A Rational Approach to the Use of Limited Shallow Groundwater Supplies Within the Small Tank 'Cascade Systems of the North Central Province of Sri Lanka

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1. Introduction

One of the more significant developments that has taken place at a very rapid pace during the last decade has been the construction of agrowells under the numerous small tanks that are located within well defined small tank cascades. Each agrowell irrigates between 0.25 to 0.50 ha by lift irrigation during the dry yala season. The small tank cascades (STCs) range in size between 1,000 and 4,500 ha, and within each such cascade one finds between *6* to **8** small tanks of varying size. **A** total of 457 small tank cascades (STCs) have been identified and demarcated across nine major river basins that made up the North Central Province (NCP).

It is reported that at present there are approximately 12,500 agrowells located within the Anuradhapura District alone. The main issue at stake, however, is how many agrowells could be permitted in this region, bearing in mind that there is an upper limit to the safe exploitation of this shallow ground water resource that occurs within these cascades.

2. General Background

Groundwater occurrence in the study area can be divided into two main categories.

i. Shallow groundwater in the soil overburden and weathered rock.
ii. Deeper groundwater in the deeper fracture zones of the basement hard rock.

The nature of occurrence and the behaviour of the **shallow groundwater** in the soil overburden and saprock has been described by Panabokke (1959). **As** could be observed in Figure 1, this shallow groundwater level rises almost to the surface during the wet (maha) season, and this water table goes down gradually through the dry season to a very low level along the floor of the valley in this undulating landscape.

The agrowells which are usually located in the lower aspects of the landscape exploit this shallow groundwater table. In general, an agrowell has a depth of between 5 to 10 m and a diameter of around 5m. Most agrowells are dug in the soil overburden and the saprock or weathered rock, and only a very few penetrate into the fracture zones of the hard basement rock.

The deeper groundwater which is restricted to deeper joints, fractures and fissures in the underlying basement rocks, occurs at depths beyond 50m and this can be exploited only

by deeper boreholes. These are locally referred to as "tube wells", and are used mainly for domestic requirements and drinking supply wherever the quality is satisfactory.

3. Hydrology of the Tank Cascade Environment

The nature of small tank cascade systems, their general setting and their main hydrological characteristics have been adequately described by Sakthivadivel et al **(1996).** Some aspects of the groundwater in the cascade and the amounts of recharge that take place have also been discussed in the same publication.

It is observed that the shallow groundwater is mainly confined to a narrow belt along the main valley of each cascade, and to a smaller extent along the side valley of the cascade. This is shown schematically in Figure **2.** Because this shallow groundwater is confined to a specific landscape position within a cascade of small tanks, the seepage from small tanks help to recharge and augment the shallow groundwater aquifer. In the study area it was observed that almost all agrowells are distributed around the small tanks situated within the cascade.

All agrowells that were studied in this survey could be grouped into three categories as follows:

- i. Agrowells in the upper cascade catchment area.
- ii. Agrowells in the intermediate mid-cascade catchment area.
- iii. Agrowells in the lower reaches of the cascade area.

In general, it is observed that around 20 percent of agrowells are located in the upper catchment area, 40 percent in the intermediate mid-cascade area, and 20 percent in the lower reaches of the cascade area.

During pumping, agrowells showed a varied drawdown and recovery rates. Those in category 1, showed a drawdown of 1m/h and a recovery time of 2 days; and those in category 2 showed a drawdown of 0.8m/h and a recovery time of 1 day; and those in category **3** showed a drawdown of 0.7m/h and a recovery time of 1 day. Agrowells located close to irrigation channels and below small tanks show a quicker recovery time.

Although the siting of most of the already functioning agrowells have not been made by using scientific methods, several of the groundwater potential areas had been identified by the indigenous knowledge of villagers. These are based largely on geomorphological relationships that could be easily observed in the field.

4. Methodology

The following five step procedure was adopted in the field studies.

1. Plotting available data on 1:50,000 scale cascade maps.
ii. Demarcating potential areas for shallow groundwater extraction in each cascade based on geomorphological characteristics.
iii. Field checking of well data plotted on 1:50,000 scale maps.
iv. Field checking of potential areas and existing agrowells and their performance.
v. Confirmation of groundwater potential in predicted areas (where agrowells are not present) by means of electrical resistivity and light drilling surveys.

The fracture zones and lithological strike lines were drawn on the cascade maps in order to demarcate the potential areas for agrowells. It was also observed that the underlying rock at the soil-rock interface is very highly weathered, and that the lower level of this weathered zone is highly fractured. The transsmissivity in this fractured weathered rock is very high and it forms a very effective pathway for groundwater flow to take place.

In the field studies, geophysical surveys were employed to verify the results of the geomorphological and topographic interpretation, especially in those instances where the presence of water is not indicated on the ground, but where farmers had requested the siting of agrowells based on their own understandings (Senaratne 1996).

Geophysical surveys were conducted at locations where there were no previously constructed agrowells. The resistivity data obtained from the soundings were analyzed using RESLXS, a special software developed by the ITC of Netherlands (Senaratne 1996).

A total of 50 cascades spread across 12 Divisional Secretariat Divisions (DSS) distributed across the Anuradhapura district of the North Central Province were studied by the foregoing method, and the potential area for location of agrowells were demarcated in each of these 50 cascades on maps of scale 1:50,000.

5. Determination of Number of Agrowells within a Cascade

In order to determine the number of agrowells that could be constructed within a cascade the following assumptions have been made.

i. A cascade is a closed system.
ii. Water contribution to a cascade is only through rainfall.
iii. Water loss from a cascade is only through evapotranspiration, tank evaporation and surface and underground outflow.

Using the following relationship

Rainfall - Evapotranspiration = Tank Retention + Groundwater Flow + Surface Flow + Soil Saturation,

the groundwater availability in a cascade is calculated.

The potential recharge per agrowell is estimated assuming a depth to water table of 4m; maximum depth of agrowell as 7m; and a 50 percent volume of underground storage is extractable in order to satisfy environmental requirements (Senaratne 1996).

6. Results and Discussion

Based on the foregoing methodology the number of agrowells recommended in respect of the 50 cascades which are spread across 15 DS Divisions are shown in Table 1.

It could be observed that in three cascades more than 150 agrowells are recommended per cascade; and that in 18 cascades less than 150 but more than 100 agrowells are recommended per cascade; and that in 13 cascades less than 100 but more than 50 agrowells me recommended; and that in **7** cascades less than 50 agrowells are recommended. For the remaining 9 cascades no agrowells are recommended.

Of these nine cascades, there are five in which the number of agrowells has already exceeded the upper critical limit. Since this can give rise to serious environmental hazards, timely action should be taken from now on to limit any further expansion of agrowell construction in this region. In sum, the upper limit of the total number of agrowells that could be safely accommodated within the 50 cascades is approximately 3,600. Although it is estimated that at present there are a total of approximately 12,500 agrowells distributed across 457 cascades in the NCP, it does not necessarily follow that each of these cascades could support an average of 72 agrowells per each cascade. There are some cascades in the drier regions that could support only a few or no agrowells, while those in the better hydrologically endowed areas could support more agrowells. Thus a variable density based on the degree of hydrological endowment is recommended as a rational approach.

References

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SUMMARY

The shallow groundwater in this region occurs mainly within a narrow belt along the main valleys of a cascade, and to a lesser extent along its side valleys. Agrowells within this study area could be grouped into three broad categories according to their position in the upper, mid- and lower aspects respectively of a cascade valley. **A** procedure for determining the maximum number of agrowells that could be permitted within a cascade has been briefly outlined. It is estimated that within the selected 50 cascades studied, the maximum total number of agrowells that could be permitted is 3,600; and that within five of these fifty cascades studied, the permitted upper limit has already been exceeded.

Table 1

Number of Agrowells Recommended for each Cascade

DS Division	Cascade Name and Number	Area ha	Number of Agrowells
'ADAWIYA	1 NAWAGASWEWA	299	32
:EBITHIGOLLEWA	2 KUNCHUTTUWA	1671	116
	3 KOLIBENDAWEWA	2565	65
	4 THAMMANNEWA	1451	140
	5 USGOLLEWA	701	165
IEDAWACHCHIYA	6 MAKICHCHAWA	2816	10
	7 MURUTHAMADU	4226	
	8 PARANAHALMILLEWA	3750	
	9 KONGOLLEWA	1643	117
IUWARAGAMPALATHA CENTRAL	10 TAMMANNEWA	1835	90
	11 GALPOTTEGAMA	1778	106
	12 GALKADAWALA	1044	122
	13 BELLANKADAWALA	1451	99
IAHAWILACHCHIYA	14 DUNUMADALAWA	782	108
	15 SANDAMAELIYA	19381	
?AJANGANA	16 IHALA THAMMENNAWA	2991	107
JUWARAGAMPALATHA EAST	17 KUDAKALETHTHEWA	1308	82
IIHINTALE	18 UKKULANKULAMA	2020	102
	19 MAHAKIRINDEGAMA	1483	91
	20 KATUPOTHA	1064	165
	21 MANKULAM	1225	70
	22 MAHA RAMBAWA	749	115
?AMBEWA	23 KAPIRIGAMA	2321	102
	24 PIHIMBIYAGOLLEWA	3425	
	25 KENDAWA	1204	104
‹AHATAGASDIGILIYA	26 HAMMILLEWA	2869	18
	27 RANPATHWILA	3137	
	28 GANGUREWA	3141	
	29 MAHAKIRIMETIYAWA	2393	39
	30 PANDARELLEWA	2654	38
	31 NELLUGOLLEKADA	2762	72
IOROWPATHANA	32 DUTUWEWA	2328	117
	33 PULIYANKADAWALA	2430	71
	34 DEMATAWEWA	2678	38
	35 DIYATITITHTHA WEWA	3241	91
;ALENBINDUNUWEWA	36 CHCHANKULAMA	1022	145
	37 HIMBUTUGOLLEWA	2421	1
	38 SIVALAKULAMA	2204	60
	39 KARUWALAGASWEWA	545	151
	40 TAMMANNEWA	135	126
	41 DIWULWEWA	2375	87
'HIRIPPANE	42 MAHAKANAMULLA	4494	
	42 ULAGALLA	4918	
	44 PAHALA AMABATALE WEWA	1601	96
	45 WANNAKKULAMA	998	113
ᵓALUGASWEWA	46 MAHADIWULWEWA	2054	72
	47 PALUGASWEWA	1860	113
	48 WERAGALA	898	112
ᵓALAGALA	49 HALMILLEWA	933	109
	50 MEEGASWEWA	4421	

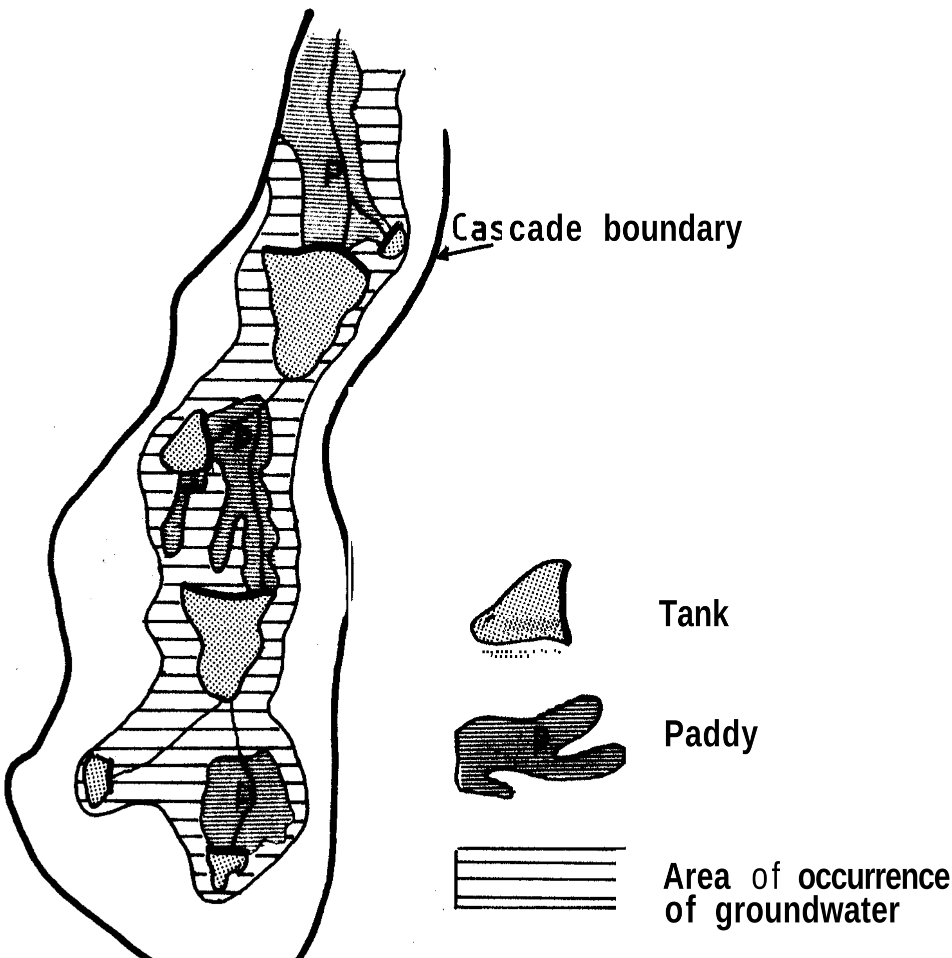

Figure. 2. Schematic Representation of Groundwater area within a Cascade

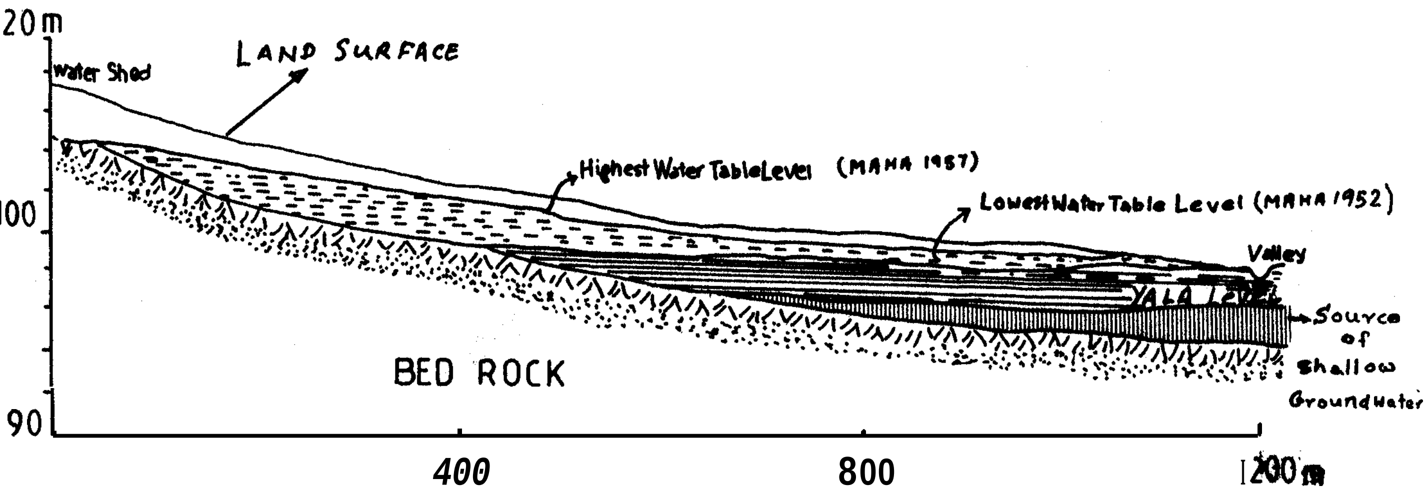

Fig.1 Ground – water table behavior   Maha – illuppallama (1950– 1960)