INDICATORS FOR IRRIGATION PERFORMANCE ASSESSMENT

INDIAN NATIONAL COMMITTEE ON IRRIGATION AND DRAINAGE

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FOREWORD

The rapid expansion of irrigation facilities through construction of a number of major, medium and minor irrigation projects, since the beginning of the planned era of development has played a major role in increasing food production to meet the needs of the growing population of the country. The need for performance evaluation studies of the completed projects is being increasingly felt since past few years for improving the overall efficiency of the projects. The main objective of evaluation studies is to find out how far the project has achieved the planned goals and if not what are the reasons/bottlenecks in not achieving the targeted benefits. Efficient and equitable distribution of water is an important requirement for proper management of an irrigation project and poor management of project would lead to low yields and thus reduce the economic benefits. Evaluation of the performance of a system as a whole or its components will help in improving the operation and management of the project. Because of the large gap of about 10 m ha between potential created and utilised, it is imperative that performance of projects is improved and to achieve this goal, their evaluation is essential. Performance evaluation of an irrigation system is a stock taking exercise to assess the achievements of the system against the planned objectives. The evaluation will bring out in focus apart from the benefits, the deficiencies in project planning and implementation. Thus it will help to improve the techniques of project formulation and also to optimise the performance of the irrigation projects. For evaluation it is necessary that prescribed set of indicators is available for guidance to determine the performance of different components/aspects of the project. As such the present report would prove very useful to all concerned in this work.

Keeping this in view the INCID sub-committee on Irrigation Performance Assessment, History, Education Training and R&D has prepared the "Indicators for Irrigation Performance Assessment". Earlier, the INCID Committee on Irrigation Performance Assessment (set up in 1990) had prepared a draft on "Indicators for Irrigation Performance Assessment". This was reviewed by the present Sub-Committee and after comments from various members and discussions the present report has been prepared. The report broadly gives the distinct aspects and studies required to be carried out to judge the performance of the irrigation systems. The indicators are evolved keeping the Indian perspective in view. The Committee decided that these should be widely circulated for guidance. These are only indicative and not exhaustive.

It is felt that the report would prove useful to all those concerned with the irrigation and water resources development in general. Suggestions for its improvement/ further additions etc required, are most welcome.

The efforts put in by the Consultants officers and staff of INCID in bringing out this publication are appreciated. Special thanks are due to the Chairman & Managing Director, WAPCOS (India) Ltd. for his support to INCID and providing all infrastructure facilities to INCID Secretariat in publishing this report.

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CONTENTS

		PAGES
	Foreword	
1.	Aspects of Irrigation Performance Assessment	1
2.	Indices of Technical Performance	1
3.	Indices of Economic Performance	3
4.	Indices of Management Performance	6
5.	Indices of Environmental & Ecological Performance	8
6.	Indices of Social Performance	8
7.	Additional indices for Minor Irrigation Works	10
	References	

INDICATORS FOR IRRIGATION PERFORMANCE ASSESSMENT

1. Aspects of Irrigation Performance Assessment :

Performance of Irrigation system has to be assessed with reference to the original planning of the system. There are 5 distinct aspects of irrigation system to judge its performance. These are :-

i) Technical
ii) Economic
iii) Management
iv) Environmental & Ecological
v) Social

Under the technical aspects the issues to be considered are the planned runoff and actual availability and planned utilization vis-a-vis delivery of water in the system; the estimated evaporation losses from the system and the actual losses; the recharge of underground water and the efficiency of conveyance., separately for the main canal, branch canal, distributaries, minors and water courses and also the responsiveness of the system to sudden changes in demand, the water application efficiency on the farms and the agricultural production both in terms of crop yield and the biomass.

The issues to be considered under the economic aspects are assumptions/assessment made in the original sanctioned project and the actual achievements. Income per unit of water supplied from the system and additional income due to diversification of cropping pattern, as also change in varieties of crops will need to be considered.

While assessing the performance of management of the irrigation system the farmer-managed system and the Government managed system will have to be dealt separately. The issues to be considered will be the management cost per hectare of irrigated crop, equity in allocation of water as well as equity in distribution.

Under the environmental and ecological aspects, damage to land, forest and the displacement of population alongwith water quality and the positive impacts on environment due to the project would be considered.

The most important issue to be considered under the social aspect would be equity in water supplied followed by harmony in the operation of the system.

The indicators which need to be considered for each of these aspects are separately described below .

2. Indices of Technical performance :

i) Yield Index

At any given irrigation source of water, hydrological yield series are established for assessing the availability of water. The yield is expressed in terms of dependability at 95%, 90%, 75%, 50% etc. The actual yield of water at the project site may be different.

$$\text{Yield Index} = \frac{\text{Actual yield}}{\text{Estimated yield while formulating project}}$$

(at the same dependability).

ii) **Index of Availability**

The availability of water can be raised by increasing the capacity of reservoirs.

$$\text{Index of availability} = \frac{\text{Actual availability of water}}{\text{Estimated availability of water while formulating project}}$$

(at the same dependability)

Where the availability is less it can also be expressed in terms of the same water being available at a lower dependability.

iii) **Evaporation Index**

At the time of project planning certain quantum of water is estimated to be lost through evaporation. After completion of the project, actual withdrawal data and evaporation data are available. As such index of evaporation could be expressed as follows.

$$\text{Index of Evaporation} = \frac{\text{Actual evaporation}}{\text{Estimated evaporation}}$$

This index will be worked out as a moving average over a period of 10 years.

iv) **Ground Water Recharge Index**

When the irrigation system is designed, a certain amount of water is expected to infiltrate into the ground. This infiltration, recharges the groundwater. The ground water recharge index can be expressed as increase in the availability of ground water expressed as a percentage of the increase as estimated in the project. In cases, where no such estimate was made in the project, this increase in availability of ground water may be added while working out the Index of availability.

$$\text{Ground water Recharge Index} = \frac{\text{Actual increase in availability of ground water}}{\text{Estimated increase in ground water.}}$$

In Deccan areas where the ground strata is heterogeneous, it is very difficult to estimate the increase in ground water availability after commissioning of the project. Therefore, this will have to be estimated in an indirect way e.g Number of wells before and after irrigation, density of wells, (i.e well per unit area), area irrigated from wells before and after irrigation.

Change in water table depth over a period of time by periodic depth measurement of water table may also be indicated.

v) **Conveyance Efficiency :**
Conveyance efficiency of a channel is the amount of water delivered at the head of the offtaking channels expressed as a percentage of the quantity of water released at the head of the channel. Conveyance efficiency will be separately displayed for (a) Main Canal, (b) Branch Canal (c) Distributary (d) Minor & (e) Water course

vi) **Field Application Efficiency :**
Field application efficiency is the amount of water used by evapotranspiration by an irrigated crop in a field expressed as a percentage of the amount of water delivered at the field head.
or

Root Zone Storage efficiency is the amount of water delivered, to the amount of root zone deficit before irrigation.

vii) **Index of Loss of Live Storage :**
This can be considered as a ratio of available live storage at the performance assessment stage to the live storage which was available at the time of the commencement of irrigation from the completed project.

$$\textit{Loss of Live Storage Index} = \frac{\textit{Available live storage}}{\textit{Storage available at the commencement of project}}$$

3. Indices of Economic Performance :

3.1 Benefit Cost Ratio (B.C Ratio).

A) Estimation of annual benefits.
Annual benefits shall be computed as under :

a) Agricultural production in the area to be irrigated under pre-project conditions.

b) Agricultural production in the area irrigated after completion of the Irrigation Project.

Note : Yield/ha and the prices to be used for converting the benefits into monetary terms shall be obtained from the State Department of Agriculture. The Department of Agriculture shall also furnish the basis for recommending the cropwise yield/ha under pre & post project conditions and prices to be used.

B) Estimation of annual cost.
Annual cost shall consist of the following.

a) Interest at the rate of 10 percent on the estimated cost of the project including the cost of land development.

b) Operation and maintenance cost at prevailing rate per ha of the Gross Irrigated Area or Culturable Command Area, whichever is more.

c) Depreciation of the project based on the assumed life of the project e.g. 1 per cent of the total cost (excluding land development) for 100 year life of the project.

d) Maintenance of the Headworks at 1 percent of its cost.

e) For lift canal :

i) Depreciation of pumping system and rising mains at 8.33 percent of its cost.

ii) Charge of power at prevailing rates.

C) **Benefit Cost Ratio = $\frac{\text{Annual Benefits}}{\text{Annual Costs}}$**

3.2 Economic Rate of Return

Economic viability of the project is to be examined by using time discounted cash flow analysis. Cash flow analysis comprises of (A) Cost Analysis and B) Net Benefit Analysis and C) Comparison of these two.

A) Cost Analysis :

a) Cost

Cost in this analysis should include i) Capital investment viz. Cost of dam and appurtenant works ii) Cost of canal and distribution system inclusive of Part –I works, iii) Cost of resettlement, if any iv) Physical contingencies, ETP charges etc. However, these costs should not include i) Cost of land acquisition of both dam, canal and distribution system and ii) Price escalation.

b) Land Development (Part-II works)

These works are generally executed through institutional finance and as such do not form part of the estimate. However, for analysis purpose it is required to be considered.

c) O&M Charges

Prevailing rate of O&M charges per unit area of CCA should be considered. It is necessary to know the rates on which the project estimates are based. Since the net benefit figure for various crops are available for a particular year, it is necessary to either base the estimate on the rates of that year or to convert these costs to the reference year with the help of (a) wholesale price index and (b) consumer price index for agriculture labour. Further financial cost of construction is to be converted to economic cost by the use of standard conversion factors. The cost of the land development can be estimated on the basis of land slope, classification of the project command area and prevailing norms for land development.

Further it is necessary to know the detailed implementation schedule of the project to complete all the major works (including field channels, field drains etc) As regards land development it should be started when distributory network is nearing completion.

Thus linear transition required to bring all the projected area under irrigation should be accounted and O&M charges required will have to be worked out accordingly.

B) Benefit Analysis.

Net Benefits

It is necessary to assess the net additional benefits due to increase in agriculture produce after introduction of irrigation. The three different conditions viz i) Present rainfed crop net returns, ii) Future without project crop net returns and iii) Future with project crop net returns should be considered to assess the net additional benefits.

i) Present rainfed crop net returns :

This represents the present level of agricultural productivity under rainfed conditions before introduction of irrigation and pre project crop pattern.

ii) Future without project crop net returns :

This represents the future increased level of agricultural productivity under rainfed condition
due to advancement of agricultural technology and rainfed crop pattern.

iii) Future with project crop net return :

This represents the future projected level of agricultural productivity under irrigation coupled with advancement of agricultural technology and post project irrigated crop pattern.

The individual crop budgets for various common crops for each of these conditions are required to be developed. On the basis of this, net benefits for each of the above cases are to be calculated. Further, it is necessary to assess the loss of benefits due to lands going under submergence, dam seat, canal and distribution system etc. on the basis of crop-pattern prevailing in that area for different conditions viz. (i) & (ii) above.

Estimates of net benefits should take full account of transition periods involved in land and irrigation development and in the development of projected levels of agricultural productivity.

On the basis of above a stream of annual net benefits is developed for (i) Future with project condition and (ii) Future without project condition. Future with project benefits are required to be corrected on the basis of reservoir operation studies for historic period. Average area irrigated as per operation studies need to considered. The stream of net annual benefits is to be developed by deducting future without project and corresponding O&M charges from future with project benefits.

C) Economic Rate of Return (ERR).

It is defined as rate of discounting at which discounted stream of construction costs is equal to discounted stream of net benefits i.e. B.C. ratio is 1.

For calculating the ERR, the discounting rate should be taken as 10% for drought prone and tribal area and 12% for normal areas in the first instance. If B.C. ratio with this discounting is more than 1, the ERR is more than 10 to 12 percent as the case may be. For exact ERR a higher rate of discounting should be adopted such that B.C. ratio is less than 1 and assuming a linear relation, exact ERR should be calculated.

3.3 Water Productivity Index can be expressed in terms of kg of crop produced per 10,000 cubic meters (hecare-metre) of water supplied at the farm gate (rainfall and of ground water contribution should also be considered).

3.4 Land Productivity Index can be expressed in terms of kg of crop produced per hectare of land irrigated.

3.5 Biomass Index is the production of bio-mass (dry matter) in terms of Kg per hectare of irrigated land as well as in terms of kg per hectare-metre of irrigation water.

4. Indices of Management Performance :

i) Management Cost Index

This is the cost of management of irrigation system per hectare of irrigated crop area converted to standard crop equivalent (major crop of the region).

ii) Equity Index (Allocation)

Equity in allocation of water is defined by the quantum of water allocated to different beneficiaries in relation to the quantum of water to be supplied as per planning of the project. Equity can be defined in terms of a percentage of beneficiaries allocated with their due share of water as compared to the total number of beneficiaries.

Just as there has to be equity in allocation, there has to be equity in distribution also. Equity ratio is the share of water received by beneficiaries in relation to the share planned in the project. Equity index (distribution) can be defined as the number of beneficiaries getting their due share as a percentage of the total number of beneficiaries.

Equity can also be expressed in terms of intensity of irrigation in a given area expressed as a percentage of the overall intensity of irrigation in the project command. For example, if intensity of irrigation in the head reaches, middle reaches and tail reaches is more or less same, then it can be said that there is a high degree of equity in the system. Similarly if the incremental productivity of irrigated crop in the head reaches, middle reaches and tail reaches is of the same level then also it can be said that there is equity in distribution.

Parameters will be separately expressed for farmer managed system and Government managed systems, Farmer managed system are those where either the entire irrigation system or at least a certain significant part of the command is managed by the farmers. In such cases, the Government takes only the responsibility of supplying prescribed volume of water as per prescribed schedule at the head of a channel and the management of irrigation below that point is carried out by the beneficiary farmers. In a Government managed system the water is conveyed by the Government right upto the outlet or even upto the farm gate.

iii) Reliability of Allocation Index

This can be expressed with reference to time and frequency as follows.

a) Time

The irrigation supply may be considered as reliable if it is made within 5-7 days for heavy soils, and 2-3 days for light soils, of the approved scheduled date .

b) Frequency

The ratio of the number of actual waterings during a crop period to the approved number of watering expressed as a percentage may be taken as an Index, provided the minimum number of watering is enough to bring the crop to maturity.

iv) Response Index

Response Index from beneficiaries can be expressed as the degree of participation of beneficiaries to irrigation. It can be expressed as a percentage of the number of beneficiaries demanding irrigation water to the total number of beneficiaries.

v) Recovery Performance Index

The recovery of irrigation water charges in some States is not with Water Resources or Irrigation Department. However in most of the States it is done by Revenue Department and Irrigation or Water Resources Department do not have full information on the same. As such information in this regard will need to be collected/obtained from the respective Departments of State Govt., Recovery Performance Indicator is computed on the basis of actual recovery of water charges to targeted recovery

$$\text{Recovery Performance Index} = \frac{\text{Actual recovery of water charges}}{\text{Targeted recovery}}$$

vi) Reliability Discharge Index

Discharge carrying capacity of the canal is always a problem in most of the irrigation project. This is related to construction as well as maintenance, which results in poor performance of irrigation projects. Therefore, an indicator like reliability of the discharge can be indicated as given below :

$$\text{Reliability of Discharge Index} = \frac{\text{Actual carrying capacity of the channel}}{\text{Designed or targeted carrying capacity of the Channel}}$$

Index for reliability of discharge may be computed separately for main canal/branch canals and for small distributories/minors etc.

vii) Adequacy Index

Irrigation projects are designed to make available certain level of irrigation water. Therefore, adequacy of supply is very important, Hence the indicator of adequacy can be indicated as given below

$$\text{Adequacy Index} = \frac{\text{Actual volume of water delivered (say at farm level)}}{\text{Intended volume of water to be delivered.}}$$

viii) **Area Performance Index**

Area performance indicator is a good indicator to assess the performance of irrigation system. Experience shows that the actual cropping pattern developed in the project area is different from what has been considered during project design. Moreover, it is dynamic; hence to assess performance of irrigation project in terms of area irrigated, the concept of crop equivalence adopted in Maharashtra will be a useful guide in this case. This indicator can be indicated as given below

$$\text{Area Performance Index} = \frac{\text{Actual total area irrigated (equivalent)}}{\text{Total area contemplated for irrigation (equivalent)}}$$

ix) **Effectiveness of Control Structure Index**

For proper operation, effective use of control structures like head regulator, cross regulator, outlets, measuring devices, etc is necessary. In order to use them effectively they must be maintained properly. Therefore, in order to evaluate their maintenance performance, following indicator could be considered.

$$\text{Effectiveness of Control Structures Index} = \frac{\text{No. of control structures functioning}}{\text{Total No. of control structures}}$$

5. Indices of Environmental & Ecological Performance :

i) Land Damage Index can be worked out as the ratio of land unfit for cultivation to the Cultural Command Area (CCA).

ii) The factors such as submergence of land and forest, displacement of population are one time occurrence and hence one time evaluation may be done. For this, actual may be compared with the assumed figures.

iii) For determining changes in water quality viz salinity in mmhos/cm biological changes in mg./litre & chemical changes in mg./litre, data on electrical conductivity, biological and chemical load of periodically collected irrigation and drainage water samples will have to be analysed.

iv) The positive impacts on environment due to the project by comparing with & without project conditions may also be indicated. The likely impacts could be assured and regulated water supply in the downstream, development/increase of new forests, green belt, new settlement & township, development of transport & communication facilities, climatic changes, development of pissiculture, recreation & tourism facilities etc etc.

6. Indices of Social Performance :

The two important parameters relate to equity and conflict resolution

i) Equity Index is already expressed under "The Management of Irrigation".

ii) Conflict Resolution or harmony, is difficult to express in quantitative terms. This can be considered as the number of complaints received by the management authority (either the government officer or the water user associations) compared to the number of beneficiaries in the entire command.

If the number of complaints is negligible in comparison with the total number of beneficiaries in the command area it can be considered that the system is having a high degree of harmony.

Farmers Participation Index or achievement of PIM (Participatory Irrigation Management) may be indicated as follows :

$$\text{Farmers Participation Index} = \frac{\text{Area covered under WUA (Water Users Association)}}{\text{Total Area Irrigated}}$$

or

$$\text{Farmers Participation Index} = \frac{\text{No. of WUA's made Functional}}{\text{Target of Formation of Associations}}$$

Further, following socio-economic parameters need to be evaluated;

i) Income, consumption and savings be studied for both pre and post and with and without situations.

- Farm income - Gross, net and per capita
- Non farm income - Gross, net and per capita
- Consumption and savings per capita
- Agricultural Assets creation.
- Poverty alleviation- increase in standard of living (modern- gadgets, electricity etc.)

ii) Both pre/post & with/without approaches be adopted in analysing farm employment.

- Change in level of farm employment in general
- Gender-wise comparative effect on farm employment
- Social-strata based comparative effect on farm employment
- Family and hired labour rates in farm employment
- Migration of labour.

iii) Non-farm employment.
Non-farm employment also be studied for both pre and post and with/without scenarios.

- Non-farm employment/activities (Male-female)
- Percentage in total employment

iv) Infrastructural and institutional facilities.
Changes where required to be studied for pre and post project.
Scenario

- Electrification
- Transport and communication

- Marketing and Banking Institutes
- Postal services

v) Demographic Impacts

Demographic changes be done for pre and post periods as follows

- Percentage distribution by sex and age groups
- Urban and rural population.
- Percentage of Scheduled Caste/Scheduled Tribe in total
- Migration- (rural/urban), (urban/rural)

vi) Literacy

Literacy rates should be studied for analysing the difference over time viz.

- Percentage literacy
- Literacy by sex
- Literacy by social status.

vii) Health care and family planning.

The health and family planning should be studied for pre and project period as follows.

- Effective couple protection rate-percentage
- Number of doctors/nursing personnel per thousand population
- Immunization against major diseases
- Health care infrastructure

7. Additional Indicators for minor irrigation works :

For minor irrigation works the following additional parameters also need to be studied, alongwith other parameters already indicated in earlier paragraphs.

i) Statewise statistics in regard to achievement of potential and utilization from ground water exploitation programme i.e. Government tubewells, private tubewells, dug wells etc.

ii) Evaluation/assessment of benefits vis-a-vis targets relating to area served by irrigation wells, failure rates of wells, their yield, cost etc.

iii) Effect of ground water depletion adversely affecting private dug wells.

iv) Impact of supplemental irrigation from ground water over the field formerly irrigated only from surface water sources.

v) Impact of ground water extraction in keeping under check the trend (if any) of rising water table in surface water irrigated area.

vi) The role of percolation ponds used for storage of water for recharge of ground water in the surrounding area through infiltration and percolation process.

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