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VALUE AND DESIRABILITY OF WATER DEVELOPMENT IN EAST AFRICA - A RESEARCH AGENDA

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I. Introduction

1. Definition and purpose

In general terms, the dominant agricultural problem in East Africa is how to increase productivity with presently available and potential resources. Irrigation and drainage are two forms of technically feasible capital investment which have been shown to increase production. However, relatively large quantities of scarce capital and skilled management are utilised in design, construction and operation. Thus the contribution of this additional output to productivity can only be measured if the opportunity cost (which may not equal price) of these scarce resources are known and are used in appraisal.

Investigations of the agricultural potential of East Africa conducted by outside agencies with limited detailed local knowledge have often implied that irrigation is desirable. This is perhaps most boldly stated by the World Bank Mission to Tanganyika: "The chief factor limiting and shaping the agricultural and livestock potential of the territory is rainfall" (IBRD Mission of Tanganyika 1961). Again "In much of Uganda, a defficiency in the moisture available for plant growth is a major factor inhibiting farm investment and agricultural development" (Halcrow 1964).

Hanful a moisture defficiencies have not been conclusively demonstrated in practice. In any case such a demonstration is a necessary but not a sufficient condition for irrigation investment. It is the first objective of this study to test the hypothesis that investment in water control is necessary in parts of East Africa in order to make farmers willing and able to change their production processes so that they use all their resources of land, labour and capital efficiently.

Irrigation and drainage is also advocated as a kind of prophylactic for the Malthusian condition that is predicted for large parts of East Africa. Excessive population pressures have apparently arrived in localised areas. A second hypothesis to be tested is that water control is a sound investment for selected areas with high population pressures.

Consulting engineers and Government Water Departments generally assume that pilot projects are necessary to train local farmers and gain operational experience in areas scheduled for large-scale development. This assumption will be critically examined together with the hypothesis that indigenous irrigation systems and low cost structures, though inefficient in a technical sense, are efficient investments from an economic viewpoint. It is considered that these low cost investments are preferable in so far as they are mutually exclusive. However, as economies of scale can be expected, their role should be to provide a training ground for subsequent

sophisticated systems.

The fourth and final purpose of this study is to utilise appropriate appraisal techniques to ascertain the value of a number of selected water resource projects to each of several planning goals. It is hoped to develop an operational appraisal model to cope with situations where either complementary or conflicting objectives are set. In the course of this study a critical assessment of project planning techniques and project performance will be made. It is hope to derive ex-ante guides for project design and policy from these ex-poste observations.

Thus the study is, hopefully, forward-looking. It is aimed at those concerned with investment decisions in the water field. It is hoped that the study will be of value to Government, private industry and aid donors. However, some aspects may be of interest only to specialists. For instance, sections testing and exploring agronomic and engineering design using relevant operational research techniques such as programming and simulation.

2. Scope and extent of development

If the crude assumption is accepted that an annual rainfall of less than 750mm (30 inches) is insufficient for crop growth then 85 per cent of Kenya, 50 per cent of Tanzania and 25 per cent of Uganda are water defficient. A simple rainfall statistic is a misleading climatic index. Other factors are of critical importance including the distribution over the year, distribution between years and also the potential evapo-transpiration. (In East Pakistan I worked on a tea irrigation project that proved economically sound in areas with reliable annual rainfall up to 5000 mm (200 inches). Most of this rainfell in the four month monsoon).

In Kenya the scope for irrigation with given land and water resources is of the order of 160,000 hectares (400,000 acres). Sixty per cent of this is in the lower Tana River Basin. In Tanzania the scope is enormous with 1.5 million hectares (3.7 million acres) potentially irrigable land mainly in the Rufiji, Pangani and Kingoni Basins. Uganda is comparatively well endowed with rainfall hence most scope is for supplementary supplies to insure against periods of drought. Nonetheless a recent report has suggested that the potential area is 200,000 hectares (500,000 acres). Uganda has an estimated area of 1.4 million hectares (3.5 million acres) of swamp land. Swamp drainage presents similar problems to irrigation development, plus some special problems of soil management and flood protection.

The current extent of use of supplementary water in East Africa is difficult to estimate as the major amount is utilised by smallholders in mountain areas and in small river valleys. It is estimated that in Tanzania perhaps 80,000 hectares (200,000 acres) receive water from man made control systems. Large scale suface irrigation projects are not of major importance at present. There are approximately 4,000 hectares (10,000 acres) in Tanzania and a similar amount in Kenya. In Uganda there is probably less than 600 hectares (1,500 acres) under flow irrigation. Overhead spray irrigation is extensively used on sugar estates and on horticultural holdings but the existing capacity is not known at present.

II Future role of water development

1. Synergist of change

Advocates of irrigation and drainage often ascribe almost magical properties to this aspect of environmental control. Irrigation can result in agricultural advances, new social attitudes, grasped economic incentives and a host of secondary benefits. Emphasis should be placed on the word 'can'. Otherwise why is it that agricultural practices, yields and productivity are low on irrigated areas such as Kalolo in Tanzania where irrigation has been utilised for at least 100 years?

Too much may be expected from a single technical input such as irrigation. Change results from a host of factors being present to some degree. These include other technical inputs such as fertilisers and improved crop varieties there are also wide social, economic and political considerations. Social factors include position of women, health and education. Economic factors include effective demand, availability of labour and its remuneration. Political factors include the degree and form of Government intervention, local political power structure and land tenancy arrangements. These factors are complementary and whilst the absence of one doesn't preclude successful irrigation development it adds to the problems.

I intend to study in depth at least six projects to ascertain whether synergism results and to try to identify general propositions regarding success or failure. (This will be difficult if they are non-technical and non-economic)

2. Insurance for settlement

Another popular belief is that irrigation has a role to play in settlement and in easing impending population pressures.

Irrigation certainly removes one area of risk from settlement operation but if this is at the cost of high repayments for capital and recurrent expenses this may not be a real gain.

In recent years agricultural technology has produced resources and inputs such as fertilisers, new and improved seeds and varieties, weedicides etc. which are in effect capital substitutes for land. This is likely to take the pressure of the land in the future -- onto labour and capital. The availability of such technology may require concentration of resources in areas well endowed with rainfall. Irrigation does not appear at this juncture to be the key to forestalling predicted Malthusian conditions.

On the other hand if irrigation is demonstrated to be an essential part of the 'package' required to ensure investment in the farm system that leads to high productivity its use has to be considered. Complementary (more than additive) response to farm inputs is sometimes claimed for irrigation water. There have been several recent advances in technology of earth moving, concrete manufacture, well drilling and other engineering inputs which together with increased local construction experience may help tip the scales toward irrigation development.

3. Exploiting high value crops

Supplies of high value crops such as fruit and vegetables for urban markets and export offers considerable scope that could be filled by irrigated agriculture. For instance, irrigated agriculture can supply produce during out of season peak price periods to a small but expanding urban market. Experience has already shown that East African produce can compete successfully in European markets. At present space on air transport is limited but increasing use of tourist air flights and air freight should increase its availability.

Is there yet a case for integration of irrigation schemes with the livestock sector? For instance scheme on or near live-stock ranching areas could build up fodder reserves for drought periods. Can irrigation compete effectively for urban milk supplies? These are questions worth investigating (Hubuku).

III Economic appraisal criteria

1. Objectives of projects.

Irrigation investments have been made in East Africa by private industry in pursuit of profits and by Government to satisfy a host of various objectives. These of course include obtaining a high rate of return on capital. In addition, social returns have been considered; regional development objectives;

employment creation; income redistribution and pre-Independence
/the to provide useful employment for men detained at/colonial Govern-
ment's pleasure. In the future dietary and balance of payment objectives may prove important. It is considered that appraisal must be made in relation to the stated objectives. However in any economic assessment the social costs of meeting the objectives of say, job creation or regional development policy has also to be made explicit.

Severe problems arise when the stated objectives are contradictory. For instance a regional income equality goal might be coupled with maximum economic growth, or maximum financial return coupled with maximum number of settlers. In these cases, weighting system may have to be made. There is generally a tacit understanding that a single objective should be vigourously pursued and the remainder are for window dressing. However, the compromise situation has to be tackled increasingly as current welfare criteria take precidence in the political arena.

There is currently active discussion on the role of shadow prices for factor inputs in economic appraisal in developing economies. It is hoped that some more definitive statement can be made on this, at least for water projects, after an examination of the resource endowment in selected areas of East Africa. At this stage I consider that shadow pricing is a valuable technique for partial but dynamic analysis such as is employed in water resource project appraisal. The major problem is that there is no generally accepted technique for deriving shadow prices in the partial programming techniques used when considering individual projects. Only approximations can be made which reflect the direction but not the magnitude of scarcity or surplus.

Aid appeal to donors of irrigation has both good and bad aspects for planning agencies. It could be that the special attraction of irrigation to aid donors is such that in the absence of an irrigation project no alternative is forthcoming. Thus this aid has no opportunity costs and the recepient country can evaluate the irrigation project in terms of the real cost of the aid and the amount of complementary factors it ties up. Scarce items such as skilled management have high opportunity costs. Local costs in many instances have proven to be difficult for the host Government to meet.

2. Design decisions

Appraisal criteria are specified at two levels. Primary criteria are those previously described tests by which the overall predicted contribution of a project to a range of objectives is measured and assessed. Secondary criteria are technical and economic tests that enable the designer to judge the validity of each element of design at each stage in the planning process. Ideally several design alternatives should be tested, the optimum being selected with regard to its compatibility with primary objectives. Generally a single design is adopted often without recourse to any economic analysis. It is proposed to assess design decisions on a number of selected projects as follows:

(i) Planning decisions;
(ii) Facility decisions;
(iii) Capacity decisions;
(iv) Utilization decisions;
(v) Settlement decisions;
(vi) Farm system decisions
(vii) Organisation and Management decisions.

Planning decisions

The decision to proceed with a pre-investment survey should be based upon more than a casual observation that at times lack of water impedes crop growth or that river or groundwater is available in a particular area. For instance, there is a large body of experience in East Africa on the climate and its theoretical effect upon crop growth. Therefore it should be possible using this knowledge to map areas with high potential for irrigation development. As previously mentioned several factors must be included: precipitation involves a system with at least three components - annual quantity, time pattern of availability and certainty of achieving this. Other basic factors that must be considered include evaporation, topography and soil types.

It is hoped that it might be possible to design a series of map overlays that indicate the probability of success using a particular criterion. For instance one overlay might indicate areas where evapotranspiration exceeds mean precipitation by 20 per cent in any one month interval. A second overlay might use reliability of rainfall in any month as a criterion. It would be desirable to consider some economic variables such as location in this index.

In areas where it is found that water is in fact an important variable limiting crop output it would be encouraging to see

considered other conservation methods besides irrigation i.e. mulching, clean weeding, herbicides, contour ditches, tied ridges. Also it might be advisable to investigate whether crops currently high priced on local markets e.g. rice, might be in future purchased from countries with a comparative advantage in rice cultivation and optimistic development plans e.g. Pakistan. (It is interesting to speculate on the degree of confusion that would result if every country achieved its development goals!).

Facility decisions

Irrigation can be supplied by surface flow or by overhead sprinklers. Surface flow is usually gravity fed but low lift pumping is sometimes necessary. In many instances the form of the facility is predetermined by such factors as topography or soils. If topography is uneven or soils excessively light sprinkler irrigation is generally preferable. Not always however because, at a cost, land can be levelled and distribution channels can be lined with concrete or some other impervious material.

In instances where swamp areas are being utilised it will be necessary to provide drainage and possibly flood protection. In areas with adequate precipitation but impeded drainage water table control is all that is required. Drainage can be regarded as irrigation in reverse.

It is hoped that economic design criteria can be set out to enable planners to reach facility decisions in the light of the costs and benefits and operational convenience of each alternative system.

As some of the irrigation proposals in East Africa involve the utilisation of mountain streams and rivers in areas where extremely heavy discharges can occur for short periods there are difficult technical problems associated with flood protection and design of irrigation dams and diversion structures. For instance on the Mubuku river discharges are reputed to range between 2 cu.mecs(70 cu sec.) and more than 700 cu.mecs (25,000 cu mecs).

Capacity decisions

Installed capacity is usually designed to supply sufficient irrigation water to meet crop requirements in the one in five or one in ten dry month. Convention and the availability of statistics in a suitable form generally dictates this. A more rational procedure would be to consider higher and lower installed capacities and compare the estimated marginal return (cost) with the marginal cost (savings). It may well be that to provide

capacity to supply water to meet theoretical requirements for one month out of 60 or one month out of 120 is not sound. Capital is thus tied up in facilities that are unused in most years. On the other hand water often has a high value for short critical periods and this has to be compared with the cost of the capacity.

Some crops (such as tea,) with irrigation can be made to increase production with a more even distribution over the year. Thus fixed cultivation and processing costs are spread. Only the marginal costs of irrigating and plucking need be considered in evaluation.

Commonly installed capacity is designed to meet the one in 10 dry month but with insufficient evidence available on the supply side to ascertain if river flows will be sufficient to meet this demand. Often drought periods in the irrigated areas are correlated with low stream flow so that either capacity is under-utilised or storage must be considered.

A general problem that I intend to explore is the problem of making decisions on installed capacity with only a short time series of rainfall and streamflow data.

Utilisation decisions

Where there is either a water or a capacity constraint preventing irrigation of all crops to a technical optimum should the strategy be to irrigate as much as possible to this optimum and allow the remainder to suffer drought? Alternatively is it a preferable strategy to give sub-optimal watering to all crops and accept a lower general yield? The economics of sub-optimal watering regimes is of importance because there are costs involved with each strategy. If water is scarce sub-optimal applications may give maximum output per unit of water but a higher labour input is required and a higher installed capacity. Even where water is not scarce applications below an agronomic optimum may be desirable because the top of the response curve is flat and marginal costs e.g. pumping, may be less than marginal returns.

Settlement decisions

The actual or proposed settlement pattern should be consistent with the objectives of the project and realistic in regard to the population density of the area and the inhabitants' propensity to work. Thus a dense type of peasant settlement would appear desirable in areas such as a swamp drainage scheme in Kigezi. However, in say, the arid parts of Kenya it might be more economical to envisage an estate pattern with mechanised cultivation.

(It does not follow that pressure on the land is less in a low density area because other factors might be limiting. Neither does it always follow that the labour requirements of a mechanised irrigation estate are less than a peasant settlement. This is particularly true if the estate is specialised to one or two crops).

An issue that requires investigation is the source and previous income of settlers. If their employment on the estate results in their former cultivation reverting to bush or even a reduction in area or yield then in an economic appraisal the value added by the irrigation should be reduced by the amount of this loss. In an economic assessment it is the net contribution of the project that is of interest.

I shall be interested to see if the utilization of existing capacity is generally as low and for the same reasons as in the former French territories (Dumont 1966).

Farm system decisions

Settlement policy is closely tied up with choice of crop system. This group of decisions has perhaps the biggest influence upon the economic and financial success of irrigation projects. Three reports on irrigation and drainage in the Nile Basin have concluded that with minor exceptions it would only be economical to provide irrigation for rice and sugar cane. (Gibb-Tanganyika 1954, Gibb-Kenya Nile Basin Extension 1961, Gibb-Uganda 1955). Such an outlook is not very hopeful. The number of irrigation schemes that have proved an economic failure because of their dependence upon these two comparatively low value crops is legion (particularly when world market prices are used in evaluation). Broadly speaking if sugar cane would benefit from irrigation, so too would other crops. In the tropics there is less dependence upon a particular season for sowing crops if water supplies can be controlled. Thus the problem is to derive profitable farm systems which exploit to the fullest extent available water.

Throughout East Africa, the timing and amount of rainfall to some extent determines the sequence and area of crops grown. With irrigation this risk which indirectly effects many management decisions is controlled. Management thus has a duty to rethink the entire cropping policy. New cash crops must be considered; perennial as well as seasonal. New varieties designed to respond to advanced husbandry methods rather than to survive drought can now be contemplated. Crop calendars can be reorganised so as to lessen labour peaks and to facilitate harvest at periods of high prices or to avoid rains which may spoil standing crops such as cotton. These possibilities have been noted by a number

of studies (Halcrow-Pangani 1962 Uganda Survey' 64) and the steps have been taken to obtain the necessary data to evaluate cropping patterns. It is an appropriate time to analyse these data.

I intend to study the econonics of alternative cropping patterns in some detail at Mubuku (and elsewhere if sufficient data can be obtained). I intend to use budgeting, Linear programming or monte-carlo programming as analytical tools. I would also like to try to derive demand curves for irrigation water on selected projects using a parametric L.P. procedure.

It is an appropriate time to consider whether irrigation has resulted in simply the improvement of present farming practices or the establishment of new productive farming systems.

One set of problems which deserve attention are problems such as billharzia and sleeping sickness which may effect the welfare of the inhabitants. Cost of molluscidos and other preventive measures are real costs. Another problem is what can be called the oasis effect. In drought periods when the surrounding area is parched and consequently benefits of irrigation are the highest, the irrigated area is a green island which attracts all types of pests from big game down to birds and insects.

Organisation and Management

A recent study of irrigation in East Africa reached the surprising conclusion that "well managed, highly disciplined irrigation schemes (such as Mwea-Tebere in Kenya) do not show a higher benefit-cost ratio than unmanaged haphazard schemes (such as Kitivo in Tanzania)" (Sandford 1968) I should like to explore this statement further. At this time, I suggest there is much to be said for small scale, low-cost schemes using indigenous techniques. These schemes will enable a cadre of farmers to become familiar with irrigation practice. In due course, it will be profitable to invest in more sophisticated and highly capitalised systems because these experienced farmers will facilitate rapid uptake of the irrigation capacity. Speed of achieving forecast production has a profound effect upon benefit cost ratios. Evidence suggests that East African schemes have been slower in achieving "take off" than project designers predicted.

Decisions on the type of financial analysis and the repayment policy that the direct beneficiaries will follow have bearing on the success of a project. For public investment

projects, there are valid grounds for recommending both low and high rates of repayment. There are no valid grounds for equating the repayments with costs. This subject will be examined from the point of view of payment for a factor of production and from the more general taxation viewpoint.