IRRIGATION EFFICIENCY & PRODUCTIVITY FACTSHEET

RIPARWIN (Funded by DFID, UK Govt). ***Raising Irrigation Productivity and Releasing Water for Intersectoral Needs*** A project that examines the science and roles of irrigation productivity and efficiency within intersectoral allocation in river basins	**Authors**: M. Mdemu, B. Lankford & M. Magayane **Date**: March 2003	**Location of Project**: MATII-Igurusi, Usangu Plains, Mbeya Region, Tanzania

Introduction - this factsheet provides a summary information on irrigation efficiency and productivity within a Tanzanian/East African context. It explains three main methods for examining efficiency/productivity and makes the point that all three methods and sub-methods should be used to describe and understand water utilisation. An over-reliance on one (usually conventional) method would give an inaccurate picture and usually one that is too pessimistic. We also would like to argue that field methods of measurement are very important and that without measurement using labels (e.g. 'modern' or 'traditional' irrigation) to assume efficiency can be quite misleading.

Irrigation efficiency / productivity -what is it?

Irrigation efficiency / productivity is a multi-faceted collection of indicators varying in space and time. In irrigation systems, irrigation efficiency can be defined in terms of crop consumptive water use, irrigated area, harvested crop yield and total amount of water stored in the fields for the entire growing period. In this case **no single indicator** can explain the irrigation productivity/efficiency. Rather a combination of different water and non-water management indicators can give a better and more accurate picture.

Why is irrigation efficiency and productivity important?

Irrigation efficiency / productivity is important in that by improving because when it is improved it may lead to saving of water for inter-sectoral allocation within or outside the system, catchment or basin. This may include extra area cultivated by gains in irrigation efficiency. For example by saving 100mm depth in 9000ha irrigated area for 10 days may lead to an extra area of 2432ha with a total irrigation depth requirement of 370mm.

Method 1. Traditional ways of defining irrigation efficiency (conventional efficiency). Traditionally the overall irrigation efficiency of an irrigation system is defined as the ratio of water used by the crop to water released at the headworks. In this definition the efficiency figure is a product of conveyance, channel and application efficiencies, which implies that the efficiency decreases factorally as the domain of interest increases. The definition has disadvantages since it does not consider other water uses within the system and neglects the proportions of seepage and percolation from the water distribution system that is recycled within irrigation systems or basins. Non-conventional determination methods such as productivity or irrigation situational efficiencies become necessary.

Method 2. Water productivity-what is it?

Promoted by the International Water Management Institute (IWMI) the productivity of water can generally be defined as the physical, economical or social value of depleted or non-depleted water, either from irrigation or rain water or both expressed in terms of individual or base values of a product (physical, economic and social) for defined domain and period of study. The productivity of water is a very important concept in water management for balancing water demand of different sectors in river basins. Effective irrigation efficiency, a definition that takes care of non-beneficial evapotranspiration and water that get lost to sinks is another way of defining efficiency for integrated water resources management in river basins. This is what IWMI has coined as effective irrigation efficiency, which is defined as the beneficially used water divided by the amount of fresh water consumed during the process of conveying and applying water. In this definition the efficiency increase as the scale of water use is increased due to water reuse downstream, an important concept of the definition.

Method 3. Irrigation situational efficiency (ISE)

Lying between the conventional methods, which emphasises micro-level inefficiencies and water productivity, which emphasises macro-scale efficiencies, RIPARWIN is promoting a meso-scale concept of irrigation situational efficiency, a method inspired by conditions found in Usangu. The nature of irrigation systems in Usangu is very dynamic depending on water availability, swings of market for irrigated products and technologies of irrigation infrastructure. Irrigation efficiency in such systems need to recognise: Changes in irrigated area; Changes in irrigation seasons (wet and dry); Changes in water availability for different years; Amounts of drainage water re-use for downstream irrigators and lack of groundwater re-use.

Good indicators of irrigation situational efficiency are: Comparisons of water supply hydromodules (net and actual l/s/ha); transplanting rates; and production outputs (yield) per drainage water reuse; and the duration of seasonal standing water layer.

Do the definitions apply for all types of irrigation systems, in all seasons?

No. These definitions of irrigation efficiency for surface irrigation may not equally apply in all circumstances or to sprinkler, drip or furrow irrigation systems. It is urged that irrigation efficiency and productivity should be used complementarily when assessing performance of irrigation management/systems. While efficiency concepts provide indicative figures for a system performance in terms of water use for the intended purpose, the productivity concept provides fuller information on the amount of product that can be produced with an amount of available water. Productivity, especially the physical one (kg crop/m^3 water) has long been used as one of the indicators for irrigation efficiency. RIPARWIN researchers are still trying to determine where best to use these different methods.

More on irrigation productivity

Physical productivity

The physical value of a product in kg per unit water consumed. This is also mostly termed as more crop per drop. *We need a blue revolution in agriculture that focuses on increasing productivity per unit of water-'more crop per unit drop'*. Kofi Annan, Secretary General of the United Nations, Report to the Millenium Conference, October 2000.

Economic productivity

When the physical output is converted in terms of monetary value (\$/m^3). This also may include for a number of economic activities created as a result of presence of water like emergence of market for agricultural inputs and outputs.

Social productivity

If the societal objective of water resources development is targeted at eliminating poverty, water benefiting poor people by providing more jobs and income-more jobs per drop is considered more productive than water benefiting wealthier people.

How can you know whether productivity is low or high?

This is not easy. Normally the productivity of water can be quantified if the value added to water for the different water uses is known. For example if the value of water for domestic, agriculture, environment and social uses are known, the combination of these values in a single water system will reflect higher productivity. The valuation of water for different uses like the value of water for environmental use is one of challenges of determining the productivity of water in irrigation systems.

Methods of determining irrigation situational efficiency

System area method

This calculates the ratio of supply flow to the final command area achieved (expressed as l/sec/ha) and compares this with the net hydromodule (flow rate per ha) as calculated by the net demand modelling method. For example in Kapunga irrigation system, net demand hydromodule is 0.769l/sec/ha and actual supply hydromodule (gross) is 0.961l/sec/ha. In this case efficiency is 0.769/0.961, which is 80%.

Gross and net depth applied

Efficiency can be determined as a ratio of net depth required to gross depth applied. In Usangu plain the gross depth applied is estimated to 1847 mm while net depth required is 1070. This is about 60% efficient.

Comparison of transplanting rates

The ratio of actual transplanting rate to the estimated modelled transplanting rate from the intake flow available may give a measure of efficiency. Normally the actual transplanting rate would be lower compared to estimated transplanting rate due to water losses in distribution systems and in the fields causing lower irrigation efficiency. This method is still under development.

Studying irrigation efficiency in Usangu Plains - some facts and figures

Many professionals (stemming from Hazelwood and Livingstone 1978) mistakenly quote irrigation efficiencies of 15-30% in the Usangu Plains like in any other parts of Tanzania yet do not provide details of how those figures were obtained, or they use the conventional efficiency method which give very low readings. However, a recent study by SMUWC indicates that efficiency is in the range of 45-63% on average and potentials for improvement is high for large-scale farms. Smallholders tend to apply about 1600 mm gross, whereas the net irrigation requirement is thought to be 1050 mm net. This is about 65% efficient. Large-scale farms apply about 2300 mm gross, and because net water requirement is still 1050 mm they are about 45% efficient.

Water and period used in land preparation

In Kapunga, the average depth of water applied by irrigation is nearly 1850 mm gross (1070 mm net). The presaturation water demand is 307mm, which is 16% of gross irrigation application. Much water gets lost through evaporation, seepage and percolation by an extended period of land preparation. Normally smallholders would take not more than 7 days for wetting and transplanting from the time water becomes available to their fields (*vijaruba*). This is contrary to large-scale farms who may take up to one month before they can transplant.

Seasonal field standing water layer

It is estimated that, on average, a rice field in Usangu spends about 180 to 250 days with an average of 133 mm of standing water in it. The normal growing period for rice is between 140 to 160 days. An extended period of 40 to 90 days depicts the elongation of rice growing period. Increased depth and duration of standing water layer leads to increase in water losses through percolation. Deep percolation losses below the root zone are estimated at 660mm, which is 2.6 mm/day.

Irrigated area changes during different growing seasons

Irrigation area in Usangu plains changes from wet year to a dry year and or wet season to dry season. Efficiency in a wet year or a wet season is different from a dry year or a dry season. It may be as high as 65% in wet season and as low as 14% in dry season.

Can irrigation efficiency in Usangu be raised? If yes how?

Irrigation efficiency in Usangu Plains can be raised through better water management such as reduction of excessive standing water layer in large-scale farms, proper water distribution system, shortening of rice growing season and less water use for field presaturation. Another section on this factsheet gives more information on this.

What is the relation between efficiency and saving of irrigation water?

Through improvement of irrigation efficiency, water that could have been wasted can be saved and reallocated for other uses within the system or for other sectors downstream. The costs associated with water saving, benefits accrued and whether the practice lead to real water saving are important for consideration when thinking of water saving from irrigation systems.

Improving irrigation management, efficiency and productivity

On-farm strategies

- Agree a start date of main irrigation including nursery establishment. This is well exemplified by Madibira irrigation project.
- Restrict the area of dry season non-rice cropping under irrigation.
- Install boreholes to reduce losses via canal distribution for domestic water supply. This can also improve the quality of drinking water.
- Reduce intake flows during heavy rainfall periods and maximizing on rainfall use where necessary.
- Use short season varieties for late-transplanted rice - e.g. Basmati, to save water.
- Use clean seed to ensure even ripening and reduced season length. This has implication on gross water use.
- Improve general crop husbandry; fertilisers, FYM, weeding.
- If possible, grow rice in nurseries for as long as possible which lowers the cropped area from this concentrated growing.
- During dry years, reduce total command area, and then reduce intake supply.
- Ban of very late transplanting after an agreed date to be negotiated each year depending on the climate and river flows. Agree latest date of transplanting.
- Cease irrigation 3-4 weeks before expected harvesting date to use up residual moisture. This has been proved to have no effect on yield.
- Set a 'last date of irrigation', and then reduce main gate inflow to "dry season flow".

System strategies

- Proportional water division at intakes on a river – they increase the visibility of division of river flows between offtakes.
- Re-build, clean, reshape and raise canal walls to increase flow velocity, reduce seepage and spillage, which creates temporary swamps or unnecessarily deep water in neighbouring, rice fields.
- Use division points and canals to group farmers into smaller negotiating units within which they could either carefully divide or cycle the available water supply.
- Strengthening managerial capacity and farmer co-operation in irrigation schemes, for example on financial and farm planning. Helping farmers to sell when the price is higher increases income and economic productivity.

Can the above approach apply to the Usangu Plains?

Productivity of water to rice in the Usangu Plains is estimated at 0.2-0.35 kg/m^3 (at 15-20 % moisture content) for individual farmers. When water reuse downstream to Kapunga is considered the total productivity becomes 0.55kg/m^3. Yet there are other unquantified and unreported values and uses of the same water such as domestic use, livestock water use, fishery water use, social water use and environmental water use. Therefore the productivity may even be much higher than expected. Some of the methods for improving productivity of water outlined above can be applied in the Usangu plains especially to large-scale farms where productivity of water to rice is low (0.18kg/m^3) compared to smallholder farms (0.24kg/m^3). Efficient rice establishment methods like wet and dry seeded rice (WSR&DSR), water saving methods through alternate and drying irrigation (AWDI), use of earlier maturing verities, efficient water distribution systems are a few.

NOTES

Further questions? We hope you have found this leaflet interesting and useful. Inevitably it may raise more questions than it will answer. Please contact the RIPARWIN team:

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