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Water Management Strategies to be Adopted in Sri Lanka to Improve Food Productivity to Accommodate the Population Growth

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ABSTRACT

Food production in Sri Lanka needs to increase to feed a growing population whereas water for irrigation is getting scarcer. Major challenges Sri Lanka facing today are to save water, increase food productivity and produce more grain with less water. This article analyzes and recommends the ways in which water saving irrigation management is to be practiced to meet these challenges at the field level. The analyses were conducted using actual data collected mostly from Irrigation department and Agriculture department in all the regional offices. Water input can be reduced by reducing ponded water depths to soil saturation or by alternate wetting/drying by following good water management tecneques. Water savings under saturated soil conditions were on average between 20 % and 25 % with yield reductions between 5 % and 8 %. Yields were reduced between 15 % and 45 % when soil water potentials in the root zone were allowed to reach minus 125 mbar to minus 250 mbar. In claye soils, intermittent drying may lead to shrinkage and cracking in the fields, thereby risking increased soil water loss, increased water requirements and decreased water productivity. It therefore does not produce more rice with less water on the same field. Field-level water productivity and yield can only be increased concomitantly by improving total factor productivity or by raising the yield potential. Total rice production can be increased by using water saved in one location to irrigate new land in another location. If this is not done, as strategy of saving water at the field level, potentially threatens total rice production at large in Sri Lanka.

Keywords : Crop water requirement; Effective rainfall; Food production; Irrigation methods; Rainfall intensity; Root zone; Timing of cultivation; Water resource; Water management;

1 INTRODUCTION

WATER is one of the important basic needs of man. Without water human life is impossible to exist. The total quantity of water in the earth is estimated as 1,400 million km^3 which can neither be increased nor decreased. Around 97.4% of this water is saline, and not fit for consumption, irrigation or industry. Another 2% is locked away in ice caps and glaciers, of the balance 0.6% or 8.4 million km^3, 8.0 million km^3 is stored underground. This leaves 0.4 million km^3 water which is stored in manmade lakes, natural lakes, streams etc. However water is not distributed evenly all over the world.

In the Sri Lankan context, the island has an area of 6,560,000 ha. The total asweddumised paddy land is around 600,000 ha. of which 320,000 ha. are irrigated by major/ medium reservoirs leaving a balance of about 130,000 ha. rained or Manawari lands. The island is broadly divided into two zones. Those are wet zone, receiving an annual rainfall of 1,500 mm. or more and dry zone receiving less than this. The dry zone covers about 75% of the land area say 4,800,000 ha. The extent available for agriculture development in this dry zone is about 600,000 ha, If we deduct the extent presently under irrigation in the dry zone (about 300,000 ha) the extent that could be additionally brought under irrigation is another 300,000 ha. But we have no water in the basins where lands are available and unless some more trans basin diversion schemes are mooted we cannot significantly increase the cropping extent.

2 FOOD PRODUCTION IN SRI LANKA

The population of Sri Lanka is 17 million and the requirement of paddy per year is 2,863 million tons. According to the Central Bank Report for 1993, the total paddy production is 2,564 million tons. In addition to this, import of 299 million tons which is about 8.4% of the country's requirement of 2,863 million tons. In addition wheat had been imported in 1993. When this is added to the rice requirement, the total production is less than our total grain requirement because we do not produce any wheat

The average paddy yield had been estimated as 3.516 ton/ha. by the Central Bank and the gross harvested extent as 89% of the gross sown extent. If we are to significantly reduce the import of rice and/or wheat we have to increase the production of paddy by,

- Increasing the extent cultivated and harvested
- Increasing the yield per ha
- Cultivating other food crops
- Effecting better water management practices.

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3 Status of Irrigated Agriculture

The past rulers have taken various steps, time to time to increase the food productivity without any fore thought, to full fill their political motto. This resulted the following concerns

- We have exploited almost all the possible lands for cultivation so much so that the forest cover available has gone down to dangerous levels of about 22%. So it is not prudent to significantly increase the extents cultivated.
- Increasing the yield per ha. is being attended to by the Agriculture Department. There had been a significant rise in the 1960 to1980 period and now the increase has tapered off.
- Cultivation of other food crops has not found much favor with Sri Lanka farmers. The farmers are not prepared to shift to cultivation of other crops unless and until the marketing of these is streamlined and a good floor price assured. In some areas the farmers are cultivating paddy in well drained soils which is very uneconomical.
- Irrigation had been practiced in Sri Lanka for over 2000 year by our fore fathers. The selection of schemes was based on the areas where people were living and where there was demand for cultivating food. As such the Major and Minor Irrigation schemes were constructed in the dry zone and anicut schemes in the wet zone.

4 Importance of Strategic Water Use

Almost all Irrigation schemes and anicut schemes have been utilized for cultivation of paddy. The Irrigation System was designed with minimum investment on the channel system.

Engineers and Scientists serve the society by the application of science and engineering skills to meet the needs of the people. These needs are constantly changing and increasing. The tasks ahead of us include the conservation of water resources, the protection of the environment, the improvement of food supplies, the development of sources of energy, further development of transportation etc. for increasing population. This leaded the strategic thinking of water management, as an important area for the conservation of water resources.

5 Water Managment

Water Management could he defined as the process involved in controlling, operating and releasing of irrigation water in a project area. This could be further explained as the procedure involved in assuring that the optimum amount of water is made available to the farm for successfully carrying out operations such as ploughing, sowing or transplanting, weeding, pest control, fertilizer applications and for crop growing. Water Management could also be expressed as a comprehensive art to develop the inter-relation between plant, water and soil, for maximum crop yield with the limited quantity of water based on the harmony between nature and the human being.

Some of the most important factors that influence successful Water Management programmes are,

- Soil & soil properties
- Crop water requirements
- Effective rainfall
- Deep perculation losses
- Farm efficiency
- Conveyance efficiency
- Irrigation methods
- Timing of cultivation
- Agricultural inputs
- Extension services

5.1 Soils and Soil Properties

Water Management involves the full integration of Engineering and Soil Sciences. Therefore, the Engineer, the Agronomist and the Soil Scientist must team up to work out the best irrigation principles and practices suitable to a particular area. The knowledge of physical properties of soils is a prerequisite, to determine the quantity of irrigation.

Soil is a complex system made up of soild, liquid and gaseous materials. The solid mineral portion consists of particles of various sizes, shapes and chemical composition. These particles are classified according to the size of grains as sand, silt and clay. The spaces between the solid particles are occupied by water and air. It is this water and air are essential for root development and plant growth.It is this water which is replenished by rain and irrigation for the successful production of crops. A good water management practice is important in maintaining a suitable balance between soil moisture and air.

The proportion of sand, silt and clay present in any soil can be accurately determined in the laboratory by mechanical analysis. The particle size distribution of a soil is closely related to the water holding capacity of the soil, its infiltration, permeability and other physical properties.

Generally sandy soils are very permeable and have very low available moisture for plant growth as compared to clayey soils. Soil structure generally refers to the adhesion and arrangement of smaller particles to form large ones or aggregates. The permeability of soil for water, air and penetration of roots is influenced primarily by soil structure.The spaces between aggregates are largely responsible for free flow of water and deep root penetration.

The real or absolute density of soil is the density of the solid particles collectively, excluding the pore spaces between particles. Bulk density on the other hand is the weight per unit volume of soil where the volume includes the pore spaces present in the soil. Hence, it is easily seen that the bulk density of soil can vary according to its porosity. The bulk density is influenced by texture, structure and compactness. Porosity of the related to the bulk density. When the porosity of the soil in the range of 40-50%, workability is satisfactory.Bulk density values of irrigated soils should be known in order to calculate the volume of water requirements for irrigation as well as the amount depleted by plants. It is impractical to measure by direct means the volume of soil. It is necessary to measure the amount of moisture in soil on a weight basis and convert the weight percentage to volume percentage by use of the bulk density.

Another important aspect to which the soil bulk density values are used is to calculate the porosity of the soil. Porosity has a direct bearing upon productive value of soil because of its influence upon water holding capacity and upon the movement of air, water and roots through the soil.

Soils with high bulk density will have low porosity, which in turn will indicate a high degree of compactness. The Reddish Brown earth of Sri Lankd has an average bulk density of about 1.6 g/cc. This is high for its textural class, but the total porosity of 40% is adequate for irrigated agriculture. However, even slight over irrigation tends to reduce aeration and inhibit root growth in these soils. The Red Yellow Latosols have suitable bulk density and porosity for good irrigated agriculture.

Infiltration rate is defined as the time rate at which water percolates into the soil. Since the object of irrigation is to get water into soil where it can be stored, infiltration characteristics of a soil is of fundamental importance in irrigation. Infiltration rate is much higher at the beginning of rain or irrigation than it is several hours later. It usually decreases to a constant value after 4 or 5 hours. Soil is a porous material, composed of particles of many different sizes and shapes touching each other, but leaving spaces in between. The water in the soil or soil moisture as it is called, is stored in those pore spaces and is used by the plant. In low rain fall areas, soil moisture must be replenished by irrigation.

When all the pores in the soil are filled with water, the soil is said to be saturated. During and immediately following irrigation the soil below the water surface is nearly saturated. In very large soil pores, the water is held so loosely that water drains freely under gravity.

The amount of water retained after free drainage of newly saturated soil is called the Field Capacity. Usually it takes about 48 hours for a saturated soil to drain under gravity. Soil moisture tension is normally between 1/10 and 1/3 atmosphere, when the soil is at field capacity. Ideally, in irrigation, only enough water should be applied so that soil would be at field capacity in the root zone. Any water in excess will result in deep percolation and will not be available to plants. Removal of water from the soil by plant root, causes the soil to become dry and finally a condition is reached where water is held so tightly by the soil that roots cannot absorb it at a sufficiently rapid rate to prevent leaves from wilting permanently. When this condition is reached the soil is at permanent wilting point. For all soils, the moisture content at 15 atmospheres tension, corresponds to permanent wilting point. Usually, crops are irrigated before the soil reaches wilting point, since plant growth is retarded if irrigation is delayed till the wilting point. The difference in moisture content of the soil between field capacity and permanent wilting point is termed the "available moisture". This means that the water range of moisture content up to field capacity is available for the plant to use. As the soil dries, the roots have to exert greater force to absorb moisture from the soil. Hence it is customary to irrigate at an intermediate moisture content before the soil reaches permanent wilting point.

Experimentally, it has been found that for most soils, if irrigation is given when half the available moisture has been used up by plants there is no reduction in crop yields. This type of irrigation is generally referred to as "irrigation at 50% depletion of available moisture". Crop and soil moisture characteristics determine the percentage depletion of available soil moisture at which the soil should be irrigated for best water economy. This is usually determined experimentally by the agronomists in field irrigation trials. The frequency of irrigation therefore, will be the number of days which are required for the plants to use this predetermined percentage of available moisture. The Quantity of water applied during each irrigation would be equal to the consumptive use (crop etc.) plus the amount allowed for irrigation efficiency which could be practically achieved in the farm. This total quantity of water should bring the soil to field capacity within the root zone.

From the foregoing, it is evident that the physical properties of soil such as Bulk Density, Infiltration characteristics, permeability and Moisture characteristics play a vital part in the selection of crops suitable for the types of soils and for the preparation of the water issue schedules.

5.2 Crop Water Requirement

Crop Water Requirement is defined as "the depth of water needed to meet the water losses through Evapo-transpiration (ET Crop) of a disease free crop growing in large fields under nonrestricting soil conditions including soil, water and fertilizer and achieving full production potential under the given growing environment".

5.3 Effective Rainfall

Effective rainfall also could be defmed as that portion of actual rainfall that contributes to plant growth. Not all rainfall is effective and part may be lost by surface run off, deep percolation or evaporation. Only a portion of heavy and high intensity rains can enter and be stored in the root zone and the effectiveness is consequently low. Frequent light rains intercepted by plant foliage with full ground cover are close to 100% effective.

With a dry soil surface, and little or no vegetative cover, rainfall up to 8 mm./day may all be lost by evaporation; Rains of 25 to 30 mm may be only 60% effective with a low percentage of vegetative cover. Reduction in rainfall effectiveness can result from uneven distribution of rainfall and wasteful on-farm water management. Uneven distribution can lead to non-consumptive evaporation losses in the case of light rainfall or run off of water, which exceeds field storage capacity in the case of heavy rainfall.

Poor on-farm water management practices can lead to low effective rainfall, if fields are always at or near field capacity due to excessive irritation application, leading to rapid run off and loss of rain water.

At present Computer programs have been developed for water issues on a daily basis.

5.4 Deep Perculation Losses

Deep percolation losses are unavoidable. The losses are dependent on the infiltration characteristics of the soils. Research and practical experience in Sri Lanka have indicated that deep percolation losses under flooded paddy cultivation in soils of Sri Lanka can range between 1 mm. to 2 mm. per day in the least porous soils (LHG & alluvial soil) and up to 30 mm. per day in well drained upland soils (Reddish brown soils RBE). Deep percolation losses can be reduced by avoiding cultivation of paddy in well drained (RBE) soils, as paddy requires standing water for weed control and better yield. Other food crops should he cultivated in RBE soils.

5.5 Farm Efficiency

Farm efficiency cannot be a fixed quantity. It depends on many factors. The farm efficiency can improve with farmer education and with experience. It can also improve with extension services. From the above it would be seen that increased farm efficiency would reduce farm delivery requirements.

A well laid out farm is one in which the water received at farm entry is conveyed to all parts of the farm in the shortest possible time without causing any ponding up at the lowest point of the farm. Farms therefore have to be level without humps and depressions.

5.6 Conveyance Efficience

For the efficiency to be high, the losses in the conveyance have to be minimized. This could he achieved only by an efficient canal system with control structures, regulators, measuring weirs and well maintained channels.

5.7 Irrigation Methods

Two important irrigation methods are being practiced in Sri Lanka. For the cultivation of paddy, basin flooding is generally practised and for the cultivation of other food crops furrow irrigation is normally practised.

5.7.1 Continuous Flow Method

Continuous irrigation has been limited to the production of rice. Even though System Operators may not be knowledgeable yet water can be made to flow to the service areas continuously regardless of demand. With trained personnel however, a constant head of water could be supplied continuously to the senice area equal to the crops consumptive use plus field losses.

The continuous flow method of water issue, if uncontrolled, is the most inefficient system of water distribution. This method requires continuous supply of water to all conveyance channels namely Main Distribution and Field Channel.

The operation of the channel system under this method is relatively easier than the other systems, because there is less fluctuation in the channels due to the constant head. The following disadvantage is commonly reported against this method.

- Investment in the irrigation system is relatively lower than the other systems due to the fewer needs of control structures and measuring devices.
- Less labour is required for management.
- Less expense in conveyance construction. The conveyance capacity required is only equal to the water requirements of the service area.

5.7.2 Rotational Flow Method

This method is often referred to as intermittent irrigation. Rotation implies the cycle whereby water issues are made one after the other. Equitable water distribution could be accomplished in each area on a prearranged schedule of water issue using either a fixed discharge with variable time or fixed time with variable discharge. Rotational irrigation could be effected by one of the following practices.

- Rotation by section in main channel; water is conveyed by rotation to different sections in the main channel. This method required bigger flow capacities for both conveyance area and distribution systems.
- Rotational by section in the distributory channels.
- Rotation by section in the field canal; there water is rotated only in the rotation areas by the field channels. In this method, jbe main and distributary channels are continually conveying a constant quantity of water.

The Rotational flow method is having the following advantages over other irrigation methods practiced,

- Water could be reasonably regulated and evenly distributed into every conveyance channel.
- Operator can use the rainfall more effectively
- More Water is saved from percolation.
- Water application losses are minimum. Management is concentrated on areas under water issue. The probability of more seepage and surface run-off is less.
- Equitable distribution of water is possible over the upper, middle and lower reaches of the areas.
- High irrigation efficiency attainable.

Eventhough it this method is having several advantaged it is having its demerits also. They are listed below,

- High cost of conveyance channels.
- The method requires efficient management and more personnel to operate and maintain the channel system.
- Requires participation and close co-operation of the water users.

5.8 Timing of Cultivation

This is a serious problem that is frequently encountered. If the cultivation issues commence according to the predetermined dates, then water issues can he more efficiently carried out. On the other hand, if some of the farmers are not ready on the date of the first issue, then the water issue has to be extended beyond the last date decided at the Kanna Meetings. That means channels would be conveying water for a longer period than envisaged thereby contributing to increased conveyance and evapo-seepage losses.

An ideal cultivation season should be so planned that during the entire rain the plant would be in such a stage of growth so as to he able to withstand temporary flooding, otherwise the crop would be damaged partly or completely. This could happen in the case of a plot where irrigation had not commenced at the proper time, but was delayed.

Another reason why all farmers are unable to commence cultivation on a fixed date, is the lack of farm power. Lack of credit facilities too can contribute in a large way towards the farmer not being able to hire tractors.

In most of the projects the amount of farm power available by both buffalo and tractors will also be limited. As such, it is sometimes or more often problematic to be ready for sowing at the same time. Therefore, these operations have to be well planned and a strategy established through Farmer Associations, for the different stages, so that the land soaking and ploughing operations can be achieved in 2 or 3 blocks depending on the magnitude of the project area.

5.9 Agricultural Inputs

The availability and supply of inputs that make the farmers adhere to the decisions taken at the Kanna Meetings regarding, water issues are: credit, seeds, fertilizer, tractors, buffaloes, agrochemicals etc. A high level monitoring of the availability of all these to the farmers is very vital for the commencement of cultivation as per Kanna Meeting decisions. Credit to the farmers is very vital. Farmer organizations have to play a vital role in organizing the farm power necessary for the project area on the basis of predetermined progranunes. That is, the availability and adequacy of farm power in the project area has to be known. Invariably this is not sufficient. It therefore becomes necessary to augment this input since the rest of the activities are only a follow-up and certainly will be gone through by the farmer.

The selection of the variety of seed paddy should be done judiciously. It is the responsibility of the extension service to ascertain the availability of different varieties of seed and intimate to the cultivator, to enable them to arrive at an appropriate decision at the Cultivation Meeting regarding the use of the appropriate variety. Issue of seed paddy from Government sources should be controlled, so that only an approved variety for the particular area is issued. Fines or total withdrawal of irrigation water should be imposed on the farmer who disregards the decisions.

5.9 Extension Services

Appart from all the above eight important parameters the extension service is also contributing a lot to water management to improve on Farm Efficiency. The key factors covering the extension services are listed below,

- Farmer training on water saving practices.
- Promotion of water saving crops.
- Promotion of dry sowing in the Maha season.
- Induce and assist farmers not to use water for weeding and other operations.
- Demonstration of plots.

4 Conclution and Recommendation

Based on the finding by analyzing the above factors, call for the optimum use of water for increase food production, by adhering to the following practices in irrigated agriculture, is highly recomended.

- Timing of Cultivation - The farmer must receive credit, farm power and other inputs such as seed paddy, fertilizer, to time, to enable him to commence the cultivation operations as per decision of the kanna Meeting.
- Farm efficiency has to be increased by maintaining a level farm without depression, humps etc. If the farm is level and when water is issued, it could reach all parts of the farm in the shortest possible time. The liyaddas has to be well prepared so that there is no leakage, to avoid water entering the nearby drainage. This is farm waste. This should be stopped to increase Farm Efficiency.
- Selection of crops should be on soil types. Normally rice is grow in soils such as L.H.G. or alluvial soils which are poorly drained soils. Rice is tolerant in water to a great extent. Upland crops are grown on R.B.E. soils which are well drained.
- Conveyance efficiency of the irrigation systems too should be improved with control structures, measuring devices, lined channels where necessary and canals should be cleared of weeds and well maintained at the designed bed gradient.
- Extension services by farmer training could also improve farm efficiency.
- Preparation of water schedules for rotational irrigation and adhering to cultivation calenders will also improve efficiency of water use. Continuous monitoring using tensiometer and augers to probe the soil moisture deficiency, will give beneficial results.
- Awareness in the farmer that water is scarce and expensive, will also improve the efficiency of water use. Farmer organizations should see to the satisfactory maintenance of canals and canal structures under the field canals.
- Encroachment in the project area too can affect the conveyance efficiency, because these areas are not catered by proper canal system. Cultivators of encroachments resort to breaking of structures etc., to get water from nearby canals. Water losses could be minimized by having, some form of canals in the encroachment areas, wherever possible.

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