THE INSTITUTION OF ENGINEERS, CEYLON

Some Studies on the Economics of Water Resources Development and Irrigation Supply in Ceylon

By S. ARUMUGAM, B.Sc. (Lond.), M.I.C.E., M.I.W.E., M.I.E.C.
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Water is the cheapest commodity on earth; its very cheapness leads to a lack of appreciation of its value and failure to grasp its worth as a national economic resource.

It is dammed, stored, conveyed, distributed, run down the field channel and delivered at the door step of the rice field—all this for a maximum possible charge of Rs. 5/- per acre, for a whole year, which really works out to about one rupee for a quarter million gallons or a cent for over 2,700 gallons, of this commodity.

Introduction

Economic evaluation of the value of water is most difficult to assess, nevertheless, its economic worth determines and controls the scope of land development.

From time immemorial, ever since man attempted water conservation, economic considerations would doubtless have lead to final decisions and acceptances of conservancy projects.

Unfortunately history has not recorded such considerations in detail, except for a passing comment here and there. We do not know, today, what considerations weighed with King Vasabha in the selection of the eleven tanks, constructed by him, during 65 A.C. to 109 A.C., or how King Maha Sena selected the famous 16 large tanks that made him immortal, or why Kala Vapi was constructed and at the Kala Wewa site by King Dhatusena (459-477 A.C.).

Even if these were executed on a Rajakariya basis and therefore the magnitude of costs were immaterial, some yard stick would have been used for measurement of advantages, disadvantages, preference of particular sites and in the final selection between alternate proposals.
Of course, for that great master mind, Parakrama Bahu I (1153-1186), whose prodigious achievements were stupendous, his famous dictum, that water that comes from rain must be made useful to man and not be allowed to run to waste to the sea, was the yardstick.

The Portuguese did not embark on much development work in Ceylon.

To the Dutch East India Company, cultivation of the economic exportable crops and their cheap transportation from the interior by waterways, to the sea port for shipping was the main concern in development agriculture.

In the early years of their occupation, the British were pre-occupied with other matters. Credit however goes to Sir Emerson Tennent, Colonial Secretary 1847, for pressing Government for the active revival of water resource development in Ceylon and the culmination of his efforts, later, was the framing of the Irrigation Ordinance of 1856, described as "Ordinance to facilitate the revival and enforcement of ancient customs regarding Irrigation and Cultivation of Paddy Lands".

First known Economic Considerations

Irrigation works, then, received the following economic consideration, and were classified accordingly:

(1) Remunerative Works

Such works pay the cost of construction of the work in ten equal annual instalments and afterwards a maintenance rate, not exceeding ten cents per acre, was payable in perpetuity.

(2) Aided Works

These works were required to pay a water rate equivalent to the interest (at 4%) on the capital cost (but capital investment itself was free—an aid) and cost of maintenance and operation of the work. The total of the rate was not to exceed Rs. 1/- per acre, for economic reasons.

(3) Gratuitous Works

From these, no return was expected and no rate was charged; but the payment of the usual paddy tax then prevalent was considered sufficient.

There are several of these "remunerative" Irrigation Works in function today, as Major Works, which, in conformity with the above, repaid the entire capital investment to Government within the stipulated 10 year period and now pay only a fixed rate of about one rupee per acre or even less.
In the case of aided works, the water rate was raised later from Re. 1/- to Rs. 2/- per acre, in perpetuity.

By 1914, the levying of an "Irrigation Rate", computed in a more realistic manner, was instituted. The existing works, however, were allowed to continue to function under the terms and conditions already contractually agreed upon, but new works were to pay an "Irrigation Rate". This would be dealt with later, in these studies.

**Water Requirement**

The important factor in all assessment of irrigation development potential is the value assigned to the "Duty" of water, or the water requirement of the crop to be irrigated. Duty has been defined as the ratio between the volume of water used and the area of crop it matures. The base of the duty is the time during which the flow is used; this conventionally covers the whole cultivation period. Also the place of measurement has to be stated when defining duty; the quantity of water issued at the head of a channel is more than the quantity delivered in the field due to conveyance losses in the channel.

Since this ratio determines the total extent that could receive benefits of irrigation supply, for a given definite storage, its primary contribution to the economic study of any irrigation development project, will at once become evident.

The purpose of agricultural development is to increase crop yields. Water is not the only contributing factor for such increase. Nevertheless, without sufficient water supply, crops would fail. So that, the determination of the exact quantity of just that "sufficient" supply, so that no more (and of course, no less) need be supplied, becomes a fundamental study in Irrigation Science.

For the want of sufficient data, the practice is to assume a stipulated figure, such as five acre feet per acre, as 'duty', for a rainy season cultivation under any irrigation project in Ceylon. That indicated the assurance of a successful cultivation in an acre of land, if five acre feet were available as storage for supply to that acre over the cultivation period. The corresponding requirement for a dry season cultivation was, of course, very much more.

1 Now the prevalent duty for a cultivation season under each scheme, could be arrived at from actual records of issue and supply maintained at each project. Given below are the computations for duty at five different large irrigation projects, situated far apart, in different directions of the Island.
<table>
<thead>
<tr>
<th>Scheme</th>
<th>Year</th>
<th>Extent Cultivated in Acres</th>
<th>Duty</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Maha</td>
<td>Yala</td>
</tr>
<tr>
<td>Nachchaduwa</td>
<td>1959/60</td>
<td>5,318</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1961/62</td>
<td>2,930</td>
<td>6.19</td>
</tr>
<tr>
<td>Kalawewa</td>
<td>1959/60</td>
<td>8,888</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1960/61</td>
<td>8,268</td>
<td>7.06</td>
</tr>
<tr>
<td></td>
<td>1961/62</td>
<td>6,784</td>
<td>7.84</td>
</tr>
<tr>
<td>Iranamadu</td>
<td>1959/60</td>
<td>18,844</td>
<td>1.17</td>
</tr>
<tr>
<td></td>
<td>1960/61</td>
<td>10,000</td>
<td></td>
</tr>
<tr>
<td>Ridiyagama</td>
<td>1959/60</td>
<td>6,117</td>
<td>7.53</td>
</tr>
<tr>
<td></td>
<td>1960/61</td>
<td>6,100</td>
<td>7.48</td>
</tr>
<tr>
<td></td>
<td>1961/62</td>
<td>6,053</td>
<td>6.57</td>
</tr>
<tr>
<td></td>
<td>1962/63</td>
<td>6,053</td>
<td>6.71</td>
</tr>
<tr>
<td>Padaviya</td>
<td>1959/60</td>
<td>1,902</td>
<td>5.65</td>
</tr>
<tr>
<td></td>
<td>1960/61</td>
<td>1,900</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1961/62</td>
<td>4,206</td>
<td>4.14</td>
</tr>
</tbody>
</table>

The water requirement would obviously vary from scheme to scheme, depending on the nature of soil, the cultivation habits of the community under that scheme, the rainfall during cultivation period, and, of course, with the judicious and frugal use of irrigation supply maintained by the officers in charge of cultivation.

The above and such figures collected for more recent years would indicate more precise values of duty, which should be used at these projects rather than a generally stipulated all Island figure.

It is even suggested that cultivation superintendents and cultivation officers and others in charge, should receive special recognition, as an incentive factor, when they effect saving in water supply over the corresponding amounts used in the previous years—for their creditable performance in reducing water requirement consistent, nevertheless, with “sufficiency” of supply.

**Irrigation Rates Levied in Ceylon**

Irrigation rate or water rate is the amount payable by a cultivator of a land which is benefited by a Major Irrigation Work.

This rate refers to the amount the cultivator has to pay for the facilities of irrigation water supply to his land for the cultivation of rice or other crops.
An Irrigation Rate comprises of:

1. A charge for the capital outlay in the construction of the Irrigation Scheme;

2. A charge for improvements effected to it subsequent to construction;

3. A charge for the maintenance and operation of the scheme.

Recovery of Irrigation Rate

Imposition of Irrigation Rates is governed by Irrigation Ordinance No. 32 of 1946. Section 2 of the Ordinance defines the Irrigation Rate as a charge in favour of the Crown imposed upon the land, to which it relates in respect of water supplied or to be supplied to such land or in respect of the cost of or incidental to the construction or maintenance of any major Irrigation Work benefiting or intending to benefit, such land or of all or any of such matter in combination. The recovery of maintenance rate contemplated in the Ordinance is to reimburse the cost of maintenance and operation of major irrigation works.

Observing that full advantage was not being taken of the irrigation facilities provided by the Rice Industry, it was thought that lower irrigation rates could stimulate the industry. A select committee appointed in 1925 to inquire into and advise on the water rate leviable on irrigable lands, recommended in Sessional Paper XXV of 1926 that “in view of the risks due to malaria, pests, flood, drought, scarcity of labour and that as lower rates would tend to increased purchase of land for paddy cultivation and hence to increase production, the Paddy Industry in the Dry Zone was unable to pay an irrigation rate in excess of Rs. 2/- per acre per annum”. This recommendation was accepted by Government and the maximum rate of Rs. 2/- per acre per annum was in vogue for 10 years from 1928 to 1937 and was later extended till 1943. In 1933 the Dry Zone maximum of Rs. 2/- per acre per annum was made applicable to the whole island. During the 10 years period however, general remission of irrigation rates took place in certain years. In 1940 in order to stimulate the cultivation of paddy during the war years, the rate was waived on all cultivated lands whilst rates were levied on uncultivated lands under the major works.

“The construction rate in addition to maintenance rate was recovered from the proprietors towards the reimbursement of the cost of construction of the Irrigation Work concerned. To encourage the Agricultural Industry, it was however decided in 1950 to accept the cost of construction as a liability of the State and to impose on the cultivators only a Maintenance Rate.
Present Practice—Maintenance Rate Only

The Maintenance Rate, which is the only rate now levied on lands under Major Irrigation Schemes, is of three categories:

(a) Fixed Rate;
(b) Variable Rate; and
(c) Seepage Rate.

(a) *The Fixed rate* is a levy laid direct in accordance with the provisions of the Irrigation and Paddy Cultivation Ordinances of 1889 which were in force before the enactment of the Irrigation Ordinance of 1917. This rate ranges from -/-25 cents to Rs. 2/- as fixed by the proprietors of the various Irrigation Schemes which were in existence before the enactments of the Ordinance and continue to be in vogue in perpetuity.

(b) *The Variable rate* is computed in accordance with section 55 (2) of the Irrigation Ordinance No. 32 of 1946 on a pro rata basis among all lands on specification depending on the annual maintenance cost of each Irrigation Scheme which has been constructed, subsequent to the enactment of the Irrigation Ordinance. This rate is subject to revision every 5 years by the Revenue Officer as prescribed in section 55 (3) of the Irrigation Ordinance No. 32 of 1946 and is at present subject to an over-riding maximum of Rs. 5/- per acre per annum fixed in 1950. This maximum was fixed in 1950 but since then the cost of maintenance has considerably increased.

(c) *Seepage rate*:—Lands which do not get direct water supply from an irrigation scheme but derive benefit from seepage water, pay a rate equal to one half of the variable rate payable by lands which derive benefit from direct supply from the Major Irrigation Schemes. This is called Seepage rate.

Rates Levied at other Works

There are Schemes where actual supply of storage for irrigation of crops is not made, but facilities are nevertheless provided to aid development of the land. These recent activities are in the nature of protecting lands from entry of floods, preventing ingress of salt water from the sea, and or effecting drainage of low lands—Land Drainage and Reclamation Projects. At these projects, lands receiving benefits are levied a flat rate of Rs. 2/- per acre per year.

The Village Irrigation Work

In the case of Village Works, where the facilities afforded do not contribute to a large scale cultivation, Government constructs the scheme and maintains the structures whilst the proprietors maintain only the earthwork in lieu of rates. This is in the nature of a social service by the State to the agricultural peasant.
Computation of Irrigation Rates

Actual computation of the grand total of all irrigation rates recoverable from the beneficiaries of all the Schemes in Ceylon, for a particular year, worked out as follows:

1. Levied on lands liable to a fixed irrigation rate
   - 600 @ 1/- 25 cts. = 150
   - 563 @ 1/- 50 cts. = 281
   - 129,168 @ 1/- = 129,168
   - 11,274 @ 2/- = 22,548
   Rs. 282,527

2. Levied on lands liable to variable rate (Flood Protection and Salt Water and other Schemes)
   - 394 @ 1/- 72 = 283
   - 55 @ 1/- 52 = 55
   - 14,781 @ 1/- 60 = 23,650
   - 72 @ 3/- 75 = 270
   - 11,100 @ 2/- = 22,200
   Rs. 39,138

3. Levied on lands liable to a variable irrigation rate (subject to Rs. 5/- ceiling)
   - 146,161 @ 5/- = 730,805

Total: Rs. 929,410

Cost of maintenance and operation of the above works required an expenditure of Rs. 2,620,000 by Budget, for that year. Thus it becomes evident that the total amount recoverable by way of irrigation or water rates is only a fraction—just over one third, of the expenditure, necessary to maintain the Major Irrigation Works in the island.

Irrigation Water Tariffs and Recoveries in other Countries

Relevant to the study of the recovery of irrigation rates in Ceylon, it is cogent to ascertain the practices prevalent in this respect, in other countries. The system of Irrigation Water Tariffs and recovery of Water Rates employed in various countries has interested the Economic Commission for Asia and the Far East. The material collected by them in 1962 provides very relevant and authentic information and is summarised below together with information collected from other sources:

India

A vast territory of over 300 million acres is under cultivation in India; of these, about 25% is under irrigation. The more recent Bhakra-Nangal Project has for its target the irrigation of 34 million acres.

Water tariffs are usually based on the area irrigated, different systems of this being used in the various states, in arriving at the actual rate of charge. Rates vary with the nature of crop. An
attempt made in certain areas to levy water rate on the amount of water used had been given up. Ground water used, pumped from deep tube wells, is however charged for by the actual amount of water used.

Pakistan

Over 20 million acres are under irrigation in Pakistan which has a land territory about ten times as much. The Sukkar Barrage benefits $\frac{7}{2}$ million acres. The more recent projects are the Upper and Lower Sind Projects and the Brahmaputra Scheme.

No direct recovery is made for irrigation.

Burma

About 20 million acres are under cultivation in Burma, of which about one tenth is under irrigation. All the schemes consist of diversion projects of rivers and water ways. Large storage reservoirs are now being constructed above the diversion weirs.

The water rate is based on the extent of land irrigated and the nature of soil; in fact, it is collected with the land tax, immaterial of quantity of water consumed.

Malaysia

Water tariffs in Malaya are based on the extent of land. The actual value of the rate levied is however dependent on the quality of the soil of the land: thus Class A lands are levied at $6.00 per acre and Class C lands only $2.00 per acre.

Under the Irrigation Ordinance a person guilty of wasting water is liable to imprisonment.

Japan

In Japan about 10 million acres are irrigated; the crop is usually rice; more than one cropping season is practised. Having three crops annually on the same land is by no means an exceptional practice.

Recovery of water tariff consists of levy of flat rate on the land owner, sufficient to cover costs of maintenance and operation of the scheme, only.

Australia

In Australia over 6 million acres are provided with facilities for irrigation; only half of the extent do actually receive irrigation annually due to limited water resources. The crops irrigated consist of pasture and fodder crops, fruit orchards, citrus plantations, etc.
The Snowy Mountain project is to divert the flow in the east flowing Snowy River into the west flowing Murray and Murrumbidgee Rivers, thereby providing two million acre feet of water for irrigation annually by erecting seven major dams and 85 miles of tunnel and 400 miles of aqueduct.

Each irrigator is usually entitled to a basic quantity of irrigation water supply (in acre feet) depending on the extent of his land; he has to however pay extra for every acre foot consumed by him over and above his basic water right. The cost of supply itself is about 15 shillings (gravity supply) and about 60 shillings (lift irrigation supply).

The rates are determined so as to meet the cost of administration, maintenance and operation.

**Egypt.**

The birth place of irrigation practice, dated as far back as 3,000 B.C. by King Menes, the First Pharaoh who initiated a dyke along the Nile, all irrigation works are still dependent on the River Nile and are considered part of essential service to the community.

Recently they embarked on the High Aswan Dam Works.

Irrigation water is *not sold* to the cultivator but is delivered to him as part of national service. Cotton is grown universally and some rice cultivation is done when there is excess water available.

The land owners pay a land tax.

**Israel**

As Israel is a land adjoining the desert, water resources are very limited and availability of water supply is at a premium. The National Irrigation Scheme envisages the conveyance of flow in Jordan by underground conduits, over 100 miles distant, to recharge the underground aquifer for lift irrigation of over a million acres.

Charges are made by the water supplied; the actual rate is computed to meet all costs spread over a period of 20-25 years.

**Union of Soviet Russia**

The U.S.S.R. is a land where irrigation works of immense magnitude are undertaken. Among the recent works are works of stupendous magnitude. These are (1) the Stalingrad Reservoir, with a water spread as long as the length of Ceylon and capable of irrigating an area nearly three times as large as Ceylon (actually 45 million acres); (2) the Kara-Kum Canal, 812 miles in length (250 miles completed) to irrigate an area more than half the area of Ceylon (actually 10½ million acres). Generally all
expenses of construction of these works are borne by the State, but those who receive water from these schemes pay a rate for the quantity of water; the actual rate works out to a minimum of approximately one (say) Kopeckă per cubic meter, i.e., about Rs. 10/- per acre foot.

**United States of America**

Many recent projects, irrigating extents of a million acres each, have been undertaken in the U.S.A. The U.S. Bureau of Reclamation has built over 150 large-scale storage dams.

Among the foremost irrigation works are the Hoover Dam in the Colorado River Basin, a structure 726 feet high, the 550 feet high Grand Coulee Dam to irrigate one million acres, the Shasta Dam, 602 feet high and several such others.

All costs expended on the projects are reimbursable and the rates levied on water consumed provide for every item of expenditure.

To summarise: only in some countries is the capital cost investment in irrigation projects recovered; most of the countries actually do recover cost of maintenance; we have also certain other countries where this activity is considered a national service and any recovery is indirect, i.e., by way of land tax.

"Selling Water" or charging by the amount of water consumed is adopted in countries where there is extensive new development.

In Ceylon, a case cannot be made out for the adoption of charging for amount of water issued, although, visiting foreign economists have advocated such.

But there certainly is a strong case for the recovery of the total cost of maintenance and operation of each Major Work Scheme.

**Economic Evaluation—Benefit/Cost, Studies**

Economic of water resources development is a sequence of modern thought. Doubtless economical conditions did weigh in final decision from time immemorial, ever since man attempted water conservation. The subject, however, has of late crystallised into a rational concept.

The beginnings of computable considerations of the benefits of water resources projects may well be said to have originated from the requirement in the U.S.A. of their Flood Control Act of 1936, which stipulated the principle that the acceptence of a project proposal by Government would depend "... if the benefits to whomsoever they may accrue are in excess of the estimated costs, and if the lives and social security of people are otherwise adversely affected".
Since 1936, numerous books and many articles in professional journals have appeared on the subject of economics of water resource development; most of them are from American sources. Elaborate procedures have since been adopted for the economic analysis of water resource projects, before such project proposals pass through the four stages of—

1. Feasibility studies;
2. Project formulation;
3. Detail design and finally
4. Construction.

Are the benefits of the project to the community more than the cost of the work—in what ratio? Thus cost—benefit ratio evaluation becomes fundamental for the successful launching of a development project.

The deduction of its value or its evaluation depends entirely on the data assumed and used in the derivation of its value.

This benefit/cost ratio has become now the yardstick of measurement of any development proposal. It is the decision making tool and certainly serves its purpose in the technique of economic analysis of water resources development.

Considering a specific project where:

Area benefited, 2,000 acres of rice cultivation and 1,000 acres of vegetables and other garden crops.

Construction cost of the project, Rs. 5 m.

1. Benefits

*Rice Production*—Extent 2,000 acres.

(Assumption a) Average yield 50 bushels/acre/crop.

(Assumption b) Two cultivations are possible every year.

.: annual production $2,000 \times 100$ bushels.

(Assumption c) Value of the rice produced at Rs. 6/40 per bushel.

.: Total value of the rice produced

\[= 200,000 \times 6.40\]

\[= Rs. 1.28 \text{ m.}\]

*Vegetable Production*

(Assumption d) Estimated value of vegetable and garden crop produced per acre per year Rs. 1,200/-

.: Total value (vegetable crop) Rs. 1.2 m.

Hence total benefit that accrues to the community as a result of the project is

\[Rs. 1.28 + Rs. 1.2 = Rs. 2.48 \text{ m.}\]
II. Costs

*Rice Production*

*(Assumption d)* Cost of rice cultivation assumed as Rs. 200/- per acre, each cultivation.

\[ \therefore \text{Total cost } 200 \times 2,000 \times 2 = \text{Rs. } 0.8 \text{ m.} \]

*(Assumption f)* Cost of maintenance of the storage works, e.g., water rate, assumed as Rs. 10/- per acre per year.

\[ \therefore \text{Total maintenance cost } = \text{Rs. } 0.02 \text{ m.} \]

*Vegetable Production*

*(Assumption g)* Cost of vegetable cultivation assumed as Rs. 750/- per acre per year.

\[ \therefore \text{Total cost of vegetable production } 1,000 \times 750. \]

*(Assumption h)* Cost of maintenance, water rate, etc. as before Rs. 10/-.

\[ \therefore \text{Total } 1,000 \times 10 = \text{Rs. } 0.01 \text{ m.} \]

\[ \therefore \text{Total cost of production of rice and vegetable } = \text{Rs. } 1.58 \text{ m.} \]

III. Investment and Repayment of Investment

Estimated capital cost of construction of the project = Rs. 5 m. (by loan).

*(Assumption i)* If this amount is presumed to become necessary for expenditure with the progress in construction, at Rs. 1 m. per year, for a total of five years, then interest at 6% becomes due, as each part of the loan is secured, hence:

<table>
<thead>
<tr>
<th>Amount Secured</th>
<th>Principal and Compound interest payable (6%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Year</td>
<td>Rs. 1 m.</td>
</tr>
<tr>
<td>2nd Year</td>
<td>Rs. 1 m.</td>
</tr>
<tr>
<td>3rd Year</td>
<td>Rs. 1 m.</td>
</tr>
<tr>
<td>4th Year</td>
<td>Rs. 1 m.</td>
</tr>
<tr>
<td>5th Year</td>
<td>Rs. 1 m.</td>
</tr>
</tbody>
</table>

\[ \text{Rs. } 5.975 \text{ m.} \]
(Assumption f) If repayment be spread over a period of 25 years, then the uniform annual amount of repayment, often termed the amortization (or sinking fund depreciation) is obtained, as shown in the appendix.

The annual amount of repayment of capital and interest works out to Rs. 5.975 x 0.07823
Working out to actually Rs. 467,439.

Total cost per year of the project being sum of the cost of production plus amount of repayment — Rs.1.58 + Rs. 0.47 = Rs. 2.05.

Conclusion
From above, we get:
Total benefit per year from A above = Rs. 2.48 m.
Total cost per year = Rs. 2.05 m.
Total Benefit/Cost Ratio = 2.48
                         2.05 = 1.21

To proceed now to go over the process of derivation of the Benefit/Cost ratio, as above, it would be noted that as many as ten assumptions were presumed at various stages of the evaluation. It is, therefore, of fundamental importance to ascertain the values of these assumptions before any attempt is made to assess the value of a project from the financial ratio itself; if the computer and the reader be used to different values of these assumptions naturally, the basis of the whole computation gets altered. The ill remarks that are often made against this Benefit/Cost computation, that it can be "altered to suit" is because of different values assumed.

Now to scrutinize each assumption, for conditions in Ceylon in general, and to irrigation development projects in Ceylon in particular:

Assumption (a)
Average yield of rice in bushels per acre per crop
It would vary from country to country and even in Ceylon it is different in different parts of the country and it certainly is not the same for a maha crop as for a yala crop. Also, with the adoption of improved methods of cultivation, it would increase from year to year.

Hence the necessity for an accepted standard figure, which all would agree for the project under consideration.
Assumption (b)

How many cultivations will be possible per year

In Ceylon, maha cultivation is generally always possible everywhere. For yala, there is always a restricted cultivation. But in areas of S.W. Monsoonal benefit, a full yala is obtainable. Hence the assumption here has to vary with the locations.

Assumption (c)

Value of the Rice Produced

A reasonable figure has to be standardised and every one to agree to use that figure, although the actual cost may vary if the producer be himself a cultivator or otherwise, etc. etc.

Value now conventionally accepted is Rs. 6/40 per bushel.

Assumption (d)

Value of Vegetable and Garden Crop

Remarks as in above.

A figure of Rs. 1,200/- per acre per year has been used.

Assumption (e)

Cost of Rice Cultivation

A reasonable figure has to be agreed upon by all comptors as standard.

A figure of Rs. 200/- per acre per crop has been generally used and may therefore be accepted as standard value.

Assumption (f)

Maintenance cost would include water rate and maintenance of field channels, etc.

A figure of Rs. 10/- per acre per year is generally used as standard.

Assumption (g)  }  Comments as above.

Assumption (h)  }

Assumption (i)

A rate of 6% for Foreign Loans is a generally accepted standard we can, however, reduce the rate of interest for loans raised locally. This figure has to be standardized—say 4%—?

Assumption (j)

Period of useful life of the project

This would obviously vary with the nature of the project to be launched. An irrigation development work could easily last for years.

A period of 40 years has however been known to be used.
APPENDIX

Derivation of Formulae and Factors used in Benefit/Cost Computations

In these evaluations, the conversion of future benefits and costs to a common time basis forms the fundamental stage in the computation.

The present worth \( P \) of a series of equal annual amounts \( A \) payable at the end of each year for \( n \) years at rate of interest \( r \) is

\[
P = A \left[ \frac{(1+r)^n - 1}{r (1+r)^n} \right] \tag{0}
\]

For the derivation of the above formula, we have the relationship between Principal, and sum due at the end of \( n \) years at interest \( r \) per cent. (compound interest),

\[
S = P (1 + r)^n \tag{1}
\]

When \( S \) is the sum of money due at the end of \( n \) years, when present worth \( P \) is invested at \( r \) rate of interest.

i.e. \( P = S \left[ \frac{1}{(1+r)^n} \right] \tag{2} \)

Now, if an equal amount \( A \) be invested at the end of each year for \( n \) years, the total amount at the end of \( n \) years, will be the sum of the compounded amount of each investment

i.e. \[ S = A(1 + r)^n - 1 + A(1 + r)^{n-2} + \ldots + A(1 + r) + A \]

or \( S = A[(1 + r) + (1 + r)^2 + \ldots + (1 + r)^n] \]

\[
\text{by subtractions}
\]

\[ rS = A(1 + r)^n - 1 \]

by substitution for \( S \) in (2),

\[
P = \frac{A}{r} \left[ \frac{(1+r)^n - 1}{(1+r)^n} \right] \times \frac{1}{(1+r)^n} = A \left[ \frac{(1+r)^n - 1}{r (1+r)^n} \right]
\]

which is equation (0)

also conversely \( A = P \left[ \frac{r(1+r)^n}{(1+r)^n - 1} \right] \tag{3} \)

The expression \( \frac{r(1+r)^n}{(1+r)^n - 1} \) is called the

*Capital recovery factor.*
That is, the amortization is obtained by multiplying the Principal by the Capital recovery factor.

Ready reckoners have been prepared where the values of the factor are shown for different values of (r) rate of interest and (n) number of years.

<table>
<thead>
<tr>
<th>No. of Years (n)</th>
<th>Value of Capital Recovery Factor when (r) rate of interest is:</th>
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<tr>
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