Tropical Agricultural Research Vol. 5 1993

A Preliminary Study on Agro-wells in Hard Rock Aquifer, With Special Reference to Well Performance

C.S. De Silva

Faculty of Engineering Technology
The Open University of Sri Lanka
Nawala, Nugegoda.

ABSTRACT. *The overall objective of this preliminary study was to understand the performance of the large diameter wells (agro-wells) used for supplementary irrigation from the extensive, shallow aquifers associated with the weathering of crystalline basement rocks.*

The case study area was located in the north western province of Sri Lanka and observation bore holes were constructed at 10m and 50m distance from the agro-well in different directions. Daily water levels in wells and observation bore holes have been monitored along with rainfall and evaporation. Pumping tests were conducted at the end of the wet season when the water table was high.

Results show that the well water level is directly correlated with rainfall, and the abstraction from the well during pumping is mainly from well storage. The also shows that the recovery of the well is slow due to low transmissivity of the aquifer. It takes a long duration to fill the well to be ready for the next day's pumping. Calculated transmissivity and storage coefficients by Jacob's method are 58.0 m^2/day and 0.0032 respectively.

Consecutive, long hours of pumping may dry the well during mid season. Optimal pumping regimes, irrigation methods and cropping patterns need to be devised to use this valuable resource efficiently for sustainable agriculture.

INTRODUCTION

Agriculture in the dry and intermediate zones of Sri Lanka has developed in response to an unpredictable climate, and limited water availability is the main constraint to agricultural production. In these areas, farmers often compensate for the unreliable rainfall by cultivating large areas. With increasing population densities, this practice is becoming more difficult to support the traditional farming system. Better rainfed farming methods can improve crop production, however, they cannot guarantee crops because of the unreliability of the rainfall. Dependable crop production can only be achieved in drought periods by the use of irrigation. However, large irrigation schemes are expensive, inadequate, inefficient and difficult to manage. In addition, they do not integrate well with existing rainfed farming systems and can produce a range of socio-economic, health-related and environmental problems. Small scale irrigation, in contrast, can be relatively inexpensive, more efficient and can be managed by the farmers themselves, along with their traditional farming systems. Therefore, developing limited groundwater resources for small scale irrigation is essential for sustainable agriculture.

Nearly, 90% of the land area of Sri Lanka is occupied by metatamorphic crystalline rocks, the so called "hard rocks" by hydrogeologists. These rocks are virtually devoid of any primary porosity, but bestowed with "secondary porosity" due to fracturing and weathering which permit storage and flow of groundwater (Fernando, 1968). Large diameter wells are ideally suited for hard rock aquifers of low transmissivities (Sakthivadivel and Rushton, 1988). The government of Sri Lanka has realised the importance of large diameter wells (agro-wells) as a source of supplementary irrigation and started the national agro-well programme in 1988/89. It has been in operation for the past four years. In addition, the Agricultural Development Authority (ADA), provincial councils and a number of Non Governmental Organizations (NGO) have been implementing agro-well programmes of their own. At present, the total number of agro-wells would approximately be about 6500 (ADA, 1992). Even though these agro-wells have been in operation for the past four years, hardly any investigations have been conducted to study the well and aquifer performance, available ground water resources, safe yield etc.

Therefore, a research project was designed to study the aquifer and well performance for long term pumping, estimation of available ground water resource, and optimum cropping patterns suitable for safe and long term use of this valuable resource. This paper will present only the preliminary test results conducted during the on going project, to understand the well performance during pumping and recovery phases.

METHODOLOGY

Kobeigana in the north western province in the Kurunegala district was selected as the main research site. This area is within the intermediate zone but its climatic conditions are closer to those of the dry zone. The study area has gentle slopes with low undulating topography. The entire district is dotted with small ancient tanks locally called "*Wewa*" which were used for irrigation. Most of these tanks have now been abandoned (Figure 1). A few rivers flow along the boundaries of the Kurunegala district. Among them "Deduru oya" is an effluent river. All these rivers carry low flows of water during dry months.

The rainfall in the study site ranges from 800-1300mm and is characterised by more prolonged dry spells. The period from September-October to March-April is called *Maha* season and the period from April-May to August-September is called *Yala* season.

Farmers in this area own about 2 ha of land. General land use classes in this area are coconut, paddy and home garden. During the *Maha* season farmers cultivate paddy in the lowlands and vegetables in the uplands with supplementary irrigation by agro-wells. During the *Yala* season, both the paddy land and the uplands are used for intensive vegetable cultivation with well irrigation.

Generally farmers cultivate a number of crops on their land. Vegetables such as Cucumber, Brinjal, Bittergourd, Snakegourd, *Bandakka*, Beet, long beans and cash crops such as Chillie, red onions and several other leafy vegetables are the most common crops grown. In addition vegetables are grown under young coconut trees. During the dry season, farmers are entirely dependant on agro-wells for irrigation. These wells are also used during the wet season for supplementary irrigation.

In the village of Kobeigana (Gopallewa) 30 farmers were selected within a single catchment area. Among these thirty farmers fields of 4 farmers were selected for daily water level monitoring. Observation bore holes were installed up to the well depth at 10m and 50m distance from each well. Agro-wells are 6.1m in diameter and depth. Observation bore holes were 2" in diameter. Rain gauges and evaporation pan were installed in the middle of one farmer's field for daily measurements. Well spacing is not specific in this area and wells have been constructed wherever convenient for the farmer, without consideration of hydro-geologic properties and spacing.

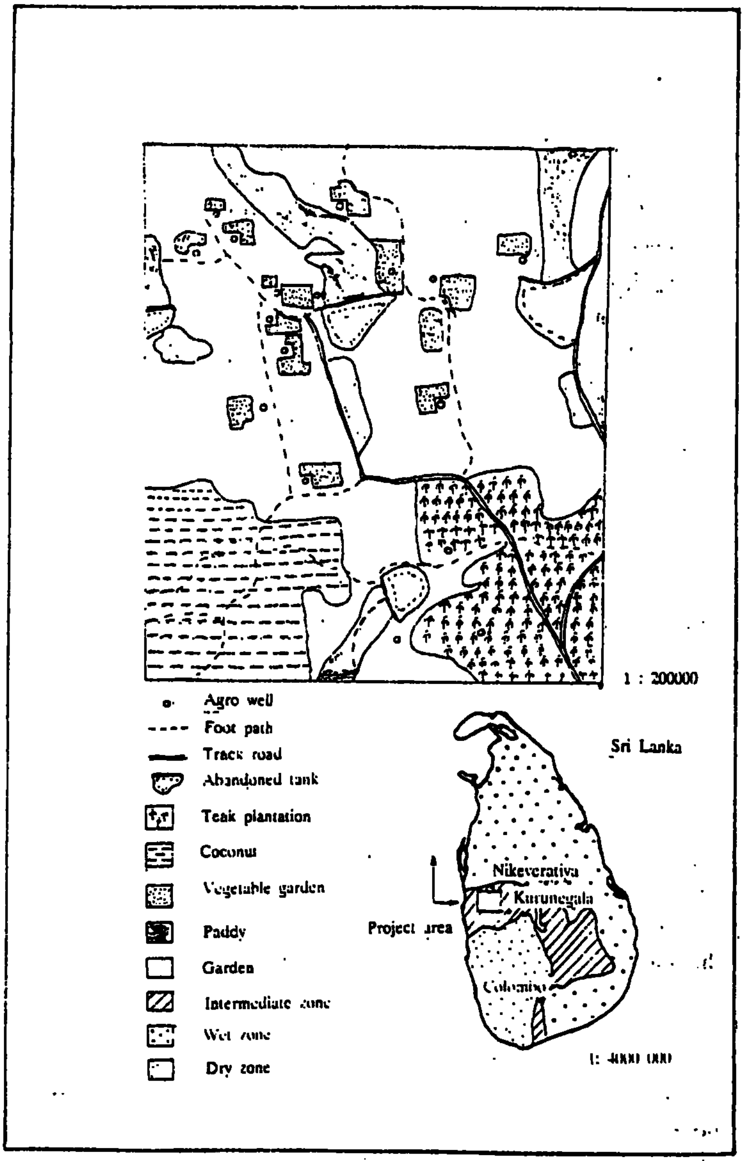

Figure 1. Location and description of study area.

Generally these wells are located on higher ground except for a few in paddy lands. General spacing observed between two nearby wells is 180-200m.

Pumping tests were conducted soon after the *Maha* season, and water levels in the production well and observation borehole have been monitored during pumping and recovery phases at different time intervals. Pumping tests were done along with the farmer's normal irrigation practice and the water was distributed 100m away from the pumped well evenly, without over irrigation to make sure that there was no recharge to the aquifer.

Well and observation borehole water levels at 7 a.m. daily, and before and after pumping (whenever the farmer pumps from his well) were recorded along with pumping hours. The rainfall and evaporation were measured and information on crops cultivated were gathered.

RESULTS AND DISCUSSION

Response of well water level to rainfall

Daily well water levels at 7 a.m. and the daily rainfall data shows the quick response of the well water levels to rainfall (Figure 2). During the end of May '93 with two days of heavy rainfall, groundwater table rose nearly to the ground level (30-40 cm below ground level). It was also observed that, during the drought period, water table dropped and the volume of water in storage reduced. This behaviour of the well may be due to the unconfined nature of the aquifer (Driscoll, 1986).

Well and observation bore hole performance during pumping and recovery phases

Pumping tests were conducted during the end of the wet season. Figure 3 shows that while the well water level dropped quickly during pumping, very little response was observed in the bore holes at 10m distance (I and II) from the pumped well. Observation bore holes at 50m distance (III and IV) from the pumped well did not respond at all to the pumping. It clearly shows that the large diameter well acts as a reservoir from which a pump mounted above the rest water level can produce a sustained yield over a number of hours.

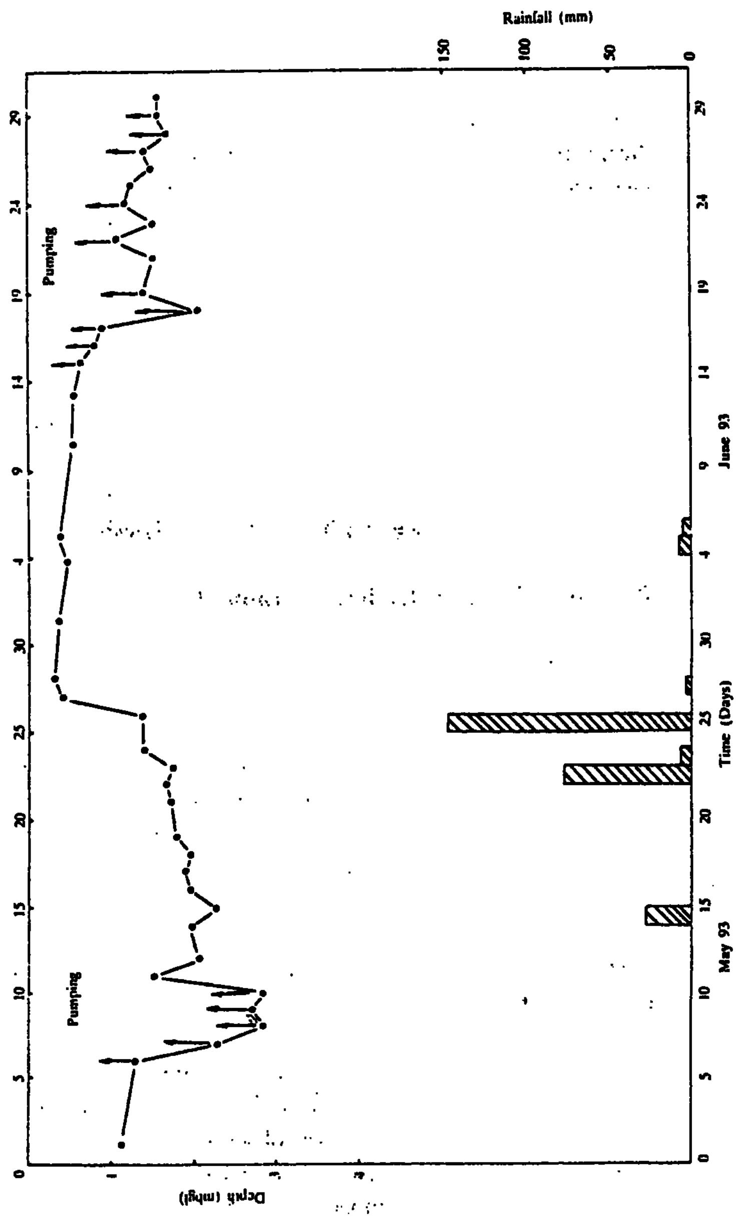

Figure 2. Relationship between rainfall (mm) and well water level (mbgl).

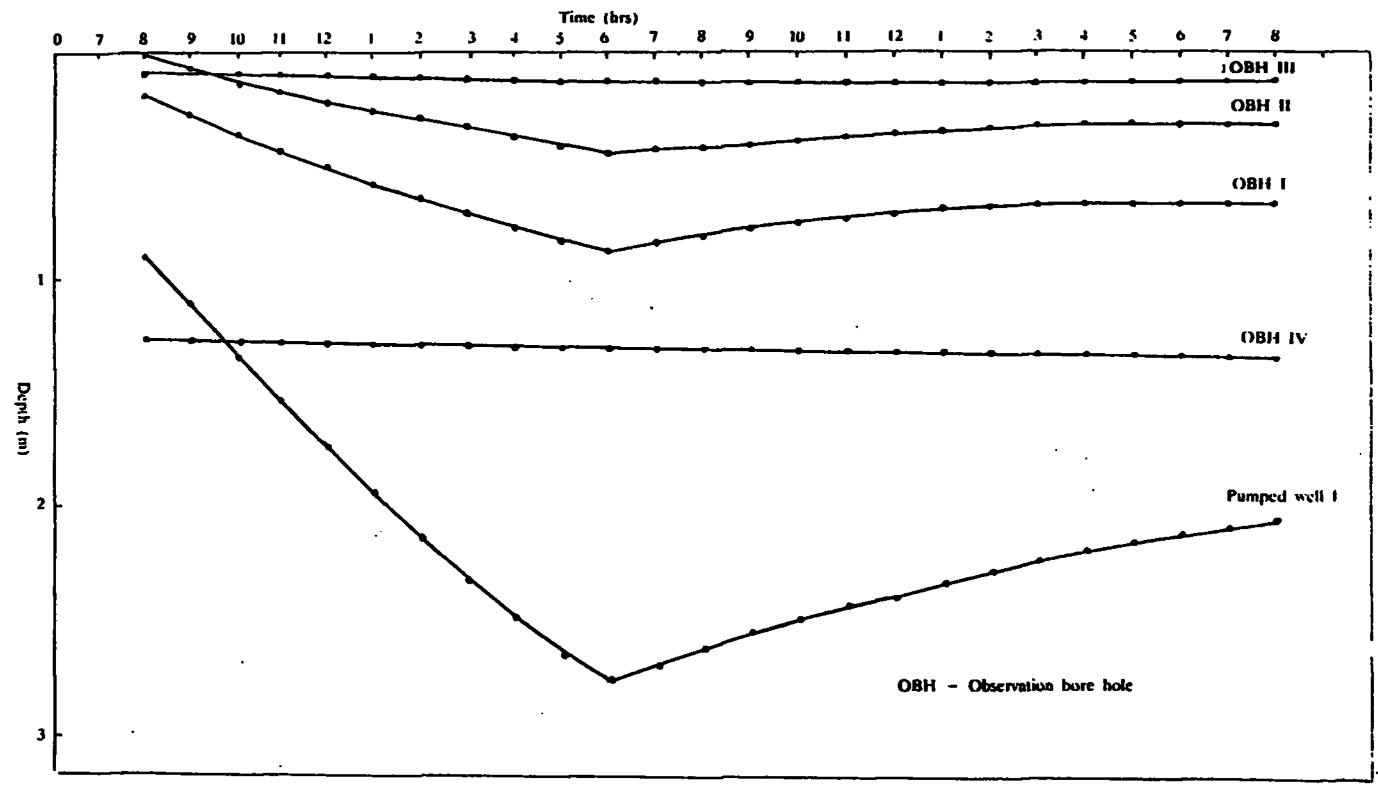

Figure 3. Water levels in well and observation bore holes during pumping and recovery phases.

During the pumping phase most of the water is taken from well storage and only a small portion is withdrawn from the aquifer (Sakthivadivel and Rushton, 1988).

Cone of depression

Figure 4 presents the cone of depression around the well due to pumping. This illustrates how transmissivity of an aquifer affects the shape of the cone. In a formation with low transmissivity, the cone is deep with steep sides and has a small radius (Driscoll, 1986). The explanation for this cone shape is that, a greater hydraulic head is required to move water through less permeable formation, than more permeable formation. Pumping tests were analyzed by the modified non equilibrium equation of the Cooper and Jacob method (Todd, 1980). Both pumping and recovery curves were used for calculation. For the pumping phase, a factor of 0.75 is included as well storage correction. Therefore, contribution of flow from the aquifer is only 25% of the pumps discharge. Average pump discharge rate is 150 m^3/day. Average values of transmissivity and storage coefficient of several pumping test analysis are 58 m^2/day and 0.0032 respectively.

Recovery behaviour of well after pumping at the end of the wet season

Normal irrigation practices of the farmers well were recorded daily. Figure 5 shows the recovery as a percentage of the drawdown after several single pumping slots of less than 4 hrs during dry days. According to the results, 25% and 50% of the recovery occurs after 9-10 hrs and 22-24 hrs respectively. Generally farmers expect their well to be full the next morning, after the previous day's pumping. Recovery percentage on the next morning was always less than 50% recovery. 75% of the recovery occurs after 3-4 days. These results were for the situation when farmers pump for less than 4 hrs per day and the next pumping is after 3-4 days. However, there are occasions when they pump for more than 4 hrs, on consecutive days. Under this situation recovery takes a longer period than that shown in Figure 5.

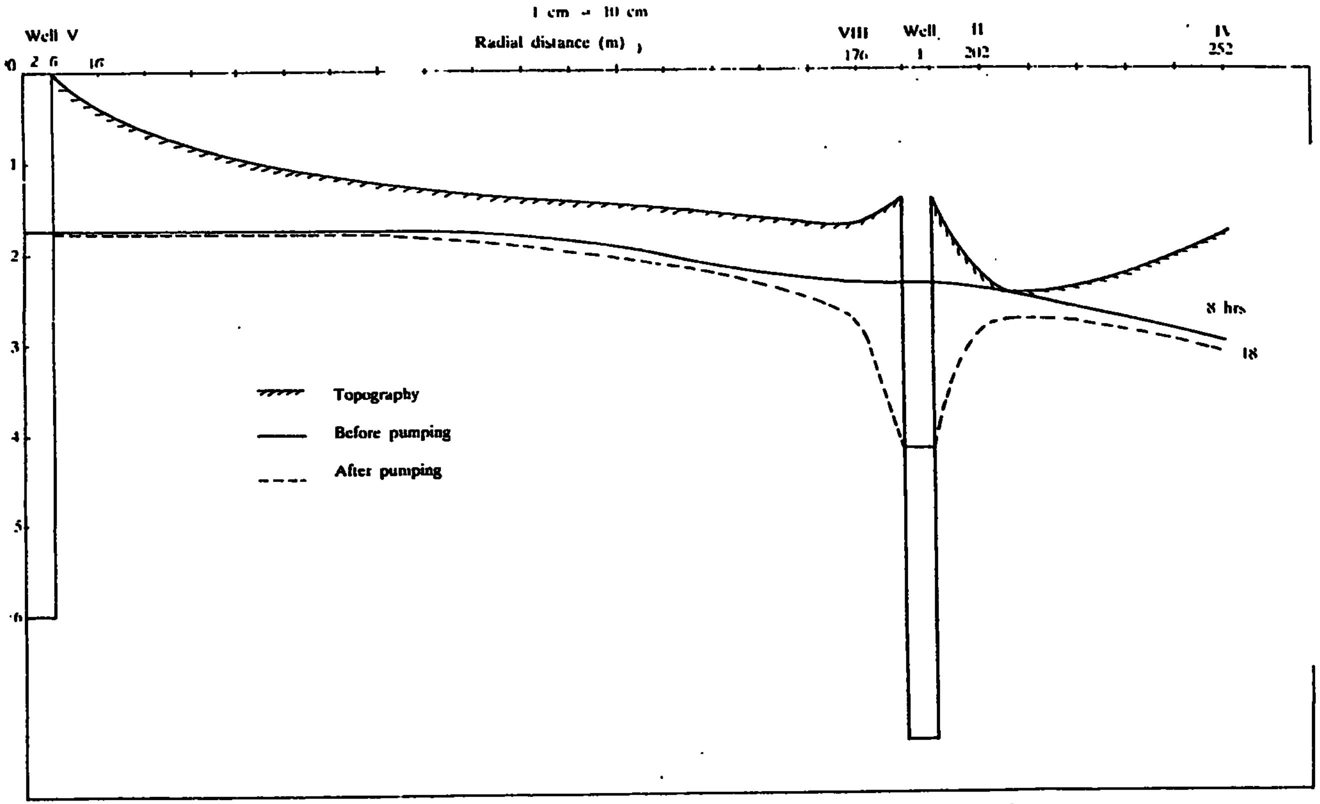

Figure 4. Cone of depression in agrowell due to pumping.

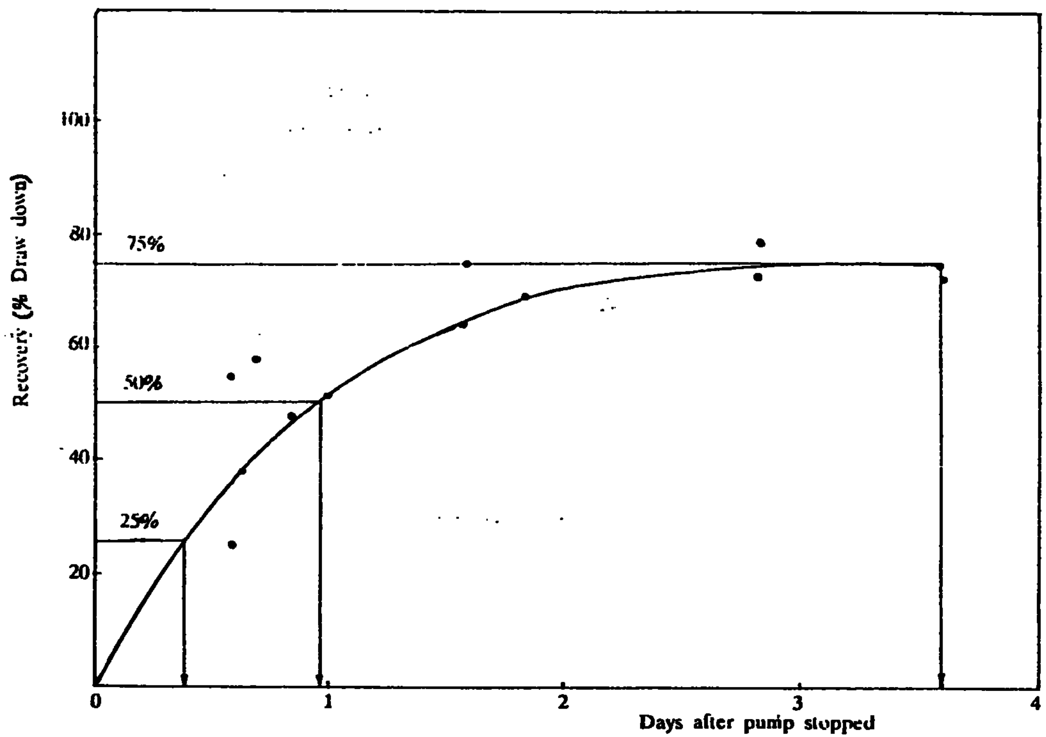

Figure 5. Recovery as a percentage of drawdown after <4 hrs pumping.

CONCLUSIONS

The following conclusions have been drawn from the preliminary study. However, a long term study should be carried out to validate these results.

1. Water level in the agro-well is positively correlated with the quantity of rainfall.

2. Most of the water abstracted during the pumping phase is mainly from well storage and a small portion from the aquifer.

3. Cone of depression during pumping illustrates the low transmissivities of the aquifer. Calculated transmissivity and storage coefficient were 58 m^2/day and 0.0032 respectively.

4. Recovery patterns as 25, 50 and 75 percentages of the drawdown after pumping of less than 4 hrs at the end of the wet season were obtained at 9-10 hrs, 22-24 hrs and 3-4 days respectively after the pump is switched off.

Agro-wells are unsuitable for long duration, pumping on consecutive days due to their slow recovery patterns. These wells should be allowed to recover for long hours before pumping to make sure that there is enough storage in the well for abstraction. Therefore, studies should be undertaken in areas where agro-wells are used intensively, to manage this valuable resource efficiently. Studies should be conducted to match optimal pumping regimes and cropping patterns. The present study will be continued for 12-18 months further to estimate the groundwater resource, to design optimal pumping regimes and cropping patterns in order to maximise the income of farmers who use agro-wells for supplementary irrigation to achieve sustainable agriculture.

REFERENCES

Agricultural Development Authority (ADA) of Sri Lanka. Agro-well programme, Personal communication - 1992.

Driscoll, F.G. (1986). Groundwater and wells, Johnson Division, St. Paul Minnesota, U.S.A.

Fernando, A.D.N. (1968). The use of Aerial Survey in the Investigation for Groundwater in Ceylon. Proc. CAAS., Twenty - fourth Annual Sessions, December 1968.

Sakthivadivel, R. and Rushton, C.R. (1968). Well hydraulics with special reference to Hardrock Terrains. J. Applied Hydrol. 1: 1-16.

Todd, D.K. (1980). Groundwater Hydrology, Wiley International.