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REQUIREMENTS FOR CONTRIBUTIONS

Articles in the field of agricultural economics, suitable for publication in the journal, will be welcomed.

Articles should have a maximum length of 10 folio pages (including tables, graphs, etc.), typed in double spacing. Contributions, in the language preferred by the writer, should be submitted in triplicate to the Editor, c/o Department of Agricultural Economics and Marketing, Pretoria, and should reach him at least one month prior to date of publication.

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THE ECONOMICS OF IRRIGATION FARMING IN SOUTH AFRICA*

by

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INTRODUCTION

South Africa is comparatively ill provided with arable land. It is estimated that about 12 per cent of the land - approximately 12 million morgen - is cultivated, and it has been said that it will not be possible to increase this area to any considerable extent. The reasons for this are firstly that the greater part of the country is mountainous and therefore not arable, and secondly that lack of natural water resources limits expansion in the areas where arable soil with a high potential is still found.

Of the total area under cultivation, approximately 983,000 morgen can be classified as irrigation land, as shown in table 1.

TABLE 1 - Irrigation land in the Republic of South Africa, 1963[1)]

		Irrigated area Morgen
1.	State water schemes	211,958
2.	Irrigation districts	252,420
3.	Other irrigation authorities	17,270
4.	Irrigation in Bantu areas	35,428
5.	Private irrigation with surface water	220,000
	Total for consistent irrigation with surface water	737,076
6.	Flood irrigation by flooding with rainwater or from rivers	122,979
7.	Irrigation from wells or boreholes	123,000
	Total irrigated area	983,055

According to Table 1 only about 740,000 morgen can be regarded as land receiving consistent irrigation with surface water. This area should increase considerably on completion of the Orange River Scheme and a whole series of smaller schemes which are being developed. Nevertheless it is doubtful whether the total area brought under irrigation will ever exceed two per cent of the total area of the country. It is estimated, therefore, that about 42 per cent of the country's potential irrigable land is at present under irrigation.

The relatively low percentage of arable land which, it is estimated, will eventually be used for irrigation farming must be attributed to the following factors:

(a) In the areas where land is still available, natural water supplies for irrigation are limited.

(b) In areas where reasonable quantities of water are still available, land suitable for irrigation farming is limited. This water can only be used for agricultural purposes by piping it over long distances at a high cost.

(c) The needs of a modern commercialised community are such that there is severe competition for water between secondary and primary industries, and the more industrialised South Africa becomes, the more intense this competition will become.

WATER UTILISATION IN AGRICULTURE[1)]

When the marginal productivity of water used for various purposes is compared on a national level, agriculture is overshadowed by most other sectors. But this should by no means be taken to indicate that water must be used for other purposes rather than for agriculture. If water were very scarce or if sectors other than agriculture required proportionately more water, a reallocation of water would have been economically essential.

Examples of the estimated quantities of water required to produce agricultural products worth R2 as compared with the quantities required for

* Paper read at the National Irrigation Symposium, Department of Agricultural Technical Services, October 1967.

1) Jordaan, J.M. Paper read at a meeting of the Suid-Afrikaanse Akademie vir Wetenskap en Kuns, June 1966.

1) Van Wyk, S.P. "Die Ekonomie van Waterbenutting". Annual Congress of the South African Association for the Advancement of Science, 1964.

TABLE 2 - Water required to produce products worth R2

Industry		Agriculture	
Product	Gallons of water	Product	Gallons of water
Steel	60	Fresh milk	4,400
Oil from coal	800	Wheat	14,000
Leather	70	Lucerne	22,000
Electricity	500	Potatoes	3,500
Paper pulp	300	Rice	6,000
Processing of			
Cheese	200	Wool (drinking-water)	550
Butter	300	Beef	700
Milk	300		

industrial products worth R2 are shown in table 2.[2)]

The figures in table 2 give an indication of the relative benefit derived from water used for various industrial and agricultural products and are important in establishing a policy where the development and allocation of water supplies are involved.

As stated it would be incorrect to deduce from these figures that on a national level the utilisation of water for irrigation is irrational. The important consideration is whether the allocation of water to various industries is correct - it would be unrealistic, for instance, to use water for irrigation (which has a low marginal productivity) at the expense of industrial production which may have a higher marginal productivity.

Take for example the catchment area of the Vaal River. There is at present still sufficient water for industrial, mining and domestic purposes and even for irrigating the large Vaalharts Irrigation Scheme. It is the Government's policy to encourage the decentralisation of industry. In so far as decentralisation does not take place and the rate of development of the past decade is maintained, the Vaal River will eventually not meet all these needs. The price of water will of necessity rise, and industries with a low marginal productivity will either have to increase their efficiency or withdraw from production. This means that irrigation farming will suffer first and probably most severely, unless it can be developed in areas where water is cheaper.

Agriculture uses water for production in two forms, i.e. for dry-land farming, making use of natural rainfall, and for irrigation farming.

DRY-LAND FARMING

Technological progress has advanced dry-land farming tremendously, and the notable rise in production on dry lands still by no means reflects the full potential.

From a national point of view, the dry-land potential for field and animal husbandry production is already so great - without taking into account further technological progress - that there is at present no pressing need for the development of new irrigation land for the support of the nation. The only exceptions are the production of highly intensive products such as vegetables, most kinds of fruit, cotton, tobacco and so on for which irrigation is necessary. From an economic point of view, therefore, there is no urgent need at the moment to develop irrigation land for products which can be produced economically on the available irrigation land and dry lands.

IRRIGATION FARMING

Considerable expense is involved in bringing land under irrigation. Expensive land and the high running costs of irrigation necessitate intensive farming systems. The following are some of the factors determining the success, and consequently the economy, of irrigation farming:

(a) Cost involved in capital works such as dams, weirs, canals, irrigation systems and per unit of land irrigated.

(b) Current costs per unit of water, which will be affected by factors such as the distance over which and the height to which the water must be brought.

(c) The water requirements of the crops to be grown and the productivity of each additional water unit when it is used for the various crops.

(d) Climatic conditions: The marginal productivity of water is greatly influenced by climate which, together with other natural and biological factors such as diseases and pests

[2)] Stander, G.J., "Water and water utilisation in South Africa". National Institute for Water Research, C.S.I.R., Pretoria.

determines to a considerable extent which crops can be produced.

(e) Quality of soil: Soil depth, slope, subsoil, drainage, brackishness, are all factors determining the success of irrigation farming.

(f) Marketing possibilities: Distance from markets often has a determining effect on the intensiveness of production, as has the supply of competing products obtained from dry-land farming.

CHARACTERISTIC ECONOMIC FEATURES OF IRRIGATION FARMING

1. Production

(a) Irrigation farming may be defined as a farming system where more intensive utilisation of production factors such as seed, fertiliser and labour is made possible because one of the uncontrollable factors, namely rainfall, has become a controllable factor in the form of irrigation water. Utilisation of water therefore makes intensive farming possible.

(b) The availability of water reduces drought risks, usually ensures greater stability of farming income and thereby justifies greater expenditure on production factors. But this also makes greater demands on the soil. Greater inputs are not possible on poor soil or on soil unsuitable for irrigation.

(c) Irrigation water enables the farmer to grow a wider range of crops and to produce high-income crops. The effect of this may be so great as to result in a complete change of farming systems in a given region. In this way, for instance, the Vaalharts area, previously used for extensive stock farming was developed.

These advantages make irrigation farming an attractive investment proposition. Unfortunately investors often tend to attach too much importance to these advantages and overlook other limiting factors which may affect production, such as the quality of the soil, the occurrence of hail and frost, distance from the market and capital investment required to obtain the necessary irrigation water.

2. Management requirements and irrigation farming

It has been pointed out that irrigation water creates favourable conditions for vertical expansion or intensification of the farming system. Intensification and everything it involves requires, however, greater management ability in respect of decisions about the choice of crops, and the preparation of a farm plan and its execution.

It is striking that in spite of the greater demands made on management by irrigation farming, knowledge of certain aspects of irrigation farming in South Africa is extremely limited. Here reference is made to knowledge of the water requirements of plants grown on various soil types and in various agricultural regions, the suitability of the different soil types for irrigation farming, and the effect of the application of water on soil, irrigation practices and methods and the effect these have on water utilisation and costs; and the financial implications of supplying irrigation water under various irrigation conditions.

3. Land prices

The relatively higher prices paid for irrigation land may be attributed to the opportunity created by water for vertical expansion or intensification; in other words, higher yields per unit and the greater yield stability ensured by water. Price differentiation between regions is also affected by other natural and economic factors which combine to determine the economic potential. That is why there are such tremendous differences between the prices of irrigation land in various parts of the country, e.g. Vaalharts from R600 to R800 per morgen and Paarl grape growing area R3,000 per morgen.

From an investment point of view, the relatively higher prices paid for irrigation land compare quite favourably with the price of land in the more extensive agricultural regions. This conclusion is based on the fact that land under irrigation is more remunerative than land in the more extensive areas. The data in table 3 will clarify this statement.

TABLE 3 - Capital required for a net farming income of R4,000[1)]

Area	Total capital investment required for a net income of R4,000	Net income per R100 of capital investment
	R	R
Molopo	80,000	5.00
S.E.O.F.S.	64,829	6.17
Swartland	48,899	8.18
Western Transvaal	49,382	8.10
Vaalharts	27,027	14.80
Hex River Valley	16,957	23.60

[1)] Data from economic investigations by the Division of Agricultural Production Economics.

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Table 3 clearly indicates that a considerably smaller investment is required in the intensive irrigation areas than in the more extensive agricultural regions to obtain the same net farming income. By comparison irrigation farming is, therefore, a more favourable investment than other farming enterprises.

4. Intensive and extensive irrigation farming

As has been pointed out, the crops to be grown in an irrigation area will be determined not only by the presence of irrigation water, but also by factors such as rainfall, temperature, evaporation, types of soil, distance from the market and demand for the product. Together these factors determine the choice of crops and the intensiveness of production. Differences in soil and temperature are very largely responsible for the fact that wine grapes are only grown in some parts of the Western Province, whereas other parts are suitable for the production of table grapes. The Lower Orange River Scheme is, so far as soil and temperature are concerned, suitable for a wide range of high-income crops such as vegetables and fresh fruit, but the distances from markets necessitate farmers to produce lower-income non-perishable products such as lucerne, cotton, wheat and to some extant dried fruit. On the Vaalharts scheme with its colder winters and relatively short growing season it is possible to concentrate on the production of wheat, maize, groundnuts, potatoes and cotton. These specific characteristics which make a region suitable or unsuitable for the production of high-income crops, also determine whether such a region will develop as an extensive or intensive region.

5. Farm size

The typical characteristics of irrigation farming mentioned above also have an effect on the size of irrigation units, thus

(a) The high net income per unit of area obtained by the application of water as a production factor means that farmers can make a living on relatively smaller farming units and contributes towards making irrigation units relatively smaller than units in other branches of agriculture.

(b) The greater management ability per unit of area demanded by irrigation farming means that the average manager can only maintain the same management efficiency as in dryland crop farming on a smaller irrigation unit.

(c) The higher capital requirements per morgen for irrigation farming tend to make irrigation units smaller, which for the average investor with limited capital makes this type of farming still an attractive investment proposition.

The effect of the factors mentioned, is that generally speaking irrigation units are considerably smaller in terms of area than dryland crop farming units.

6. Income and cost ratio

The gross income obtained per unit of area is normally considerably higher in the case of irrigation farming than for dry-land farming and the reasons for this are:

(a) Higher yields per morgen are obtained because of more favourable production conditions and more intensive input of the means of production.

(b) Because moisture is no longer a limiting factor, the soil can be utilised productively for longer periods of the year by reaping at least two crops or by growing crops which require a longer growing season.

(c) The presence of water makes the production of high-income crops possible.

Over against the gross income there is, however, the expenditure incurred in obtaining the gross income. This expenditure can be divided into two categories, namely - fixed costs and variable costs.

Fixed costs consist mainly of interest and depreciation on buildings, improvements and machinery, and to some extent regular labour costs, whereas variable costs include items such as fuel, repairs, seed, fertiliser and feed bought.

Of these two groups of costs, it is mainly fixed costs which may give rise to difficulties. The reason for this is that fixed costs might in certain instances be greater than would be justified. The capacity of a tractor and other implements might for example exceed actual requirements, while lighter implements would be unsuitable. The irrigation farmer thus finds that his limited area of land has to bear the total fixed costs and that his costs per morgen are consequently higher than those of a farmer on a larger unit.

The fixed costs per morgen are, however, not the determining factor for profitability per morgen of a particular farming system or farm size but the relationship of gross income per morgen to total farm expenditure per morgen. In an intensive irrigation region (such as that of wine grapes in the Western Province) with a relatively high gross income per morgen, high fixed costs per morgen may therefore be quite justified since the ratio of gross farm income to total costs, which include fixed costs, will still be fabourable. In the more extensive irrigation areas with a relatively lower gross income per morgen (such as the Vaalharts scheme), the ratio of gross income to total expenditure may, however be less favourable. In these areas the farm size will therefore become more important, since a larger farm will enable the farmer to have lower fixed costs and therefore a more favourable net income per morgen.

THE UTILISATION OF WATER AS A PRODUCTION FACTOR

Irrigation water as a production factor is defined as follows by Heady and Jensen[1]: "Irrigation is a farming practice which differs from fertilization or other practices only in that the resource concerned is water rather than fertilizer, seed, labor or other material. As with seed, fertilizer, lime and other variables used in production, water can be applied to a fixed resource, an acre of soil, in different forms and amounts. It obeys the laws of diminishing returns and therefore the principle of marginal/cost-marginal revenue applies in decisions of its use for a farmer with unlimited capital. The principle of opportunity cost applies for the farmer who has limited capital and can invest his funds elsewhere in the business; the principle of allocating water between acres according to the marginal productivity principle also applies where only a limited supply of water is available or where the farmer has equipment for handling only a given amount."

According to the authors economic laws and principles must therefore govern the farmer's decisions regarding the most economical application of water as a production factor.

The decisions which the farmer will make on the most economical application of water will be affected by -

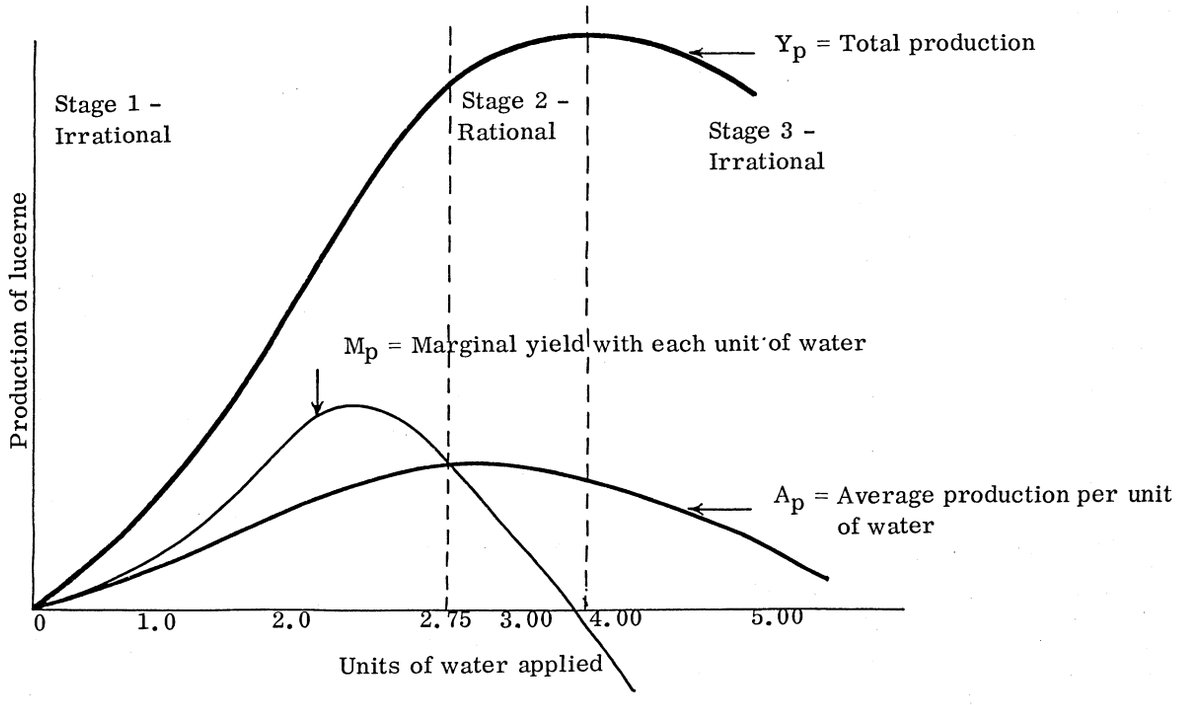
(a) The quantity of water available, i.e. whether an unlimited or limited supply is available at all times.

(b) The cost involved in obtaining the water.

Careful planning is essential to ensure efficient and economic use of limited supplies of water. Within a given farming situation it may be more profitable to use the limited supply of water for one crop, or to distribute the water amongst various crops through partial irrigation.

An analysis of the adaptation of the application of water according to the water requirements of plants and estimates of the value of additional applications of water calls for a knowledge of the relation between various applications of water and the yields obtained from crops. This relationship is known as a production function. For efficient management and planning information on the production functions of types of soil management, climate and physical application is essential.

In figure 1 the conventional production function in terms of applications of irrigation water and the yield of lucerne is illustrated.



[1] Heady, Earl O. and Jensen, Harold R. "Farm Management Economics", p.205. Prentice Hall Inc., 1954.

APPLICATION OF WATER

The curve Yp represents the total production on a unit of land at various applications of irrigation water. Ap is the average production per unit of water and Mp is the marginal yield with each additional quantity of water applied. The curves illustrate the law of diminishing returns.

The physical relationship between the quantity of water applied and the yield of lucerne holds important economic implications. The curves do not show the most advantageous quantity of water to be applied, but they illustrate the stage of rational production.

An application of less than 2.75 units of water is in this instance irrational and below the point where the average yield per unit of water is the greatest. The average production per unit of water increases steadily up to this point.

The production of lucerne in stage 3, that is with an application of more than four units of water, is also irrational. Beyond this point total production will decline with the application of more water.

Stage 2 is known as the rational stage of production even without careful consideration of the cost of water or the price of lucerne. The precise quantity of water which will prove most profitable can, however, not be determined without knowing the price of lucerne and the cost of water.

With a single product, lucerne in this instance and a single production factor (water) which are being considered, the greatest profit is obtained where the marginal cost of water is equal to the marginal yield of the product (lucerne). At this point an additional unit of water will cost more than the additional income obtained.

If, however, a resource such as water is limited, and in instances where there are alternative possibilities for the utilisation of water, the farmer cannot maximize his profit for each separate purpose for which he is using water. The problem here is to allocate the available water amongst the alternative uses in such a way as to maximize profits. He must therefore distribute the inadequate quantity of water amongst alternative crops, or decide to withdraw a part of his land from irrigation farming in order to apply the water on a smaller area. For distribution of this kind, knowledge of the marginal productivity of each alternative unit of water applied to the various alternative crops is therefore essential.

In general the most efficient use of a limited quantity of water and the greatest total profit will be attained by the farmer when the distribution is such that the marginal productivity of the quantity applied to each crop is equal.

The farmer's problem naturally becomes much greater under conditions of fluctuating and uncertain water supplies. Aspects to be considered here are -

(a) Must the area be adjusted over the years to the "normally expected" quantity of water?

(b) Should the area to be cultivated be adjusted at the planting stage to the quantity of water expected to be available?

In conclusion it is also important that the farmer with limited capital should decide whether to invest his limited means in an irrigation unit or in alternative investment possibilities in his farming enterprise. In this case the principle of "opportunity costs" must be considered. The marginal productivity of capital is the determining factor here, which really means that the farmer will have to decide whether he would rather buy the product he is going to produce under irrigation, e.g. lucerne for feed, and perhaps use his limited capital to improve his herd.

IRRIGATION FARMING IN SOUTH AFRICA AND THE FUTURE

1. The past

The expansion and development of irrigation farming in South Africa was strongly influenced by Government policy in the past.

(a) Government Schemes

In the first place all the Government Water Schemes were developed directly and fully with Government funds, and these schemes are also under complete control of the State. The original purpose with most of these schemes was primarily to accommodate impoverished White families. For this reason many of the schemes are referred to as rehabilitation schemes. The result of this approach was -

(i) that farmers to whom land was granted were not selected on the basis of management ability;

(ii) that the provision of water was and is still heavily subsidised by the State; and

(iii) that economic considerations did not always receive due attention.

The result of this policy was, in the first place, that the average size of allotments on some of these schemes was too small to ensure an adequate income, and secondly that water rates paid by farmers are still unrealistically low in proportion to the productivity of water.

(b) Other schemes

The expansion and development of other irrigation schemes are encouraged by the Government by means of technical advice and assistance in the form of loans and subsidies to finance such schemes. A criticism which can be levelled against

many of these schemes is that planning and development were not always based on economic considerations. The result of this is that the cost of providing water on some schemes is out of proportion to the productivity of water in that particular area.

The problem with existing irrigation farming is not so much the re-allocation of water to other sectors of the economy, as the more efficient application of existing production resources. In some instances this can only be achieved by establishing larger farming units, whereas intensive research into the productivity of water and special guidance on the application of water are required in other instances.

2. The future

A critical review of water utilisation in the past and the type of farming system and water utilisation which necessarily resulted from the original planning indicates that planning was not efficient. With the extensive proposed development of irrigation farming which has already begun and which will mean a total increase of about 50 per cent over the existing area under irrigation, the time has certainly come when serious thought must be given to the application of one of our country's most limited resources - water. The following considerations should receive attention if more economic utilisation of water in agriculture is to be attained:

(a) Irrigation schemes should be planned and developed solely on technological and economic considerations.

(b) It would be unwise to make enormous investments for horizontal expansion of irrigation land, knowing that so many existing irrigation undertakings still suffer from defects such as the insufficient utilisation of water, faulty irrigation practices and uneconomic farming units. Vertical expansion should therefore be given priority, so that the existing resources can be utilised more efficiently through adopting well-planned farming systems and farming techniques.

(c) Those who plan any future exploitation of water for agricultural purposes must be particularly careful not to establish farming units which will soon no longer provide a reasonable living. Foresight of future economic trends is therefore essential for the development of such schemes. Uneconomic units frustrate the efficient exploitation of potential, and result in low productivity of all production factors.

CONCLUSION

Irrigation farming can take its proper place in the national economy only if it is based on the principles of economic science, together with technological and sociological considerations. Economics deal with man, in his efforts to attain optimum satisfaction. "For this reason it is eminently suitable as an aid in solving the complex problems of water utilisation. Employing economic principles to attain efficiency in the exploitation of resources, can make a tremendous contribution to national welfare, higher standards of living and general progress"[1]. (Translated).

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[1] Van Wyk, S.P. "The Economics of Water Utilisation". Symposium, the South African Association for the Advancement of Science, June 1964.