TECHNOLOGICAL OPTIONS IN IRRIGATED AGRICULTURE FOR THE FUTURE

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Introduction

Appropriate technology is essential for a developing economy. This argument holds true for the irrigated agricultural sub-sector too. The primary objective of irrigation is to alleviate the constraints of nature and to make water available at desired locations, at required times and in required quantities and frequencies for production of food and fibre under appropriate agronomic conditions. Improved technology, more specifically irrigation and agricultural technology, is the key to improving efficiency, productivity and profitability of irrigated agriculture.

This paper briefly reviews the past developments in irrigation and agricultural technology in Sri Lanka; the policy framework and the external environment within which the technological advancements have taken place; the factors that determine the choice of technology for the year 2000 and beyond; and some specific technological options for the future.

PAST TECHNOLOGICAL ADVANCEMENTS

Past growth and advancement of technology in irrigated agriculture depended basically on policies and priorities of the government. It also depended on the relative importance attached to land, water, human and financial resources, market demand and values of various forms of agricultural produce, research efforts, and the available knowledge and the information base.

Irrigation Technology

Sri Lanka is proud of a prosperous hydraulic civilization in the ancient times. The remnants of such ancient irrigation infrastructure and their fine and precise engineering features of planning, design and construction adequately demonstrate the existence of an advanced indigenous irrigation technology in the distant past.

The policy of the British government during the latter part of the 19th century resulted in partial revival of that ancient technology, through rediscovery and restoration of abandoned irrigation works. These government efforts received a new policy emphasis during the 1930s to settle landless people on restored ancient irrigation works. The external environment within which those policies had been implemented was such that land, water, financial and unskilled human (labor) resources were abundantly available; data and the information base on crops, soils, water and plants and their interrelationships and interactions were weak; research was a low priority; skilled labor and professionals were scarce. Consequently, irrigation was viewed as a pure civil engineering activity with less concern on land, water financial and human management elements in irrigation. The emphasis was on technology required for capture, regulation and storage of water for irrigation. The technology adopted within this external environment was basically typical of the ancient irrigation technology as well as the tank irrigation technology that prevailed in South India at that time. Although the government policy was to settle people on restored irrigation works and later on new irrigation projects during the post-independence period, irrigation construction technology received greater priority over the human settlement aspect and technologies required for managing irrigation water and land. However, the construction of Galoya, Uda Walawe projects and the Mahaweli complex in the recent times are notable events that marked the inflow of modern irrigation construction technology to the country.

When land was gradually becoming a limiting resource, the government policy objective changed accordingly. Achieving self sufficiency in rice became a national goal. The government policy after independence has been to increase the irrigated land area under paddy as well as to increase land productivity (paddy yield per hectare). Both the irrigated agricultural sub-sector and the technology mutually complemented each other during this period due to the new policy.

In tracing the past technological advances in irrigation, one finds a range of varying options geared to alleviating constraints imposed by the physical environment for increasing land productivity. This range mainly includes the gravity-fed surface irrigation systems – tank storage systems – typically found in the dry zone and the run-off the river or diversion weir (anicut) systems typically present in the wet and intermediate zones. Other technological options were: lift-irrigation technology for irrigating field crops grown on highlands; flood control projects (eg. Nilwala and Gingange projects) for protecting the social infrastructure and for improving the cultivability of lands and their producitivity by minimizing water-logging and prolonged inundation of agricultural lands by flood water; drainage improvement projects in coastal areas for improving land drainage; salt-water exclusion technology for preventing crop damage and yield losses due to the inflow of sea water in to agricultural lands in the coastal areas during high-tidal periods and facilitating agricultural land drainage to the sea during low-tidal periods.

The scale and magnitude of gravity-fed surface irrigation technology have been superior to other options. One notes a process of evolution within this technology itself. The sequential landmarks in the evolution are minor (small) tank systems, run-of-the-river systems, single purpose dams and major reservoirs (eg. Parakrama Samudra), multi-purpose dams and reservoirs (e.g. Gal-oya, Uda Walawe and more recently Victoria etc.), inter-connected reservoirs (e.g. Ulhitiya – Ratkinda-Maduruoya) and finally trans-basin diversion (e.g. Mahaweli complex).

While the above irrigation technological advancements were in progress, concerns for efficient utilization and management of water began to grow in the recent past, particularly after 1970. This prompted a new policy direction to seek ways and means of increasing water productivity in additon to increasing land productivity. The new concern for minimizing the quantity of water used for growing a paddy crop in a unit of land (acre or hectare) per season (Yala and Maha) emerged initially under the label of "water management". This policy dimension resulted in the emphasis of irrigation technology expanding from capture and storage of water to the distribution and management of water.

This changing external environment facilitated some irrigation technological advancements in the last two decades. Research efforts that were focussed on land and water management contributed significantly to enrich the data, the information and knowledge base on soils, land, crops and their interrelationship with water. Irrigation canal designs underwent some conceptual changes for better manageability (eg. the one-cusec field canal concept) with more agricultural orientation. Since then, the focus of irrigation technology has been on increaing the structural potential of irrigation systems by providing adequate control, regulation and measurement devices and facilities to enable emphasis on more management. Such technological interventions have been implemented through various water management improvement projects, irrigation rehabilitation and modernization projects undertaken by the government and through Mahaweli irrigation system designs and construction.

A few comments need emphasis before this section on irrigation technology in the past is concluded. Although the irrigation technology advanced at some rate to meet the needs of changing external environments and policy perspectives, on-farm irrigation technology did not progress satisfactorily. The Agriculture department as well as the land-use division of the Irrigation Department have conducted many research on various on-farm methods of irrigating other field crops and achieved successful results, those research findings have not been adequately utilized for irrigation designs. Also little research efforts have been launched on developing new irrigation design concepts, irrigation scheduling methods, canal and on-farm irrigation structure, for better management of water.

Agricultural Technology

Developments in both the irrigated agricultural sub-sector and agricultural technology mutually complemented each other during the past three decades. Agricultural technology has contributed significantly to increasing paddy yields. More specifically, bio-chemical technology, which means new high-yielding and short-age paddy varieties developed in the national agricultural research centers, and agro-chemicals and chemical fertilizers have brought a tremendous increase in paddy yields of the vast agricultural land potential created by the irrigation technology.

The last few decades have been characterized by rapid growth in both bio-chemical and mechanical technology in irrigated agriculture in Sri Lanka. New paddy varieties replaced most of the traditional low-yielding varieties. The tractor has replaced animal draught power for land preparation for rice cultivation to a considerable degree. This trend was followed by the use of transplanters in major agricultural areas. Hand-sprayers are now extensively used for herbicide and pesticide application.

The two wheel hand tractor has become very popular in settlement schemes, not only for agricultural operations, but also as a convenient mode of transport in day to day affairs. Although various kinds of planters, inter-cultivers, threshers and ploughs have been developed, they have not been adequately promoted and therefore are not in much use for irrigated agriculture in Sri Lanka. The emerging trends now are to mechanize threshing activities and to use low-head water pumps to life water from irrigation channels, drainage canals and other sources of water to grow various cash crops on unirrigable high grounds.

In contrast to the advancements in mechanical and biochemical technology, agro-industrial technology in the Country has failed to advance at the same rate. In the plantation sector tea, rubber, coconut, spices and beverage crops have been developed as export-oriented agro-based industries.

But in the irrigated agricultural sub-sector very few agro-based industries, such as hulling and milling of rice and soyameat production, have emerged. Apart from it, the vast potential available for developing rice based industries and other crops processing technology has not been harnessed.

There are many reasons for the slow growth of agro-industrial technology. Lack of a sound national agro-industrial policy and an integrated technology policy towards the food processing sector, lack of coordination among the national agencies, the Universities and the private sector for research and development, lack of encouragement for the private sector to launch agro-industries are most crucial for the slow growth in agro-industrial technology.

Choice of Technology for the Future

The choice of technology for the year 2000 and beyond is primarily governed by our vision for the future and by the scenarios that are likely to emerge within the vision. The vision itself is governed by our concerns as to the direction in which irrigated agriculture should lead for improved productivity and profitability, in an environment of rapidly limiting land and water resources and of a fast growing population.

The present status of the agricultural sub-sector is such that Sri Lanka has achieved near self-sufficiency in paddy production almost at the same time that the Country achieved its full land development potential under irrigated agriculture at reasonable economic costs. Some claim that after Mahaweli and Kirindi Oya (Lunugamwehera) Projects, no new irrigation development will be economically viable. However, the Government has in hand a few development plans based on irrigated agriculture for the future too. These are: (1) the Southern area development plan which will be based on excess water transfer from the South-West Wet zone to the extensive lands in the South-Eastern Dry Zone, (2) diversion of Kelani Ganga to the thirsting lands of the North-Western region, and (3) Kaluganga flood protection and control project.

At present there are two schools of thought. One group (Kikuchi and Aluvihare, 1990) recommends that the efforts of irrigation development and improving land and water productivity should be consolidated in the future through water management improvement and rehabilitation and modernization of the existing physical irrigation systems. This study show that investments in new irrigation development projects even with crop diversification will not be economically feasible in the future. The other line of thinking is based on a study conducted by the World Bank on the Irrigation sub-sector, under the public sector restructuring project (Shand et al 1990). This study emphasizes the need for adopting a range of sophisticated technological options to cater for export oriented other high value crops and for priority for rehabilitation and modernization in the future. But it also favours new major irrigation developments based on trans-basin diversons materializing the irrigated agricultural potential of the country along with other social and political benefits to specific regions.

There will be increaisng pressure on land and water resources in the future. It will therefore be essential to stretch the limited water supply available for irrigation over a maximum land area for maximum land and water productivity. National statistics indicate that the average paddy yields have been almost static for the past few years. The price of rice in the world market in recent times too has been not very attractive. However, at the National Rice Symposium held late last year, the consensus was to maintain the national momentum in achieving self-sufficiency in rice at a level below hundred percent. Under these circumstances limited paddy production with crop diversification and intensification will be the policy options for the future for improved productivity and profitability of irrigated agriculture.

The dwindling financial resources of the Country are imposing constraints on meeting the operation and maintenance needs of the existing irrigation infrastructure exclusively by the Government. The present Government policy on peoplization will definitely look forward to sharing the operation and maintenance responsiblities with the beneficiaries in the future who will have to take over the irrigation systems for management by themselves. Therefore the choice of technology for the future will have to consider this fact too.

The present status quo of the irrigated agricultural sub-sector makes it possible for the policy-makers to forecast a few scenarios that are likely to emerge or may be necessary to be created with the requisite policy changes in order to enhance productivity, profitability and dynamism. Two possible scenarios will be: (1) consolidating the present trends in irrigation development through rehabilitation and modernization of the existing infrastructure, keeping in mind that sustaining a desirable level of staple food production is a necessity. However, crop diversification and intensification will be essential. The choice of technology should promote such effort at improving efficiency and equity in water use, land and water productivity (yield per unit of water consumed for crop production), and the management of the systems by the beneficiaries for a wide range of crops; and (2) adopting high value export oriented crops through the use of the technology including agro-industrial technology.

The first scenario will involve a gradual build up on the already existing technology, basically to cater to crop diversification and intensification, supported by various policy measures, whereas the latter will demand drastic improvements of the present irrigation and agricultural technology. Under these circumstances one can reason out that the first scenario is most likely to come into the picture in the immediate years to come followed by the second scenario after another decade or so. The technological options for the future can be forecasted in this context.

The development of irrigation as well as agricultural technology is controlled by a number of complex and interacting factors. It is primarily controlled by the government policies, which constitute the most important variable. The other factors are labour availability, land holding size, land tenure patterns, socio-economic conditions of the farmers, local capacity to sustain a given technology etc.

Sri Lanka has labour in abundance. This labour force is in fact increasing year by year. The present government policy which advocates switching over from rice mono-culture to crop diversification is therefore a timely intervention, because most of the other field crops are highly labour – intensive and can potentially absorb more rural labour for income generation. Therefore the policy makers will have to consider the various agricultural technological options cautiously against the labour absorptive capacity of diversified cropping in the future.

The land holding size in major irrigation schemes varies from 1 hectare to about 2.5 hectares. It is reasonable to presume that the majority of farmers will grow paddy during the Maha season, when water is adequately available and

Contd on page 54

19

Contd from page 21

other field crops during the Yala season when the rainfall will be less than the average.

This alternative cropping of paddy and other field crops will involve extensive soil transformations in individual land holdings when a farmer switches over from one crop to another in two successive seasons. This situation will impose to constraints. The size of the holding will make the adoption of any sophisticated technology difficult and perhaps not appropriate. Even if such appropriate on-farm technology is available it is not possible to install technological devices permanently in the command area due to the soil transformation process required for alternative cropping.

The choice of technology for the future should suit the socio-ecnomic conditions within which any technology will have to exist. Caution should be exercised to prevent the inflow of imported technologies which might come in aid and loan packages for rehabilitation and modernization, based exclusively on the will of the donors from abroad, unless their appropriateness is appraised within a sound national technology policy. The choice of such technology should be assessed against our local ability to build up technical know-how to manufacture and to provide maintenance and after sale service for any technology adopted.

The following sections address a few specific technological options for the future along with constraints to adopting such technologies.

IRRIGATION TECHNOLOGY

On-farm Irrigation technologies

Unlike paddy irrigation, other field crops need careful control and regulation of water to keep the soil moisture regime within a narrow range for optimum yields. The conventional surface irrigation distribution systems and farm turn-out structrures, which have been designed for paddy, somewhat restrict this control. Many advanced technologies like sprinkler and drip irrigation are available with adequate operating details and information, which are suitable for irrigating other field crops in large farms. Such technology cannot be adopted easily here basically due to the small land holding size. Considering the small size of the land holdings, one possible alternative is micro-irrigation technology. This technology consists of micro-drips and specially desinged micro-sprinklers and jets. It can achieve very high efficiencies in water use and water productivity. In fact one or two private sector companies are successfully experimenting with such micro-technology (garden irrigation technology) in highlands in Mahaweli system – H area with hopes of adopting such technology in major irrigation schemes for growing high value cash crops. The research information on this technology is still not sufficient to judge its viability for irrigating field crops in the existing irrigation projects. However this technology is cheaper compared with other available technologies. It can be used in highland areas of the irrigation projects and for inter-cropping in large plantations where water is available, for irrigating crops like chillies, groundnut, papaw, banana, citrus and perhaps coconut.

Conjunctive use of water

Irrigation of other field crops may need a more reliable, dependable and timely supply of water, because they are moisture sensitive. One option that will alleviate the risks created by lack of water for irrigation will be to use ground water in conjunction with surface water in major irrigation schemes. This is already being practiced in a small scale by some farmers to grow field crops round the year. Surface irrigation raises the ground water level and it is possible to use shallow ground water to supplement surface irrigation for a period about 1-2 months after the termination of surface water supplies. Shallow wells dug in individual allotments will provide the sources of supply to farmers. Where deep ground water is available as in Jaffna peninsula or in the North-Western dry zone, a deep well linked up with each distributary canal system may be the source for conjunctive use.

Constraints to this option include; lack of knowlege on the extent, distribution, quality, yield and seasonal availability of ground water; possible inter-provincial conflicts of harnessing ground water because unlike surface water, it is difficult to identify the precise boundaries of ground water resevoirs; lack of legal provisions for utilizing and sharing ground water particularly in conjunction with surface water; lack of technical know-how in scheduling water for conjunctive use for irrigation; increased labour requirements for manual lifting of water from shallow dug wells; and the need for electricity supply in rural areas for operating water pumps in deep-water wells.

Water harvesting and recycling

The eficiency of water use in irrigation can be substantially increased by capturing drainage in irrigation project areas resulting from storms and irrigation water, in ponds constructed at intermediate locations for re-use in irrigation. The ponds may be linked to the irrigation distribution systems. It has an added advantage. When both paddy and field crops are grown in the same command area the ponds can be used to store canal water during the night for irrigation during daytime on the following day. The constraints are site specific to pographical features that prevent locating such ponds, and complex land ownership patterns.

Water-level and flow control devices in Irrigation canals

The hydraulic efficiency of surface irrigation canal systems can be potentially improved by precise water level and water flow control in main and distributary canals. Automatic water level and flow control devices have already been in use in other countries. This technology is still new to Sri Lanka. It was tested as a pilot experiment in one major irrigation scheme (Rajangana project in the North-central province) a few years ago, but the results were not sufficient for any judgement on this technology. More experimentation is necessary before automation in canal water level and flow control in the existing surface irrigation distribution systems can be adopted. However such technology will increase the operational flexibility of the existing irrigation systems, partially if "on-demand" type irrigation practices are to be adopted in the future. It will also facilitate volumetric measurements of flows delivered to canals. In fact, volumetric measurements might be necessary in the future to recover the cost of irrigation water delivered to the farmers, similar to the water charge for domestic water supply. The major constraints in adopting automation technology would be the foreign-exchange required for capital and recurrent expenditure involved in the purchase and maintenance of such equipment.

Technology for operation and maintenance

The existing practices for operation and maintenance of surface irrigation systems are gradually becoming outmoded with the increasing trend towards increased cropping intensities, crop diversification, combined use of ground water with surface water for irrigation, and the involvement of the beneficiaries in managing the systems. In the first instance, the technology for the control, regulation and measurement of water particularly at tertiary levels of irrigation systems must be as simple as possible for operation, maintenance, construction and for monitoring performance exclusively by the beneficiary farmers. Automatic water level and flow control devices must be adopted in main systems, only if such technology will bring absolute advantages and benefits for improved management of such systems by the irrigation agencies as well as of the tertiary systems by the beneficiaries for alternative operational requirements. However in the long run it will be necessary to achieve high standards in the operation and maintenance of the irrigation projects. In this context micro-computers will have to play an increasing role in irrigation management. Micro computers can be effectively used to operate various simulation models for planning crops and water issues in order to obtain optimum productivity and profitability under the constraints imposed by the limits of resource availability. They are also useful in scheduling irrigation water particularly when both paddy and other crops are grown in combination.

Technology for improved drainage control

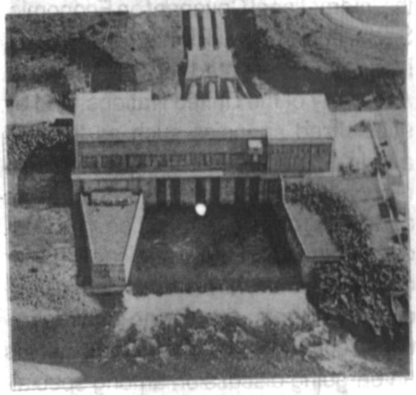
Adequate drainage is essential for growing other field crops. It is also necessary to prevent water-logging particularly in valley bottoms and at tail-end reaches of canals near drainage lines, in order to increase land productivity and land suitability for cultivation of field crops. A multitude of agricultural technologies like sub-surface drainage are available. However Sri Lanka being a country blessed with a radial type drainage network, that consists of a large number of natural streamlets and riverlets, can take care of agricultural drainage. However, research will be required to develop techniques for the disposal of effluent from irrigation projects, because drainage water from irrigation projects is polluted with dissolved salts, agro-chemicals and fertilizers. This will be a grave necessity in the long run because of the potential damage that irrigation practices can cause to the bio-physical environment. Currently our knowledge base on effluent quality control and drainage water disposal from irrigation projects to major rivers and the sea is limited. Research is required to evolve a technology for this purpose.

Agricultural technology

The productivity of rice in wet zone and minor irrigation systems is low. Presently, there is a gap between potential and actual yields in both wet zone systems and in many minor irrigation systems; and the farmers in these areas have the lowest incomes. A programme of diagnostic and applied research to identify problems and practical measures to improve yields would produce benefits in terms of total rice production by the year 2000.

Agricultural technology which is mainly concerned with agro-industrial development too has to play a key role in the future for a dynamic, productive and a profitable irrigated agricultural sector. Some technological options are discussed in the following paragraphs.

For a dynamic and profitable irrigated agricultural sector, agro-industrial development will be essential. Agro-industrial development refers not only to industries based on agricultural produce but also to industries based on agricultural by-products, inputs like agro-chemicals, fertilizers and agricultural machinery. At present straw is used for paper production but the full potential is not harnessed. Agro-industrial development should also take care of processing, storage, transportation, packaging and marketing of the agricultural produce too.



The cost of crop production may be substantially reduced if the basic inputs such as agro-chemicals and chemical fertilizers can be locally produced. Lack of research on this area is the major constraint to adopting technology for producing agro-inputs within the country. If the private sector can be encouraged with the necessary government collaboration and support to undertake research and production, this constraint can be gradually alleviated in the future.

The agro-processing industry in irrigated agriculture must undergo substantial development in the future. At present only the hulling and milling industry for rice has been developed to a certain level. Several technological options can be explored to develop industries for producing various brands of agricultural produce particularly for rice, for making pulses more palatable, for extracting oil from groundnut and sunflower etc. The agro-processing industry if developed appropriately, will play an important role in irrigated agriculture in the future by generating renumerative prices for the produce, reducing post harvest losses, absorbing the fluctuating agricultural output to meet the demand, and enabling the agricultural produce to compete for export markets.

Contd on page 63

Contd from page *55*

Packaging of local agricultural products and transportation of packed products from the farm-gate to local and international markets without losing quality should be developed as a technology in the future. This include technology for grading, packing, storage and transport.

The range of field crops available to Sri Lankan farmers, particularly the crops with a potential for export is limited. Research has a major responsibility in the future to identify a wide range of crops that can be grown for export markets. The present approach in irrigation development whether it is new construction or rehabilitation, is to alleviate the constraints of the natural physical environment, particularly the climatic constraints, to suit growing of a limited number of crops including paddy under irrigated conditions. Agricultural technology in the future should developed to the extent that it can evolve new crop species and varieties through "genetic engineering" that can be grown in the different agro-climatic regions of the country.

Conclusions

Although many technological options are available for the future, the adoption of such options is constrained by many factors. Prominent among them is the lack of (a) an agro-industrial development policy; (b) an integrated national technology policy for the food processing sector; (c) technical know-how; (d) research geared towards national interests; (e) coordination among the Universities, other research institutions, the Department of Agriculture and the Private sector; and (f) institutional supporrt and incentives from the State to encourage the private sector in research and in undertaking agro-industrial development.

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