decided to concentrate on building awareness among users aimed at voluntarily groundwater management initiatives. The Project argued that farmers needed to develop their knowledge on local hydrological conditions before they could make sound decisions on groundwater management. It was also assumed that better awareness of the local hydrological balance would help motivate communities to optimally manage the available groundwater. To improve knowledge and create awareness APWELL trained groundwater users as barefoot technologists with the task of collecting hydrological data. The process aims at demystifying the groundwater science and at enabling the community to emerge as planners and managers of their resources. This intervention is referred to as Participatory Hydrological Monitoring.

1.1 The PHM Concept

Participatory Hydrological Monitoring (PHM) is an effort to sensitize the individual groundwater users on judicious use of groundwater. PHM improves the users' understanding of local groundwater resource characteristics. This helps local communities to form a community opinion to support appropriate measures for managing the available resources equitably. The objectives of PHM can thus be summarized as follows:

- creating awareness on groundwater resource availability,
- establishing the local micro catchment level rainfall – recharge relationship,
- develop appropriate water use plans matching with the utilizable groundwater reserves,
- establish need for conservation of groundwater and need for increased recharge.

Geo-hydrological monitoring involves systematic monitoring of different aspects of the hydrologic cycle, viz. rainfall, surface run-off, infiltration, sub-surface run-off, evapo-transpiration and groundwater draft.

In August 1999, APWELL reviewed its site selection procedures, resulting in a number of modifications, especially the priority ranking of mandals, for site selection. Under the new approach simple criteria such as

- ✔ *stage of groundwater development,*
- ✔ *groundwater potential,*
- ✔ *groundwater quality*
- ✔ *area under surface water irrigation*

have been used as benchmarks for shortlisting the most potential mandals in an APWELL district. Stakeholder workshops are used as a platform for doing these priority ranking exercises. Based on these exercises 146 mandals (35% of the total) in the project area spread over 7 districts were categorized under the safe ranking ranges of 1-3. Only in these mandals additional exploratory work was undertaken using integrated hydrogeological and geophysical methods.

Based on EVA studies 414 watersheds were cleared on technical grounds from an environmental angle. Adopting social validation the list was further pruned to 360 watersheds for project intervention.

Artificial recharge of the deeper aquifer is considered essential for ensuring sustainability of borewells. With special focus on groundwater recharge of productive aquifers, APWELL has taken up a pilot programme to identify suitable methodologies for artificial recharge of groundwater through a blend of scientific and people actions. Two hydrological units/watersheds viz., Kalugotla (Kurnool district) and MC Thanda (Anantapur district) were taken up for pilot implementation of artificial recharge activities.

APWELL, though basically an irrigation project, has also focused on drinking water quality testing, as it is found (through sample surveys) that about 50% of APWELL farmers (partly) depend on irrigation borewells for potable water, especially during the time they stay on the farm. During September – December 1999, 135 samples have been analysed in the seven project districts. Water quality analysis results in Prakasam district revealed presence of fluoride beyond permissible limits. All (148) borewells, falling in critical mandals of Prakasam district have been considered for water quality studies. Samples were collected in March-June 2000. Based on the test *results, a drainage basin around Markapur town has been identified as a fluorosis prone area. Pre- and post-monsoon water quality analyses were conducted in this watershed (Yedala vagu) during 2000-2001. For creating awareness, signboards have been put up on all the borewells warning against excess fluoride.*

In India, data collection on the different components of the hydrological cycle is carried out by various State Government Departments and Central Agencies, such as the Meteorological Department, Surface and Groundwater Department, Agriculture Department and Planning. Based on the collected data Central and State groundwater agencies prepare estimates on available groundwater resource, groundwater balances, and the stage of groundwater development. The groundwater balance computation data is then passed on to planners at the Centre and State who use it for understanding the regional groundwater development status of large administrative units/ drainage units and prepare appropriate investment plans and legislation.

The regional-level monitoring efforts of government bodies provide limited understanding of the micro-level groundwater balance. The latter requires a larger density of monitoring wells and a better understanding of micro level variations in meteorological and hydrological parameters. Such micro level monitoring exercises are limited to certain research programmes, thesis studies and extension programmes of NGOs.

PHM facilitates groundwater user communities to identify volunteers entrusted with gathering field data which can be used by the groundwater users to get a good understanding of:

- total groundwater resource availability,
- stage of groundwater development,
- areas of excess/limited development,
- optimum number of wells that can safely be operated in view of the resource availability,
- best mix of crops matching quantity and quality of available groundwater resources,
- changes taking place in the local micro-catchments if additional groundwater structures are constructed.

The concept of PHM revolves around three key points:

- People understand their groundwater system,
- People understand the annual changes in their groundwater system,
- People are in a position to regulate the use of groundwater in tune with the annual hydrological cycle.

APWELL consultants prepared a first *Reference document on participatory hydrological monitoring* in December 1999. In the course of its implementation the IPM pilot has gone through a number of changes. The PHM approach that evolved over the past three years is discussed in detail in the next section.

1.2 Strategy

The first step of PHM relates to improving farmers' understanding of the local groundwater system, including the rainfall pattern, recharge, draft, and the overall balance. The awareness of the groundwater system is expected to create an interest in monitoring the local geo-hydrological system.

Initially a watershed/village can be considered as the appropriate unit for monitoring. Activities start with Extensive Participatory Hydrological Monitoring (EPHM) which focuses on monitoring water levels in borewells. In EPHM the basic requirement thus is an instrument to measure water levels. Farmers are trained to systematically measure and record static and pumping water levels.

In areas where groundwater users show an interest in learning more about the local groundwater system, the scope of the programme can be expanded to include more parameters, which is then referred to as Intensive Participatory Hydrological Monitoring (IPHM). As part of IPHM volunteers need to be monitor additional parameters especially rainfall and groundwater draft. The IPHM data from inputs for calculating the water balance in the watershed, on an annual basis. *Water Budgeting* is the final step in the ladder to realize the goal of IPHM: based on the water balance outcomes, the water available for irrigation can be calculated water on a seasonable basis and crop plans are adjusted accordingly. Hydrogeologists and agriculture scientists can provide guidance in water budgeting, the selection of suitable crops, and the adoption of water saving technologies.

To make the IPHM meaningful and accurate there is a need to rope the entire farming community into the programme, and not merely APWELL project beneficiaries.

> *Under the APWELL programme EPHM has been popularized in 122 clusters each with more than 10 successful borewells. IPHM is taken up at selected watersheds/ aquifer systems in four hydrological units viz., Peda vagu (Kurnool), Poleramma vagu (Prakasam), Bollasandu vanka (Anantapur), VSS Puram (Chittoor), Erra vagu (Cuddapah), Bhasker Rao Kunta (Nalgonda), Manda vagu (Mahbubnagar) and Manne vagu (Mahbubnagar). In the IPHM sites rain gauge stations have been set up to record daily rainfall. Additional primary data is also collected before start of kharif and rabi seasons to facilitate crop-water budgeting. The crop-water-budgeting programme is used to assess groundwater availability and prepare crop plans. The annual crop-water budgeting exercise coincides with Kharif and Rabi crop plans. To expand the programme to a micro-basin the Upper Gundlakamma sub-basin in Prakasam district has been identified. This basin covers 192 villages in 7 mandals.*

1.3 Stakeholders

The ultimate aim of PHM should be build the capacity of the farmers to record geo-hydrologic data, interpret it and use it for better management of the local groundwater system. Thus, primary stakeholders in PHM are: individual groundwater users, volunteers, opinion leaders, community workers, hydrogeologists and agriculture extension workers. Government departments involved in groundwater management and NGOs active in water sector naturally become secondary stakeholders in PHM.

Farmers, volunteers and opinion leaders play a major role in popularising the concept of PHM. To start with they need to be targeted for knowledge transfer and implementation of physical works. At a later stage, they in turn should become facilitators for replication of the concept to a wider audience.

Community workers would have established initial rapport between the technical staff and farmers. Later, they become the vehicle for disseminating scientific knowledge to farmers, and act as a bridge between farmers and technical staff.

Hydrogeologists with the required academic qualification and field experience should be identified. S/he should be the resource person providing inputs related to delineating the watershed/aquifer system, training farmers, identifying observation wells, installing scientific equipment, providing support services to grass-root level functionaries, apart from guiding farmers on the intricacies of data collection, and their interpretation and usage. His/her role is of utmost importance in documenting and disseminating the results of PHM activities.

> *Women (poor or rich) are affected first by water shortages as water is regarded as the responsibility of women to the extent it relates to household chores. The PHM programme should therefore ensure women's participation in its different activities. Gender Specialists could be involved to ensure the participation of women farmers in PHM.*

1.4 Steps in PHM

The methodology developed during the last three years based on the experiences gained in the APWELL Project is summarized in the table on the next page. This methodology offers scope for modifications based on the physical, social and cultural settings. An activity schedule is part of the table.

Steps	Time Plan in weeks																							
	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Staff orientation/training																								
Desk study																								
Delineation of the hydrological unit																								
Field Reconnaissance Survey																								
Meeting with opinion leaders																								
Dissemination of the concept through cultural medium (Kalajatha)																								
Participatory Resource Mapping (PRM)																								
Resource Inventory (water and crop)																								
Socio-economic survey																								
Preparation of base document																								
Identification of observation wells																								
Identification of sites for rain gauge																								
Social Feasibility study																								
Procurement of measuring instruments																								
Establishment of observation well network																								
Establishment of rain gauge station																								
Identification of volunteers																								
Training of volunteers: module 1																								
Fixing the responsibilities																								
Facilitating farmer data collection																								
Training of volunteers: module 2																								
Introduction of Hydrological Monitoring Record (HMR)																								
Establishment of display board																								
Formation of Groundwater Management Committee (GMC)																								
Training of GMC: module 3																								
Facilitating documentation and dissemination																								
Handing over of assets																								
Resource Inventory Updating																								
Preparation of Crop-plan																								
Water balance estimation																								
Participatory Crop-Water Budgeting (PCWB)																								
Training of GMC: module 4																								
Crop adoption survey																								
Farmer Mela																								

Gearing Up

Before taking up the actual PHM activity at field level, it is necessary that the implementing agency itself be geared up. This phase may take three to six months, depending on number of hydrological units targeted. This chapter deals with the four main steps required to be taken during the gearing up phase:

- Staff orientation and training
- Desk study
- Delineation of the hydrological unit
- Reconnaissance

2.1 Staff orientation and training

A staff orientation and training are regarded the most important step in getting PHM started. It will be part of the overall capacity building strategy that should be developed for the teams constituted for different administrative/drainage units. The team composition should be multi-disciplinary. A general appreciation of work done by different discipline specialists is key to a smooth grounding of the PHM activity. Groundwater user group representatives, like farmers, industrial users, domestic users, who show interest in the activity should be invited to be part of the team. The team need to be given an orientation into the geo-hydrological cycle in a simple yet technically sound fashion. The themes to be covered should include

- Hydrological cycle
- Occurrence and distribution of groundwater
- History of groundwater development in the area
- Delineation of a hydrological unit
- Significance and utility of monitoring tools
- Optimum network for the area
- Data collection frequency
- Data collection and recording procedure
- Groundwater balance estimation
- Crop-water requirements
- Crop-water budgeting
- Participatory tools for effective farmer-scientist interaction

Visuals (charts, models and field visits) need to be used for orientation/training.

APWELL initiated PHM work through its District Training Unit (DTUs) which are *operational in each project district. A DTU consists of government staff, and NGO project staff, and includes a range of professional specialisations such as engineering, hydrogeology, sociology, agriculture science, gender and institutional development. Given the multi-disciplinary nature of the PHM pilot, it was important that members of PHM teams learn about each other's area of specialisation. In addition, the project could fall back on a broad pool of progressive farmers who are seen as role models by others in the village on account of their innovative and beneficial farm trials. These farmers were targeted by the project for initial training inputs along with members of DTUs. In several project activities these farmer representatives have proved their worth by successfully carrying the message to the larger farming community in the village.*

APWELL uses a strategy of mixing professional staff and progressive farmers together for initial orientation/training programme at district level. As the initiative is innovative and best understood by the APWELL consultants, for all district level training/orientations programmes, they have been used as resource persons.

2.2 Desk study

After the training/orientation, staff takes up assessment of the target area through a desk study. The desk study is preceded by collection of maps, documents and other relevant information from different agencies working in the target area.

The desk study essentially consists of thorough review of topographic, geological, geomorphological and hydrogeological maps of the area under consideration for taking up PHM activity. A thorough review of the previous work carried out by other agencies is another important item under the desk study. Periodicals and statistical abstracts on Agriculture are another important part of the desk study. Apart from technical aspects related to groundwater, a general sociological review is also carried out using the information in the District Gazette, Handbook of Statistics and other data available with the NGOs.

The desk study gives a broad idea of the area under consideration in terms of physical features and social fabric apart from the general cropping pattern, area under irrigation, sources of irrigation, etc.

Delineation of the hydrological unit

Groundwater does not operate independently but in a larger arena of hydrological system. Topography, rock type and status of development govern the occurrence of groundwater. Except, in cases where there is inter-basin flow, the best unit to manage groundwater is the watershed. This is especially true in case of hard rock areas wherein groundwater occurs in unconfined or semiconfined condition. Thus the understanding of the aquifer system, at least in hard rock areas, is directly related to accurate delineation of watershed.

Delineation of aquifer system, in case of inter-basin flows, is little bit complicated and calls for thorough study of structural map and field checking. Standard procedure is yet to be developed for such delineation. The usual assumption is that the inflow into the watershed/basin is equal to the outflow from it. Simple method of delineation of watershed is based the surface drainage, especially in hard rock areas.

Survey of India toposheet (1:50,000) should be used for delineation of the hydrological unit. The drainage pattern should be first studies and independent units that converge to form independent drainage networks need to be defined. The boundaries of the watershed need to be defined and the same examined in the field to visualise the ridge points and the basin outlet. Using the map area of the watershed should be calculated.

Figure 2-1 shows an example of delineation of hydrological units (one of the watersheds where IPHM activity is underway).

2.3 Reconnaissance

Reconnaissance of the delineated watershed/ hydrological unit should provide the opportunity to appreciate the complexities of the watershed and groundwater occurrence and movement in the area. Informal interaction with farmers during reconnaissance allows the team to know about the leaders and progressive farmers in the different villages.

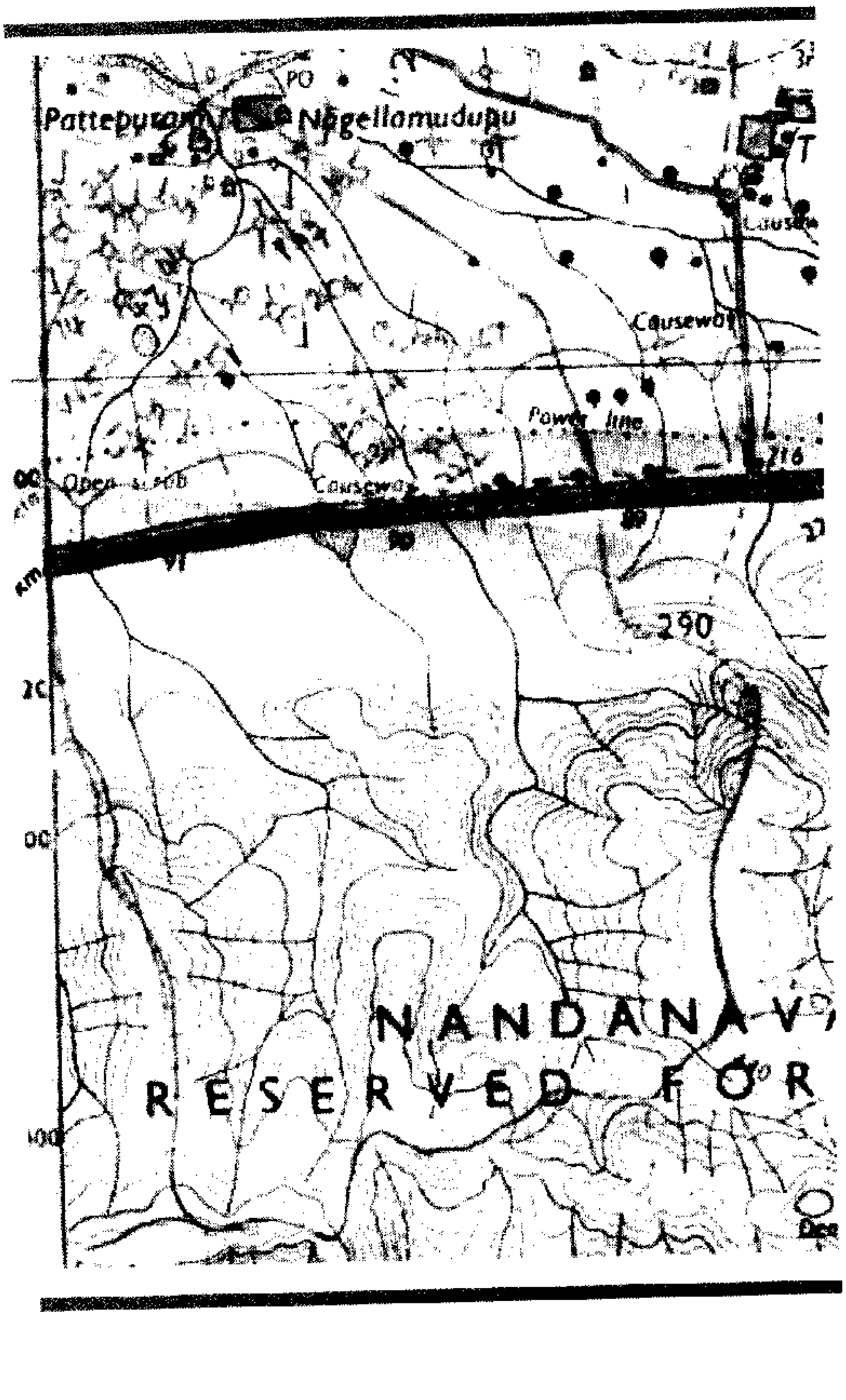

Figure 2-1: Delineated Poleramma vagu watershed, Tarlupadu, Praksam District

3 Preparatory Phase

The preparatory phase involves a range of technical and social components. During this phase financial and technical inputs also become relevant. The different activities to be taken up during the preparatory phase are discussed in the next sections.

3.1 Meeting with opinion leaders

Respect for the elders and for talented people is highly valued in rural communities. These people, here referred to as the opinion leaders, are important from the PHM perspective as everyone respects their words. Convincing opinion leaders in a village is therefore essential to gain the confidence of the community at large. It is also easier for project staff to pass the message of PHM, if opinion leaders understand the concept and content. It will be advantageous if opinion leaders act as mouthpieces of the project activity, creating a positive atmosphere for ensuing PHM activities. Opinion leaders could include village level political leaders, caste heads, rich farmers, educated persons, teachers, or priests.

Through its core activity, the provision of groundwater irrigation systems, APWELL, has established a lot of goodwill among the poorer sections of rural communities. Though small and marginal farmers are the immediate project beneficiaries, opinion leaders generally receive APWELL positively because they think that project inputs contribute to improving the overall welfare of the village. Under the PHM activity,

Figure 3-1: APWELL staff interacting with opinion leaders at a non-APWELL village

APWELL contacts opinion leaders whose words are respected by the community. If possible, some of the selected observation should wells selected belong to opinion leaders. In regular meetings of the borewell users, opinion leaders are invited to debate water management issues. Special orientation sessions are held for farmers, including non-APWELL farmers. During these orientation sessions, general awareness is built on topics like the hydrological cycle, causes for water table depletion, water saving techniques, and bio-farming.

Each agency intending to take up PHM will have to formulate its own strategies for gaining easy entry into villages.

3.2 Dissemination of the message through innovative approaches

PHM objectives need to be made known to the entire community in order to sensitise them to the need for judicious use of groundwater and to propagate the need for a good understanding of the local groundwater system. Innovative methods need to be adopted to spread these messages. Kalajatha folk art, cultural programmes, sketches, street plays, video, music, etc, can be used to attract larger audiences as well as to make the programme appear relevant to everyone.

Figure 3-2: Kalajatha to spread the concept of PHM

APWELL has used the services of two cultural teams to pass on project messages. Project staff conducted a number of orientation sessions for these cultural teams to explain the project initiatives. Picking up from these sessions, the kalajatha troupe has come up with a number of songs, sketches, dance items, golla suddulu (a folk art of the Telangana region).

Initially, a kalajatha programme consisted of a very broad range of themes like the objectives of APWELL, implementation processes, environmental pollution, depleting groundwater, organic farming, etc. After about 200 programmes at target villages of APWELL, the teams clearly understand the focus of the Project. Building on their experience, kalajatha teams have now developed a three-hour programme exclusively on the PHM activity. The Kalajatha on PHM includes songs on water, golla suddulu explaining the practice of PHM by farmers, and a play comparing PHM farmers and other farmers. This Kalajatha is effectively used in PHM villages, not only those covered under the borewell programme but also in villages taken up as part of PHM expansion.

APWELL has produced audio cassettes, a video-tape and compact disc with songs and other kalajatha programmes covering all aspects of the project. These audio-visual are used at meetings, trainings and other occasions. Generally these tools are more effective in disseminating PHM messages than training session and other conventional methods of rural communication. APWELL audio and video recordings could very well be used by other agencies involved in PHM. As the kalajatha troupe hired by APWELL is fully oriented towards the PHM concept, its services can be used when entering new villages or to train new troupes.

3.3 Participatory Resource Mapping

Document the pre-intervention scenario is very important for activities like PHM. Participatory Resource Mapping (PRM), a participatory exercise conducted at village level for assessing its natural resource base, is used to this end. Steps followed in PRM exercise are:

1. Cadastral maps of villages falling in the delineated watershed are procured.
2. Toposheet features are interpreted and transferred to the cadastral maps.
3. Village elders are contacted to fix a time for the PRM exercise.
4. At the scheduled time the PHM facilitator team reaches the village.
5. After about 50-100 villagers are gathered representing all social groups, the purpose of the exercise is explained.
6. Based on the landholding in the village, the village map is divided into four-six parts.
7. For each part of the map, a group is formed consisting of farmers of that area and two facilitators.

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5. After about 50-100 villagers are gathered representing all social groups, the purpose of the exercise is explained.
6. Based on the landholding in the village, the village map is divided into four-six parts.
7. For each part of the map, a group is formed consisting of farmers of that area and two facilitators.

8. Farmers work with the survey numbers and locate all water bodies on the map: tanks, kuntas, streams, dugwells, dug-cum-borewells, borewells, filter points, drinking water sources (handpumps, standposts, etc.).
9. Farmers then classify water resources as: functional or defunct; poor/moderate/high yielding.
10. Farmers then go on to locate power sources such as transformers, power stations.
11. Land is then classified into: single/double/triple cropped.
12. Each component of the derived map is then redrawn using rangoli powder.
13. Necessary changes in the map are made in the validation meeting conducted in the evening

Figure 3-3: PRM exercise at Kothapally village, Mahbubnagar District

3.4 Resource inventory

As a follow up to PRM a more detailed resource inventory needs to be taken up. This is essential to take stock of a village's overall resource situation before implementing PHM. There are three main components of resource inventory: water, agriculture and livestock.

Under the water component, a random well inventory and inventory of surface water bodies is carried out. Specific data gathering formats are used for the well inventory, including information on well type, location, well depth, well yield, number of pumping hours, static water level and pumping water level. Collection of historical rainfall data from a nearby rain gauge station is another important activity under the resource inventory. Information pertaining to surface water bodies needs to be collected from the village panchayat or from the minor Irrigation Department. The water level data being regularly collected by the groundwater agencies from their network of observation wells should also be accessed. This wide range of data should be analysed to understand local groundwater behaviour.

Soil samples reports need to be studied or sampling carried out to know the soil's suitability for different types of crops. Actual crops grown need to be compared with the soil analysis results. Crop information is available in the form of the results from random field surveys and from secondary information provided by the Agriculture Department and the Handbook of Statistics.

The Environmental Viability Assessment developed by APWELL or similar modelling techniques used by others can be used for understanding the local groundwater balance.

3.5 Socio-economic survey

It is important that apart from the technical data, data pertaining to socio-economic conditions of the inhabitants of the watershed are documented as well. Again, a specific data gathering format should be developed suited to the needs of PHM. Apart from common socio-economic parameters, provision should be made for including information on beliefs and values concerning water in general and on groundwater in particular.

The socio-economic survey needs to be combined with a wealth ranking exercise to understand the region's socio-economic stratification in relation to access to water resources.

Table 3-1: Proposed outline baseline document

Chapter	Chapter title
1.	Location and extent
2.	Drainage
3.	Rainfall and climate
4.	Geology
5.	Hydrogeology
6.	Geomorphology
7.	Status of groundwater development
8.	APWELL intervention in the watershed
9.	Intensive Hydrological Monitoring – Action Plan
	Annexes

3.6 Additional literature

A desk study of available sources is required to avoid duplication of work already carried out by government agencies and NGOs. Data being collected by the different government agencies should be used as critical inputs to the PHM study. Data collected by NGOs, research institutions, other projects should be used for the preparation of a baseline document.

After secondary and primary data are collected and analysed, a baseline document can be compiled, including benchmark information. The baseline document should help strategise the micro-level intervention as well as providing data on which later monitoring and evaluation efforts can be based. A typical outline for the baseline document is shown in Table 3-1, while Table 3- the data that where collected by the APWELL Project.

Table 3-2: Data collected by APWELL Project

Agency/Institution/Department	Data Collected
AP State Groundwater Department	➢ Water level data
	➢ Hydrogeology map
	➢ Stage of groundwater development
Panchayat Raj Engineering Department	➢ Water quality analysis reports
AP State Irrigation Development Corporation	➢ VES data
	➢ Lithologs
	➢ Pumping test data
	➢ Borewell history
Office of the Mandal Development Officer	➢ Rainfall data
Regional Agricultural Research Station	➢ Agro-meteorological data
Office of the District Statistical Officer	➢ Rainfall
	➢ Temperature
	➢ Crops
APWELL Project	➢ EVA results
	➢ Borewell technical details
	➢ PHM data
NGOs	➢ VES data
	➢ Watershed treatment details
NICNET	➢ Population data
	➢ General statistical data
Bureau of Economics and Statistics	➢ Handbook of Statistics
Sumadhura Technologies Pvt. Ltd.	➢ Geology map
	➢ Geomorphology map
	➢ Map of geological structures
	➢ Water quality map

Once the baseline document is ready, the project is ready up to take physical action at the community level. A tentative plan of action should be part of the baseline document.

3.7 Identification of observation wells

Groundwater is under constant so-called *hydrostatic pressure* as a result of the underground movement of water. When untapped, wells maintain a water level referred as the water *table* or *piezometric level,* which is the upper limit of the groundwater reservoir. When the groundwater draft is more than the recharge, the pressure is decreased resulting in lowering of the water table. Therefore, the water level in wells is direct indication of the status of the groundwater resource.

A complete inventory of wells in the hydrological unit targeted for PHM needs to be carried out during the PRM exercise. In the PHM clusters production wells are selected as observation wells, as the aim is to get a picture under pumping conditions.

The project's hydrogeologist needs to prepare a tentative list of observation wells.

In the APWELL project the following steps are part of the identification of observation wells:

- *Using a centimetre graph, the watershed is divided into 100 ha grids. Four centimetre boxes would make one 100 ha grid.*
- *For each of the 100 ha grid units, one borewell (failed or successful), if available, is selected as observation well. It is good practice to selected at least one failed borewell is in each watershed.*
- *In case no borewell is present in the 100 ha grid, dug-wells are selected in stead.*
- *It is ensured that observation wells are equally spread over the drainage basin. At least two wells are located in the recharge area, two in the watershed's central part and one at the mouth of the watershed. Care is taken to ensure that the highest yielding, the lowest yielding and failed borewells are included.*

3.8 Installation of rain gauges

Rain gauges need to be installed in representative villages. Individual or group of farmers need to be requested to identify land which can be exclusively used for monitoring rainfall.

Proposed sites need to be inspected for technical suitability for rain gauge installation. Site conditions that need to be fulfilled to allow scientific monitoring of rainfall include:

- The site should be an open place without any obstructions in the form of trees, walls, etc.
- Distance between the rain gauge and the nearest object should not be less than twice the height of the object. In no case the distance should be less than 30 m.

- The ground should be flat without any unevenness and should not be located on the side or top of a hill.
- In hilly areas, where level ground is difficult to find the rain gauge should be located where wind cannot form eddies.
- The distance between the rain gauge and the fence should not be less than the height of the fence.

3.9 Social feasibility study

After the technical selection of the observation wells, the owners of the selected wells need to be contacted. The utility of monitoring in their wells needs to be explained. Farmers may think that their participation will result in restrictions on groundwater use or monitoring of their power consumption. It should be explained this is not the case. Any reluctance to participate in the monitoring should be accepted without questioning and alternative wells selected. Once the selection process is complete, the wells need to be located on the watershed map and integrated with the PRM map.

Finalizing the site for establishing the rain gauge station will requires a similar exercise.

3.10 Instruments for monitoring

The different parameters to be monitored under PHM need to be measured using reliable yet simple monitoring tools. The essential tools are:

- Water level measuring equipment,
- Rain gauge,
- Discharge measurement unit (calibrated drum),
- Stop-watch.

3.10.1 Water level measuring equipment

Water level measurements may be made with several types of equipment. The choice of equipment depends on several factors, including the accuracy or ease of measurement required, type of structure (borewell/open well), and pumping activity of nearby wells.

Chalked steel tape

The most accurate measurement is obtained with a chalked steel tape. This method utilizes a graduated tape with a weight attached to one end. A quality steel tape has limited elasticity and with sufficient weight attached to its end it will hang vertically in the well. The lower part of the tape is coated with chalk, and the tape is lowered into the water until the lower part of the tape is submerged. By lowering the tape slowly the contact of the weight with the water's surface can be heard. For wells with deep water levels, it may be necessary to approximately know the depth to water or to make several measurement attempts to ensure that the tape is not submerged below its chalked length. The tape is held at the reference point and the tape position recorded. The depth to the water level below the reference point is determined by subtracting the length of wet tape (indicated by wet chalk) from the total length of tape lowered into the well. The measurement should be repeated to ensure its accuracy and to ascertain that the measured water level is static.

Electric measuring tape

Electric measuring tapes typically consist of a pair of insulated wires whose exposed ends are separated by an air gap in an electrode and contain, in the circuit, a source of power such as flashlight batteries. When the electrode contacts the water surface, a current flows through the tape circuit and is indicated by an ammeter-needle deflection, a light, and (or) an audible signal. The "hold" depth against the reference point on the well is read directly from the tape as depth to water. Because the tape medium may be easily bent and the weight is often less than that used on steel tapes, the accuracy of electric tapes is considered to be less accurate. The tape can be calibrated against a steel tape and if several electric tapes are used in a study, they should all be calibrated against a reference steel tape.

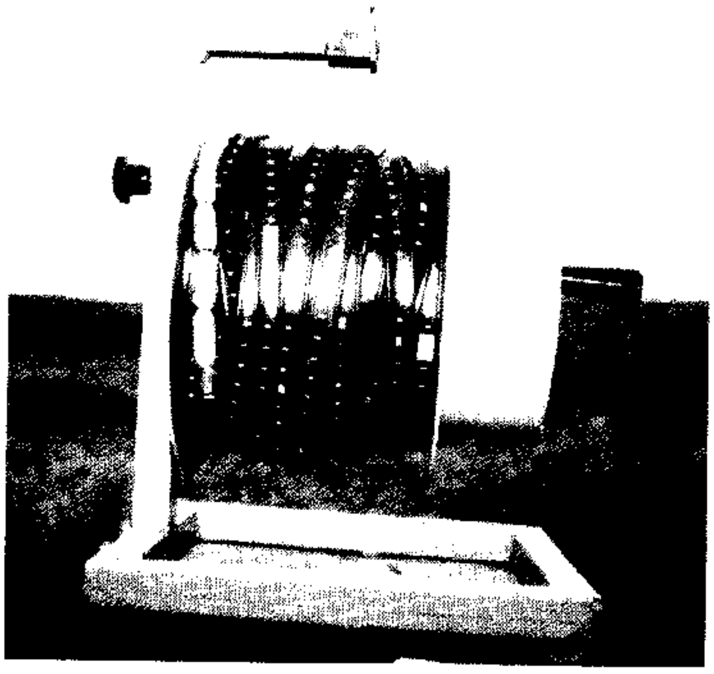
For the purpose of hydrological monitoring under the APWELL Project, APSIDC manufactured its own brand of water level indicator. One of the main bottlenecks during the implementation of the PHM pilot has been the quality of this water level indicator. Halfway through the pilot, the project has switched back to the commercially manufactured water level indicators. Two popular brands are found useful viz., IGIS and JAKS.

All the brands work on the same principle, with a liquid sensitive probe. When the probe comes in contact with water or liquid, the electronic circuit is completed and a 'beep' sound is generated, indicating the contact. JAKS and APSIDC brands are similar to each other in all aspect, except for the make of the probe.

- Assembled in pre-fabricated plastic VIP beauty case
- The electronic parts are fixed to the back of the housing cover
- Measuring cable is wound on a steel winch housed in the lower housing box
- Cable of TV antenna quality
- Measuring cable calibrated using paint and embossing technology
- Carrying bag made of cloth material is provided
- Probe consists of perforated steel frame housing plastic float and end of the electronic circuit

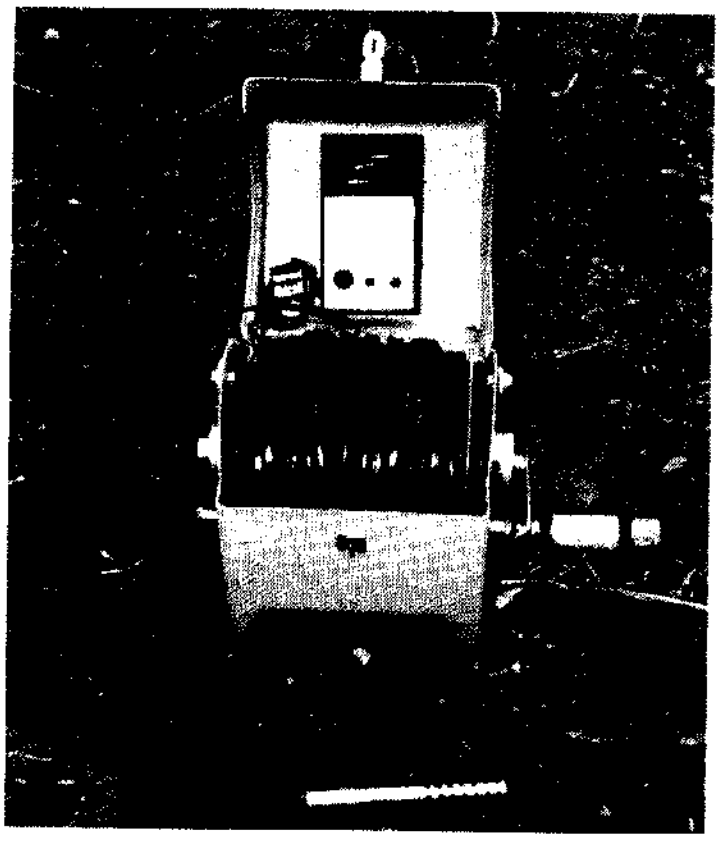
Figure 3-4:
Water level Indicator – APSIDC

Figure 3-5:
Water level Indicator – IGIS



- Assembled using a hardy steel frame
- The electronic parts are housed in a cylindrical metal box
- Handle and handle lock provided
- Cable of superior TV antenna quality
- Measuring cable calibrated using paint and screen printing technology
- Separate metal box is provided for housing the assembly
- Probe consists of liquid sensitive metal cylinders connected to the measuring cable with internal wiring

Figure 3-6:
Water level Indicator – JAKS



- Assembled in pre-fabricated PVC housing
- The electronic parts are fixed to the back of the housing cover
- Measuring cable is wound on a steel winch housed in the lower housing box
- Cable of superior TV antenna quality
- Measuring cable calibrated using paint and embossing technology
- Carrying box is provided
- Probe consists of perforated steel frame housing plastic float and end of the electronic circuit

3.10.2 Rain gauge

Several types of rainfall measuring instruments or rain gauges are available. In PHM pilot, Symon's non-recording type rain gauge is sufficient.

A Symon's rain gauge consists of a cylindrical vessel with an internal diameter of 127 mm and an enlarged base with a 210-mm diameter. In this cylinder a rain-collecting bottle made of glass or plastic is placed. Over the top of this bottle a glass or plastic funnel is inserted. The top section of the funnel is provided with a circular brass ring of exactly 127-mm internal diameter. The capacity of the bottle is up to a rainfall of 75 mm to 100 mm.

With each rain gauge a cylindrical graduated measuring glass is supplied. Each graduation of this glass reads 0.2 mm. The reading accuracy should be 0.1 mm.

3.10.3 Calibrated drum and stopwatch

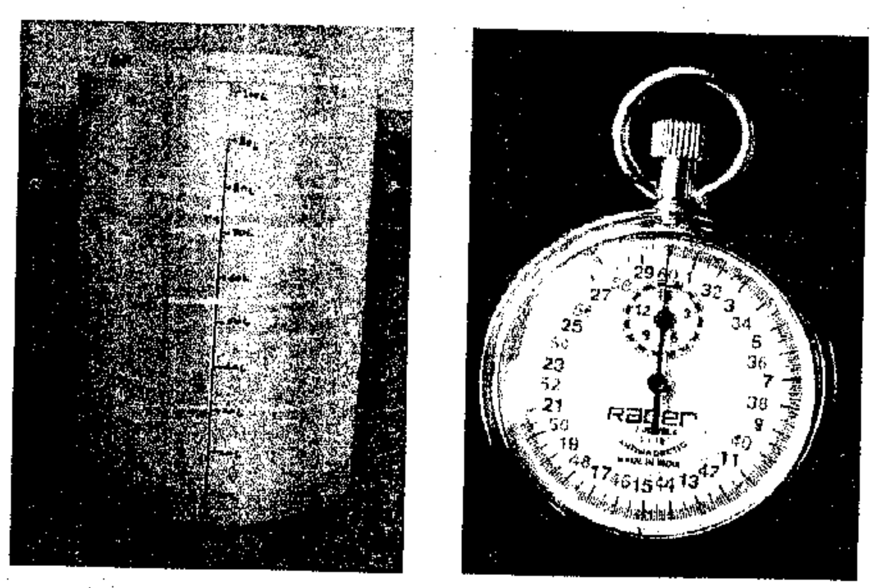
Borewell discharge can be measured using several methods. The volumetric method is simple and affordable for rural communities.

In the APWELL method, a calibrated drum with a capacity of 100 or 200 litres is used along with a stopwatch to measure the discharge of the observation well. Ready reckoning conversion tables are provided to farmers for converting the discharge in terms of litres per minute.

The Syntax type of drum is used for the purpose of PHM. Dimensions of the discharge drum vary depending on the height of the delivery pipe from the ground level. The white transparent drum is calibrated for every 20 litres. The drum of 100 litres capacity is also used depending on the field situation and suitable conversion tables have to be used.

As handling of a digital sports watch is a little complicated for the farmers, the conventional steel body stopwatch is used in PHM for timing the time it takes to fill the calibrated drum. This Indian made stopwatch comes with 60 seconds (one minute) cycles. There is provision for measuring till 15 minutes. This stopwatch proved to be robust and simple in use when compared to the plastic body sports stopwatch.

Figure 3-7: Calibrated drum and stopwatch



3.10.4 Modifications to existing structures

Additional modifications need to be carried out in the borewells to allow water level monitoring. These include:

- Provision of a conduit pipe for lowering the water level measuring tape.
- Delivery lines from the borewells for measuring discharge.
- The rain gauge site needs to be fenced with barbed wire mesh

3.11 Establishment of observation well network

3.11.1 Provision for water level measurement

During the selection of observation wells, the essential requirements for measuring water levels and discharge need to be discussed with the well owner. Where modifications need to be carried out these should be examined critically. It is not uncommon for enthusiastic individuals to implement changes causing temporary or some times permanent inconvenience to the farmer.

APWELL borewells are production wells with the entire pump assembly installed. While measuring the water levels, it is found that the probe of the water level indicator may get jammed in the borewell. To overcome this difficulty, a special lowering pipe is installed in each of the observation wells. A heavy duty PVC (blue) pipe is used for this purpose. These pipes are available in the markets in 6-meter lengths. GI couplings are used to join the pipes. At the top, above the casing pipe, a coupling is fitted with a removable nipple. A hole is made in the borewell cap, using gas-welding equipment. For newly commissioned wells, the hole is pre-made, at the workshop. A washer is used above the hole (slightly bigger than 1"), so that the pipe in brothel will rest on the casing cap. Pipes are lowered one by one using the couplings, till the top of the motor is touched.

Farmers reported difficulty because of the measuring pipe when the pump motor has to be lifted for repair. The motor is not coming out smoothly on account of the small gap between the motor pipe and the lowering pipe. Some farmers have therefore removed the measuring pipe. The main reason for this difficulty was the usage of GI couplings. The problem has been solved by replacing the GI couplings with PVC ones.

3.11.2 Making provision for measurement of borewell discharge

The procedure adopted by APWELL to make a provision for discharge measurement was as follows:

- *The entire pump assembly was lifted to a sufficient height to enable the drum to be placed underneath the delivery pipe*

- *The borewell assembly and distribution system was detached by unscrewing "L" bends.*
- *A "T" bend was put at the end of delivery pipe, with the leg of the "T" parallel to the ground surface.*
- *A pipe of 1 meter length was fixed at the end of the "T", parallel to ground surface*
- *A removable cap was fixed the end of the T.*
- *The diameter of all the material used in making discharge measurement provision matches the diameter of the delivery pipe. Figure 3- shows an example of the discharge measurement provision made.*

Provisions need to be made for measuring discharges from pumping wells. Wherever the flow is through an open channel no major modifications appear necessary. In cases where the water distribution is through a sub-surface pipeline, however, additional modifications become a necessity. A simple alteration at end of the delivery pipe will provide room for discharge measurement.

Figure 3-8: Provision at the borewell to allow for discharge measurement

3.12 Establishment of a rain gauge station

A rain gauge is set upon a concrete block of 60 x 60 x 60 cm. The rim of the funnel should remain at least 305 mm above ground.

The concrete bed of the rain gauge should be built in such manner that in the centre there is hole left measuring 76.2 mm-height and 210 mm width. In this whole a concrete bed of 25.4 mm should be laid on which the base of the rain gauge is placed. Care should be taken that 50.8 mm of the bottom portion of the rain gauge remains below ground level. After fixing the metal pipe of the rain gauge, other components (collection jar and funnel) should be placed in it and closed with the cap.

In case the height of the fencing is more than the limit, the rain gauge is built above ground level, so that other dimensions matched those of Figure 3-. Fencing is designed based on site specific conditions and availability of land.

Figure 3-9: Section of the concrete slab showing rain gauge installation

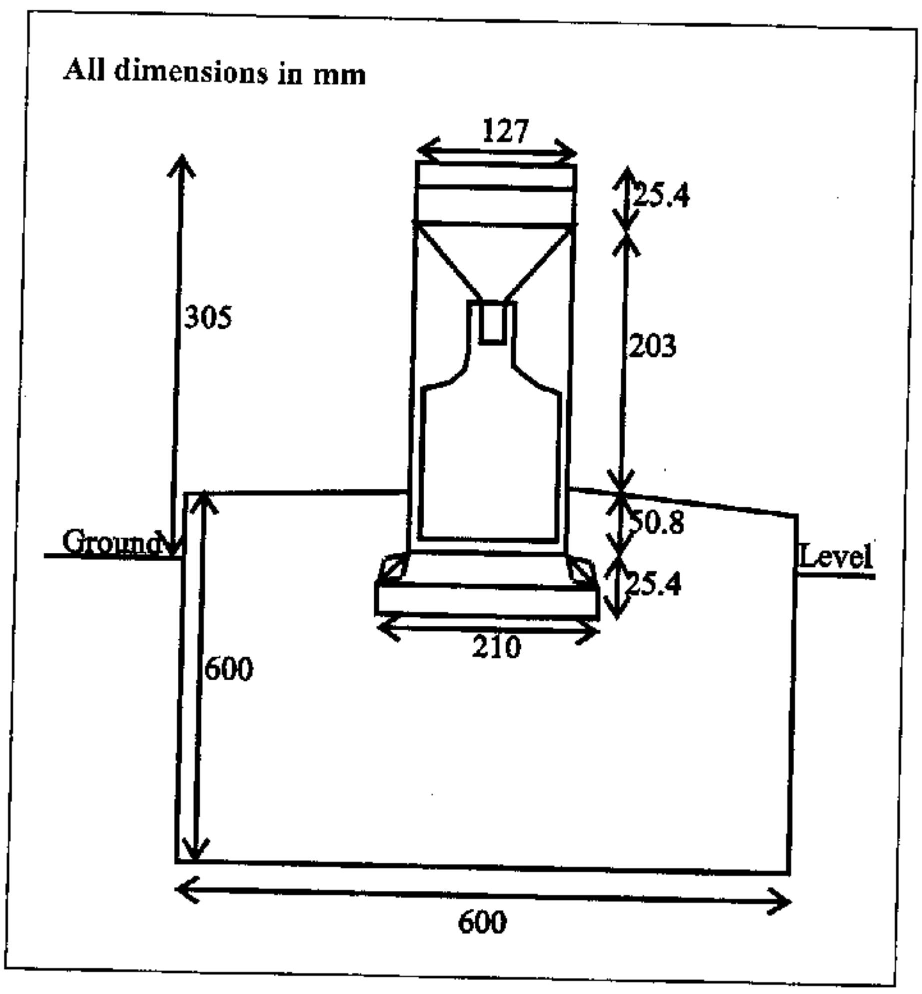
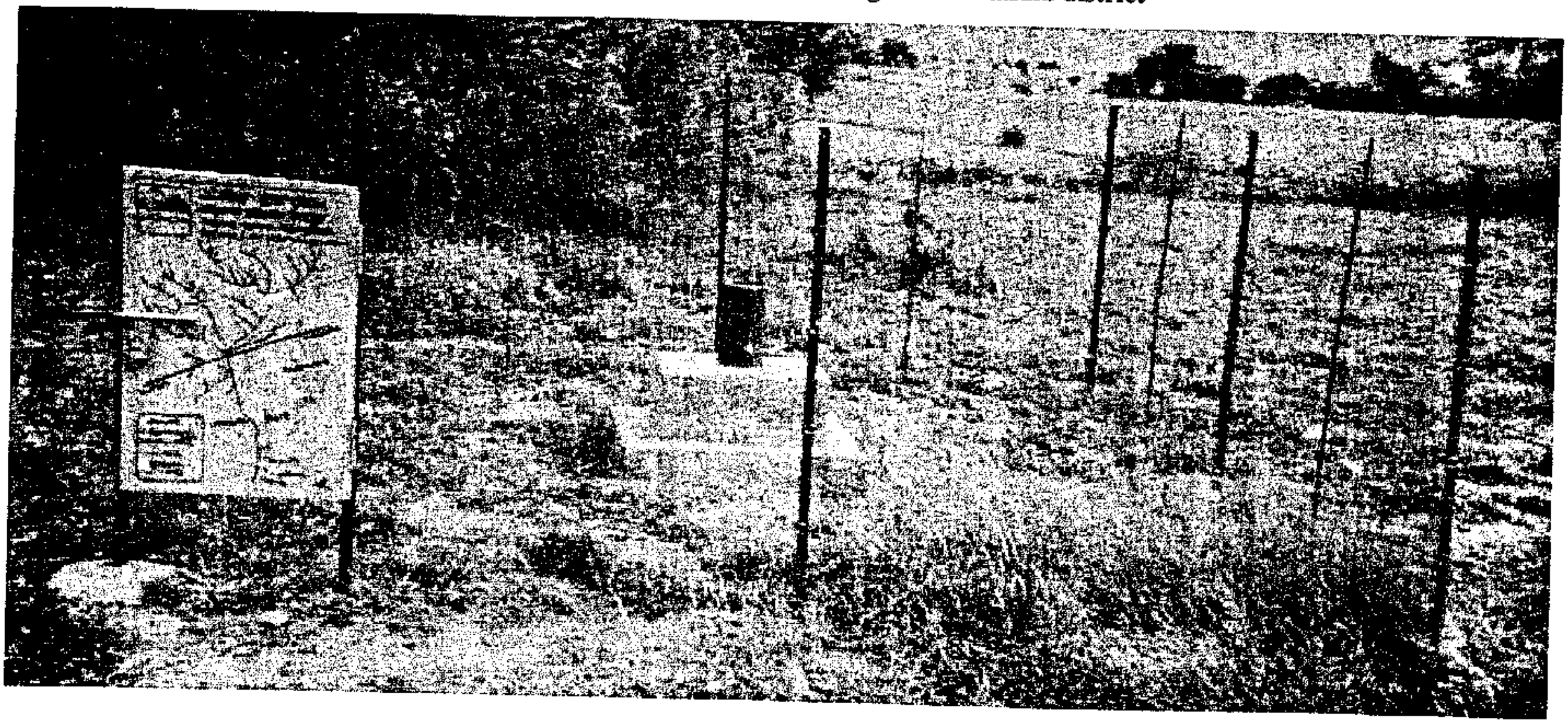


Figure 3-10 shows the rain gauge station installed at one of the PHM villages in Prakasam district. At this place, an area of 400 cm by 400 cm is fenced off. The height of the fencing is 150 cm. A gate of 150-cm height by 80 cm width is provided. Iron angler poles (0.25 gauge) are erected along the boundary with 100-cm distance between poles. Wire mesh is welded to the iron angler poles.

It is not advisable to procure the material in bulk and at a time. Material procurement should be based on the stage of the activity in each of the PHM villages. This method not only avoids storage problems but also reduces scope for mismanagement.

One of the APWELL farmers, Mr. Jangamappa from Anantapur district, has been experimenting with low-cost water level indicators. A prototype prepared by him is presently being field-tested. If found suitable and sufficiently sturdy, Mr. Jangamappa's water level indicator would bring down the cost of PHM activity drastically. However, mass manufacturing of the instrument and its marketing are aspects the farmer needs to think about before going in for large-scale manufacturing.

Figure 3-10: A rain gauge station at one of the PHM villages in Prakasam district



3.13 Identification of volunteers

By the time the previous steps are completed, there would have been plenty of interaction between the community and project staff. It should therefore not be difficult for the staff to identify motivated farmers. There could be number of farmer volunteers who are interested in one or the other aspect of the PHM, for example a literate farmer willing to help his fellow villager with recording of hydrological data. Some of the opinion leaders would be interested to act as contact persons for a cluster of observation wells. A stall owner might be interested to record rainfall daily at his shop's opening time. It is for the grass-root level staff to identify suitable volunteers from among the local communities who would later become messengers of the PHM initiative.

For the purpose of data collection the farmer owning an observation well is the right person to collect water level and borewell discharge information. Strategically, both the male and female members of well-owing family should be trained in all the aspects of hydrological monitoring since gender roles might be different in different communities. However, it is wiser to have a volunteer supervising data collection for a cluster of 4-5 observation wells. S/he would also help farmers recording and analysing water level and borewell discharge data.

Similarly, ideally the farmer donating land for rain gauge station also acts as a volunteer for collection of rainfall data. However, this may not be possible everywhere. In such cases, a family members or a neighbouring farmer interested in the tasks and having the required skills can identified as volunteer.

Since the skilled farmers tend to (seasonally) migrate in search of income, it is prudent to target a higher number of farmers for skill training than those who will immediately be involved in data collection. Women farmers must be trained along with men to ensure a gender balance.

With the identification of farmer volunteers, the stage is set for community action for sustainable management of groundwater resources.

4 Triggering Community Action

On completion of the physical activities action at the community level should be initiated. This chapter discusses the various steps to be taken up during this phase.

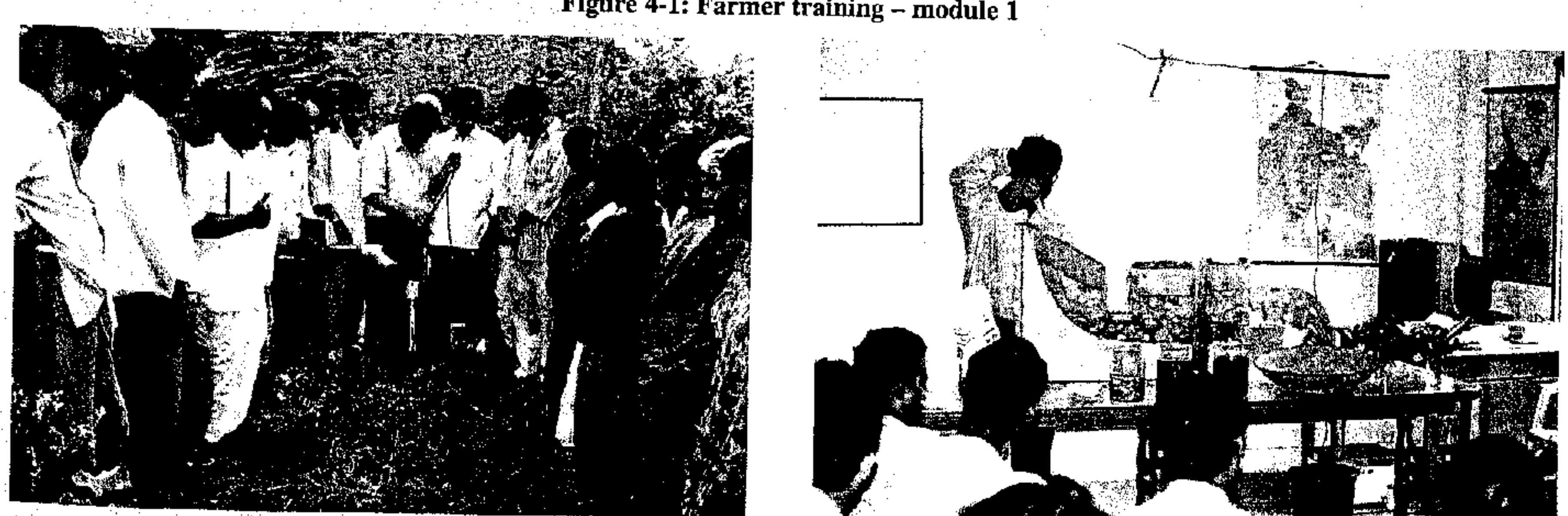
4.1 Module 1: training of volunteers

Once farmer volunteers have been identified, it is time for community capacity building. This is crucial to the successful implementation of the PHM pilot. After establishing linkages with the community at large, the stage is set for introducing the concept of PHM. The capacity building of farmers is not only aimed at triggering discussion on environmental aspects with focus on groundwater depletion, but it serves to transfer skills required for hydrological monitoring. Participants in the orientation training need to be the owners of the wells selected under PHM as well as volunteers willing to be participate in data collection.

A one-day training session is required before the start of data collection. The timing of the training is very important because volunteers should get an opportunity to try-out whatever they learn in the training.

The training first orients the farmers towards the concept and content of PHM, and, second, introduces the monitoring tools. The second session essentially includes practice by the farmers in handling the equipment and in the data collection protocol. The number of trainees should be limited so that personal attention can be given to all participants.

Figure 4-1: Farmer training – module 1



Topics to be included in the orientation session are general in nature, covering topics such as the hydrological cycle, factors governing borewell yields, causes of environmental pollution, and the importance of PHM. Visuals such as charts, OHP-sheets and LCD projections, need to be extensively used in this session. Live models, wherever available, can be used to demonstrate the dynamic nature of an aquifer system. The session needs to be interactive, e.g. by showing a visual and initiating discussion on the same.

In the second session the focus should be on explaining the utility of the monitoring tools, their functioning, design, together with simple maintenance procedures. This session should largely take place in the field and participants should be encouraged to use the equipment, and be encourages to raise question to clarify doubts.

The farmer training team (FTT) is considered as an innovative and highly successful training model field-tested by APWELL. In the later stages of PHM implementation, the more active trained farmer volunteers in each district have been constituted as and acted as resource persons for PHM training module 1. In principle the FTT has an equal number of men and women to ensure gender equity in the team but also to ensure women participation in PHM training.

Another idea being tried by APWELL to popularise the concept of PHM is to organize special training and exposure trips for school children. Apart from offering a locally relevant form of education, this also may help creating a 'pressure group' at the household level.

4.2 Allocating responsibilities

Working with the communities, it is found that although initial enthusiasm is generally high, when it comes to taking up tasks, only few people remain interested. During the training sessions potential volunteers need to be identified. At the end of the training each participant is invited to tell other participants about his/her back-home action plan while other participants chip in with advice. During this exercise, the interest and skills of each participant comes out clearly. The responsibilities need to be clearly understood by all. Persons responsible for rain fall data collection need to be told to collect data at 8 am on every rainy day. The persons responsible for water level data collection and discharge measurement should be instructed to perform their tasks once every fortnight.

4.3 Facilitating farmer data collection

Data collection is an uphill task if it is considered as a technical programme, but when translated as a programme with practical utility the task becomes easy. Without compromising too much on the quality of data, the procedures for data collection should be kept as simple as possible using simple formats with minimum entries.

4.3.1 Rainfall

Rainfall measurement is based on the level of rainwater collected in the jar. To maintain the commonality and to allow for comparison with data collected by other agencies or stations, the standard procedure prescribed for collection of rainfall data is followed in the PHM activity. The volunteers should be instructed to collect the amount of rainfall received on every rainy day at 8.00 AM. The steps followed in collection of rainfall received are:

1. The measuring jar is carried to the rain gauge station along with the farmer's Hydrological Monitoring Record (HMR), described below in section4.4.
2. The lock of the gate is opened followed by the lock of the rain gauge.
3. The conical flask is removed by unscrewing it from the fixed part of the rain gauge.
4. The collection jar is taken out.
5. The water collected in the collection jar is carefully poured into the measuring jar.
6. If the water collected is more than the capacity of the measuring jar, the first filling is thrown away and the remaining water is poured in the measuring jar.
7. If there is still water remaining in the collection jar, step 6 is repeated.
8. The number of measuring jar fillings is noted.

Figure 4-2: A farmer volunteer measuring rainfall in Prakasam district

9. In the final measuring, if the water fills the measuring jar only partly, the reading on the measuring jar is noted.
10. The number of fillings and last reading is added to arrive at the rainfall received on that day.
11. The value is noted in the HMR.

4.3.2 Water level

Initially the data collection on water level can be on a fortnightly basis. The following procedure is recommended:

1. Time elapsed since last pumping is noted;
2. The water level indicator is opened and checked whether it is functional.
3. The nipple of the blue pipe is removed (with a spanner, if required).
4. The probe with the measuring cable is slowly lowered into the well through the blue pipe.
5. Lowering is stopped once the beep sound is heard.
6. The measuring cable is slightly lifted and jerked, before lowering it again.
7. The jerking and lowering is repeated twice or thrice to make sure that exact Static Water Level (SWL) is represented.
8. The reading on the measuring cable is noted.
9. Then, the well is pumped continuously for at least two hours.
10. Just before the power is switched off or expected to be cut, pumped water level is measured, by repeating the steps 4 – 8.

Back at home, all the readings are entered in the relevant boxes in the data collection format.

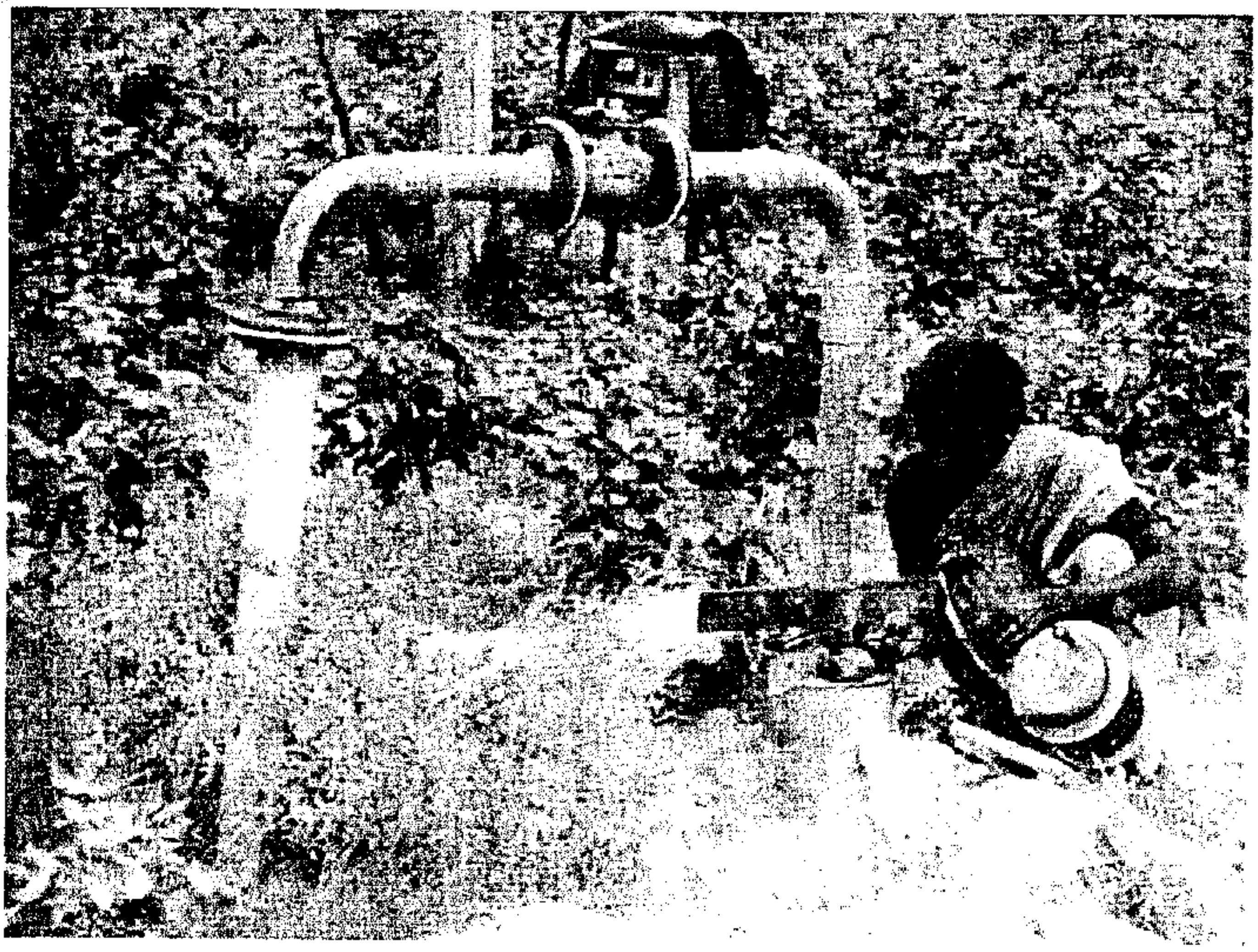


Figure 4-3: A woman farmer volunteer measuring water levels in her observation well

4.3.3 Borewell discharge

Measurement of borewell discharge is also recommended to be done on a fortnightly basis. On fixed days, discharge measurement should be done twice. The first measurement is carried out after one hour of pumping. The second measurement should be done before shutting down the pump. The procedure that is followed in measuring borewell discharge is:

1. The calibrated drum should be placed under the pipe, and the stopwatch started.
2. When the water touches the 100-litre (or 200-litre if it is 200 litre drum) mark, the stopwatch reading is noted down.
3. The discharge should be computed.
4. The measurement should be carried out repeatedly and the average calculated.

Figure 4-4: Farmers of Prakasam district measuring borewell discharge

During the first two to three months, project staff should regularly attend the fortnightly data collection by the volunteers to provide in-the-field guidance. During the next phase, trained and confident volunteers can act as supervisors.

The original approach of APWELL at the launching of the PHM pilot was to wait till farmers collect hydrological data for one full hydrological year before initiating any participatory data analysis. During the implementation stage, it was found that *farmers become curious about the overall picture at watershed level. Rising to the occasion the PHM staff started discussing the reasons for different situations in different parts of the watershed. Later, it was felt that the mid-way brainstorming on fresh data is useful for retaining the interest of the farmers. During interactions with the farmers, the following issues normally come up for discussion:*

- *Failed wells show a SWL more or less similar to the wells in the vicinity.*
- *Wells in the discharge areas yield more than those in the recharge areas.*
- *Failure of wells within short distance from functioning wells may occur when the borewell does not strike the fracture zone.*
- *The SWL gradually declines after rains end. This is due continued pumping in the absence of recharge in the rabi season.*
- *Though fresh rains come in June, SWL starts building up only in July.*
- *Drawdowns (difference between PWL and SWL) are more in the dry season than during the monsoon.*
- *Low yielding wells have a higher drawdown than high yielding wells*

It is apparent that farmers are able to understand the utility of measuring rainfall, water levels and discharge, at least for comparing the performance of wells location wise and season wise.

4.4 Module 2: Training of volunteers

After data collection starts, the farmers will realize the need for systematic storage of these precious data. At this point, a farmer's Hydrological Monitoring Record (HMR) booklet needs to be provided. Also experiments should be done with display boards at the village centre showing the results of hydrological monitoring by farmers.

Volunteers with writing skills should be identified for training for the second module, which focuses on maintaining the HMR. The first sessions deals with the recording of water levels, borewell discharge and daily rainfalls. These are explained through practical exercises. Resource persons for training should be professionals with good social skills.

In the second session of the module is best done at the display board location. Each component of the display board needs to be explained. The updating of display board is demonstrated by the trainers. This is followed by a practice session. During the latter sessions volunteers should use the field data collected by farmers.

The Hydrological Monitoring Record design could include:

- *Cover page consisting of project logo, name of the watershed, district and name of the Borewell user association.*

Figure 4-5: Training of volunteers – module 2, at Mahbubnagar district

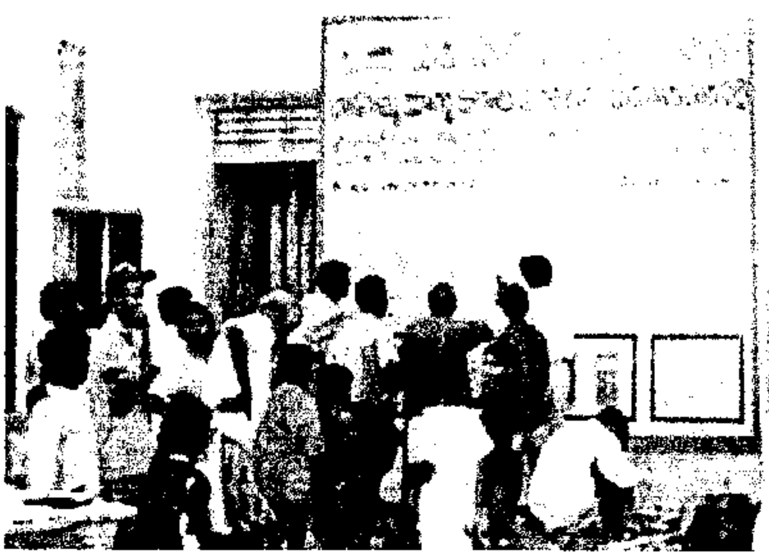
- *First page giving location of the observation well, well code and names of the farmers under the borewell.*
- *The second page is kept blank for pasting the part of toposheet showing the location of the concerned observation well, as well a the location of other nearby wells as points of reference.*
- *The fourth page furnishes the technical data of the borewell. Details pertaining to drilling, pumping test, and commissioning are documented. The information on the first till four pages needs to be taken down only once with inputs by the project staff.*
- *The table on the fifth page provides space for recording SWL, PWL and borewell discharge.*
- *The same page layout is repeated on the next nine pages to accommodate data recording of ten years.*
- *A conversion table is provided after the water level and discharge table*
- *The table that provides space for recording rainfall data of one full hydrological year follows the conversion table, which is again repeated to accommodate 10 years.*

Figure 4-6:
Farmers updating HMR

4.5 Erection of display boards

The display board is crucial for generating interest in the community. Four types of display boards should be used in the PHM pilot phase for awareness generation viz., water level type, rainfall type, watershed type and signboard type.

The water level display boards are erected at central sites, for example a school or the panchayat office. Walls of the buildings can be used paint a table making provision for updating of SWL and PWL in the observation wells. Farmer volunteers use the earmarked columns against each observation well to enter the data. Provision is made for data entry for one hydrological year. Permanent markers are used to update the data, which is repainted after one year.



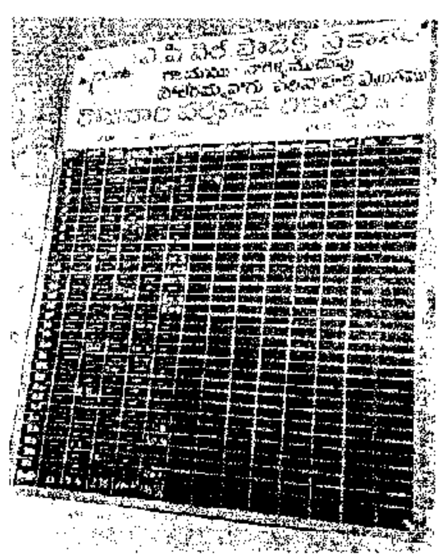


Figure 4-7: Display boards – water level type and rainfall type

At villages where a rain gauge station is established, a board is erected at the village centre to display the rainfall received on a day-to-day basis. Provision is again made for one hydrological year, after which the board is repainted.

A huge 6 by 4 feet, metal and wood display board is erected at the centre of all the villages that are part of the target watersheds. The watershed map is transferred from the toposheet onto the display board. The board also shows a figure marking a vertical section of the watershed along three different profiles, covering the observation well network. The subsurface lithology is clearly depicted in the latter figure, which calls for reliable technical inputs by project staff. Enough provision is made at the bottom portion of the board (painted in black) to mark the results of data analysis. Farmers use this space to write with a permanent marker. This type of board is erected where PHM is implemented on an intensive scale, referred to as IPHM.

Apart from the display boards, used for updating the data and for creating awareness on the functioning of the aquifer system, other small, 1 x 1 metre sized boards mark the implementation of the PHM pilot. These boards are erected at strategic locations such as village centres, road turnings, and rain gauge stations.

Display boards showing watershed details with a provision for updating the hydrological data not only facilitate understanding of the hydrological regime, but also initiate discussions among the water users.

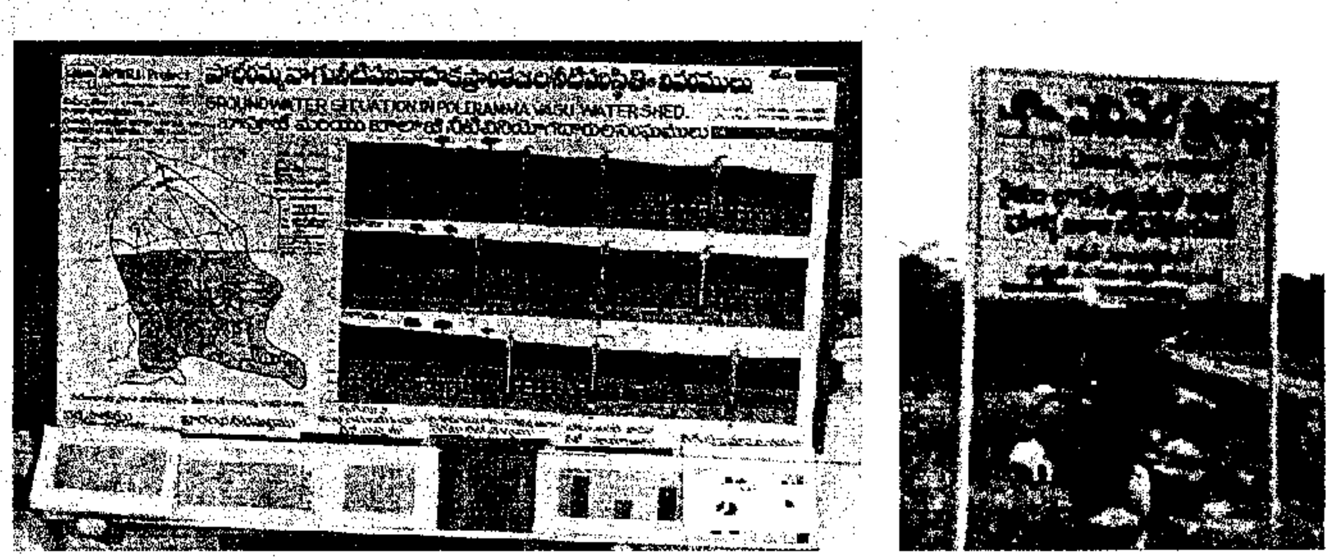


Figure 4-8: Display boards – watershed type and signboard type

4.6 Formation of groundwater management committees

In the village context, several people's institutions already exist due to intervention by government and non-governmental organisations, mostly groups formed with an activity-specific objective. For example, woman development programmes have created self help groups and the watershed development programme has formed watershed committees. Apart from these issue-specific institutions, there is the panchayat raj body duly elected by adult Indians. Wherever possible, PHM should use existing institutions dealing with water to promote the concept and content of the activity. Where there are no institutions working for sustainability of water resource, a new groundwater management committee (GMC) can be organised.

APWELL organised farmers into water user groups (WUGs) at the borewell level. A typical WUG consists of eight to ten members, two each from each family owning land irrigated by a particular borewell. The WUG is responsible for the operation and maintenance of the borewell, including crop planning and equitable water management.
At village or cluster level several WUGs are federated into a borewell user association (BUA). The functions of BUAs include training, conflict resolution related to water management, keeping of a common fund to meet expenditures incurred above the WUG level. Another important institutional building exercise undertaken by the project is the formation of women self help groups (SHG). SHGs bring all women members of the WUG together. SHG activities are instrumental in mainstreaming gender concerns in the entire project.

4.7 Module 3: training of GMC

Given the GMC's focus on sustainable management groundwater resources in a hydrological unit, it can definitely provide support to the implementation of the Land, Water and Tree Act. The best approach is to create an enabling environment at grass root level instead of propagating a control approach through legislation.

Needless to mention that the GMC, with its focus on sustainable groundwater management, needs to possess skills, knowledge and information enabling it to meet its tasks. Trained farmer already possess skills regarding running of people's institutions and in PHM data gathering. It will be to the advantage of the GMC that some of the PHM farmer volunteers are included in its membership.

The main function of a GMC will be to trigger discussion in the farming community about the status of groundwater development and act as a pressure group for initiating measures aimed at sustainable groundwater management. This calls for good organisation and communication skills. Training module 3 covers management aspects relevant to groundwater resource management and effective methods of rural communication.

the topics covered in module 3 include: conduct of a meeting; maintenance of records (minutes of meetings, accounts, borewell logbook); participatory tools for rural communication, operation and maintenance of borewells; water sharing agreements; legislation pertaining to groundwater; institutions involved in groundwater management. The training methodology is similar to that of previous modules. One additional feature of module 3 is an exposure visit to existing GMCs familiar with PHM activities. Farmer-to-farmer interaction has proven to be more effective than interaction between a facilitator and farmer. Farmer training teams (see section 4.1) are also used wherever feasible.

4.8 Facilitating documentation and dissemination

Depending on the receptiveness of the community, regular farmer level data collection may be realized in the first one to two years after the completion of physical works. The role of professional facilitators is of great importance during this transition phase during which it is attempted to make the scientific domain accessible to farmers. Motivation and self-confidence forms a key to success.

During the first phase, maintaining process documentation and recording technical data poses a challenge. In APWELL the process of PHM is documented in the form of photographs, records and staff reports as well as through minutes of meeting of people's institutions, and display boards. For dissemination of PHM learning, the Project uses the media, video and film, and it publishes reports. Exchange of success stories between PHM villages is another important activity. Farmer level documentation needs continuous facilitation by the staff during the initial phase.

Documentation that is not shared within the community has limited value. Hence, facilitators need to look for ways and means to disseminate data collected by farmers. Formal meetings of people's institutions offer a good opportunity for disseminating information relating to sustainable groundwater management. Informal chats in small groups, special meetings with opinion leaders offer further opportunities.

4.9 Handing over assets

It is not possible for any project, to continue village level activities forever. However, the onus of post-project sustainability is always on the project itself. To ensure the sustainability of project initiated activities, proper handing over has to take place. Handing over can be understood differently by different people. In case of PHM, the handing over means the change of ownership of the project assets.

APWELL adopts an approach of phased hand-over. In the regular borewell programme, a borewell is handed over to the WUGs one year after the wells commissioning. Material appended to the borewell (like a water level measuring pipe, discharge measurement provision, etc.) is handed over along with the borewell.

The water level indicators and rain gauge stations located on the farmer's field are handed over to the BUA or GMC after data is collected for one hydrological year. All the BUAs in the PHM watersheds collect a common fund from the WUGs in a village to meet the expenditure on common spending. Among others, BUAs use this fund for maintenance and repair of PHM equipment.

5 Crop-Water Budgeting

As mentioned in previous chapters, both governmental and non-governmental agencies are making efforts towards improving the groundwater situation through watershed development activities. Research has established that watershed treatment does not necessarily result in improved groundwater levels. In general only a marginal improvement is possible through watershed treatment. GEC 97 puts the increase in annual recharge by 2% of the rainfall received. For many watershed development programmes it is simply impossible to establish the impact on groundwater levels, since they have not collected proper base line data. Even when such data are available it is not easy to attribute increased groundwater levels solely to watershed treatment. However, watershed development programmes have a broader agenda than mere groundwater recharge and as such are a positive step towards sustainable land and water management.

It is often noticed in the watershed villages that farmers come with the pleas of construction of more wells, as they have improved the groundwater situation. Private drillings also take place with the hope that they strike water, even if they have earlier drilled several failed borewells. Looking from a water balance angle, the benefit accrued by the watershed treatment is thus nullified by increased groundwater extraction.

Efforts like watershed treatment, artificial recharge, tree planting, all target the *supply side* of the groundwater management. Simply put, they try to put more water into the ground, logically to sustain a larger use. So far, very little attention has been paid to the other side of the coin, *demand side* management. The APWELL project tackles the demand side of groundwater management in the book titled – *sustainable groundwater utilization.*

It is rather easy to convince farmers to contribute to supply side management, because this mostly requires limited inputs by individual farmers. Moreover, farmers tend to regard watershed treatment as an opportunity to increase the groundwater draft. On the other hand, demand side management is quite unattractive, as farmers see little reason to curb wastage of water, or to increase their knowledge more about crop water requirements, change cropping pattern, let alone close their borewells. In quantitative terms farmers also have no way of gauging what would happen over a period of time, if the present rate of extraction continues.

The Crop-Water Budgeting (CWB) exercise is an initiative taken up under the PHM activity, *attacking the problem from demand side.* It is considered as the final step in the chain of PHM aiming at sustainable groundwater management by the farmers themselves. This exercise can be taken up only when farmers have generated authentic and continuous data for at least the first part of a hydrological season.

After four years of PHM implementation a full-fledged CWB exercises were done in eight IPHM watersheds in the seven APWELL districts, in October/November 2001 and repeated in 2002. The methodology suggested in this chapter is the built on the results of these experiences.

5.1 Resource inventory updating

The baseline data document prepared before the start of the PHM intervention generally provides a good insight into socio-cultural aspects of the watershed community and the status of the water resources in general and groundwater resources in particular. This information is very useful for the activities carried out during the CWB phase. However, the available baseline data need to be updated to ensure the validity of the CWB estimations.

Resource inventory updating uses the same survey formats used for the base line survey, combined with several pictorials and graphs generated by the participatory exercises. The information is presented to the community in small group meetings. Changes are made based on their feedback. As in case of base line survey, detailed inventories are carried out by professional staff through transect walks with the farmers. Subsequently the information is compiled, transferred on to charts, and validated in a meeting of groundwater users in a village/watershed.

The seasonal groundwater balance estimation is thus based on two types of information: (i) data provided through the resource inventory updating activity, and (ii) PHM data collected by farmers. Both the types of information are required to arrive at an estimate of groundwater recharge, draft and balance.

5.2 Estimation of groundwater recharge

Recharge estimation is usually done using two methods viz., the groundwater fluctuation method and the crop-water requirement method. Recently the GEC has developed another method based on rainfall received. The GEC method is simple and avoids lengthy procedures for calculating recharge from different sources separately. It uses standard recharge values for different types of geological formations. As all the water is sourced from rainfall (except where base flows are contributing), apart from its simplicity, this method is adopted in groundwater recharge estimation.

Moreover, the entire idea of CWB exercise is to match the annual groundwater draft with annual recharge. The thumb rule is that the annual draft should not exceed the annual recharge. If we keep this in mind, historical depletion or supplementation of the aquifer does not matter. The case of MC Thanda (Anantapur District) watershed is used in this booklet to illustrate the content and usage of the CWB package.

In all the worksheets, different colours are used to indicate the nature of the cell. APWELL has evolved an MS Excel spreadsheet for estimation of groundwater recharge. The spreadsheet is in the local language, as the ultimate users are farmers, using a Simputer The Excel package contains 10 worksheets. The first eight worksheets contain one table each. The ninth sheet contains several tables that are source data for the graphs generated in tenth worksheet. Field level staff should not change yellow coloured cells that denote one-time input. Pink coloured cells also refer to one-time input but at field level. Red coloured cells are earmarked for periodic entries. Sky-blue and blue coloured cells are automated and the values appear in the relevant cells once entries are made in the yellow, pink and red coloured cells. The blue coloured cell shows the final product of the computations: the estimated groundwater recharge.

Figure 5-1 shows worksheet 1 of the CWB package. This is used to estimate groundwater recharge during June-October.

The farmers in IPHM watersheds maintain a rainfall record. The rainfall received during June-October is summed up (averaged where more than one rain gauge station is established) and entered in the red cell of the worksheet 1. Based on geological maps and field verifications, the area under each type of geological formation is calculated and entered in the pink cells of worksheet 1. After these two data inputs, the groundwater recharge for the period June-October is computed automatically in the last row of the column-recharge (blue cell). Once pink coloured cells are filled in, only one entry is needed in the worksheet 1.

Figure 5-1: Worksheet 1 of CWB Package – Estimation of recharge (June – October)

పట్టిక 1 : సీటి జమ అంచనా (జూన్ నుండి అక్టోబర్ వరకు)							
జూన్-అక్టోబర్ లోన మోదయన వర్షపాతము	349.80	మి.మి.	0.35	మీ	సీటి జమ		
నీటి ప్రాంతము లోని రాళ్ళ రకాలు	విస్తీర్ణము					%	మొత్తము
1. మట్టి కలిగియున్న గ్రానైటు సంభందిత రాయి	100.00	హెక్టేర్లు	1,000,000	చ.మీ.	8	27984.0	ఘ.మి
2. మట్టి లేసి గ్రానైటు సంభందిత రాయి	280.00	హెక్టేర్లు	2,800,000	చ.మీ.	11	107738.4	ఘ.మి
3. తూర్పు తీరం	0.60	హెక్టేర్లు	6,000	చ.మీ.	16	335.8	ఘ.మి
4. హిందు - గంగ నదీ తీరం	0.50	హెక్టేర్లు	5,000	చ.మీ.	22	384.8	ఘ.మి
మొత్తము నీటి జమ	381.10	హెక్టేర్లు	3,811,000	చ.మీ.	14	136.443	ఘ.మి
% జి.ఇ.సి. 1997 వారి ప్రకారం							

5.3 Estimation of groundwater draft during June-October

Groundwater draft is estimated based on well discharge and the total number of pumping days. Figure 5-2 shows the relevant worksheet.

Figure 5-2: Worksheet 2 of CWB package – Estimation of Draft (June – October)

పట్టిక 2 : నీటి ఖర్చు అంచనా (జూన్ నుండి అక్టోబర్ వరకు)				
	బావులు	బావిలో బోర్లు	బోర్లు	
జూన్-అక్టోబర్ లో వాడిన బావులు/బోర్లు సంఖ్య	0	0	9	
సగటు రోజువారి పంపింగు గంటలు (జూన్-అక్టోబర్)	0	0	6	గంటలు
జూన్-అక్టోబర్ లో పంపింగు రోజులు	0	0	74	రోజులు
సగలు నీటి పరిమాణం (లీటర్లు/గం.కి)	0	0	22556	లీటర్లు/గం.
మొత్తము	0	0	90133776	90133776 లీటర్లు
మొత్తము నీటి ఖర్చు				ఘ.మీ.

5.4 Estimation of groundwater balance

The groundwater balance is estimated based on the straightforward equation that the difference between the net recharge and net discharge equals the change in groundwater storage. A positive balance implies that recharge has been higher than the draft. A draft higher than the recharge gives a negative balance.

5.5 Farmers' Crop-plan

Apart from resource inventory, crop-plans for different seasons need to be collected from farmers in small group meetings at village level. Depending upon the cropping pattern of the area, this crop-planning exercise needs to be conducted at least twice a year, specifically before onset of rabi and kharif seasons. While the kharif session is carried out during June/July, the rabi session takes place during October-November, depending on the region's agriculture calendar. The crop-plans should specifically cover the ayacut under borewell and open well irrigation.

Rabi crop planning should be extended to the end of May, thus covering both rabi and summer seasons. The crop-plan in PHM activity is to be carried out for the entire area under irrigation in a hydrological unit. This is a very detailed exercise and calls for a tight schedule of fieldwork for PHM staff. The ideal area that can be covered by one PHM team is about 500 ha.

The crop-planning exercise should be carried out in small groups using participatory tools of rural communication. Secondary data sources such as village land records (Pahaani), village cadastral maps and Agriculture Statistical Abstracts are used for cross-checking the farmer data.

Another strategy that can be used is crop planning at the level of a specific water source (well/in well bore/borewell). The ayacut under each source is known from the participatory exercises as well as from village records. Information on farmers owning or leasing land under each source is gathered from villagers as well as from village records. The crop-planning exercise in a PHM watershed will be a very useful exercise for both farmers and project staff. After the first exercise, future data collection will be easier since part of the data only need to be updated.

5.6 Estimation of crop-water requirement

The crop water requirement for a farmer's crop plan needs to be estimated for establishing whether the available resource matches the crop water demand. For this the most important information concerns the groundwater used by different crops in different agro-climatic and soil conditions. The agriculture department has calculated standard requirements for each specific area. The expertise of the agriculture department therefore needs to be availed of.

5.7 Projected groundwater balance at the end of hydrological year

Based on the computation the groundwater balance for the specific hydrological year can be estimated. In case a plot of land is served by more than one irrigation source a correct approportiation needs to be made, see Figure 5-.

Figure 5-3: Worksheet 6 of CWB package – area to be irrigated under sources other than groundwater (November – May)

పట్టిక 3 : నిలువ భుగర్భజలాల అంచనా (అక్టోబర్ అంతానికి)			
మొత్తము నీటి జము		136,443	ఘ.మి
మొత్తము నీటి ఖర్చు		90,134	ఘ.మి
మొత్తము నీటి నిలువ		40,309	ఘ.మి
నిలువ రకము		40,309	ఘ.మి
		-	ఘ.మి
రబి/వేసవి పంటలకి అందుబాట్లో ఉన్న భూగర్భజలాలు		37,049	ఘ.మి

5.8 Crop-water budgeting workshop

The CWB exercise takes farmers through groundwater balance estimation process at two stages of the monsoon year viz., end October and end May. Field level preparations for the CWB workshops include:

- Collection and compilation of individual well-wise crop plans, covering the entire irrigated area in the hydrological unit, for the November – May period.
- Detailed inventory of functional wells (during June – October).

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Figure 5-3: Worksheet 6 of CWB package – area to be irrigated under sources other than groundwater (November – May)

పట్టిక 3 : నిలువ భుగర్భజలాల అంచనా (అక్టోబర్ అంతానికి)			
మొత్తము నీటి జమ		136,443	ఘ.మి
మొత్తము నీటి ఖర్చు		90,134	ఘ.మి
మొత్తము నీటి నిలువ		40,309	ఘ.మి
నిలువ రకము		40,309	ఘ.మి
		-	ఘ.మి
రబి/వేసవి పంటలకి అందుబాట్లో ఉన్న భూగర్భజలాలు		37,049	ఘ.మి

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- Detailed inventory of functional wells (during June – October).

- Inventory of other water sources in the hydrological unit and estimation of the water that would be available for irrigation during November – May.
- Compiling PHM data (rainfall, borewell discharge, SWL and PWL) and collecting other relevant secondary hydrological data.
- Data entry in the tables of CWB spreadsheets.
- Meeting of PHM team with farmer volunteers and consultants, on the penultimate day of CWB workshop for thorough understanding of the topic and rehearsing.

The CWB workshop brings all the groundwater users in a hydrological unit together. During the preparatory phase, the staff and farmer volunteers have listed each and every groundwater user. All of them need to be invited to the workshop.

APWELL attempts to get 100% attendance in CWB workshops. It succeeded in this for five of the eight IPHM watersheds. At the remaining workshops, the attendance ranged between 80% – 99%.

The first session of the CWB workshop starts with the formal introduction of the staff and other resource persons to the farmers facilitated by the APWELL District Field Coordinator (DFC). This is followed by an exercise facilitating each of the participant farmers to know other farmers in the hydrological unit and to estimate the percentage of people attending the workshop against the total number of users. This is done with the help of the list of farmers prepared based on crop-planning and resource inventory updating exercises. Names in the list are called out loudly so that other participants remember the names. Each farmer then gives details of his/her irrigation source including type of well, self-financed/financed by others, functioning/non-functioning and reasons for non-functioning status. This exercise already generates some discussion on causes of declining level (if applicable) of groundwater sources.

Picking up issues from the discussion generated in the introductory exercise, consultants then give a briefing about the need for the CWB workshop. This generally starts with the general status of groundwater situation in the area and goes on to emphasize the need for farmer-managed groundwater systems. Activities taken up under the PHM programme are also briefly explained to provide the background for the following exercises. The briefing concludes with introducing the farmer volunteers who have been actively participating in data collection and other PHM related activities.

The second session begins with a farmer presentation, which includes visuals of the topography, geology and boundary of the hydrological unit. The presentation is done with the help of the display board, which is erected at each of the IPHM villages. Where the board cannot be transported, charts are used to make this presentation. This presentation is usually made by the President of the GMC (if it is formed) or by one of the village opinion leaders. Boundaries of the hydrological unit are described using local terms and vocabulary, followed by a description of the surface drainage. The cross-sections across the watersheds, drawn on display boards of IPHM villages, are used to explain the subsurface lithology and yields of wells. Location of observation wells, rain gauge station and other features concerning the PHM activity are shown on the map.

Then, the farmer volunteer who has been collecting rainfall data is invited to share his/her experience. The presentation includes the data collection results as well as his/her opinion on collection of rainfall data by semi-literate farmers themselves. Another farmer then builds on the previous presentation on rainfall data and links rainfall, the static water level, and pumping water level in the observation wells. The relationship between water discharge in observation wells and water levels is then discussed and explained. All the farmer presentation in this second session deal with the data collected between June-October in greater detail, often leading to discussion.

The Hydrological Facilitator sums up the proceedings of the session adding his/her remarks and goes on to explain the recharge-draft-water level relationship with the help of an LCD projector. A Graph generated in the last worksheet of the CWB package is used for this purpose.

In the third session, a farmer volunteer presents the results of the water balance estimation using worksheets 1-3 of the CWB package. The description of worksheet 1 begins with a general briefing of the geological formations underlying the hydrological unit and their respective infiltration capacities (as recommended by GEC 97). The Hydrological Facilitator helps the farmer volunteer with the computer LCD projection. Total rainfall received during June-October is then entered in the relevant cell of worksheet 1 and the resultant recharge is shown to the participants. The Hydrological Facilitator explains the logic of the worksheet and the purpose of assigning different colours to different cells. Computed recharge during June-October is shown to the participants. S/he concludes the session with the remark that future entries in worksheet 1 will be limited to only one entry and helping farmer volunteers becoming confident in handling the CWB package.

Worksheet 2 of the CWB package, dealing with estimating draft (June-October) is then presented. Reference is made to farmer interaction while collecting the data for input in the worksheet. After a brainstorming session, values are entered in the worksheet's red cells and the resultant draft is shown.

Worksheet 3, which is fully automated, is then presented. The source cell of each of the value derived in the worksheet is shown by going back to worksheets 1 and 2. The computing procedure of the balance at the end of October is explained. The participants are then invited to identify whether the balance is surplus or deficit. If the balance is surplus, the reason for making 80% of it available for remainder of the monsoon year (ie, the dry season) for agriculture is explained. In case the balance is negative, the reason for showing the available groundwater as zero is explained. The third session ends with the summing up of the results of worksheets 1-3 and the status of groundwater availability for rest of the monsoon year.

Session 4 of the workshop is facilitated by the Agriculture Facilitator and presented by another farmer volunteer. Worksheets 4 and 5 of CWB package are used in this session. The session starts with a briefing by the Agriculture Facilitator on the process of crop-planning exercise. A farmer volunteer then present worksheet 4, showing the first row and reading the names of the crops that are planned. S/he then runs down all the proceeding rows showing names of each farmer and crops planned by him/her during November-May. S/he then goes to the last row of the worksheet and reads out the total area planned under each crop.

In the transition phase switching between worksheet 4 and 5, their relationship is explained. The source cells of columns 2 and 3 in worksheet 4 are shown by going back to worksheet 4. The automated computation in worksheet 5 is then explained. Session 4 is concluded with the description and meaning of the last row of worksheet 5, which gives the total area planned for cropping, and total water requirement for the planned crop plans.

The fifth session deals with the projected groundwater balance at the end of the monsoon year (May). Another farmer volunteer with the facilitation of both Hydrological Facilitator and Agriculture Facilitator uses worksheets 6-8 in this session. Worksheet 6 is discussed first. This gives the data pertaining to other water sources. After the computation process is explained, the data entry part and the source of the data are explained. In case the participants suggest any changes in the values, the required changes are made. In the last row of the worksheet, water available from other sources (during November-May) is shown. While presenting worksheet 7, explanation is given as to how the rainfall projection (November-May) is made. The computation method of recharge estimation is explained again. In worksheet 8 the automation process is explained switching between the sheets. The resultant row of the worksheet 8 is presented.

At the end of the fifth session, participants are invited to work with worksheets 1-7 to change the situation in worksheet 8. It is observed that farmers mostly change numbers in worksheet 4 (crop-plans). They often start with reducing the area under water intensive crops going on to removing a certain crop or adding a new crop. Other worksheets usually touched by farmers are worksheets 6 and 7, changing the rainfall and water from other sources.

In the sixth session of the workshop participants are invited to voice their opinions on the groundwater situation in the watershed. It is observed that active farmers find this a good platform to express their leadership qualities. Moderation by the facilitators is needed to focus the discussion on the topic of groundwater management. Lastly, the future direction of PHM activity is announced, which includes a crop adoption survey and related group meetings. The workshop is concluded with a vote of thanks.

5.9 Crop adoption survey

One of the major activities taken up after the CWB workshop is the crop-adoption survey. This is carried out by the time farmers have sown the seeds in their fields. The objective of the survey is to document the impact of the CWB workshop in terms of change in crops planned and actual crops sown. The data collection should be through small group meetings and farm visits.

Results of the crop-adoption survey need to be shared with the groundwater users of the watershed in small group meetings as well as a meeting at watershed level. These meetings should be used to trigger discussion among farmers on the crop-water relationship and parameters that are out of the control of the farmer, such as rainfall.

5.10 Module 4: GMC training

The crop-water budgeting workshop is expected to expose the entire farming community in a hydrological unit to the intricacies of groundwater budgeting. This has to be followed by one or more training sessions aiming at strengthening the skills of farmers in crop-water budgeting. The topics also aim at enhancing the skills of GMC members in institutional management. The number of participants should be limited to a manageable number. Resource persons for training module should be drawn from the professional team, after they have been a thorough orientation at project level facilitated by the consultants.

In session 1, participants carry out a review of the PHM activity in their watersheds. Drawing upon their reflections, session 2 lists the skills required to run the GMC. The list normally consists of topics such as conducting meetings, book keeping and financial management. Session 3 focuses on these topics. Session 4 should be dedicated to handling of computations.

As computers have become common even in rural areas, it is not difficult to get a member of the GMC familiar with the operating computers. In some cases, the GMC brings along school/college going boys from the villages that are willing to help. The tools used in the workshop should be extended to computers and dedicated software packages for water balance computations. The rural computer 'Simputer' appears to suit future requirements.

5.11 Farmer melas

Farmers melas (conventions) are a good next step to popularise the results of people managed groundwater monitoring efforts. These melas offer an excellent platform for farmer-to-farmer interaction. The objective of such farmer mela is to the share the results of PHM exercises with the larger community. Farmers not yet familiar with PHM are exposed to the use of a rain gauge station, observation wells, demonstration plots with water saving devices and new crops, and are able to interact with more experienced fellow farmers. Monitoring tools, agriculture produce all need to be demonstrated in the stalls. Mela's give credibility to GMCs and confirm farmers in the importance of their activities.

6 Documentation, dissemination and linkages

6.1 Documentation and dissemination

As the pilot activities being implemented by the APWELL project try to find answers to some of the most burning issues in groundwater management, the Project has adopted an approach of sharing its learning in several platforms, at state, national and international level. This strategy is adopted to solicit feedback, but also to influence policies.

Given the pilot nature of the PHM initiative, APWELL is aware of the importance of the documentation of both the processes as well as the physical activities. The learning of PHM is documented in several forms viz., reports, papers & presentations, booklets, videos, computer packages, flip-charts and photographs. This chapter gives a brief description of the various dissemination tools.

6.1.1 Reports

APWELL publishes quarterly reports to appraise the donor and other stakeholders. Implementation of PHM activity started in the project quarter 17 (April-June 1999). A section in the quarterly report 18 (June-August 1999) gives the progress of the pilot during the quarter 17. Progress of PHM activity is a feature in all subsequent quarterly reports.

In addition the following APWELL Technical Reports deal with PHM activities:

No. 24, *Watershed Management, Hydrology and Environmental Issues: Mission Report*, October 1998.

No. 25, *Proceedings of the workshop on 'Sustainability of APWELL Borewells'*, February 2000.

No. 32, *Murky water: control over groundwater extraction*, November 2000.

No. 33, *An assessment of PHM activities and pump-set efficiency*, December 2000.

No. 34, *Training impact evaluation*, December 2000.

6.1.2 Papers and presentations

Workshops, seminar organised by national and international agencies serve as good platforms for exchange of current thinking and activities in the field of water resource management. APWELL Consultants and staff have been able to participate in a number of relevant seminars and workshops to share the concept and content of PHM. The sharing is done in the form of power point presentation and special papers, including:

- Govardhan Das, S.V. and P. Somasekhara Rao, *Participatory Hydrological Monitoring (PHM) – An effective tool for community managed groundwater systems*, Proceedings of the National conference on land resource management for food, employment and environmental security, Volume: "Advances in Land Resource Management for 21st Century". Soil Conservation Society of India, 1999
- Govardhan Das, S.V., *Monitoring, assessment and legislation of groundwater resources in Andhra Pradesh, India: Recent developments*, Proceedings of the workshop on "Agriculture Water Demand Management". The International Land Research Institute the Netherlands and Acharya N. G. Ranga Agricultural University, Andhra Pradesh. 2001.
- Wal, Jan W K van der, Joseph L. Plakkoottam, R. Ratnakar and S V Govardhan Das, *Community managed groundwater systems: Lessons from the APWELL Project*, Proceedings of the workshop on critical issues facing groundwater sectors in Sri Lanka and South India. International Water Management Institute and Tata water policy studies. 2002

Apart from the above papers, APWELL has carried the PHM experience to *the Dialogue of water, food and environmental security*, organised by International Water Management Institute (IWMI), Sri Lanka. Need for people's participation in sustainable management of water resources came out as one of the main focal points in the dialogue. Table 6-1gives an overview of presentations made at the request of other agencies.

Table 6-1: Presentations made on the PHM activity

No.	Agency	Purpose	Time
1	Department of Rural Development, Government of Andhra Pradesh	To share the experience with the members of Technical Resource Group of Water Conservation Mission, GoAP	January, 2002
2	Management of Agricultural Extension (MANAGE), Acharya NG Ranga Agricultural University, Hyderabad	Sharing the PHM experience with all the relevant government departments	February, 2002
3	Indian PIM (Participatory Irrigation Management	Sharing the PHM experience with international donors	August, 2002

6.1.3 Booklets

After a low profile starting, the PHM activity started expanding after the first year. This calls for a common set of guidelines for field staff. The 2000 *Reference Document* answered this need. It is not only a good ready reckoner for district level staff, but also resolves conflicts pertaining to specifications. It helped reducing the number of inquiries from the district staff.

The Project also designed a booklet documenting data collected by farmers. This booklet is referred to as *Farmer's Hydrological Monitoring Record* and is presently used by the farmers. It is in the local language – Telugu.

6.1.4 Farmers' data

Hydrological data collected by the farmer volunteers under the PHM pilot has generated interest from Government Departments such as the Andhra Pradesh State Groundwater Department and the Forest Department. At Prakasam district, farmers are sharing the rainfall and water level data with the APSGWD while there is sharing of rainfall data with Forest Department at Mahbubnager. Farmers of Cuddapah and Nalgonda districts share their data with the State Groundwater Department.

Two NGOs in Anantapur, MYRADA and RDT, are showing keen interest in the PHM activity. Based on the PHM data kept by farmers of PTR Palli, Dadaluru and Konampalli, RDT has decided to take up watershed activities in these villages. The PHM record is used by both the agencies for identification of sites for water harvesting structures.

In Bukkapatnam mandal of Anantapur district, the EENADU news agency has organised a chercha vedika (platform for discussion). The BUA secretary, B. Kesappa of Siddarampuram village, participated in these mandal level discussions of farmers. He highlighted the issue of judicious use of groundwater, with the help of PHM records, and urged the government officials present to allocate more money to groundwater recharge structures. The Nodal Officer responded immediately and sanctioned an amount of two lakh rupees, under the Neeru-Meeru programme.

6.1.5 Videos

Kalajatha, a form of rural folk-art has developed into an effective tool for passing on the concept and content of PHM. The Kalajatha troupe trained by APWELL has digested the PHM concept thoroughly after a year of on-the-spot suggestions by APWELL consultants and staff. As the PHM activity expands to the entire farming community, it is essential that PHM messages reach all farmers. To avoid delays, APWELL has recorded the Kalajatha performance on the video. Video shows are presently used as an entry point activity in new PHM villages.

Presently, another video is being produced to show-case the success story of the PHM activity. This is done in Telugu for usage in new PHM villages. An English voice-over is also being planned to share the PHM experience with an international audience.

6.1.6 Computer packages

Two computer packages are developed by APWELL viz., EVA and CWB. The later package (see Chapter 5) has been developed recently. The EVA package was developed for environmentally sound site selection for drilling. It has also been used in earlier water balance estimations in PHM villages.

6.1.7 Flip-charts and photographs

Several flip-charts are prepared for training of farmers at the village level. The PHM activity is also well documented in the form of photographs.

In August 2002, the Government of Netherlands was present during the Johannesburg UN Earth Summit with an entry called *water dome*. Photos representing the PHM activity with a supporting text were sent to the organisers of *water dome*.

6.2 Linkages

Sustainability of any rural initiative or project is dependent on the institutional strength of village level groups and the linkages that are established between farmer institutions and relevant governmental and non-governmental organisations. In its PHM pilot APWELL has not only tried to ensure that strong institutions developed at the village level, but also that necessary linkages are established for continued support after the project phases-out. At the district level, data collection by farmers initially generated a lot of debate in the government departments conventionally responsible for these tasks. After discussions with project staff and farmers, the departments have become convinced about the utility of the collected data and made requests for sharing them. APWELL encourages sharing of data, as it is part of the linkage building between people's institutions and government departments at local level, which, as mentioned, is important for post-project sustainability.

At the state level also, the PHM project has developed close working relationship with agencies such as the National Geophysical Research Institute (NGRI), the National Remote Sensing Agency (NRSA), Action for Food Production (APFRO) and the State Groundwater Department, in addition to the implementing agency for APWELL Project – the AP State Irrigation Development Corporation (APSIDC). Equally important have been the many informal linkage at State and grass-root level that have been developed through the interaction between the project staff and government officials.