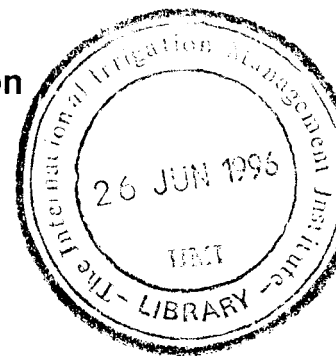


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Sri Lanka

Soil conservation / water conservation / water harvesting / tank irrigation

## Water Harvesting and Soil & Water Conservation Practices in the Dry Zone of Sri Lanka<sup>1</sup>

C.M. Wijayaratna<sup>2</sup> and W.L. Weerakoon<sup>3</sup>



### INTRODUCTION

"Two different systems were adopted in Ceylon<sup>4</sup> for conserving the abundance of water dispersed over the plains during the seasonal rains of the monsoons. According to one, the natural and effective plan of making use of the upper reaches of a valley and embanking its outlets was resorted to. The other system was based much more scientific and ambitious methods, and aimed at securing a greater volume of water than any local catchment area could have supplied. This was effected by constructing massive causeways and anicuts across the larger rivers and turning the water into excavated channels which conveyed it sometimes many miles, over apparently flat country and impounded the water eventually in large reservoirs or a chain of small reservoirs.

So careful were the inhabitants in husbanding the liquid resources on which their very existence depended, that even the surplus waters from one tank which could spill when water was plentiful, were not allowed to escape. The tanks were built in orderly method at slightly varying elevations so that there often was a series of reservoirs to take the over flow from the one above it. The exit of water was regulated by means of sluices to the rice fields. In this manner, the face of the country came to be thickly dotted with these reservoirs and the aspect of the intervening spaces heightened by cultivation"

- Brohier, 1934: P.2. -

As Brohier commented, Sri Lanka had a strong tradition of tank irrigation using an elaborate network of channels, and the historic evidence shows that, from about the 5th century to 15th, irrigation activities played a crucial role in sustaining ancient empires. "The ruins of the irrigation works show the extent of the Island's prosperity in this sphere of activity. .... the first *Aryan* settlers of the Island realized the need for a system which did not depend too heavily on the uncertainties of the seasonal rainfall" (Dikshit, 1986 pp.126, 127).

The present paper focuses on soil and water conservation and water harvesting practices suitable for the "dry zone" of Sri Lanka. Testing and promoting of an appropriate mix of such practices is a major component of the Shared Control of Natural Resources (SCOR) Project. The project is being implemented jointly by the IIMI and the Government of Sri Lanka, in collaboration of farmers. SCOR project is funded by the USAID.

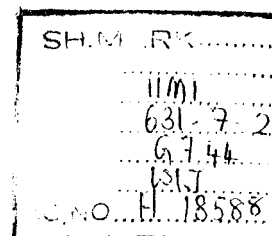
<sup>1</sup> A paper presented to the Consultation on Small Water Harvesting Schemes, organized by the Society for Promotion of Wastelands Development, 12 March, 1996. New Delhi, India.

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<sup>4</sup> Sri Lanka was named "Ceylon" before 1972.

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Rainwater harvesting for agricultural and rural development has been practiced in Sri Lanka since the pre-Christian era. The evidence indicates that as far back as in the 450 B.C. series of small tanks have been constructed to store water during the period of its abundance so that it could be used during the water deficit periods. These tanks had been constructed in such a way to join one another from upstream to downstream so that the maximum utilization of rainwater is ensured. This arrangement is described as small tank cascade system. This tank eco-system is such that the reservoir is located in the lower landscape while the area above is covered by forest, the latter serving as the catchment. On either side of the reservoir are the homesteads and further away from the catchment and homesteads is the area which is used for **chena** or shifting cultivation. Just below the dam is command area where mainly paddy and rarely other food crops are cultivated under irrigation. In ancient times the entire agricultural systems had been governed according to a set of established norms aimed at optimum utilization of land and water resources. A tank system itself has several features in order to reduce siltation, lengthen the storage life of water and a system of natural purification of water. In addition to agricultural production benefits, the small tank cascade systems offer several other benefits such as fish, flood control, maintenance of water table, lengthening the period of water availability, soil conservation and reduction of siltation. The small tank cascade technology has been **time-tested for its adaptation to the local environment.**

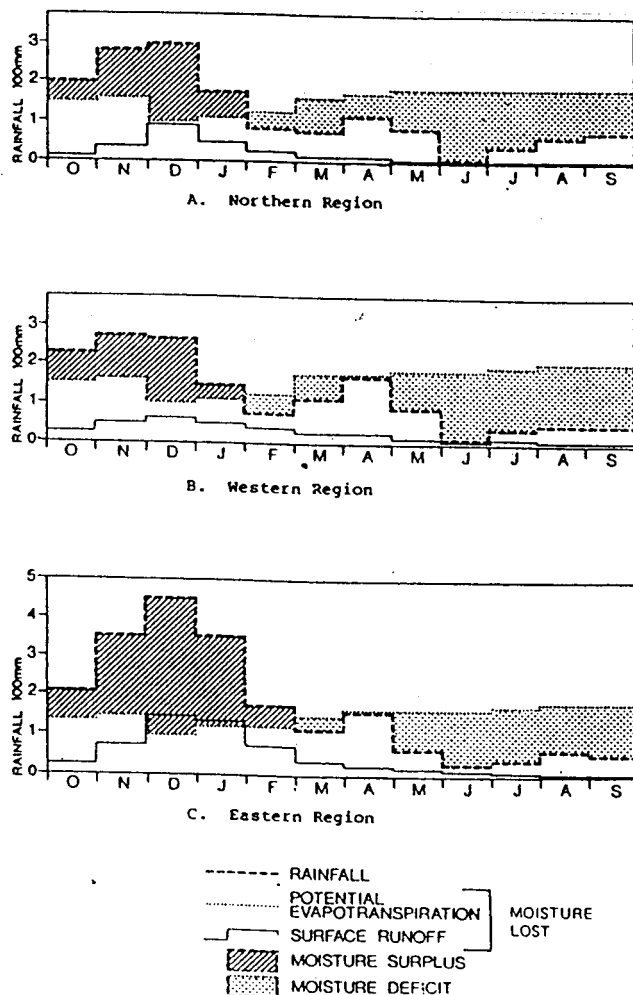
Evidence indicated that the small tank cascade system had functioned satisfactorily until the 12th century A.D. Thereafter, the system started to decline due to several reasons, and a large number of them were completely abandoned. During this long period of abandoning, some tanks were breached, siltation became serious and the people even left some of the tank eco-system. Several of such breached tanks have been restored subsequently. However, at present, only some of the tanks belonging to the pre-Christian era is in operation. The present status characterizes low and variable cropping intensity, low harvest ratios and crop yields, and deforestation in the catchments. Social problems are considered to be serious and resource degradation and depletion have appeared to be intense. The institutional system has subjected to a series of changes and the orderly manner within which tank resources were managed in the past are no longer a reality. Developing and testing strategies for re-generating tank eco system is crucial for "dryzone development". Water harvesting and soil and water conservation should be treated in this context.

## THE NEED FOR HARVESTING WATER

Sri Lanka is divided into two major climatological regions, namely, dry zone and wet zone: the rainfall isoquant of 1900 mm/annum is the boundary between them<sup>5</sup>. The dry zone receives a highly variable basically bimodal rainfall distribution<sup>6</sup>. Nearly 75 percent of rainfall comes in the wet season. Even in this case the distribution is not uniform and can be erratic. In the North-Central dryzone of Sri Lanka, the surplus water condition during October-January is followed by a long dry spell which is only interrupted briefly during March-April. "April rain may be low in one year, may fail altogether in another year and yet another year may be high but short lived and very intensive. Moisture deficit is at its highest during May-September period due to extremely low rainfall, dry winds that dry the surface and very high temperature in the windiest period, June-August" (Tennakoon, 1986 p. 62).

<sup>5</sup> The project area receives an average annual rainfall of about 1500 mm.

<sup>6</sup> Consequently, two district crop seasons, namely *maha* (wet) and *yala* (dry) are identified.



Source: UNDP/FAD and Government of Ceylon: Mahaweli Ganga Irrigation and Hydropower Survey-Ceylon. Final Report Vol. 1 (Rome 1961) Reproduced from Tennakoon 1986

**Figure 1. Moisture Surplus and Deficit in the North Central Dry Zone of Sri Lanka**

in the tank for cultivation of the fields below by gravity irrigation. These ancient irrigation models for capturing, storage and utilization of run-off date back to the fifth century BC. Some of the tanks constructed during the pre-Christian era are in use even today. As knowledge of irrigation expanded, the early settlers built small-scale reservoirs in the villages they occupied for agricultural production and domestic needs. They learnt through continuous experimentation and testing to advance from village tank to major reservoirs during the period 65-109 AD. This is a remarkable achievement in the history of irrigation in Sri Lanka (Widanapathirana, 1992, p.5). The king who had contributed the most to the development of tank irrigation systems has stated "..... in a country such as this not even a drop of water that is obtained by rain should be allowed to flow into the sea without benefiting man ....." (King Parakramabahu the Great, 1153-1186 A.D., Mahavamsa, Part II, quoted in Farmer 1967).

Poor distribution of the rainfall, and not its insufficient amount, is the main factor explaining poor performance of rainfed farming. Hence, the principles of water harvesting in ancient systems in Sri Lanka included the construction of series of storage structures on the basis of

Moisture surplus and deficit in North Central dry zone is illustrated in Figure 1. In general, success of dry season crop depends largely on the availability of water. This "risk minimization process of water regulation (tank construction) and inundated paddy cultivation which is the basis of subsistence economy in the dryzone, has evolved in conformity with the topography and drainage pattern in the region". (Tennakoon, 1986 p.72)

An analysis of the rainfall pattern, natural drainage system and the distribution of tanks in the dry zone areas of Sri Lanka, especially in the Anuradhapura district where tank-based irrigated agricultural production systems had evolved in ancient times would lead one to consider it as a rain-water harvesting system (Figure 2). In response to climatic problems, notably the undesirable distribution of rainfall, Sri Lankans in ancient times have been experimenting with various techniques to collect and store water, essentially run-off during the wet season for use during the dry months. The main method of collecting was to construct storage devices, tanks, by damming a natural depression. Through active experimentation, the Sri Lankans have devised various hydraulic structures to release the water stored

DISTRIBUTION OF MAJOR & MINOR RESERVOIRS/TANKS  
IN THE  
ANURADHAPURA DISTRICT  
SRI LANKA

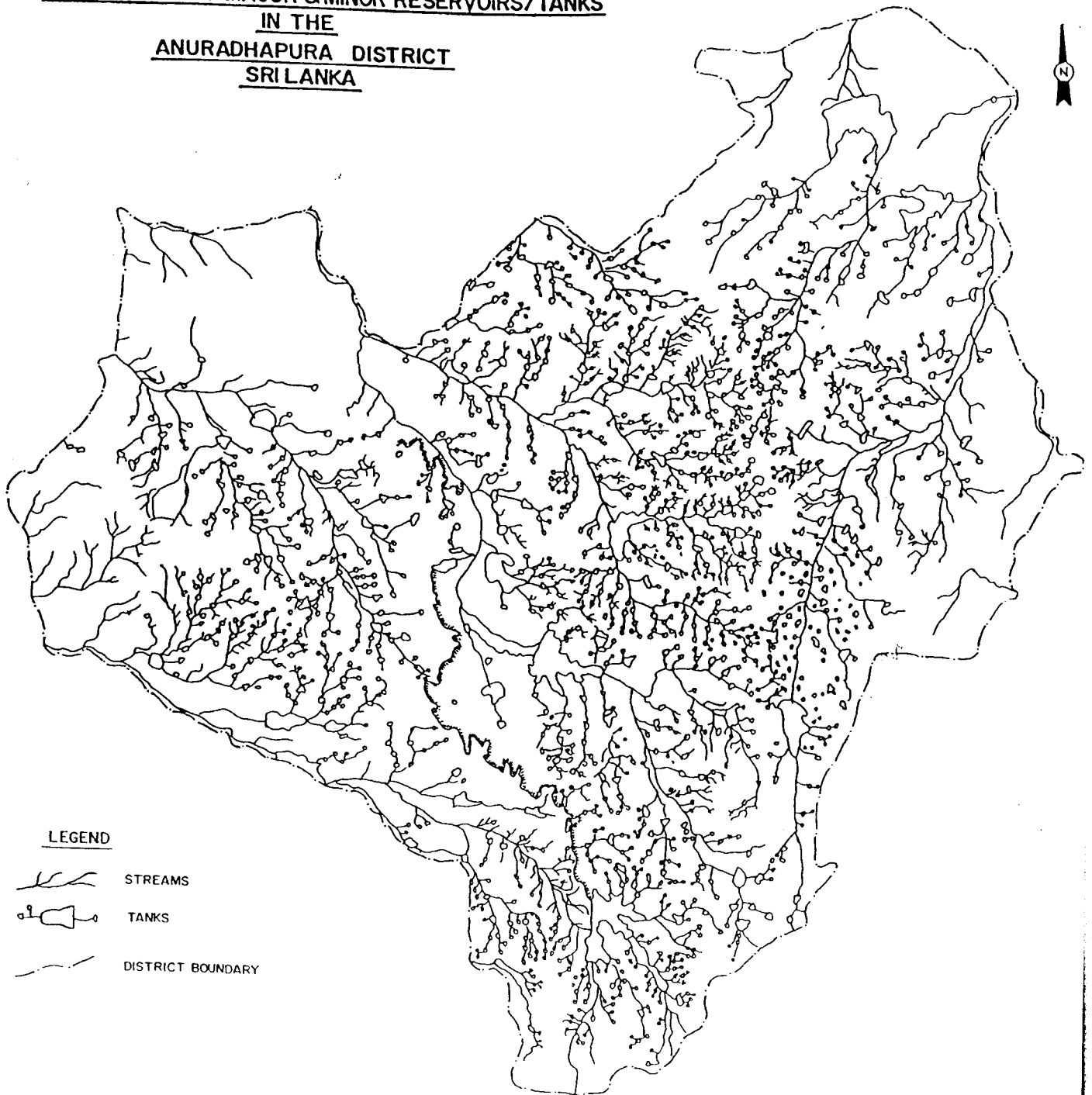


Figure 2

landscape & natural drainage characteristics of river basins/watersheds and techniques to make use of stored water for crop production<sup>7</sup>.

## **WATER HARVESTING AND SOIL & WATER CONSERVATION IN A WATERSHED CONTEXT**

A minor tank cascade system is a sub-system within a (river) basin watershed. (frequently used in this paper as **watershed**). The term watershed is defined as the area of land surface that drains water into a common point along a stream or river. The rationale for using the river basin watershed as the basic unit for integrated planning of (land and water) resources utilization is clear. The watershed is a physical entity geographically defined by an important natural resource, water; the ways in which the water in the upper parts of the watershed are used affect the ways in which it can be used downstream, and they affect the associated land resource. Thus, the various parts of the watershed are physically and operationally linked in important ways, and the potential benefits from integrated use can be large.

To develop and maintain a balance between production and protection (or conservation). SCOR is focused on watersheds as the basic planning, co-ordinating and implementation units. SCOR has selected two watersheds representing different agro-climatological and hydrological characteristics, each from the wet and dry zones of Sri Lanka. The dry zone pilot watershed, namely Huruluwewa (Figure 3) is located in the Anuradhapura district (shown in Figure 2). There are about 220 minor tanks and one major tank in the Huruluwewa watershed. In addition, ground water extraction from the weathered rock upto a depth of about 10m is taking place in an increasing rate. (Figure 4)

In the initial phase of SCOR implementation, several tank cascade systems or sub-watersheds within the Huruluwewa watershed have been selected for pilot research interventions. Prior to participatory planning aimed at revitalization of deteriorated tank ecosystems, SCOR examined the past and present land use patterns of various segments in a typical watershed.

**The SCOR approach emphasizes the need for an integrated ecosystems approach to dry zone development, considering the hydrological, socio-economic and other interventions between the various segments such as catchment, tank, command and drainage areas and associated highlands.** For example, in different zones of minor tank ecosystems SCOR project is testing different "packages" of production and conservation measures -- such as type of vegetation/crops, appropriate land and water sharing and water harvesting techniques, user rights to benefit from (participatory) conservation of land and water resources. This means that the package provides adequate incentives -- such as profits, desired cash flows as well as non-monetary benefits -- to the user to motivate her/him to conserve land and water resources.

## **ZONING OF TANK-VILLAGE SYSTEM**

Tennakoon (1974) has identified five "broad zones" in a typical traditional tank - village system (Figure 5). Zone 1 is the tank which could be considered as the "nerve centre" of the village economy. The geometry and hydrology of the tank is important as it determines the size of the area that can be irrigated and the cropping intensity. Zone 2 is the **Purana wela** (old field), which is located much closer to both the settlement and the tank.

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<sup>7</sup> As Brohier stated: "What an unspeakable blessing that against such calamities a security have been found by the introduction of a grain calculated to germinate under water ....." (Brohier 1934, p.2)

# RIVER BASINS OF SRI LANKA

## DISTRIBUTION OF WATER RESERVOIRS AND AGRO-WELLS IN HURULUWEWA WATERSHED

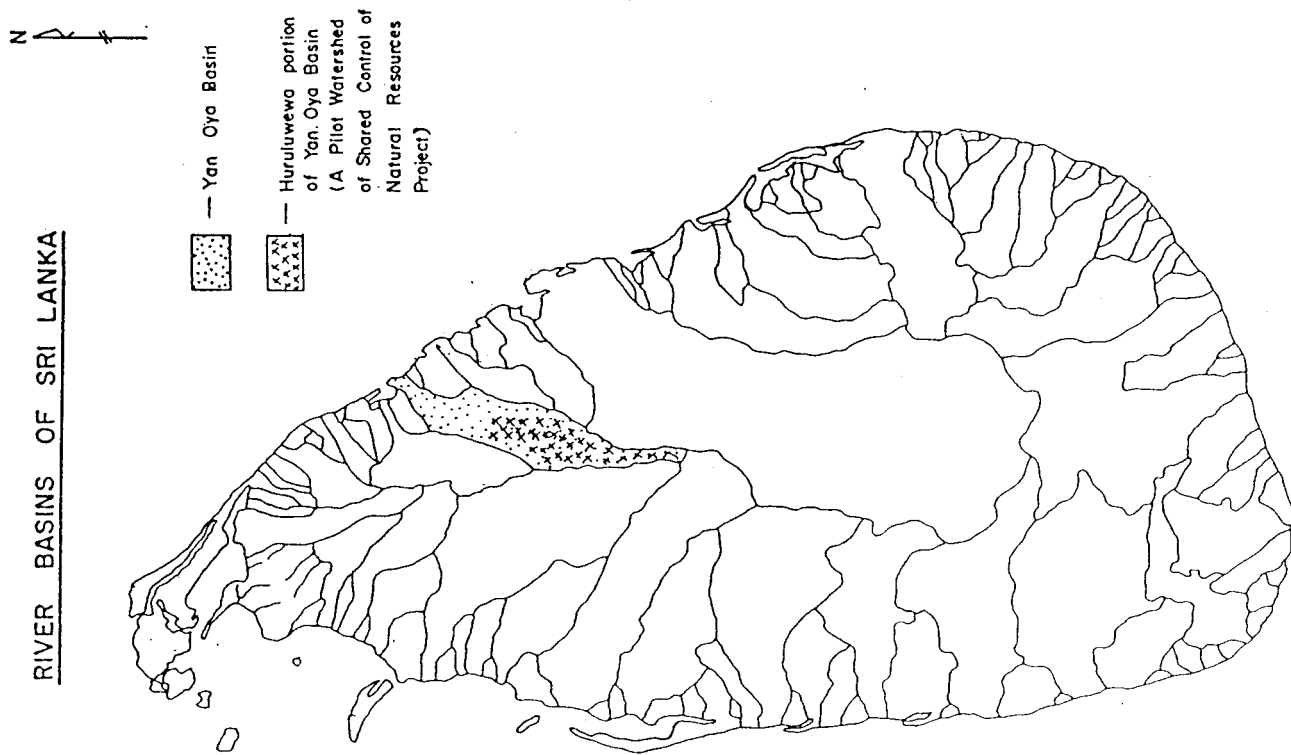


Figure 3

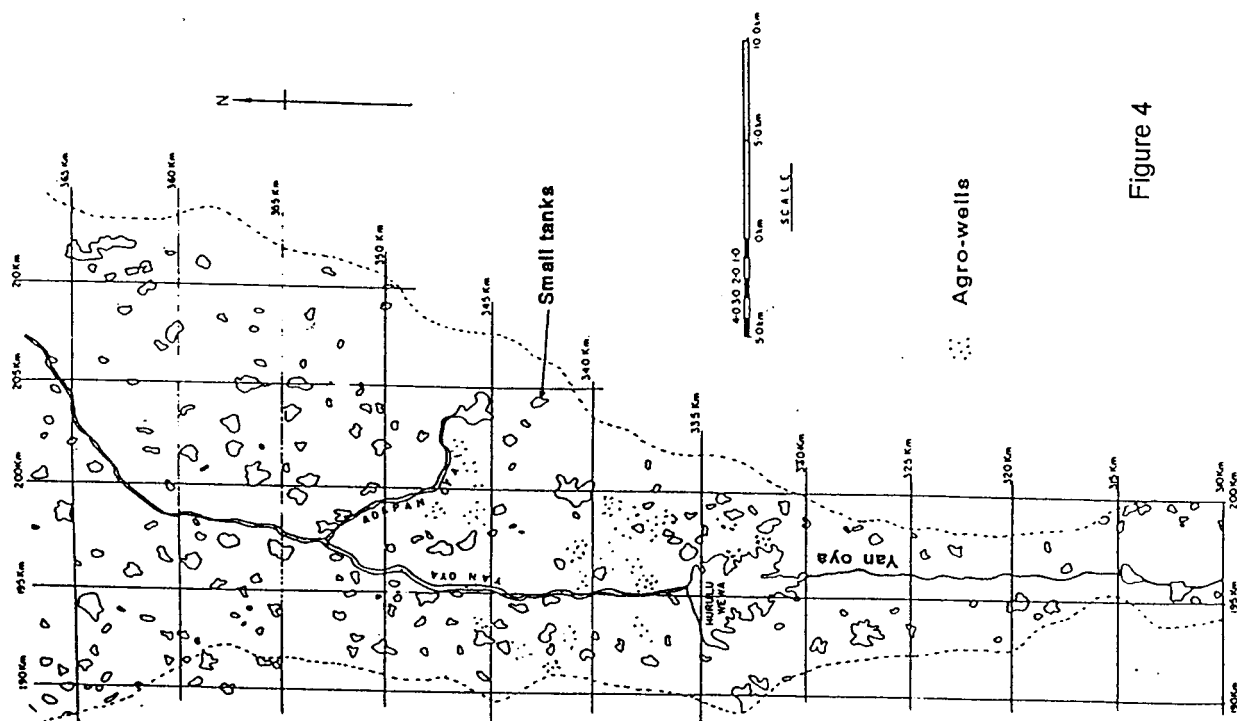
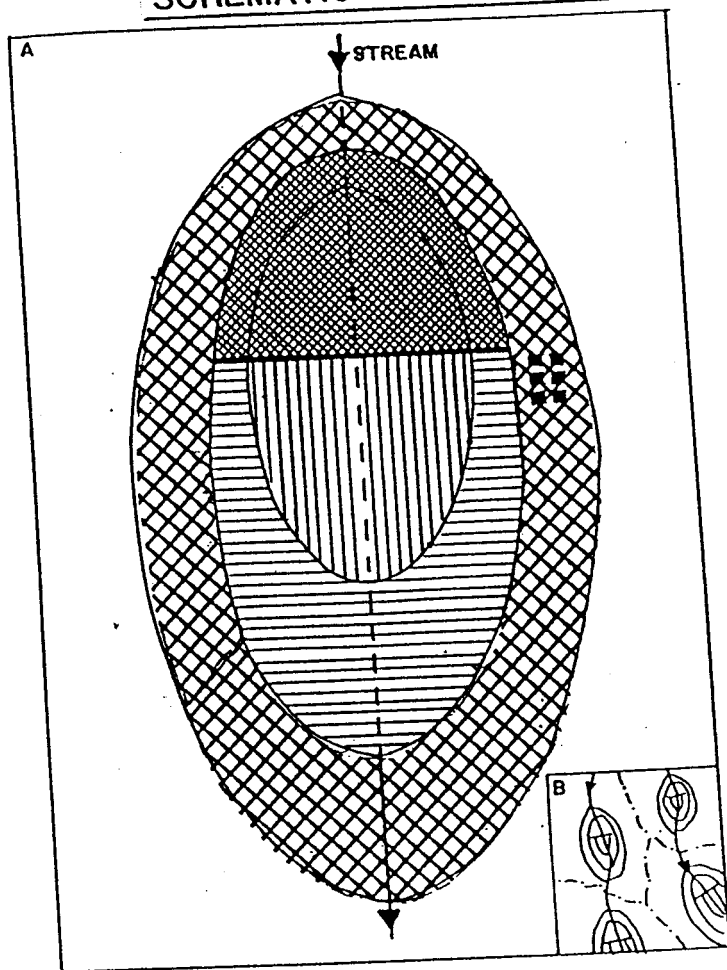


Figure 4

Figure 5

# SCHEMATIC DIAGRAM OF A TYPICAL DRY ZONE VILLAGE



(A)

- TANK BUND
- ■ ■ SETTLEMENT
- ▨ ZONE 1 = TANK
- ▤ ZONE 2 = "OLD FIELDS"
- ▥ ZONE 3 = "FIELD BLOCKS"
- ▧ ZONE 4 = PARKLANDS
- ZONE 5 = FOREST

(B)

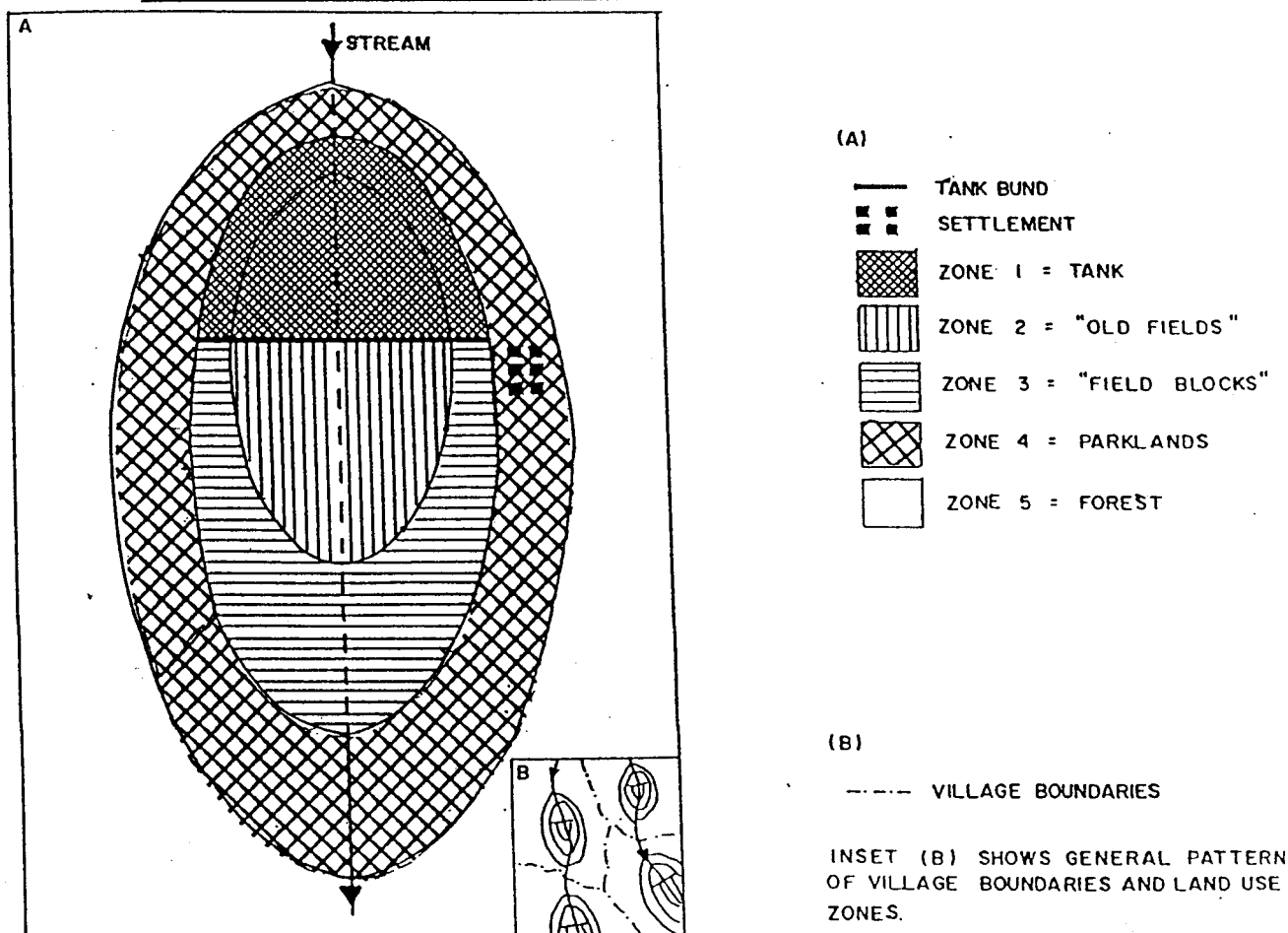
- VILLAGE BOUNDARIES

INSET (B) SHOWS GENERAL PATTERN OF VILLAGE BOUNDARIES AND LAND USE ZONES.

In traditional systems, the land in this zone, which can be irrigated even if the water level is fairly low, has been divided between all the villagers. On the contrary, the land in zone 3, which are owned by few individuals, is usually irrigated by a higher level sluice. Even in instances where the tank is operated by a single sluice, the irrigation supply can be less satisfactory due to its distance from the tank (Tennakoon, 1986). Traditionally zones 1 and 2 have been cultivated to paddy (rice). "Paddy cultivation is the whole basis of village life with institutions, customs, beliefs and values rooted in it. Secondly, under normal weather conditions the farmer always gives first priority to paddy cultivation which has its implications on highland and *chena* (slash and burn) cultivation. Thirdly, the social value attached to the ownership of paddy land, especially the 'old field', is still strong. One's place in the village rituals and festivals, role in community work, chances of becoming a leader and at one time even the right to fish in the tank were restricted to persons with some claim to 'old field'. However, in recent years this trend is fast disappearing particularly with the introduction of the market economy" (Gooneratna et. al., 1980, p. 68).

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Irrigation is nearly impossible in zone 4; mainly because of the distance and, in general, is covered short grasses, isolated trees and bushes. Zone 5 covers the largest extent of "village land" (Tennakoon, 1986). This zone is usually called the village/community forest. However, mainly due to shifting or slash and burn cultivation and illegal logging activities scrub lands have increased at the cost of forest. In the wet season **Chena**<sup>8</sup>, coinciding with the main rainy season, a variety of non-rice crops - such as grain, millets, pulses - is cultivated. Dry season chena is not common and involves cultivation of crops such as gingerly.

The home gardens are generally planted with perennial crops. In general in the study area the cropping intensity (70%-80%) and land productivity (2000-3000 kg/ha) are low in the paddy fields and large extents of under-utilized highlands, both state and privately owned (including home gardens), formed a common feature in the pre-project land use pattern.

It is proposed that an appropriate mix of water harvesting and soil and water conservation practices should be identified and promoted in the "context of integrated watershed management". For example, it is important to understand the linkages between various segments or zones of watersheds/sub watersheds, land and water use patterns and potential for improvement, process of degradation etc.

**Low land** agricultural encounters such problems as: depletion of soil fertility, moisture stress - especially in dry periods, low cropping intensity, declining land productivity and eroding profit margins. Therefore, for the **low lands** (zone 2 and 3), the aim is to enhance rice production and to plan and establish a rice-based cropping system, considering inter and intra seasonal availability of water, soil characteristics, and socioeconomic and institutional factors including markets. Characteristics of the tank-cascade systems should be considered in managing water. In the small valleys of the undulating dry zone terrain, less rapidly moving water cascades from the crests of the low ridges to the keels of the small valleys are intercepted with man-made small and narrow earth bunds of low elevation, to create tanks, big and small. The small tanks are constructed in the upper slopes of the small valleys and the bigger ones are constructed in the keels of the valleys. Furthermore, it is to be noted that the tanks in a keel usually become bigger and bigger as one moves downstream a valley. Water in these reservoirs in a valley, cascades from one to another, starting from upstream towards downstream into a considerably large reservoir far below and finally the volume of water spilled over from that large reservoir at the far end enters a large stream. (Sakthivadivel et.al. 1995)

One of the cardinal strategies adopted in tank construction in a cascading valley seems to be the strict adherence to:

- (a) have an adequate volume of water in every tank of the settled villages in a cascading valley even in a year of below average rainfall;
- (b) institute a regulated flow of water from one tank to another downstream, avoiding sudden influx of large volumes of water in order to minimize the risk of tank bund breaching; and
- (c) have some reservoirs in reserve in the head-end portions of the valley to meet irrigation shortfall of the main village fields as well as water holes for wild animals and village cattle.

In tank cascades, bunds of upstream tanks were never allowed to be raised to impound more water than originally intended to. An ad-hoc bund raising has two negative consequences -- submerging tail-end fields of the immediate upstream village and the denial of some water to the tank downstream of it, causing irrigation water shortages. Thus, spill level, diameters of irrigation sluices, as well as the

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<sup>8</sup> Slash and burn cultivation.

levels of their placement (sill levels), bund top levels, release of water per field irrigation were all done having in mind the entire network of tanks in a cascading valley. In addition, the hydraulic inter-connection of groundwater flow from one tank to another and irrigation return flow from upstream command to downstream tanks make it more important that the tanks in cascade be studied holistically to identify their hydrologic inter-connectors. (Sakthivadivel et.al., 1995)

Maximum utilization of rainfall coupled with the use of ground water and soil and moisture conservation techniques will optimize the land use in the lowlands. In such an effort farmers will be motivated to commence cultivation with the onset of monsoon rains and complete wet season cultivation utilizing rainfall, to the maximum extent possible. Then the tank water can be saved for dry season cropping. Short duration cash crops will dominate the cultivation of lowlands in the dry season. Water harvesting techniques and moisture conservation practices as well as the utilization of (shallow) ground water will minimize the risk.

Chena/shifting cultivation (zones 4 & 5) and home gardening (settlement area in zone 4) are the predominant form of farming in the **uplands** of the village-tank ecosystem.

In zones 4 and 5, much of the forest cover is depleted, consequently shifting cycle has reduced leaving no time for regeneration. Soil erosion resulting from inappropriate cultivation practices stream bank erosion and sedimentation, disappearance of natural habitat and resulting threats to biodiversity, siltation of reservoirs, pesticide and nitrate contamination of ground water, organic matter depletion and decline in soil fertility and moisture stress have become common problems.

Water harvesting techniques and soil and water conservation measures being tested by farmers and facilitated by SCOR in these areas are described in the following section. **It should be stressed that: maintaining the shallow ground water storage at desired levels, regulating run off and infiltration, improving soil characteristics and organic matter management and soil and water conservation are considered to be crucial in upland management.**

## **WATER HARVESTING AND SOIL AND WATER CONSERVATION IN UPLANDS**

Moisture stress is one of the major constraints encountered by the farmers in the dry zone of Sri Lanka. These reasons, either alone or in combination cause moisture stress in rainfed uplands. Firstly, the rainfall in the dry zone, which is usually very erratic having an un-even distribution. Yala rains are continued mostly to a very short period (April-May) and also unpredictable. Second, is the edaphic factor. As a result of continuous cultivation and subsequent loss of top soil due to heavy rain, thinning of soil depth and exposure of the underneath gravel layer are caused. Thirdly, dry winds (advection) prevailing during the dry periods accelerate moisture stress.

Moisture deficiency in the upland soils becomes obvious even during the rainy season, if there is dry spell and again if the rains cease early in the season. In yala, a few showers are experienced and as a result the farmers continue their cultivation only to grow sesame. Perennial crops are seriously damaged during the long dry periods from February to April and again from June to September as there is not enough water in the sub-surface soils. Therefore, moisture conservation and rain water harvesting have become imperative for annual and perennial crop growth.

The SCOR Project has developed an integrated approach towards improving soil moisture in farmlands. These approaches could be basically categorized into three.

1. In-situ moisture conservation
2. Water harvesting
3. Use of residual moisture and crop diversification in water deficit areas.

## In-situ Moisture Conservation

### *Establishment of graded bunds, drains and stabilisation of bunds:*

Most of the lands in the dry zone are either undulating or rolling. The graded bunds and drains are established as recommended by the Department of Agriculture (Somasiri et.al. 1990). As the bunds are liable to break due to high velocity run-off water, these are stabilized by vegetative means. As the growth of Vetiver in the dry zone is slow, Pavetta indica; a shrub belonging to the family Rubiaceae are planted on bunds. Pavetta is a fast growing hedge plant, common in the dry zone.

The primary objective of placing bunds is to optimise the soil physical attributes in the farmer field so as to minimise runoff and erosion, so that the resultant increase in infiltration of water will ensure that adequate water is stored in the soil profile for crop production, while improving ground water recharge. This unlike water harvesting, aims at preventing runoff as much as possible at keeping the rains where they fall. Drains are important in this system so as to drain off excess water, ensuring adequate aeration around roots of the growing crop. The emergence of Commelina diffusa and Aneilema spiratum of Commelinaceae which are wetland weed species (Weerakoon, 1983) is an indication that the moisture retention is improved to accommodate such weeds.

### *Organic Matter (O.M.) Management :*

Application of OM improves soil moisture holding capacity. It acts as a sponge, releases moisture gradually to the surroundings. The sources of OM introduced under SCOR are many. Of them composting, residues (or farmyard wastes) management and agro-forestry are some in-situ green manure sources.

### *Shade Management:*

Integration of hedge-row cultivation (alley cropping) is an important aspect in soil moisture conservation. In hedge-rows, especially in Gliricidia, the canopy cover is managed at a high lopping height, so as to receive some shade for the growing crop avoiding any damage caused by direct broad sunlight. These also serve as interspaced wind barriers, minimising advection and resulting low temperature, vapour pressure and increased soil moisture creating favourable micro-environment for crop growth both annual and perennial.

### *Mulch Management:*

This has been a very successful in-situ soil conservation strategy. Mulch prevents runoff and keeping the rains that fall, without allowing water to be evaporated. Usually previous crop residue, weed thrash, green leaves are applied as mulches for both annuals and perennials. The experience show for crops such as chilli that if a thick rice straw mulch is applied, the soil moisture could be conserved for a longer period beyond normal, without irrigation or rain. Cost of fuel could be reduced if crops are planted under agrowells. Added advantage is weed density in mulching systems is low.

## Water Harvesting Techniques

### *Clay Pot (Pitcher) Irrigation:*

This irrigation is a low-cost technology for conserving water, particularly in areas with scarce water resources. A clay pot is buried closer to the plant and filled with water. For a crop like coconut two such pots placed on both sides are needed. At the end of the rainy season or during dry spell water is collected from elsewhere to fill the pot. The underlying principle is that pots will release water through the micropores slowly in response to root extraction from the soil around them. Unlike conventional drip irrigation system that release water at a fixed rate under pressure, porous pots respond relatively to the demand.

The pots used are about 7 litre capacity and they are egg shaped. Water movement can be controlled by keeping pot surface sealed with wax or by burning that leaves a considerable porous patch at the plant side. This is a very efficient system for establishing tree crops in the uplands.

There are intermittent rains during dry spell. Palmyra leaves can be used to made rainwater collecting funnels and the amount of water collected to the porous pot can be measured by calculating the perimeter of the Palmyra funnel.

### *Orchard or Eye-brow terrace and Sand Pit:*

This is a modified terrace system. The terrace is used where soil is too shallow and slope of the land is too steep for bench terraces. Eye-brow terraces are small v-shaped, placed behind the tree, facing the tree and the hill side of the slope. Run-off water is trapped with the eye-brow ridge. The system can be further improved by introducing 0.5 m deep sand pit with sealed bottom and 03 sides with polythene leaving the wall at the plant side. The pit is filled with dry cow dung and sand and the runoff water is absorbed by the pit and in turn the roots of the growing tree. The mouth of the pit could be covered with rice straw mulch so that any evaporation that could take place will also be avoided.

### *Mini-Amuna or Pond System (check dams) :*

The rolling and undulating nature of the relief create natural drains or streams causing gully erosion. If these streams are blocked partially by check dams (or mini amuna) and pits, the ground water table can be kept raised. To construct mini-amuna, begin at the top of the slope. Amunas are generally closer together on steeper slopes. Strong pegs or stakes should be driven into the ground across the canal extending a distance outside the canal on both sides. Gliricidia or bamboo cuttings can be grown to form a living barrier. As a result the associated upland areas can be developed by growing fruit trees as the ground water table is high. Also small scale cultivation would be possible with dug wells as the ground water recharge is greater now.

### *Roof Rainwater Harvests*

The roof of the house can be considered the catchment area of the rainfall. Various materials ranging from thatch and palm leaves to corrugated galvanized aluminium are used to construct roof catchment. Water is conveyed from the roof to the storage point along gutters made out of split bamboo and down pipes. Rainwater flowing out of roof can be collected into a tank constructed in an upper elevation in the farm land. A type of drip irrigation system could be

developed using local materials can be connected to the water tank. High income crops such as grapes, citrus etc. could be raised with this water.

### **Use of Residual Moisture and Crop Diversification in water Deficit Area**

#### *Use of Residual Moisture in Paddy Lands:*

The residual moisture from the Maha rainy season is being increasingly used to grow a non-rice crop. The usual practise is to broadcast the seeds of Mung bean (Harsha) a day before harvesting the paddy crop. Cultivation of such a crop costs nothing as the crop is planted with zero-tillage and grows on both residual moisture and residual fertilizer. The method is called, sandwich cropping or ratoon cropping and this measure is gaining ground in SCOR area as a mid-season crop.

#### *Crop Diversification for Water Deficit Paddy Lands:*

A new approach towards water deficit tail-end paddy cultivation, where drainage is high and the amount of irrigated water receiving is not adequate has been developed. These lands are converted to cultivate banana mixed with other crops requiring less water. Usually middle and ground storey could be accommodated in the spacing grown for banana. In order to mitigate moisture stress in these lands, rice straw or weed thrash are used as a mulch. Gliricidia wind breaks are established along the border and also as interspaced planting, so that any damage caused by wind is minimized.

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