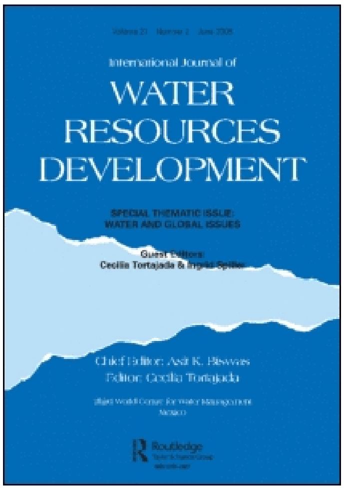

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Asit K. Biswas

Monitoring and Evaluation of an Irrigation System

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Abstract

Monitoring and evaluation of irrigation projects has been a neglected subject in the past. While some lip service has been given to this subject, with few exceptions, it has received very little attention or consideration as a part of the overall management process for the projects. It is argued that without a continuing and effective monitoring and evaluation system, it is unlikely that the project benefits can be achieved or they will be optimal. A comprehensive monitoring and evaluation system is recommended for irrigation projects at four interrelated levels: planning, design and construction of physical facilities; operation and maintenance of irrigation and drainage facilities; agricultural production and achievement of socio-economic objectives.

Introduction

THE objectives of water resources development, a major purpose of which — especially in developing countries — is irrigation, have drastically changed over the past two decades. Broadly speaking, such changes can be attributed to the increasing awareness of planners and decision-makers to social needs and goals. Historically, the main objective of water development has been economic efficiency, and the technique used for its evaluation has been benefit-cost analysis. The concept was that benefits, to whomsoever they may accrue, should exceed costs.

Gradually to this single objective of economic efficiency other objectives have been added. In the early sixties, a second objective was accepted: regional income distribution. Two more were added during the late sixties: environmental quality and social well-being. Inclusion of the last two objectives was a belated recognition by the water resources planners of the facts that the welfare of society has other dimensions beside economics, and that social-political elements, even though they may be intangible and thus non-quantifiable, need to be considered within the decision-making framework.

By the mid-seventies, however, most water resources planners had dropped the social well-being objective, at least explicitly, primarily becuse they were unable to incorporate it meaningfully within the planning process. It was argued that to some extent social well-being was an integral part of economic efficiency, regional income distribution and environmental quality objectives, and thus some significant parts of this objective were already automatically incorporated in the planning process. While there is some truth to this argument, there are some important aspects of social well-being which have not been traditionally considered for water development projects. One major lacuna is the fact that very little rigorous analysis is carried out at present on the nature of the beneficiaries in contrast to the nature of the benefits. Thus, generally insufficient and unreliable information is available on who will receive the benefits stemming from the projects. For example, policy-makers receive very little concrete information as to whether the benefits will accrue primarily to the rich landowners in the project area or if the small farmers and landless labourers will benefit significantly from the development as well. While much lip service is given to the nature of the beneficiaries in the analyses of some water projects at present, a rigorous review of the water projects that are currently being planned or are under development will clearly indicate the superficiality of most of such analyses.[1]

Generally, as a rule, analyses for the objective of economic efficiency is more rigorous than analyses for regional income distribution or for environmental quality. It is not unusual to find the analyses for the last two objectives somewhat cursory or even non-existent.

Under the present circumstances, all water development projects invariably have to consider economic efficiency, before they can be officially approved. However, the general tendency has been to inflate the benefits and reduce the costs in order to get the necessary project approval. Ex-post economic evaluations of water projects, even in a developed country such as the United States, indicate that a vast number of them did not achieve a benefit-cost ratio of even 1:0, irrespective of what planners and proponents had estimated earlier. If developing countries are considered, one would indeed be hard pressed to identify an irrigation project that was completed within the initially estimated budget and time, and producing the anticipated stream of benefits.

There has been some intense disappointments with the results of certain irrigation projects undertaken during the past two decades. For example, a review of the irrigated agriculture projects in the Sahel by the Club du Sahel and CILSS (1980) concluded that the area under modern irrigation doubled during the period 1960 to 1979, but "generally speaking, during the past few years, the development of new areas has barely surpassed the surface (area) of older ones which had to be abandoned." A major conclusion of a workshop on "Aid to Irrigation", convened by the Development Assistance Committee of OECD (1983), was not only an expression of general dissatisfaction with the performance of large-scale irrigation projects in developing countries but also the radical suggestion that for some areas of Africa, "irrigation should not be generally promoted until existing schemes were shown to be productive and until well-tested technology and comprehensive plans have been prepared."

1. For an analysis of this situation, see Biswas (1971, 1973, 1976).

There have been other reasons for pessimism as well. Nearly half of the world's irrigated area is afflicted with some degree of salinity or alkalinity. It was estimated during the United Nations Water Conference, that by 1990, out of 92 million hectares of irrigated land in developing market economies of Africa, Asia and Latin America, 45 million hectares would require improvement at an estimated cost of more than 22,000 million US dollars at 1975 prices (Biswas, 1978). Irrigation projects generally do not appear to have contributed to equity. An analysis of the experience of the United States Agency for International Development (US AID) indicates that irrigation is "at best a re-affirmation of the existing social and economic distribution of assets, but more often, it will tend to exacerbate differences in both income and social prestige" (Steinberg, 1983). Often estimates of cropping patterns and intensities, average yields, farm prices, employment and income generation, and availability of credit and inputs such as pesticides, fertilizers and seeds, extension services and marketing facilities have turned out to be pious hopes rather than reality. In addition, environmental and health costs of irrigation projects have been substantial (Biswas, 1982).

On the positive side, it is an undeniable fact that timely, reliable and well-managed water supply and its effective use is a most crucial requirement for the modern high-yielding agricultural production. This is clearly indicated by the fact that even though only 20 per cent of the world's agricultural land is irrigated at present, they account for 40 per cent of the global agricultural production (IDRC, 1979). It is quite clear that without adequate water control, the world food problem cannot be resolved.

This state of affairs has a special interest for an organization like IFAD, whose clientele is clearly defined — rural poor. Not only was the objective of social well-being dropped nearly a decade ago, but also, as mentioned earlier, water development projects generally do not carry out analyses of the nature of beneficiaries. Projects do consider economic benefits "whomsoever they may accrue" but not who are going to receive these benefits, by how much and within what timeframe. Such a state of affairs is highly unsatisfactory for an organisation such as the International Fund for Agricultural Development (IFAD), since the impacts of irrigation projects funded are supposed to accrue primarily to the rural poor.

Theoretically and conceptually it should be possible to design and operate an irrigation project where much of the benefits accrue to the rural poor. This would require unconventional policy approaches which would favour small farmers over large. Because such a policy woud be revolutionary in the area of irrigation, it is likely to be resisted by vested interests and also by the general inertia of the existing situation. Thus, if IFAD is to meet its mandate successfully, it is not only essential that unconventional policy options be developed for irrigation, but also to monitor and evaluate the results regularly, to ensure that the project is effective in terms of optimum flow of benefits to the IFAD target groups.

Monitoring and evaluation of irrigation projects

Irrigation projects have thus generated both extreme optimism and pessimism, especially in recent years. Undoubtedly a major reason for the existence of such diametrically opposite views is due to the lack of effective monitoring and evaluation (M and E) of irrigation projects. M and E process has received much lip service during the past decade, but has seldom been carried out comprehensively on a continuing basis. The analysis of US AID's experiences in irrigation projects indicated that M and E activities of both donor and recipient countries have "come in for criticism from each group about its own organization and about the activities of its counterpart," and that "too little of it gets done by either group" (Steinberg, 1983).

In the context of the present discussion, monitoring is defined as "continuous or periodic surveillance over the implementation of an activity (and its various components) to ensure that input deliveries, work schedules, targetted outputs and other required action are proceeding according to the plan".[2] Since the purpose of monitoring is to achieve efficient and effective project performance, it is an integral part of the management information system and is an internal activity. Evaluation is defined as "a process which attempts to determine as systematically and objectively as possible the relevance, effectiveness and impact of activities in the light of their objectives. It is a learning and action-oriented management tool and an organization process for improving activites still in progress and future and planning, programming and decision-making."

It can be persuasively argued that because of the indifferent past performances of irrigation projects in achieving their stipulated objectives, it is absolutely essential that monitoring and evaluation become an integral part of the management process to ensure future stream of benefits occur to the right target group. It can be equally argued that one of the main reasons for the failure of irrigation projects to meet the approved objectives in the past is due to the lack of appropriate monitoring and evaluation, and the failure by the management to use monitoring and evaluation successfully as a management tool. Figure 1 outlines the operational aspects of the M and E system.

Monitoring and evaluation for irrigation projects have many requirements, the principal ones for most purposes are the following:

(i) timeliness;
(ii) cost-effectiveness;
(iii) maximum coverage;
(iv) minimum measurement error;
(v) minimum sampling error; and
(vi) bias-free.

These considerations are shown diagrammatically in Figure 2.

(i) Timeliness

Management decisions generally have a time dimension, and timeliness of certain decisions could be more important than others. Thus, M and E information needs to reach decision-makers on time so that the contents of the information supplied serves as a fundamental basis on which rational decisions can be made. In other words M and E information needs to be converted into action as shown in Figure 3. Management success depends not only on the timeliness of the information but also quality, extent and form of the information channelled into the decision-making process.A problem arises because even if required M and E information is available, it is often not channelled into the decision-making process since it is either in a diffused or inappropriate form or could not be obtained and analysed within the timeframe by which decisions have to be made (Biswas, 1976).

If M and E information from the project does not reach the decision-makers on

2. These definitions are extracted from a draft ACC report on monitoring and evaluation.

FIGURE 1: OPERATIONAL ASPECTS OF MONITORING AND EVALUATION SYSTEM

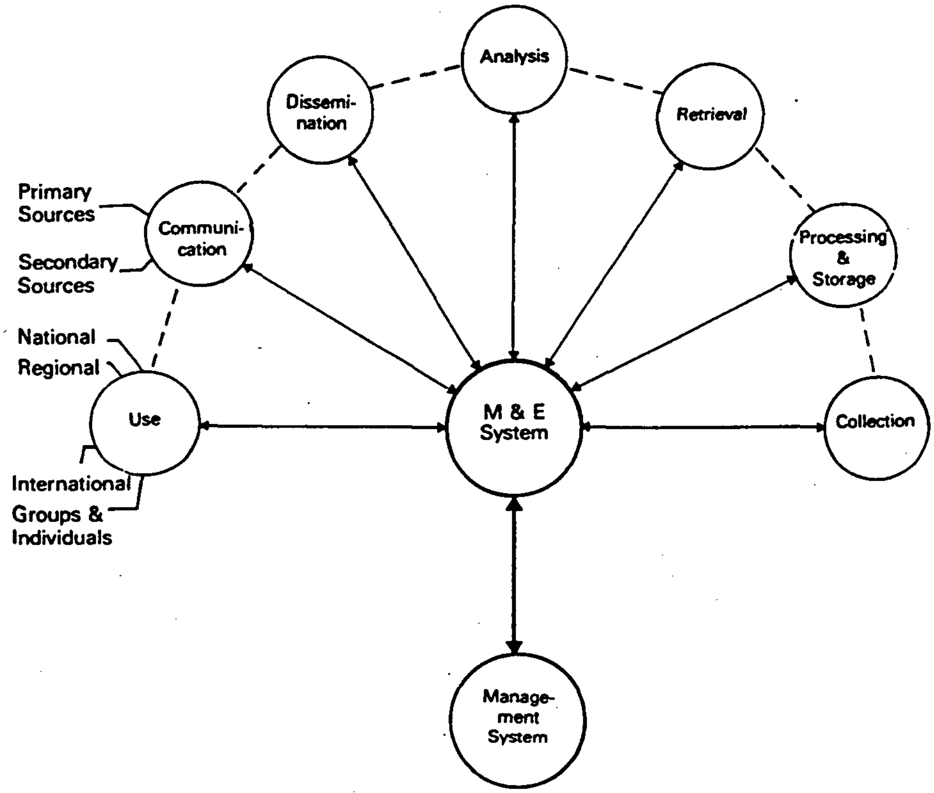


FIGURE 2: MAJOR REQUIREMENTS FOR MONITORING AND EVALUATION OF IRRIGATION PROJECTS

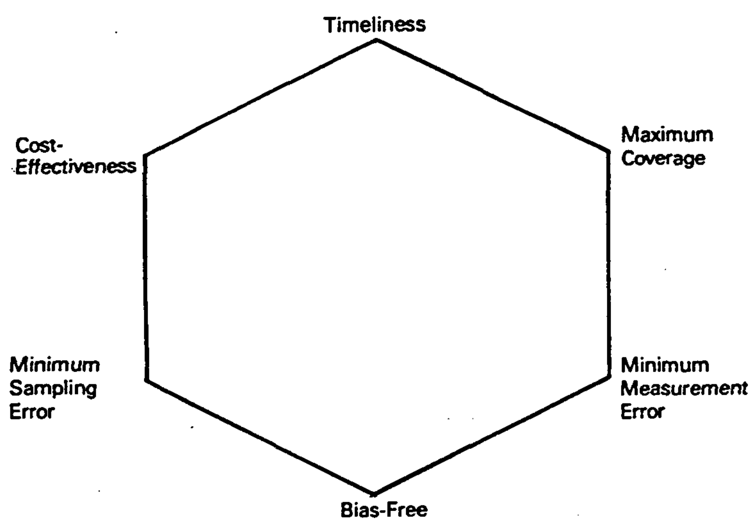
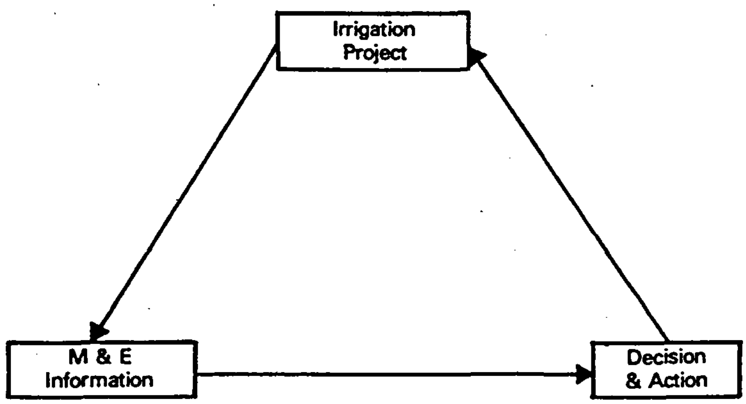


FIGURE 3: ROLE OF MONITORING AND EVALUATION WITHIN THE CONTEXT OF IRRIGATION PROJECTS



time, it is possible that one or more of the following consequences, which are not mutually exclusive, may occur:

- the wrong decision may be taken;
- the decision taken may not be optimal in terms of agreed objectives;
- no decision may be taken when one is essential;
- the decision taken may result in irreversible damages; or
- the decision taken may unnecessarily increase the cost of the project and/or time required for completion.

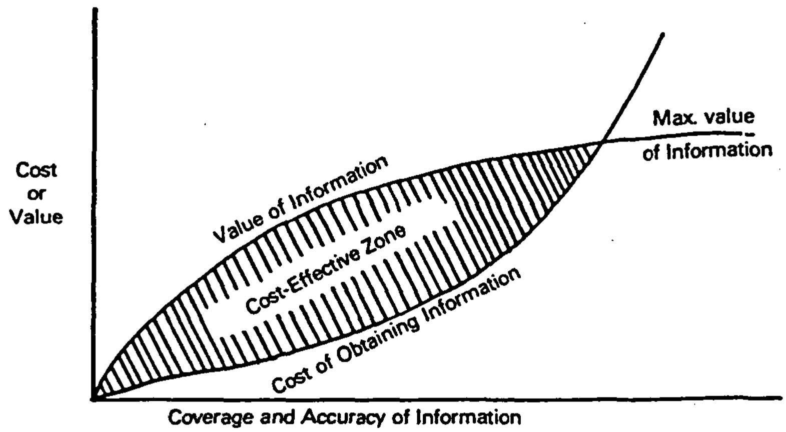
It is therefore essential that M and E information from the project should reach the people who need it on time and on a continuing basis.

(ii) Cost-effectiveness

Since financial resources, expertise, man-power and equipment available in developing countries are invariably limited, there is always pressure for the M and E system to be effective. This may essentially mean sensible trade-offs between the depth and context of information, as well as between amount, relevance and accuracy. Information collection, analysis and processing require time and money. Thus, as a general rule it should be remembered that the value of information collected should exceed the cost of obtaining that information.

For most projects, from a decision-making viewpoint and at any specific point in time, value of information generally increases with the increasing extent and the accuracy of information available. However, for most decisions, value of information generally approaches a plateau after a certan point, beyond which the value may increase only very, very marginally as shown in Figure 4. The cost of obtaining information, however, continues to increase wth increasing coverage and accuracy. Thus it can be argued that the shaded area in Figure 3 is the cost-effective zone, beyond which the cost of obtaining information will rapidly exceed its intrinsic value. Exactly where within the shaded area a decision has to be made will depend on the specific projects concerned, but the trade-off considerations will very often be a value judgement.

FIGURE 4: COST-EFFECTIVENESS OF MONITORING AND EVALUATION INFORMATION



Data collection for the sake of collection is an expensive luxury, even though such collection processes can be seen in many instances in both developed and developing countries. For a M and E process to be efficient and cost-effective, it is essential to know who is going to use the data, what types of data are necessary, for what purposes they will be used and when they should be available.

(iii) Maximum Coverage

For M and E of irrigation projects, especially large ones, a major difficulty arises from the fact that a wide area has to be considered both in terms of the human and animal population as well as the general environment. The problem becomes even more complex if the impacts of the projects of the IFAD target population are to be monitored, since rural poor would generally be scattered all over the area, and it may not be an easy task to reach them. Thus, maximum coverage may prove to be expensive, complex and time-consuming.

As a general rule, sociologists and anthropologists prefer to have maximum breadth of coverage possible. However, given high resource costs of manpower, time, transportation and other factors, as well as high opportunity costs, a decision may need to be taken to restrict coverage to some selected aspects which are essential for M and E, and then use the rest of the available resources to obtain more detailed and reliable data on specific aspects and areas. Thus, "maximum" coverage in this context means collection of maximum data that are relevant and necessary for the M and E of specific objective(s), subject to the constraints of resources available and the timeframe for reviews and decisions.

(iv) Minimum Sampling Error

Since it is generally neither possible nor desirable to monitor developments in the entire project universe, sample surveys are essential. M and E of irrigation projects will invariably cover not one issue but several, and it should be remembered that what may be considered a suitable sample size for one issue or discipline may be too large or too small for another. For example, for analyses of rainfall, one rain-gauge per square kilometre will be considered by hydrologists to be a very dense network, and not necessary unless for a very specific purpose, but similar sample sizes would be totally unacceptable to statisticians or sociologists. Thus, based on ultimate use of the information to be collected and practical consideration, sample sizes have to be decided carefully.

(v) Minimum Measurement Error

In contrast to anthropologists and sociologists who prefer maximum coverage, engineers and physical scientists are more concerned with the accuracy of measurements and data collected. A good M and E system naturally should have small sampling error and minimum measurement error. In any event, there is always a trade-off between coverage, sampling, and precision, and the final decision that has to be taken on all these aspects would have to be case specific.

For irrigation projects, and specifically for the IFAD target population, measurement error is a real problem for small farmers and landless labourers, who are often illiterate and thus may have considerable difficulty with explicit numerical quantifications. Accordingly, they may be somewhat vague or imprecise about changes, especially when they are of the order of 15 to 20 per cent. The enumerators and data collectors should be aware of this problem and ensure that modest changes are accurately reflected.

(vi) Bias-free

M and E of irrigation projects often suffer from biases, which stem from the general tendency to concentrate on some specific issues at the cost of other equally important issues. The biases commonly observed are concerned with the following:

- major structures and canals but not watercourses;
- head of watercourse but not tail;
- water entering watercourses but not losses;
- irrigation but not drainage;
- roads along canals and watercourses but not fields where access may not be easy
- or comfortable;
- visible structures but not people;
- contact with rural elite but not farmers;
- large farmers but not small;
- farmers but not landless labourers;
- man but not woman;
- project staff but not junior;
- users of services but not non-users;
- review during healthier, better-fed dry season when climate is pleasant but not during food-scarce, unhealthy and unpleasant wet season;
- emphasis on the visible but neglect of social relationships; and
- extrapolation of trends over the entire project area on the basis of a glimpse at one specific point and/or period in time.

There is also a tendency in irrigation projects which are multi-faceted, to introduce biases in terms of one's own discipline. Thus, M and E carried out by undisciplinary people often tend to emphasize areas that are of primary interest to them. The problem emphasis of different disciplines in the area of irrigation, and the standard solutions proposed could be the following (after Chambers, 1983).

Discipline	*Problem emphasis*	*Solution*
Administrators	Poor coordination	New organization with administrator as coordinator
Agricultural Economists	Agricultural prices and marketing	Improve marketing and prices
	Lack of credit	Provide credit
	Risks of production	Reduce risks
Agriculture Extensionists	Farmers unaware of good agricultural and water management practices	More extension service to farmers
Biologists	Inundation impacts on flora and fauna	Reduce impacts by changing scale or location
Economists	Inefficient water use	Water pricing
	Low return on capital and underutilization of potential	More investment
Engineers Agricultural	Poor land levelling	Level land
	Poor maintenance or lack of field channels	Improve situation
Engineers Civil	Inadequate structural development	Construct more/better structures
	Poor operation and maintenance (O & M)	Provide more funds for O & M
Engineers Drainage	Salinity and waterlogging	Construct comprehensive drainage system
Environmentalists	Too much damage to the environment and ecosystems	Stop construction or reduce scale of development
Lawyers	Central-Provincial relations or international implications	Resolve potential legal problems
Political Scientists	Inequitable distribution of agricultural production and water	Change power structure
Sociologists	Inequity and conflict over agricultural production and water distribution	People's participation and conflict resolution
	Rehabilitation of displaced people	Preparation and implementation of better plan for rehabilitation

It should be realized that in the real world an issue is an issue, and it only becomes technical, economic, or sociological depending on a person's discipline, experience and ways and means of approaching it. Thus, for M and E of irrigation projects, it is preferable to use inter-disciplinary individuals, who may specialize in one discipline but are flexible, observant, sensitive, eclectic and are capable of intermixing and questioning inventively. Since in reality, it may be difficult to find such interdisciplinary individuals, one may have to depend on who is available. This can be done by carefully selecting a multidisciplinary team, which can offset biases by juxtaposition of insights of various disciplines. However, it should be noted that the choice of a multidisciplinary team does not necessarily produce a real multidisciplinary approach and effort.

Characteristics of Irrigation Projects

As a first step for M and E of irrigation projects, it is essential to get a clear picture of the characteristics, problems and potentials of the projects. These characteristics could be physical-technical (e.g. project scale, soil, climate, cropping patterns and intensity), socio-economic (e.g. population, land-income distribution, quality of life indicators) or institutional-organizational (e.g. structure of operating agencies, watercourse organization). A selected list of major project characteristics is outlined below. It should, however, be noted that some characteristics would be more important or relevant for one project than another. However, overall, these characteristics will provide a good picture of a project, its general environment and its beneficiaries. Information on such characteristics also especially helpful for inter-comparison of irrigation projects.

Irrigation Project Characteristics

I. *Physical-Technical*

1. Project Scale (area in ha)
    - Large
    - Medium
    - Small
2. Period of Existence
    - Under construction
    - Recently completed (date)
    - Operating for some time (date)
3. Project Type
    - Gravity
    - Pump
        - Energy Consumption
        - Energy Generation
4. Soil
    - Type (sandy, clayey, loam, etc.)
    - Colour (red, brown, black, etc.)
5. Climate
    - Mean annual precipitation (mm)

Percentage occurring during specific period (e.g. 70% during May-August)
Temperature ranges (maximum-minimum)

6. Water available for irrigation (ha m^{-1})
7. Water Use
   Surface water
   Groundwater
      Public
      Private
   Conjunctive
8. Groundwater
   Number of wells
   Maximum pumping capacity
      per well (lps)
      Total (cumecs)
   Maximum permitted/planned annual pumpage (million m^3)
   Actual annual pumpage (million m^3)
9. Terrain conditions
   Gentle slope (m km^{-1})
   Steep slope (m km^{-1})
   Undulating
10. Drainage conditions
   Good
   Medium
   Poor
11. Main canals
   Number
   Total length (km)
   Length lined (km & percentage)
12. Watercourses
   Number
   Total length (km)
   Average area covered per watercourse (ha)
13. Drainage instituted
   Area drainage provided (ha)
   Type (vertical, horizontal, open, tile, etc.)
   Spacing (m)
14. Continuity of irrigated areas
   Continuous
   Discontinuous (due terrain conditions, interspersed with rainfed and agriculture, etc.)
15. Cropping pattern

	Crops	Area cultivated (ha)	Irrigation dates From	To
(1)	....	....	....	....
(2)	....	....	....	....
(3)	....	....	....	....

II. *Socio-economic information*

16. Population
    - Total in command area
    - % engaged in agriculture
    - Landless labourers (actual number, or estimate of % population or subjective, e.g. large or few)
17. Farm units
    - Number
    - Average size (ha)
18. Land tenure
    - % of farms of different sizes operated by owners, part-owners and tenants
    - Overall owners — part-owners — tenants ratio
    - Characteristics of tenancy arrangements
19. Land-income Distribution
    - Very skewed
    - Medium
    - Even
20. Inputs
    - Seeds
    - Fertilizer
    - Pesticide
    - Labour
        - Human
            - Family
            - Hired
        - Animal
    - Machines (type and numbers)
21. Credit
    - Sources
    - Extent
    - Adequacy
22. Extension services
    - Agriculture
        - Area/farmers covered per staff
        - Focus of effort
        - Technical competence
    - Water distribution
        - Length covered per staff
23. Experience in irrigated farming
    - None
    - Some (number of years)
24. Irrigation water charges
    - Basis (volumetric, flat rate, etc.)
    - Level
    - Charges as % of total annual D & M for irrigation
25. Quality of life indicators
    - Child nutritional status (anthropmetric measurements)
    - Literacy rate and/or school enrolment by age

Drinking water (distance to be travelled or time for water collection)
Sanitation
Electricity coverage
Expenditure on shelter improvement and contents
Clinics

III. *Institutional or Organizational*

26. Operating Agency (ies)
    - Structure of project organization
    - Characteristics (centralized, highly stratified, etc.)
    - Coordination
        - Means (area commissioner, coordinating committees, etc.)
        - Between agriculture and irrigation
        - Between surface water and groundwater
    - Support services (e.g. transportation, communication, equipment, maintenance, workshops, etc.)
27. Watercourse Organization
    - Date started
    - Functions
    - Size, both membership and area
    - No formal organization
    - Social cohesion (strong village council, level of local cooperation, etc.)

Framework for monitoring and evaluation

Irrigation projects are complex to monitor and evaluate, since a large number of specific and specialized tasks have to be performed, both concurrently and sequentially, in a coordinated manner, by a variety of professionals, with decisions being made by local, regional, national and international institutions which may have direct impacts on projects. In addition, all the project benefits and costs, both direct and indirect, are not confined to the project boundary: some of them could occur far from the area. Thus, it is not easy to define an area which could be said to contain all project impacts.

Time dimension of impacts is another complicating factor. Some impacts are immediate, and thus can be identified during implementation phase or soon thereafter. Some other impacts, however, could be slow to develop, and thus may not be easy or even possible to monitor meaningfully in the early stages. For example, some unanticipated changes in ecosystem and the environment could easily take more than a decade of operation of the project, before they could even be identified and thus their monitoring could begin. Salinity development in irrigation projects, under certain circumstances, could take 15 to 20 years, but in others it could take only 2 to 3 years, depending on physical conditions, drainage provided and effectiveness of operation and maintenance procedures. Thus, irrigation projects need continual M and E, even when the projects appear to be functioning most efficiently for several years. The time dimension also makes intercomparison of impacts of different irrigation projects a difficult task.

From monitoring and evaluation viewpoints, irrigation projects can be logically arranged into following four interrelated levels:

I. Planning, design and construction of physical facilities,
II. Operation and maintenance of irrigation and drainage facilities,
III. Agricultural production, and
IV. Achievement of socio-economic objectives

Of these four levels, probably the easiest one to handle in terms of monitoring and evaluation is the first one — planning, design and construction of physical activities. It is also a discrete phase, which is completed once the construction of physical facilities is over. In contrast, the other three levels require continual monitoring and evaluation during the project life to ensure that the system is operating at the desired efficiency, and that the objectives of the project are being continued to be met.

I. Planning, Design and Construction of Physical Facilities

This is one level of activity where some forms of monitoring and evaluation have always been a standard practice. It has been a common practice among engineers and surveyors to monitor:

(i) progress of planning and design on schedule and within financial limits;
(ii) use of equipments and construction materials;
(iii) construction of structures according to previously designed plans;
(iv) project costs do not exceed budget estimates; and
(v) construction proceeding on schedule.

Thus, for the engineering and technical aspects, there would normally be a technical inspection and cost-accounting system already integrated within the project in some fashion. What may be necessary is to review the existing system or the system proposed to see if some further improvements can be made to make it more efficient.

There are areas, however, where monitoring is essential at this level, but are seldom done — except in an anecdotal fashion. Information on the following aspects is recommended.

Employment: Employment creation during the planning, design and especially construction phase of irrigation projects is rarely considered to be an important criterion, and is seldom explicitly considered in most developing countries in order that the potential could be maximized. If the projects are designed to use labour-intensive methods from the beginning, the poor — especially large number of unskilled workers, including women, can benefit from them best (Biswas, 1980). Unfortunately, engineers' training is geared to, and their prestige is most enhanced by, capital-intensive projects. Thus, engineers, unless they are "socialized", have a tendency to upgrade and recapitalize labour-intensive public works projects. The following type of employment data need to be monitored.

	Local		National, excluding local		Foreign	
Employment (m/m)	Men	Women	Men	Women	Men	Women
Professionals						
Skilled						
Semi-skilled						
Labourer						

It is necessary to monitor the wages being paid to men and women to ensure that women receive the same wages as men for an identical amount of work. It is equally necessary to ensure that children are not employed in contravention of the agreed United Nations' labour convention.

Other information that should be collected during this phase of activity is:

(i) Equipment
Classified by type, number and cost, and whether manufactured nationally or imported.

(ii) Materials used
Classified by type of materials, by units used and cost, and whether produced nationally or imported.

(iii) Farmers' participation in project design
Very seldom do farmers participate or are consulted on project design, including important issues such as canal alignment, which is a very important consideration in terms of equity. Information should be collected on the extent of participation during this phase, type of people who participated, e.g. large or small farmers, landless labourers, etc., the process by which the participation took place, positive and negative aspects of the participation process and the extent of women's participation.

II. Operation and Maintenance of Irrigation and Drainage Facilities

Operation and maintenance (O and M) is one of the most underestimated aspects of irrigation projects in developing countries. And yet, if the benefits from irrigation projects are to occur on time and to the specific target groups, it is essential that O and M be carried out efficiently to ensure that water supply is reliable, farmers at the tailend receive their regular and fair share of water and the drainage system is functioning properly so that salinity and waterlogging problems do not occur. A review of past irrigation projects will indicate that most project agencies are generally not ready to undertake O and M work when the construction phase is completed. Until recently, O and M was accorded low priority, at least when judged by the actual performances, by both governments and international institutions or donor agencies. Thus, not surprisingly, funds available for O and M are most inadequate, and often maintenance efforts continue to be postponed, until a major crisis appears and it can no longer be postponed. During this period, the efficiency of the projects continues to decline, and during a crisis situation, generally the problem faced is more complex to resolve technically and more funds have to be exended than had the maintenance works been carried out on a regular basis.

Another problem pertains to the attitude of the technical staff. Design and construction phases of irrigation systems are considered to be glamorous, and thus not only do the best staff prefer to work in such areas, but also their superiors prefer to assign them to those tasks. O and M assignments are seldom considered to be desirable (Hotes, 1983), and thus are often staffed by inexperienced and/or below-average calibre staff.

Primarily as a result of the above two factors, efficiency of irrigation systems a decade after construction is mostly very low: around 20 and 40 per cent. This means that 60 to 80 per cent of water abstracted from the rivers does not reach the agricultural fields (Biswas, 1983).

Another major problem worth noting is the fact that poor though O and M is for irrigation, it is even worse for drainage. Poor drainage contributes to salinity and waterlogging development, but since such problems take some time to develop in most cases, the magnitude and extent of the problems are seldom realized until they become serious.

This is especially true where an M and E system does not exist or is not functioning properly.

The following items need to be monitored at this level:

(i) Irrigation and drainage channel maintenance
- actual discharge in comparison to design discharge
- number and dimension of breaches
- presence and extent of weed growth
  - fixed weed
  - floating weed
- status of maintenance and cleaning of facilities
  - by irrigation department
  - by agriculture department
  - by farmers

(ii) Water distribution (both adequacy and reliability)
- Variations between
  - upstream and downstream of command
  - head and tail of watercourse
  - large and small farmers

(iii) Tubewell irrigation
- actual discharge in comparison to design discharge
- frequency of breakdowns
- operating time lost due to breakdowns and other problems (identify these problems)
- workshop performances (do large farmers receive prompt service but not small, time and cost of repair services, availability of spare parts, adequacy of technical expertise and emergency services, etc.)

(iv) Water quality
- sediment concentration
- salt content in ppm
- presence of toxic chemicals (e.g. pesticides) and other serious pollutants

(v) Water misallocation
- evidence of misallocation (falsification of records, living standards of officials indicating unofficial income, failure of senior staff to take actions, evasiveness of answers on inequitable water distribution, interviews with large and small farmers at both head and tail of watercourses, etc.)
- source of pressure for misallocation
  - large farmers
  - local influentials
  - officials
- beneficiaries and losers due to misallocation
- reasons for misallocation
  - social structure of area
  - lack of legislation or its non-implementation
  - absence of accountability of staff to farmers
  - and poor staff morale or motivation

(vi) Related to O and M staff
- adequacy of clear, written procedures for O and M staff

are the procedures followed? If not satisfactory, why?
technical skills of senior and junior staff
staffing situation compared to what has been sanctioned (staff turnover, presence of temporary staff, delays in recruitment, etc.)
adequacy of resource availability
staff
equipment
finance

III. Agricultural Production

The fundamental objective of any irrigation project is to provide efficient water control in order to increase agricultural yields. Efficient water control, referred to at the previous level, by itself not the sufficient condition to maximize agricultural production, which simultaneously requires other essential inputs as seeds, fertilizers, pesticides, machineries, energy, as well as extension, credit and marketing facilities. It is equally important to ensure that irrigation water and the factors mentioned are available to the farmers in an integrated and timely basis. For M and E at this level, all the factors mentioned — with the exception of irrigation water which has already been considered in the previous level — need to be considered.

Information needs to be collected at critical times for each cropping season, which can then be used to provide better co-ordination between the different organizations responsible for the various inputs and services. At the end of the cropping season, an overall performance review of the season needs to be carried out. This review will be helpful in preparing an integrated, and more improved plan for the subsequent cropping season.

In many irrigation projects, M and E of agricultural production may require the maximum effort when compared with the other three levels mentioned in this section.

There are many factors which need to be monitored. While the decision on the extent of monitoring will be project-specific, the following information is desirable in most cases for each cropping season.

(i) Area planted by crop
average yield

(ii) Input Use. For each of the following: seeds, fertilizers and pesticides
kind used
rate of use
cost and amount purchased
acquisition problems, if any
timing of application
percentage of farmers using various inputs
which farmers? their characteristics

(iii) Factors resulting in slow adoption of inputs
yield considerations
non-yield considerations, e.g., taste, colour, pest or drought resistance, length of straws, etc.
risk not commensurate with benefit
lack of credit
non-availability of specific inputs
minimum package too large
technical problems, e.g., equipments for pesticide application

(iv) Credit
- sources of credit
- extent of credit by each source
- adequacy of credits
- repayment performance, e.g. payment of agricultural loan for preceding season
- overall indebtedness

(v) Extension services
- frequency of contacts of farmers (especially small farmers) with extension staff
- farmers' view of the attitude, motivation and quality of extension staff
- farmers' response to recommendations of extension staff
- level of satisfaction for overall extension services. If not satisfied, why?

(vi) Pest and weed infestation
- type and timing of infestation
- extent of infestation (negligible, slight, average, major)
- area of infestation
- loss due to infestation

(vii) Labour
- human
  - family (number and period)
  - hired (number and period, male-female, payment characteristics)
- animal
  - own (type and number)
  - hired (type, number, cost)
- machine (type, own or hired, hiring charges)

(viii) post-harvest facilities
- storage (type, quality, adequacy, etc.)
- access to mills
- marketing of surplus crops
  - what alternative outlets available for marketing within easy access
  - who purchased surplus?
  - price received
  - any agreement to sell surplus before harvest

IV. Achievement of Socio-Economic Objectives

The fundamental objective of irrigation is to increase agricultural production, which will not only increase availability of food for people, but also directly contribute to increased income generation of both farmers and non-farmers. Increased productivity and rise in farm income could go a long way to achieve the socio-economic objectives of the project.

It is, therefore, absolutely essential to monitor the impacts of the project on the proposed beneficiaries. For example, it is quite possible that an irrigation project may enhance the employment and income potential of landless labourers due to intensified agricultural activities. Equally, it could replace overall employment potential by undue emphasis on mechanisation, which could make the life of landless labourers far worse than the pre-project level. Similarly, it may be possible that the income of small farmers and landless labourers increases significantly due to the project, thus making more equitable income distribution in the area. Alternately, the benefits could accrue primarily to the large farmers at the cost of small ones, and thus make income distribution even more skewed than ever before. Depending on specific irrigation projects, both alternatives have been observed in the past.

It is equally important to monitor the impact of increased income on some quality of life indicators. For example, is the increased income improving the quality of life of the people in the project area, e.g. better literacy rate, improved health services, provision of clean water and sanitation, etc., or is it being primarily used for conspicuous consumption, as has been observed in certain instances.

From a management viewpoint, it is essential that M and E be carried out continually so that decision-makers are aware of the developments in order that appropriate policies may be formulated and implemented on time to reverse undesirable trends. To this end, both intended and unanticipated impacts should be monitored.

Several aspects need to be monitored at this level, the major ones of which are the following:

(i) Gross income
- agricultural production
- livestock
- rent (hiring out of machines and draft animals, leasing out of land)
- nonfarm income
  - wages of family members
  - remittances received
  - trades, artisanship, etc.
  - interest from money-lending
  - house rents
  - others

(ii) Expenses
- agricultural
  - cost of inputs (seeds, pesticides and fertilizers)
  - wages of labourers
  - hiring cost of farm machinery and draft animals
  - energy costs (fuels, lubricants, etc.)
  - maintenance and repair of farm machinery
  - irrigation charges
  - tenancy charges
  - other expenses
- livestock
  - fodder and feed
  - wages of labourers for feeding, grazing, etc.
  - charges for grazing land
  - other expenses (veterinary, etc.)
- non-farm expenses
  - taxes, rents, etc.
  - transportation charges
  - loan interests
  - maintenance and repair of houses
  - other expenses

(iii) Livestock
- total number of species
- herd and flock demography
  - herd structure

fertility
mortality
quantity and seasonal distribution of products consumed and sold
age and sex of animals sold or slaughtered
rates of weight gain of young animals

(iv) Housing
type of house
general condition of the house
number of rooms
inventory of major possessions (examples — radio, TV, bicycle, motor cycle, scooter, electric fan, sewing machine, etc.)

(v) Energy
electricity availability within the house
electricity supply continuous or intermittent (if latter, periodicity and problems)
type of energy used for cooking (kerosene, gas, firewood, agricultural residues, etc.)
who collects firewood and time spent on collecting firewood
how much firewood and agriculture residues purchased/sold at what cost

(vi) Water supply
source or sources of water used for domestic purposes by season (pipe connection to house, standpipe, well, pond, river, etc.)
if no pipe connection to house, who collects water, distance to source(s), time needed per day for collection, number of water-collection, number of water-collection and water-use journeys per day
reliability of supply
quality of drinking water

(vii) Sanitation
flush toilet
pit
other type
no sanitary facilities

(viii) Nutrition
main items of food consumed, both home-grown and purchased
diversification of diet
anthropometric measures for children, height by age, weight by age and height by weight
main nutritional deficiencies

(ix) Medical care
type of facilities in the area (if none, distance to the nearest facilities)
condition of buildings
staffing
in-patient facilities, including number of beds
availability of major drugs, equipments, etc.
main local diseases
presence of other medical staff in the area, including alternative medicine
infant mortality rate
major problems

(x) Education
- literary rates
- number and type of schools
- physical conditions of schools
- number of students by sex
- attendance rates
- availability of teaching side (books, pencils, blackboards, notebooks, etc.)
- number of classes
- number of teachers
- if no school in the area, distance to primary, middle and high schools
- major problems

(xi) Environmental issues
- type and incidence of water-borne diseases
- depth of water table
- area waterlogged
- area saline or alkaline
- information on reforestation and deforestation
- condition of grazing fields
- erosion/sedimentation problems
- micro-climatic impacts
- other problems

(xii) Farmers' organization
- membership of the organization
- meetings attended
- are benefits of membership
  - tangible
  - high probability that likely to be profitable
  - accrue sooner than later
  - marginal
  - no visible benefit
- trust/suspicion of officers of organization
- who benefits from present activities
- any coercion for participation

Concluding remarks

During the past three decades, irrigation projects in developing countries have received a massive amount of financial support. For example, irrigation is the largest subsector of the agricultural and rural development sector of the World Bank and the IDA lending (Hotes, 1983). During the period March 1948, when the very first loan was made to a developing country for irrigation and power (13.5 million US dollars for Chile), and June 1982, the World Bank's agricultural lending has amounted to 26.7 billion US dollars, of which more than 10 billion US dollars was for 285 irrigation projects. The total project costs have been around 2.5 times the amount of the loans. Similarly, according to OECD (1982) estimates, total official commitments to irrigation by bilateral and multilateral donors in 1980 amounted to 2.2 billion US dollars, of which 88 million US dollars was contributed by IFAD. The total commitment in 1980 was nearly 3 times that for 1976, estimated at 762 million US dollars. Nearly 20 per cent of capital aid to food and agriculture for the 1976-80 period was for irrigation.

With such massive investments in irrigation projects in developing countries, it is essential that systematic monitoring and evaluation of the projects be carried out in order that (Malhotra, 1982):

(i) timely corrective actions can be taken for maximising project impacts, and thus achieving the project objectives;
(ii) goal achievements can be determined;
(iii) lessons can be learnt for more effective project design and management;
(iv) project assumptions can be verified; and
(v) overall project impacts can be analysed.

Because of these considerations and massive investments in irrigation projects, monitoring and evaluation issues have assumed greater importance in recent years than ever before. Because of general scarcity of investment funds, it is essential that the funds available be used as efficiently as possible to maximise development efforts, which without continual monitoring and evaluation can clearly not be achieved.

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