Effective Utilization of Available Water Resource by Following Proper Irrigation Practices in Sri Lanka

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Abstract— Sri Lanka is a pearl shaped island situated about 35 km. from the southern tip of India. It is exactly 880 km. north of equator and this land of 65,610 sq. km is only 435 km. long and 225 km. across it's widest. Monsoon rains occurring during the two distinct periods from May to September namely the South-West Monsoon and from December to February the North-East Monsoon along with the convectional and depression rainfall during the inter monsoonal periods contribute to the annual precipitation. Sri Lanka is divided into 103 natural river basins, with catchment areas ranging from 10 to 10,500 sq. km. Sixteen of these rivers flow through the wet zone. The base flow of these perennial rivers of wet zone are very low and flood discharges are high. The streams in the dry zone have poor run-off and are generally not perennial. The annual precipitation is about 110,000 million cu. meters, the run-off being 47% of this. The wet zone contributes 40,000 million cu. meters of perception of which the run-off is 65%. The practice of irrigation in Sri Lanka has a tradition of over two thousand years, with the first earth dam believed to have been constructed in 504 BC. The earliest settlers from India in Sri Lanka possessed a knowledge of irrigation and rice cultivation, having presumably settled on the flat dry zone plains which were ideal for rice cultivation. This research article deals, how the water resource is effectively utilized by following systematic scientific and proper irrigation practices in Sri Lanka.

Index Terms— Cropping Intensity, Perception, Crop Water Requirement, Water resource, Irrigation duty

1 INTRODUCTION

THE Democratic Socialist Republic of Sri Lanka formerly known as Ceylon is a pleasanty sunny, beautiful, pear shaped island situated about 35 km. from the southern tip of India It is exactly 880 km. north of equator and this land of 65,610 sq. km is only 435 km. long and 225 km. across it's widest. But only a few countries in the world can match Sri Lanka for its unique geographical features. This is what Mahatma Gandhi, the father of India said about Sri Lanka when he visited here "The natural scenery that I see around me is probably unsurpassed on the face of earth".

The charm of Sri Lanka lies in many factors, its blue seas and golden sea beaches, its jungles with a variety of wildlife like elephants, leopards, deer, bears etc. and mountain peaks and its salubrious climate. There is no nation from Egypt of Pharaohs to modern Britain, in whose literature this island has not at some time or another been mentioned by one or the other of its many names like Lanka, Eelam, Serendib, Taprobane, Ceilao, Zeilan to recall a few.

Caressed by the swelling waters of Indian Ocean, 1230 km. of golden beaches ring the island. From the beaches the land rises lightly at first and then steeply to form the south of central rugged hill country reaching up to Pidurutalagala, the island's highest peak at an altitude of 2521 meters.
Generally speaking the relief of the country may be said to constitute:-

- A mountainous area covering the south central part averaging in elevation from about 900 m. to 2000 m,
- An upland belt at an elevation of about 300 m. to 900 m. surrounding the montane country.
- The flat coastal plain which occupies the rest of the island.

2 CLIMATE OF SRI LANKA

There are no marked climatic seasons in Sri Lanka. Due to the country's proximity to the equator, the mean temperature on the plains ranges from 27° C to 26° C, but the maximum width of the island is only 225 km., therefore the oceanic effect helps to reduce the temperature in the plains while the altitude modifies the temperature in the highland. It falls off at a steady rate of 1^0 C for 165 meters rise in elevation. The average temperature varies from 26.7° C in Colombo which is the capital on the west coast to 24.4^0 C in Kandy the main city in the central hills, where the last king of Sri Lanka lived, to 28^0 C [5] in Trincomalee a strategic seaport in the East coast which is well known in the world, as this was a base of the British during world war two. The highest temperature are observed in April and May and the lowest in December through January. Relative humidity are essentially constant throughout the year varying from about 70% during the day to as high as 95% at night as the temperature falls.

Climatically, Sri Lanka has no 'off-Season', weather conditions being generally throughout favourable the year, the sun shining practically all the time. Warm sunny days are the norm with showers falling lightly to keep the fields watered and the vegetation lush.

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3 MONSOONAL PATTERN

The pattern of the monsoons in Sri Lanka has remained almost unchanged during the 2500 years of its recorded history. Monsoon rains occurring during the two distinct periods from May to September namely the South-West Monsoon and from December to February the North-East Monsoon along with the convectional and depression rainfall during the inter monsoonal periods contribute to the annual precipitation [6].

Based on the rainfall pattern the island is divided into three distinct zones. (Figure. 1) The south western quadrant of Sri Lanka receives the maximum amount of precipitation from both monsoons ranging from 2500 mm. to 5080 mm. or even more per year. Because of this rainfall characteristic the south-west quadrant is called the Wet Zone and Intermediate Zone. It covers 30% of the land area of the land of the island and contains about 75% of the total population of about 14 million people. It also accounts for about 70% of the cultivated lands. The balance area of the island by comparison is called the Dry Zone and receives about 1270 mm. to 1910 mm. of rainfall in a year mostly during the short North Eastern monsoonal period. The monthly average rainfall patter is given in Table 1 [1].

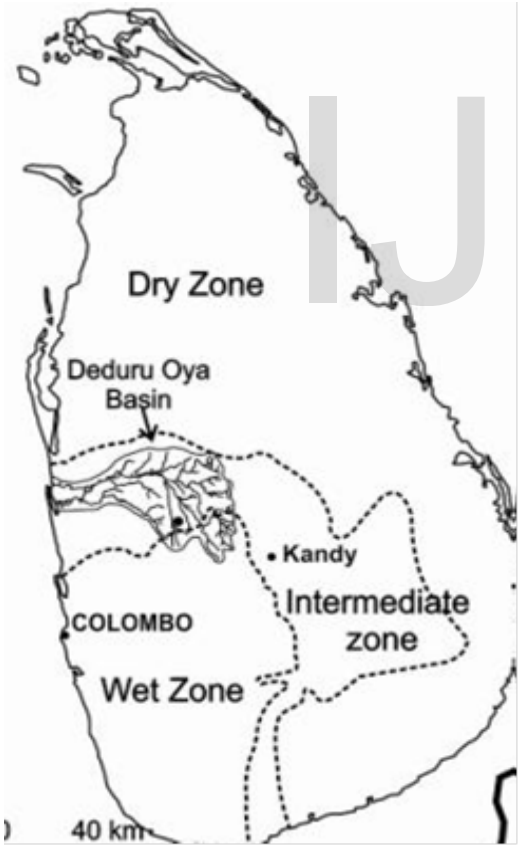

Figure. 1 Climatical Zones of Sri Lanka

Table 1. Monthly average rain fall

Month	Rainfall in millimetre		
	Wet/Intermediate Zone	Dry Zone	All Island
January	107	191	150
Febru-	66	69	69
March	145	84	114
April	224	102	163
May	297	74	185
June	236	23	130
July	198	28	114
August	147	46	97
Sep-	196	69	132
October	358	196	277
No-	292	305	300
Decem-	155	269	213
Total	2421	145	1944

4 RIVER BASINS & PRECIPITATIONS

Sri Lanka is divided into 103 natural river basins, with draining areas ranging from 10 to 10,500 sq. km. Sixteen of these rivers flow through the west zone [9]. The base flow of these perennial rivers of wet zone are very low and flood discharges are high. The streams in the dry zone have poor run-off and are generally not perennial. The annual precipitation is about 110,000 million cu. meters, the run-off being 47% of this. The wet zone contributes 40,000 million cu. meters of perception of which the run-off is 65% [7].

5 IRRIGATION WORKS

The practice of irrigation in Sri Lanka has a tradition of over two thousand years, with the first earth dam believed to have been constructed in 504 BC. The earliest settlers from India in Sri Lanka possessed a knowledge of irrigation and rice cultivation, having presumably settled on the flat dry zone plains which were ideal for rice cultivation. They devoted their energy to the storage of water in reservoirs finding the distribution of rainfall unsatisfactory and the rivers and streams not perennial in the areas where they had established their homesteads.

From such beginnings, engineering skills were developed resulting in the progressive build up to about the 12th century of magnificent earth dams and their reservoirs, and canals linking rivers with reservoirs and interconnecting reservoirs like Tank Cascade System TCS (Figures. 2 a & b).

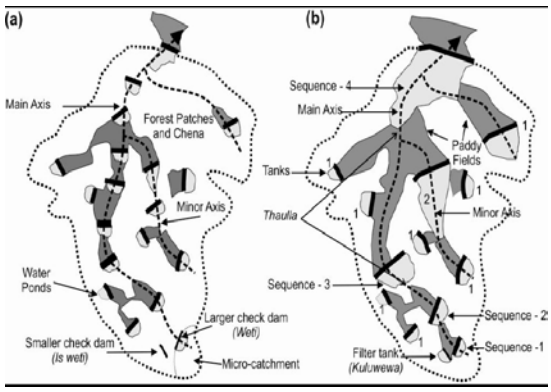

Figure.2 Schematic diagram showing progression of check dam based water ponds and associated with a TCS man-made features

All these irrigation works were abandoned for a few centuries during the time when Sri Lanka was ruled by foreigners who were not interested in rice cultivation but in the plantations sector in the wet/intermediate zone where spices and tea are grown and which do not need any irrigation because of abundant rainfall.

However, almost all the important ancient irrigation works are now restored and are operating. New irrigation works of comparable proportions to ancient works have been constructed in the last four decades.

Sri Lanka is now engaged in the rehabilitation and improvement of already constructed irrigation works through Dam Safety and Water Resource Planning Project for the assured irrigation for more than 300,000 ha. of new lands and providing assured irrigation facilities to 100,000 ha. out of the above lands served by the ancient and modern irrigation works. This project involves providing dam safety measures to more than twenty five major dams. There are other projects presently going on with various funding for the rest of the irrigation schemes including irrigation distribution networks.

6 Irrigation systems Design in the Past

During the past three decades till about 1972, canal designs were done on assumptions adopted from the past practices in Sri Lanka as well as in neighbouring India. The distribution systems were designed for cultivation of only paddy of 3, 4 and 5 month varieties with a three weeks water issue for land preparation for each of the varieties [6].

Main canals were designed varying from 572 to 857 ha. per cumec tor mean with 30% variation. Branch or Secondary canals were designed for a duty of 572 ha. per cumec with 25% variation. Distributary or Tertiary canals for a duty of 500 he. per cumec with 15% variation and the field canals from which only the fields are irrigated, were designed for a duty of 429 ha. per cumec without any variation.[3]

Manning's formula with a rugosities co-efficient of 0.0225 was used for design of earth canals. Critical velocity ratio varying from 0.84 to 1.02 and limiting velocities of 0.76 m/sec. for small canals and 1.07 m/sec. for large canals were adopted for the designs. Turn-outs were designed for maximum discharge at head of 2/3rd the full supply depth in the parent canal.

Main canals were aligned along contours, Branch, Distributary and Field canals along contours and ridges. Field canals were preferred on ridges. Particular attention was not paid to limit the number of farm lots or the extent commanded by a field canal. Lengths were any thing from 100 m. to 1500 m and area commanded were any area between 2 to 50 ha. Also there was no investigation done for land use classification. In any type of soil paddy only was planned. In the earliest irrigation projects individual farms were 2.0 ha. and in recent years it was reduced to 1.0 ha. without any proper macro economic studies.

7 Design of Present Project Systems

Development of present projects, extensive feasibility studies are being carried out. By those studies and findings and from the experiences of the problems of irrigations in the earlier projects, a new set of criteria for the design of the distribution system is adopted. The same criteria are adopted in all other new projects whether small or large. These design criteria have been tested in pilot projects and still further studies are in hand for any refinement if found necessary.

7.1 Selection of Crops, Cropping Pattern and Cropping Calendar

The soil surveys are done in the project areas and land use is classified with a view to select the suitable crops. Unlike in the past, paddy is not proposed in all the areas of new projects. Based on the results of the land use investigations, paddy cultivation is proposed, in the low hemic clay soils of the low land areas and a variety of crops such as cotton, soya beans, groundnuts, green grams cowpea, pulses, chilies and onions in the reddish brown earth of the uplands. Cropping patterns are drawn giving due consideration to type of soil, crop preference, sufficiency of food crops to meet the demand and the financial returns from cultivation operations. However, from traditional requirements a cropping pattern of paddy for Maha season is allowed in all uplands.

The cropping calendar is prepared on the basis of climatic conditions of the project area and proposed agricultural practices, Sri Lanka there are two distinct cultivation seasons namely Maha or *Perumpoham* from October through March and Yala or *Sirupoham* from April through September.

7.2 Crop Water Requirementss

Evapotranspiration .requirements are still computed on the basis of the evapotranspiration of grass as the reference crop and crop factors and growth stages based on FAO Irrigation and Drainage paper No. 4 on "Crop Water Requirements", Experiments and studies are being carried out in pilot projects for computation of crop factors and others and it is hoped that the actual experimental figures will be adopted in the future designs.

Normally 178 mm. of water is used in 15 days for preparation of lowlands and 38 mm. in the same 15 days for upland fields. In Sri Lanka at present both draft and machine tillage power is very limited and therefore a staggered cultivation is adopted constituting of 3 parts. At any point of time, thus tillage and land preparation will be performed only on 1/3rd of the total area cultivated

On the basis of limited experimental data 102 mm. and 152 mm. of water are allowed as losses in lowland farms for Maha and Yala seasons respectively to provide for percolation and leakage through the dykes. Upland farm losses are provided for on the basis of an irrigation application. Efficiency of 50% to allow for deep percolation and runoff, as all the canals are generally earthen canals, canal conveyance losses from reservoir to farm are assumed as 30% but in near future it will be replaced by the correct experimental value from the experiment and studies in hand.

The effective rainfall is taken as 0.67 x (R-25.4) mm. in satisfying a part of the water requirements, where R is the monthly rainfall in mm [4]. The maximum value of effective rainfall considered is 228.6 mm. and rainfall equal to or less than 25.4 mm. is ignored. Similarly for upland crops and upland paddy effective rainfall is considered as 0.67 x (R-6.4) mm. with a maximum value of 76.2mm. and ignoring rainfall equal to or less than 6.4 mm. 75% probability of monthly rainfall is used in crop water requirements[4] computations to determine the canal duties.

7.3 Canal Duties

Canal duties are computed using monthly peak water requirements allowing for evapotranspiration, conveyance losses, percolation, and leakage and considering effective rainfall etc. According to conditions encountered for the above features, for projects in dry zone, the canal duty for main and branch canals is now taken as 357 ha. per cumec. The field canal duties are 557 ha. and 276 ha. per cumec for lowland and uplands respectively the distributary canal duty is based on the number of field canals taking off from it.

7.4 Canal Design

Manning's formula with rugosities coefficient of 0.025 and Critical Velocity Ratio between 0.90 and 1.25 is applied to obtain the earth canal conveyance sections. The limiting velocities adopted for canals are 0.46 m/sec for canals carrying up to 0.71 cumec; 0.76 m/sec for over 0.71 and upto 8.50 cumecs and 1.07 m/sec for over 8.50 cumecs.

Regulators are provided to ensure full supply depth in canals when it is not discharging the quantity corresponding to full supply depth. The maximum spacing of regulators is determined to ensure a head of 2/3rd full supply depth for maximum discharge of turnout located farthest away from the regulator.

Intermediate turnouts are designed to supply maximum discharge at controlled water surface elevation which will be between 2/3rd full supply depth and full supply depth.

7.5 Turnout Areas

To ensure equitable distribution of canal supply, farm turnouts are now designed to divide the supply from the field canal equally between two farmers at a time on a rotation basis. It is found that 0.014 cumec is the convenient stream size that could be effectively handled by farmer. As it is the case, the field canal is designed for a constant discharge of 0.028 cumec. On this basis a field canal will command 16 ha. of lowlands on a continuous 24 hour irrigation period. When the irrigable area is upland the duration of Irrigation is limited to daylight period of 12 hours and extent commanded by the field canals 8 ha. The area commanded by a field canal is termed as 'Turnout' and therefore the irrigation systems is designed on the basis of turnout areas.

7.6 Layout of Canals

The main canal is generally a contour canal aligned at an elevation of bed level plus depth of cut with a bed gradient 0.00035. It is double-banked where it is crossed by large drainage streams. Conveyance sections are changed with every reduction between 7% and 15% of command extent with corresponding reduction of bed width between 5% and 15% and full supply depth between 2% and 5%. Wherever possible minor reservoirs are incorporated along the main canal to serve domestic and operational needs.

The consideration in aligning branch canals are same as for main canals except that these may be aligned along the ridges as well. The maximum canal drop in branch canals aligned along a ridge is generally limited to 1.5 meters.

Distributary canals are aligned along ridges with a bed gradient of 0.0004. These canals generally command 10 field canals over the turnout area basis, the maximum being 25 field canals. Canal drops on this canal are limited to a maximum of 1.2 meters [10].

Field canals are aligned along ridges or across contours with a bed gradient of 0.0004. They are double-banked and canal drops are limited to 0.9 meters.

The layout of irrigation canals also includes the layout of drainage canals namely, Turnout drains, Secondary drains and Main drains.

7.7 Layout of Farms

There are two types of farms in an irrigation project. The lowland farms are generally located in the lower half of the valley and soil types are mainly poorly drained low humic gley soils and sometimes alluvial soils. In these farms the cropping pattern is paddy for both Maha and Yala seasons [2].

The other type is upland farms occupying the area between the main canal and the lowland farms and constituting between 25% and 40% of the command area. The soil in the area is Reddish Brown Earth varying from well drained to imper-

fectly drain. Cultivation of cash crops, namely, cotton, sugar cane, tobacco and etc. are proposed in these areas.

A common shape and side proportions are adopted for the farm lots as far as possible. The farm lot is a rectangle shape with sides generally in 1:3 proportion. Where, from topographic and other considerations farm lot of parallelogram or trapezium shape is required, the sides proportions is retained to 1:3 and the acute angle in the lots is kept between 70^0 and 80^0.

7.8 Irrigation Methods

The lowland farms are irrigated by 'basin method' with each basin varying between 0.08 and 0.10 ha. the length of each basin not exceeding 30.48 meters. Furrow irrigation is practised in upland farms. The recommended maximum length of furrow is 60.96 meters with the length of the farm in the direction of irrigation not exceeding 182.88 meters.

8 Maintenance and Operation of Irrigation Projects

Immediately on completion of construction of a part in major schemes or the complete project in respect of a minor scheme that could be operated, the area is taken up for operation and maintenance.

8.1 Maintainance

In all irrigation projects, the Government is responsible for the maintenance of all components of the project. After an initial period of 5 years of maintenance, the responsibility of maintaining the field canals and drainage canals up to 0.90 km or serving 40.47 ha is transferred to the farmers benefitted by them. However, the responsibility of maintaining the structures in field canals is with the Government.

Maintenance activities are divided into maintenance of

- Head works (includes dams)
- Distribution systems
- Roads
- Buildings

Head works and Distribution systems maintenance, as they relate to hydraulic features of an irrigation project and are vital, receive largest maintenance attention and therefore reasonable fund flow. Maintenance programme for head works provides for periodic and methodical attention to ensure that all appurtenant works are in good order and that they perform as designed. That of distribution systems, emphasise the conveyance of water and upkeep of the operation. The maintenance of roads and buildings are taken up in a suitable period of the year when minimal attention is needed for others.

8.2 Cultivation Proceedure

Cultivation in an irrigation project, commences with the holding of a cultivation meeting between farmers of the project and Government officials consisting of technical and administrative personnel about a month ahead of each of the respective Maha and Yala seasons. The meeting is held to decide on the main items of cultivation operations as listed below.

- Extents to be cultivated
- Cropping pattern
- Dates of first and last Issue of water
- Last date for land preparation and transplanting or broadcasting of paddy
- Dates by which the farmers complete their contribution of maintenance of field canals
- Dates for perimeter fencing of farms to protect the crops from stray cattle and other animals
- Dates for harvesting, threshing and transport of produce.

Regarding the extent to be cultivated, the decision is invariably to cultivate the full extent in the scheme for Maha. For Yala, the extent is decided upon the firm availability of water in the reservoir at the end of Maha cultivation.

8.3 Water Deliveries

Water is distributed in most of the projects according to rotation system with rotation made between single distributary canal and group of distributary canals. Further rotation is also provided in the deliveries to farms under each field canal. The delivery of water up to the field canal is the responsibility of the Government through the Irrigation Engineer. The distribution of water to farms under a field canal is done on a voluntary basis by the farmers on a roaster arranged by a group leader elected amongst themselves and the leader is called the 'Vel Vidane' or 'Vatta Vidane'.

9 The Problems of Water Management

The list below gives roughly the problems encountered in authers experience as water resource Engineer when auther was in charge of some irrigation projects during authers carrier in Government service around three decade in practicing a good effective water management in Sri Lanka.

- The farm lots are not levelled
- Lack of provision of devices to measure deliveries of water in the distribution systems.
- Control gates in turn-out structures are of wooden shutters operating in grooves.
- Canals not lined and therefore extensive seepage losses
- The supply to farms from field canals are by open cuts in canal
- At some places one canal serves as both supply and drainage canal.

In addition, the sociological problems that contribute to poor water management are the inability of the farmers to get credit in time, tillage power, seeds, fertilizer, extension services and etc.

10 Conclusion with Possible Solutions

From the experience the auther gained in the field of water management in Sri Lanka out of the studies and from ob-

servation of very successful irrigation projects during the period of authers stay in India and Thailand, auther feel effective water management to a certain degree can be achieved in those old schemes in Sri Lanka when the following measures are taken

- Introduction of measuring devices in the irrigation systems. Parshal flumes in Main and Branch canals; Weir Boxes and Weirs in turnout structures for distributary canals and field canals.
- Stage gauges and current metering be employed to measure run-off and drainage to study and control water balance of irrigated areas.
- Wooden Planks for control gates be replaced by iron slide .gates with screw type hoisting arrangements.
- Canal lining' be provided if not for the entire lengths at least at identified points of excessive seepage
- When modernization programme are undertaken, the distribution systems be re-designed on turnout area basis.

In addition, as early as possible, land consolidation of the farms with each lot having water supply drainage and access facilities be carried out.

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