GEOHYDROLOGICAL INPUTS TO GROUNDWATER SHARING THROUGH USER GROUPS IN PARTS OF MEHBOOBNAGAR AND ANANTHPUR DISTRICTS OF ANDHRA PRADESH

By

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Background:

Advanced Center for Water Resources Development and Management (ACWADAM) is a not-for-profit organization working in earth sciences applications, particularly in the area of groundwater resources management. It consists of a team of professionals from the field of earth sciences. ACWADAM's main thrust has been in the processes of capacity building and facilitation, founded strongly on its research base.

ACWADAM, with support from the FORD FOUNDATION, has embarked on strengthening Civil Society capabilities in groundwater management, using watershed management as a platform. As a part of this endeavour, ACWADAM has begun a fifteen-day training programme on basic hydrogeology or groundwater science for professionals from Civil Society Organisations or NGOs. The training aims to bridge the gap between scientific understanding about the resource and available technical solutions. The training also focuses on developing better understanding of groundwater resources, especially in watershed development programmes within dryland areas of India. This, in other words is expected to bring about an overall improvement in the technical capabilities of organizations engaged in watershed-related activities. The training is not intended to be a stand-alone exercise in capacity building. Rather, it is the first step towards providing facilitation to promising trainee organizations in their respective field areas. The facilitation aspect has also begun, with ACWADAM working with several organizations in different parts of the country, subsequently after course of the first year which is continued till the project period.

Field facilitation note for WASSAN:

The concept of field facilitation under the Ford Foundation supported training on groundwater in watershed management is primarily aimed at working in collaboration with a selected set of trainee organisations after these organisations have attended the

training conducted by ACWADAM in Pune. The facilitation itself is flexible enough to allow a very healthy interaction to develop between ACWADAM and any partner organisation. At this stage, it is felt that larger organisations like WASSAN will benefit most from the training-facilitation combination and take learnings from the classroom to their field sites for implementing improved groundwater management practices.

The facilitation to WASSAN included a field visit that was conducted by the ACWADAM team to study their ongoing activities under the APDAI and groundwater management programmes in two of the districts of Andhra Pradesh and to provide specific inputs towards improving the mechanisms to be devised for the same at the different sites. The field facilitation was a component of the training attended by Dr. Satish Kumar, of Watershed Support Services and Activities Network, WASSAN at ACWADAM during June 2008. It was further agreed upon by ACWADAM to facilitate WASSAN under this project. (Subsequently, another member from WASSAN, Mr. Chandrashekhar attended ACWADAM's training in December 2008). WASSAN has already felt that such an exercise will be most beneficial for their watershed projects and groundwater management programmes in Andhra Pradesh. The objective of the field facilitation at the WASSAN site in Mehboobnagar, Anantpur Districts is to begin providing scientific inputs to the groundwater management projects undertaken by WASSAN and also evolve a longer term process of infusing good scientific principles in both supply and demand management of groundwater in the region. This process has begun with preliminary hydrogeological studies which included mapping of rock types in some of the project areas and specifically conducting pumping tests in two of the areas to acquire a better understanding of the aquifer properties.

The ACWADAM team visited the study areas in Mehboobnagar and Anantpur districts between the 12th October and 18th October, to begin work on this collaboration, which is partly supported by the Ford Foundation through ACWADAM. The first visit involved the following components, clearly highlighting the importance of a systematic methodology of the process of understanding groundwater:

1. A meeting with WASSAN colleagues. This meeting was interactive and helpful in deciding the exact interventions and specific inputs required by WASSAN to their watershed and groundwater management projects with locations where the facilitation would take place.
2. A reconnaissance visit to WASSAN sites in Mehboobnagar and Anantpur districts and understanding the proposed programmes that would be implemented by WASSAN.
3. A study of the hydrogeology of the selected area.
4. WASSAN and ACWADAM will together study the selected watershed and develop a monitoring network to understand the groundwater dynamics in the watershed. ACWADAM will help WASSAN set up such monitoring networks and demonstrate how they can be used to understand aquifers, demonstrate the process of monitoring and to establish similar systems in different areas..
5. This study is expected to provide a platform to possibly undertake planning, implementation and complete impact assessment of a watershed development

project using the subject of hydrogeology as a sort of template for the World Bank supported project on groundwater demand management.

6. Some 1-2 months down the line, ACWADAM - WASSAN can organize a facilitative workshop aiming at the field staff working on watershed projects to develop a groundwater management plan.

The progress of the project would form a part of a self evaluation exercise on the facilitation and possibilities on how it can be improved with respect to other organizations in the forthcoming two years.

Facilitation details:

WASSAN is working on different watershed projects in AP whereas it is also facilitating work on community based groundwater management in parts of Mehboobnagar and Anantpur districts among many other. WASSAN is keen to have pilots of groundwater management based on the existing borehole system through a sharing mechanism based on 'pooling' of borewells.

ACWADAM team visited the Mehboobnagar and Anantpur study area from 12th October 2008 to 18th October 2008. The objective of this visit was to facilitate WASSAN in their work on different projects with respect to hydrogeology and groundwater management.

The ACWADAM team held a meeting on 13th October 2008 with the WASSAN team on the facilitation component with the possible interventions needed for their on-going projects. ACWADAM made presentations regarding their experience in groundwater management, stressing the importance of infusing appropriate scientific understanding of aquifer systems, well behaviour and groundwater quality as part of the groundwater management effort. Groundwater management presentation based on the Pondhe initiative was presented to the WASSAN team, which led to discussions about WASSAN's own experimentation in Chellarpur, Nagireddypalle, Gundlapalli, Mungalavaripalli and Gorantlavaripalli. The project details were discussed during this meeting which gave a brief idea about the objectives behind the groundwater management effort by WASSAN. This interaction was important in taking the next step in the process of co-operation between these two organizations.

Geological setting of Andhra Pradesh:

Most of the rocks in Andhra Pradesh are of Archean age. Some rocks belonging to Proterozoic era are also found. Age of the rocks ranges from older than 3100 m.y. to as recent as Cretaceous to Holocene times. The bulk of the Archean rocks are represented by gneisses and a few schist belts. Most of the gneisses belong to the Unclassified Basement group of rocks while others belong to the Dharwar supergroup or Eastern Ghat group of rocks. The Cuddapah group comprising of slightly metamorphosed sedimentary rocks occupies the district of Cuddapah and parts of Anantpur as well. Many basic intrusions in the form of dykes as well as quartz and pegmatitic veins are seen transversing the Archean rocks as well as the Proterozoics. The terrain in most parts of

Andhra Pradesh is flat with granitic or gneissic residual hills rising and forming highgrounds at places. The dykes as well as quartz veins on the basis of their hardness and other properties form linear ridges or valleys. *WASSAN's project areas are located mainly within the older basement setting of igneous and metamorphic rocks – granites, gneisses and schists*. The individual settings are summarised in the project area-wise narrative summaries of field work given below.

Chellarpur:

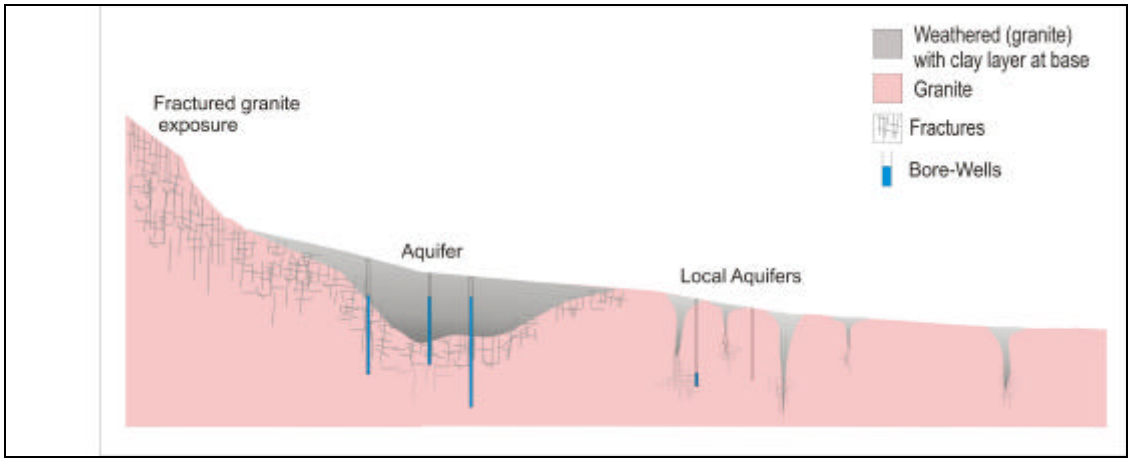
Mr. Bakka Reddy alongwith Mr. Krishna accompanied the ACWADAM team. Some of its field staff was also present for this visit. This team first visited the Chellarpur area. Groundwater management system based on borehole pooling is being implemented by WASSAN with five farmers through common irrigation system using the sprinkler method.

Rapid geohydrological observations of the area indicated the presence of a self regulating system, wherein the group is located within a small watershed, tapping a localized groundwater system. The pooling of these five boreholes is an innovative method of managing such a localised groundwater system. The present system of resting one borehole for one week with pumping of other four boreholes is carried out to irrigate and meet drinking water needs.

A local hydrogeological survey was carried out in Chellarpur within the five farmers agricultural land holding and adjoining regions. The rocks in the area are mainly granites showing limited metamorphism. The granites show fresh exposures at a few places. Here they are in the form of outcrops which form the elevated portions in the region. The low-lying and gently undulating areas are underlain mainly by weathered granitic rock. The depth of weathering may vary at different places in the region. The weathering of the granitic rocks has given rise to a typical medium to coarse grained sandy soil, which is seen in many weathered granitic terrains across India. The granites typically showed numerous close spaced fractures along the entire exposure. Majority of the fractures showed a trend in $90^0 – 270^0$ (east-west) direction. The fractures were markedly high in number and density in the granitic exposure towards the northwest direction of the village.

The aquifers in the area are mainly formed due to the deep seated weathering in these granites at locales which show extensive fracturing in the rocks along preferred orientations (fracture zones). A conceptual diagram of the aquifers in the area is shown in the diagram below. The aquifers are local and often isolated from one another. This understanding is based on a rapid hydrogeological survey and need to be confirmed with more solid investigations.
The aquifers in the region are somewhat deep aquifers tapped at around 40 ft (12 m) which show evidence of confinement. The confinement could be related to the presence of clay layers between the interface of the weathered and fractured rock. The extent of the weathering is determined by the fractures present in the rock. If the fractures are numerous and closely spaced (such as along fracture zones), it facilitates deep weathering

of the rocks and the aquifer is of a slightly larger extent as may be the case in the aquifer/aquifers tapped by the boreholes in the study area. The areas where the fracturing is relatively less dense, the aquifers are local in extent resulting in very limited yields of the wells tapping them.



Conceptual diagram showing Aquifers in Chellarpur area (diagram not to scale)

The ground water management method applied in the area may answer the question of equity in the utilisation and distribution of groundwater to an extent, but the question of sustainability would still remain unanswered unless some estimation on groundwater storage and transmission can be established. This will require appropriate understanding of the aquifers tapped, their extent and their properties. An attempt at answering these issues was made with the help of a pumping test on the observation borehole (owner: Bala Krishnappa) in the area. However, the pumping test was not carried out in ideal conditions because of the following reasons:

1) Irregular power supply.
2) Simultaneous pumping of four other boreholes within a radius of 50 m, which might be tapping the same aquifer.
3) The water level represented in the borewell at the beginning of pumping may not be the actual static water level as desired.

So the data obtained and the values of the aquifer properties obtained from the analysis of the data may have lower confidence based. The Transmissivity (T) and Storativity (S) values obtained for the aquifer tapped by the observation borewell are summarized in the table below. The values obtained by the use of different methods of pumping test analysis may vary, but all lie in a fixed range.

Method used for analysis	**Transmissivity (m^2/day)**	**Storativity**
Cooper-Jacob	50	0.0002
Theis recovery	40	-
BGSPT	20	0.002

Specific Capacity by Slichter's method (C) : 25 lpm/metre of drawdown

Our own observations regarding the values (based on past experience of working in such terrains): a higher T is expected, the value of S may be in the range of 0.0001 to 0.001. The specific capacity ought to be slightly higher. However, since all wells were pumping, we believe that estimates of T and C above may be much lower than the actual values.

An in-situ water quality measurement on the water of the observation borehole gave the following results:
pH - 7.88
Salinity - 116 ppm
Total dissolved salts (TDS) – 163 mg/l
Electrical conductivity- 234 µs
At Temperature of 29.9 °C

The results of water quality suggest the water to be relatively low in TDS and salinity. This might point towards fresh recharge to the aquifer, leading to little rock water interaction. Also the pH is well within the range of 6.5-8.5. The bacterial contamination and the potential fluoride content in the water need to be first assessed before using the water for drinking purpose. The geological setting is clearly within a high-risk fluoride zone; however, only detailed monitoring of fluoride will help ascertain whether it is a problem of not.

Gundlapalli:

The plan in Gundlapalli area, which was visited on the same day, is to install sixteen tanks of 3000 litres capacity for vegetable cultivation. The water for filling up these 16 tanks would be obtained from one borewell which has an average pump discharge of 24,000 lph.

The borewell showed a static water level of 5 ft (1.5 m) bgl. There is a tank located downstream which has water upto the months of February – March. Also another borewell located at a distance of 10 m is not considered in the plan, as the yields are quite low. A dug well was located 30 m upstream of the borewell. The dug well faces exhibited weathered granitic rock. The static water level in the well was higher than the water level in the tank, clearly indicating that groundwater flowed into the tank, at least in the static (natural) condition.

From the water levels it can be inferred that there are two aquifers in the region. The shallow unconfined aquifer tapped by the dug well and discharging water to the tank downstream. The second aquifer is tapped by the bore wells and might be a confined aquifer, similar in nature to the aquifer observed in Chellarpur. The borewell may be receiving water from both the shallow as well as deep aquifers since its water level coincides with the water level in the dug well. The yields seem to be high and so can sustain protective irrigation as planned by the WASSAN team. Yields may reduce later, in summer, as the tank water depletes indicating desaturation of the shallow aquifer.

The hilly area in the south east direction of the watershed holds potential for recharge. A few fractures are observed trending in East-West direction which will facilitate recharge to the deeper aquifer. A dugout percolation pit with shallow depth but large dimensions might be useful in this area. The bare slopes also need to be treated with soil conservation measures.

It wasn't possible to conduct a pump test on the borehole but WASSAN proposes to conduct a pump test on this borehole and send ACWADAM the data for analysis. A detailed longtime pumping test with recovery and readings from observation wells also are required to ascertain the yield as well as other aquifer properties.

Nagireddipalli:

The joint visit to Nagireddipalli was conducted the next day. In this area, the plan is to use tank water and water from a couple of dug wells for protective irrigation on an area of 36 acres owned by 16 farmers.

The area showed a typical 'Tor' type of geomorphology seen commonly in granitic and gneissic terrains. The granitic highlands in the area were thickly vegetated. The forest department has taken a few soil conservation measures. The area shows very few bore wells which are also in turn low yielding. So the dependence of agriculture is mainly on the shallow aquifer of the region. The shallow aquifer in the region is formed due to weathering of the granitic rocks. The yields of the dug wells in the region are good in the winter season but rapidly reduce later in the summer also corresponding with the drying of tanks upstream. A preliminary hydrogeological traverse of the adjoining tank and hills was undertaken to understand and study the field conditions, to suit the agricultural water demand for rabi season cropping. A detailed pumping test was also conducted on one of the dugwells (owner: Hanmaiyah). The analysis of the pumping test suggests the following aquifer properties.

Method used for analysis	Transmissivity (m^2/day)	Storativity
Cooper-Jacob	288	0.6
Theis recovery	270	-
BGSPT	305	-

Specific Capacity by Slichter's method : 115 lpm/metre of drawdown

The transmissivity values are on the higher side as the test was conducted just post-monsoon when the aquifer is saturated completely. Also the Storativity value estimated is very high indicating influence of tapping some surface water source directly (the upstream tank, for instance). A similar, longer duration pumping test conducted in summer season will give a better estimate of the different properties of the aquifer. Also it was clear that the tank as well as the dug well are located in a discharge area. The measures taken by forest department may be facilitating recharge to the aquifer, especially if some regional fracture trends correspond to the forest sites. A need is

expressed to protect the vegetation in the higher areas to sustain the natural recharge to the aquifer.

An in-situ water quality measurement on the water of the dug well gave the following results:
pH - 7.96
Salinity - 160 ppm
Total dissolved salts (TDS) – 228 mg/l
Electrical conductivity- 326 µs
At Temperature of 29 °C.

This indicates some amount of rock water interaction, but still the resident time of water in the rocks may not be more than a year and the water extracted every year from the well is probably from the same monsoon cycle.

Mungalavaripalle:

The third day of fieldwork was utilized in studying the two sites from Ananthpur district. In Mungalavaripalle the groundwater management plan is similar to the one at Chellarpur where pooling of bore wells and their combined use is planned. Here the scale of pooling is higher and about 13 borewells are being planned to be pooled together in a similar manner as in Chellarpur.

The area shows granitic / gneissic basement rocks. However, there are a higher number of quartz and pegmatite veins traversing the rocks in different directions. A prominent dyke, which may be gabbroic in composition is seen trending in the northwest – southeast direction from the south of the proposed area of implementation. The 13 bore wells are clustered in two different groups. Group 1 consists of bore wells 2, 3, 4 and 5. The rest of the bore wells on the southwest form another group. The water levels in these borewell groups need to be monitored to ascertain whether these are tapping the same aquifer or two different aquifers. There are also many dug wells located in the area. The water levels observed in these dug wells are quite deep. These levels correspond to the water levels in the bore wells in the area. It is possible that the dug wells are tapping the deeper aquifers in the area. A few dry dug wells in the area are very shallow and do not go below the thin clay layers that are present at a certain depth.

A detailed geological mapping of the area is necessary as there may be many concealed localized dykes and veins in the area which may make the storage and movement of groundwater more complex. Also pumping tests and continuous water level monitoring is required to delineate the aquifers and recharge discharge areas. Also, for pump selection and plan of pooling must be devised only after the aquifer properties and well capacities are ascertained. *This geohydrological setting, from our experience, is also a case for fluoride mobilization, hence need to check out if fluoride gets mobilized under these conditions.*

Gorantlavaripalle (Nalacheruvu):

The objective of WASSAN is to try out a similar groundwater management strategy as in Chellarpur in this area. The objective of the visit was to do a feasibility study for such a system in this area. The area is geologically very complex and forms a part of Kadiri Schist belt. The rock types are varying and range from granites, gneisses, basic dykes, hornblende schists, quartzite to a variety of mafic rocks. Also, the area is structurally very complex, exhibiting many fracture zones and other lineaments in the field as well as from the satellite data. Due to lack of time a detailed study was not possible, but it was suggested that a detailed geological study of the area is required to delineate aquifers and to assess the feasibility of such a groundwater sharing exercise in the area. The next visit is likely to divulge details regarding the conditions in this area.

Specific suggestions and outcomes through discussions between ACWADAM and WASSAN staff during field visits:

Chellarpur:

- In Chellarpur the site selected for cooperative groundwater management based on the five boreholes and application through sprinkler irrigation system for protective irrigation is appropriate for that particular area.
- Many close spaced fractures are seen along the exposure adjacent to the road (Location specific in latitude and longitude are N 16^0 58' 42.5", E 77^0 37' 02.0", with elevation approximately 560 m) just northwest of Chellarpur village. The upper catchment of this area is a good site for recharge to deeper aquifers.. The agricultural land is surrounded by this topography on three sides, making it a self regulating system within itself – a system appropriate for local level groundwater management pilots.
- The eastern side hillock needs to be protected through a vegetation cover and constructing farm ponds on the gentle slope at the interface of hillock and agriculture land as it would enhance the recharge system significantly.
- The current pooling exercise of boreholes linked with sprinkler irrigation system is useful in regulating the utilization of groundwater. Systematic, sustained pumping tests on these bore holes should be practiced to ensure that conditions within the aquifer are not adversely changing in the long run. These pumping tests would essentially benefit the understanding of the dynamics of groundwater in the region as well. A fruitful application of this study would clearly enhance the agricultural productivity through knowledge of assured water availability for crops thereby helping to decide changes required, if any, in the cropping pattern.

Gundlapalli:

- Need to conduct a detailed long term pumping test with observation wells measuring the drawdown and recovery readings to ascertain the yield of this bore hole. Present status as observed would suffice the vegetable cultivation through the 16 tanks gravitational irrigation water supply. Yields may reduce considerably due to desaturation of shallow aquifer during summer.

- The current structures and other watershed interventions already in place are supplementing the groundwater levels in the aquifers with addition to the tank storage.

Nagireddypalli:

- The natural forest adjoining the Nagireddypalli agriculture land and tank is probably helping maintain the balance in the shallow groundwater system. The recharge from these areas is key factor for sustenance of this system as well as the system downstream. The tank and wells location is in natural discharge area with no treatment measures required for additional recharge. Protection of the forest cover on either side hillocks forms crucial for groundwater management system.
- In addition to the existing natural system, Forest department have taken good soil conservation measures, especially to supplement infiltration to shallow aquifer systems.
- Shallow aquifer system holds potential in the area.. Storativity of the well may be less as well yield decreases after the tank upstream dries up.

Mungalavaripalli (Gandlapentta):

- The water levels in the two bore well groups mentioned above need to be monitored to ascertain whether these are tapping the same aquifer or two different aquifers.
- A detailed geological mapping of the area is necessary as there may be many concealed localized dykes and veins in the area which may make the storage and movement of groundwater more complex.
- Need for pumping tests and continuous water level monitoring is required to delineate the aquifers and recharge discharge areas. Pump selection and plan of pooling must be devised only after the aquifer properties and well capacities are ascertained.

Gorantavaripalli:

- Need for a detailed study is required with intensive field work to understand the complex geology. Structural control is evident from the drainage patterns observed on toposheet of the area. Detailed hydrogeological mapping needs to be carried out in this area. These interventions would be fruitful for the present groundwater management project.
- A detailed field study in the area is planned as an upcoming activity to delve deeper into the hydrogeology of the area. This would help ACWADAM and WASSAN analyze the situation and provide inputs to the watershed planning and groundwater management programme.
- During discussions it emerged that Gorantavaripalli has high fluoride present in groundwater, hence water quality testing needs to be carried out for the different water structures and drinking water sources: 14 parameters suggested for monitoring: *pH, hardness, TDS, alkalinity, calcium, magnesium, sodium, potassium, bicarbonates / carbonates, chlorides, sulphates, nitrates, fluoride, arsenic.*

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