PERFORMANCE ASSESSMENT OF IRRIGATION SYSTEM A CASE STUDY OF MAHAKALI PROJECT IN NEPAL

A DISSERTATION

submitted in partial fulfillment of the
requirements for the award of the degree
of
MASTER OF ENGINEERING
in
IRRIGATION WATER MANAGEMENT

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CANDIDATE'S DECLARATION

I hereby declare that the work which is presented in this dissertation **"PERFORMANCE ASSESSMENT OF IRRIGATION SYSTEM - A CASE STUDY OF MAHAKALI PROJECT IN NEPAL"** in fulfillment of the requirement for the award of Degree of Master of Engineering in Irrigation Water Management in Water Resources Training Centre, University of Roorkee is an authentic record of my own work, carried out during the period from 16th July, 2000 to 30th November, 2000. under guidance of **Shri R.P.Singh**, Visiting Professor, W.R.D.T.C., University of Roorkee, Roorkee.

The matter embodied in this dissertation has not been submitted by me for the award of any other degree or diploma.

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This is to certify that the above statement made by the candidate is correct to the best of my knowledge.

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(RAJENDRA PRASAD YADAV)

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LIST OF ABBREVIATIONS

ADBN	= Agricultural Development Bank of Nepal
AOs	= Association Organizers
AIC	= Agriculture Input Corporation
BRAPA	= Brazil Agency for Agriculture Research Programme
BCS	= Bhakara Canal System
BMBC	= Bhakara Main Branch Canal
BMB	= Bhakara Main Branch
BLGWP	= Bhairawa Lumbini Ground Water Project
Bn	= Net Benefit
C_u	= Christians Uniformity Coefficient
C_v	= Coefficients of Variance
C.C.A.	= Culturable Command Area
C_n	= Net Cost in nth Year
CBR	= Central Bureau of Roads
DTWs	= Deep Tubewells
DAO	= District Agricultural Office
DOA	= Department of Agriculture
DOI	= Department of Irrigation
d/s	= Downstream
EIRR	= Economic Internal Rate of Return
FIRR	= Financial Internal Rate of Return
FBC	= Fetehabad Branch Canal
FSD	= Full Supply Discharge
GOI	= Government of India
Gr	= Gross
GDP	= Gross Domestic Product
HMG/N	= His Majesty Government of Nepal
HYV	= High Yield Variety
IC	= Indian Currency
IDA	= International Development Agency
IRR	= Internal Rate of Return
ISF	= Irrigation Service Fee

IWMI	= International Water Management Institute
IIMI	= International Irrigation Management Institute
ICID	= International Commission for Irrigation and Drainage
IQR	= Interquartile Ratio
J.T.	= Junior Technician
J.T.A.	= Assistant Junior Technician
MIP	= Mahakali Irrigation Project
MOA	= Ministry of Agriculture
M&R	= Maintenance and Revenue
NRS	= Nepalese Rupees
NEA	= Nepal Electricity Authority
NPV	= Net Present Value
n	= Number of Year
NISP	= Nepal Irrigation Sector Project
O&M	= Operation and Maintenance
O,M & M	= Operation, Maintenance and Management
P.Os	= Pump Operators
PA	= Project Authority
RPIP	= Research Programme on Irrigation Performance
RWS	= Relative Water Supply
SMS	= Subject Matter Specialist
SAR	= Staff Appraisal Report
t	= Tone
T	= Index
u/s	= Upstream
US	= United State
USAID	= United State International Agency for Development
UNDP	= United National Development Program
vs	= Versus
WUAs	= Water Users Associations
WUGs	= Water Users Groups
WUACC	= Water Users Association Co-ordination Committee
WYC	= Western Yamuna Canal,
$	= Dollar

SYNOPSIS

The irrigation system performance now a days generates considerable interest in government agencies associated with Irrigation development, funding agency and the water users. The good management of water has always been recognized as an important components of successful irrigation over the World .Irrigation water is considered as prime limiting factor for crop production. Necessity of integrated and scientific Management of irrigation to achieve optimum utilization of created potential has now been fully realized.

In many large projects, it is found that the potential created are not fully utilized . Quite often many irrigation projects has failed to meet the defined objective.

This may be due to unscientific operation, faulty water distribution methods , improper irrigation scheduling, poor Maintenance of canal network system , skew socio-economic condition and mostly duet lack of farmers participation .

With the above consideration in mind, a case study has been under taken for Mahakali Irrigation Project (stage-1) of Nepal . The performance study has been under taken in the command area of the project to examine whether the project is serving its defined objective or not.

The existing practice is to be studied from view points of water use agricultural production, water supply and demand, joint management and socio-economic aspects of farmers by making use of available data and methods.

This study may provide the understanding of present status of fulfillment of the objective of the project as well as necessary improvement and modification needed for optimal use of water resources .

CHAPTER – 1

INTRODUCTION

1.1 GENERAL

In recent years talk of irrigation system performance generates considerable interest in government agencies associated with irrigation development, the funding agency like World Bank and the users. The rising cost of irrigation development, dissatisfaction with current level of performance and greater awareness of environmental issues, are mainly responsible for undertaking performance audits. The shortfalls in performance can be cited at almost every level of irrigation sector. At system level, there is disappointment in cropping intensity, yields from many irrigated areas. The economics of irrigated agriculture are such that many farmers have not able to achieve a more prosperous and better quality of life. At the level of water distribution, there are innumerable references to inequity of water distribution leading to major disparities between head and tail areas, to deficit water supply and loss of production in some locations or to excess water delivery and development of water logging and salinity in others. Water supply at given location are often poorly matched to crop needs, highly variable in both timing and discharge and are, sometimes of increasing poor quality.

Good performance is not only a matter of high output but also one of efficient use of available resources. It is possible to improve the performance through modern technology and better management. The knowledge of existing level of performance and Projections of performance levels in past improvement phase is essential for suggesting improvements. Meaningful performance appraisal is only with a clear understanding of how we define an irrigation system, its management and objectives for which it has been created. The vastness of the subject makes it incumbent to delineate the boundaries along with anticipated outputs and evaluate the achievements relating to project objectives so that deficiencies may be rectified by necessary improvement in the infrastructure and management requirements.

1.2 OBJECTIVE OF PERFORMANCE

The performance of a management system can only be measured in terms of its objectives. Irrigation schemes have multiple and some times conflicting objectives and perception about performance will vary depending upon the value attached to different goals by person or organization making the assessment. There are different aspects of project performance, which may relate to financial, institutional, design construction and operation of system.

Th e water delivery to field by operating irrigation facilities is to supply water to crops for sustained increase in agricultural productivity increased incomes in rural sector and built up rural economic development, which will improve livehoods of rural people and sustained socio-economic development for entire economy. Hence the ultimate objective of irrigation system development is of increasing agricultural productivity in sustainable manner and ultimately improving the quality of life of water users.

1.3 OBJECTIVE AND SCOPE OF STUDY

The exploitation and utilization of water for irrigation require that there are periodic evaluation of its utility and efficiency of use. Most of the expansion of irrigated area has occurred through capital investment in infrastructure for capture, storage and distribution of water and in the conversion of rainfed areas into irrigable land.

There is need of not only basic information about the input and output of system, but also a framework within which this information can be processed and evaluated. This framework has to be capable of allowing assessment of performance in individual systems and permit comparisons with its define objective in the appraisal of project to determine the initial investment and operational inputs.

The main components of project under study are :

(a) Improvement to existing irrigation and drainage system about 3,400 ha (net)

(b) Extension of irrigation and drainage system by 3,200 to 6,600 ha (net)

(c) Construction of an interconnected inter connected net works of all weather public roads and canal service roads.

(d) Construction of building for engineering and agricultural activities and staff quarters.

(e) Strengthening agricultural extension and training activities including construction and operation of pilot demonstration-farm-cum-training centre.

(f) Procurement of materials, equipment and vehicles for construction, survey and laboratory activities and project O & M.

(g) Provision of technical services, including foreign and local consultants for project implementation and aerial photography and mapping.

(h) Fellowship foe Nepali students to study civil, mechanical engineering and agriculture and

(i) Undertaking agricultural development activities in The Bhairawa-Lumbini Ground water project over a Three year period.

The above activities are carried out to achieve the following main objectives on basis of which the performance evaluation of a irrigation system will be done.

(j) To increase the cropping pattern and coverage area i.e. cropping intensity in command area.

(ii) To increase the yield of crops and hence increase in production.

(iii) To reduce O & M cost by active participation of farmers with project authority for suitable development of irrigation system.

(iv) The economic internal rate of return should be more than the forecasted at the time of project formulation.

The purpose of performance evaluation studies is to identify the status of irrigation project in term of all activities, which contribute to wards improvement in utilization and production productivity and examine their sensitivity to improvement in utilization production productivity. The scope of study therefore, is to include analysis of following giving due stress to items of special relevance to the project objectives taken for study.

(i) Water Resources Potential

The assessment of surface water and its availability at project site and its comparison with the project formulation.

(ii) Planning and Design

Critical evaluation of

(a) Water availability in the system

(b) Water utilization

(c) Losses in conveyance and distribution system

(d) Cropping pattern

(e) The system.

Comparison above with existing system based on actual data and with project formulation.

(iii) Irrigation Potential

Irrigation achieved year wise and crop-wise and its comparison with that planned and designed as original approved project appraisal. Reasons for change in cropping pattern and distribution system.

(iv) Irrigated Area

Compilation and analysis of

(a) Data of delivery of water

(b) Data of area irrigation crop-wise, head middle and tail reaches.

(c) Timeliness of availability.

(d) Potential utilized V/S potential created, the gap in utilization and there of.

(e) Rotational supply/contineous supply.

(v) Socio-Economic Aspects

It includes

(a) Analysis/review of level of actual achievement in area irrigated production and productivity.

(b) Agricultural performance.

This will include analyses of extension services to farmers, agricultural inputs, credit service, facilities and other infrastructure facilities such as farm roads markets and communication.

(vi) Joint Irrigation Management.

The evaluation of joint irrigation management of irrigation system includes.

(a) Operation and maintenance practices of irrigation system.

(b) Review of organizational set-up of project.

(c) Water Users Association and its active participation in water management.

(d) Water charge and its recovery.

(vii) Benefit Cost Analysis of the Project :

It includes analysis of

(a) Original BC ratio and present BC ratio.

(b) Assessment of internal rate of return.

(viii) Discussion, Conclusion and Recommendation :

(a) Operational plan of the project based on the availability of water and improved system.

(b) System improvement.

(c) Cropping pattern.

(d) Organizational improvement if needed.

(e) Improvement on farm development works if needed.

(f) Water charge rate.

(g) Water charge recovery.

(h) Improvement in operation and maintenance of the system by suitable change in management.

(i) Suggestions for further study and research for similar projects in future.

CHAPTER – 2

SURVEY OF LITERATURE

2.1 GENERAL

Performance evaluation of irrigation systems is very complex issue. The complexity increases if the objective is not clearly defined. Meaningful performance appraisal is possible only with a clear understanding of how we define an irrigation system, its management and objective for which it has been created. There are numerous technical papers presented / worked out by different experts for performance of irrigation system.

An indepth critique of the objective of irrigation is given in Small and Svenden (1990) who stated that goals were crucial to performance assessment and their clear specifications and classification as to whether they were related to inputs, outputs or efficiency were needed. They conceptualized irrigation purposes within a nested means and end framework in which a narrow purpose is seen as a means of achieving some specified end. In the hierarchical order of objectives, the end of first level of objective becomes the means of next higher level of objective (Table 2.1). At each level of assessment a whole system view is required because the constraints at different levels influence, the performance of other levels.

If we limit our discussion to technical performance at the hydraulic level of water distribution system then the success of an irrigation system can be measured by how it supplies, the required quantity of water at the right time in an equitable manner to users served by the system.

The water delivery system can have many objectives but there is a broad agreement that most of them can be included in adequacy, equity and timeliness. In cases where water quality is a problem, a fourth dimension of quality will have be added. Water delivery management is not an end in itself but it is a means of increasing agricultural productivity in a sustainable manner and ultimately improving the quality of life. It is therefore necessary to establish linkage between the secondary or intermediate objectives and ultimate objectives. Abernethy (1987) has shown how all the objectives can combined into a single objectives of productivity.

Table 2.1 : Irrigation Purpose as Nested Means and Ends

Level of End	Means	Ends
Proximate	Operation of irrigation facilities	Supplying water to crops
Intermediate -1	Supply water to crops	Sustained increase in agricultural productivity
Intermediate -2	Sustained increase in agricultural productivity	Increased incomes in rural sector
Intermediate -3	Increased income in rural sector	Rural economic development
Ultimate	Rural economic development	(i) improved livehoods of rural people (ii) Sustained social economic development for entire economy

Source : Small and Svendsen (1990)

We must also give careful consideration to the type of productivity that we are going to use in making our analysis . Productivity means production per unit of input. So we may have a land productivity (tonnes/hectare), which is usually called yield; or we may have a water productivity (kg of crop / m^3 of water), which in the United States literature is usually called water use efficiency; in some circumstances labour productivity will be a more important feature and so on. The land productivity tends to receive the greatest emphasis in the literature, but in cases where management of water is focus of concern, there is at least a prima facia case for saying that water may be the dominant constraint on output, and that water productivity ought to our primary criteria for good performance. A way of resolving, the point is to ask whether in case any water so saved by good management, it can be put to alternative use, or whether it will simply be wasted. If there is not alternative demand for it, then water productivity is not an important objective.

Figure 2.1 (derived from Abernethy 1985,1986) illustrates the application of this ideas. This is an observed history of water deliveries throughout one season to a land unit

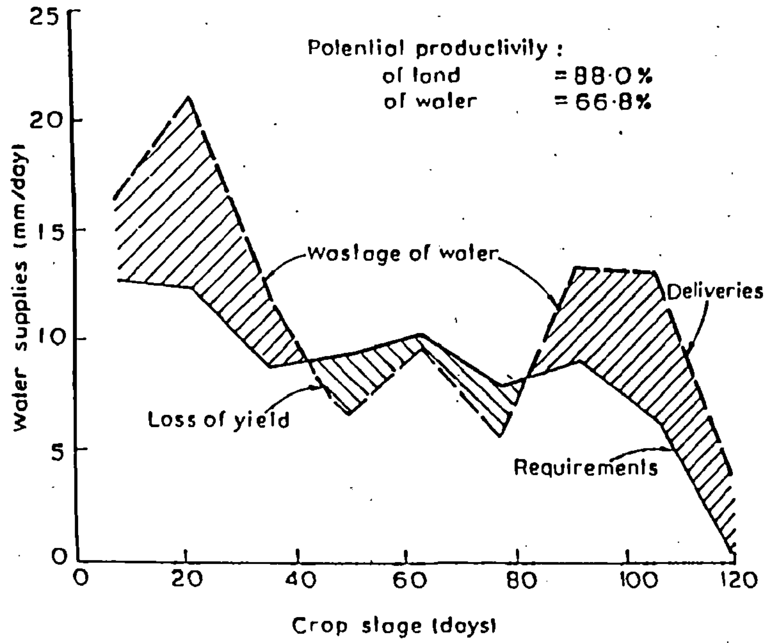

Fig. 2.1 Effect of timeliness of water supply upon the productivity of land and water

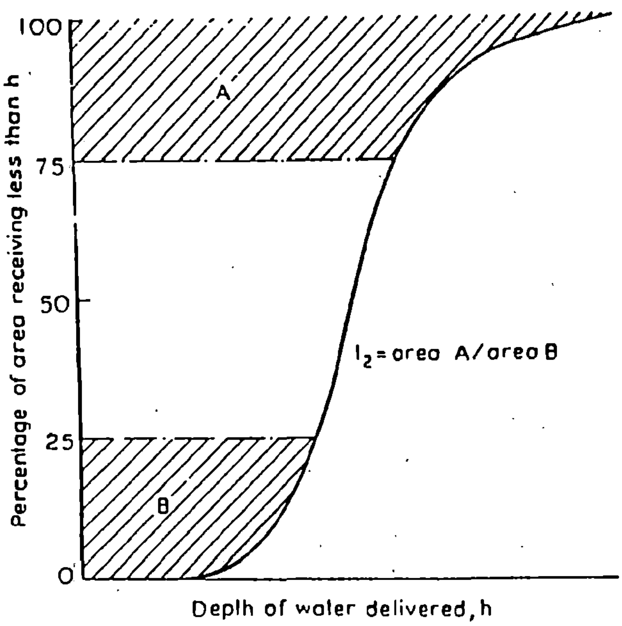

Fig. 2.2 Definition of inter quartile ratio

in Sri Lanka, where a rice was the sale crop. In the figure the crop water requirement (inclusive of a seepage allowance, and with deduction made for effective rainfall) is also shown. From this we see that in the early and late stages of the season deliveries were in excess of needs, where as in the middle of the season there was not enough water. If we are in conditions where land productivity is the dominant criteria, then it is only the water deficit period that need concern us: at other times the supply is clearly adequate for crop needs. But if we are in conditions of overall water deficiency in this particular irrigation system, or in this river basin generally that is, if any saved water can be used else where – then we must regard water productivity as an important fact of good management performance. In that case we must equally be concerned with the water waste implied by the period of over-supply.

Using this reasoning and the yield versus water deficit coefficients provided by Doorenbos and Kassam, we find that particular water supply regime would give a potential land productivity (yield) of 8 8.0 percent, that is to say, the yield will be 88.0% of what could have been obtained under the same agricultural inputs and climatic environments with a water supply perfectly matched with requirements. On the other-hand, the same data gives us a potential water productivity, defined in parallel terms of only 66.8%. In general, we shall except to find that the potential productivity of water is substantially less than that of land, in the systems where total supply is reasonal adequate, which includes most of the south-east Asian rice systems; but water productivity probably exceeds that of land in the water deficient systems, such a much of Pakistan.

C.L. Abernethy extract-two salient numbers that indicate the overall effectiveness of the water management arrangements, and their fairness among the many uses of system facilities. These numbers are (1) median potential productivity, P 50, and (2) Inter-quartile ratio of productivity I_P.

The use of the potential productivity parameter p_{50} and Ip opens the way to analyses of several key questions concerning irrigation management. Before considering some of these, it is worth examining briefly what the parameters tell us, and what they do not P_{50} is superior, as an indicator of irrigation performance, to irrigation efficiency, because it reflects not just the amounts of water delivered, but also their relationship to the requirements of crop production. It does, however, contain the effects of conveyance

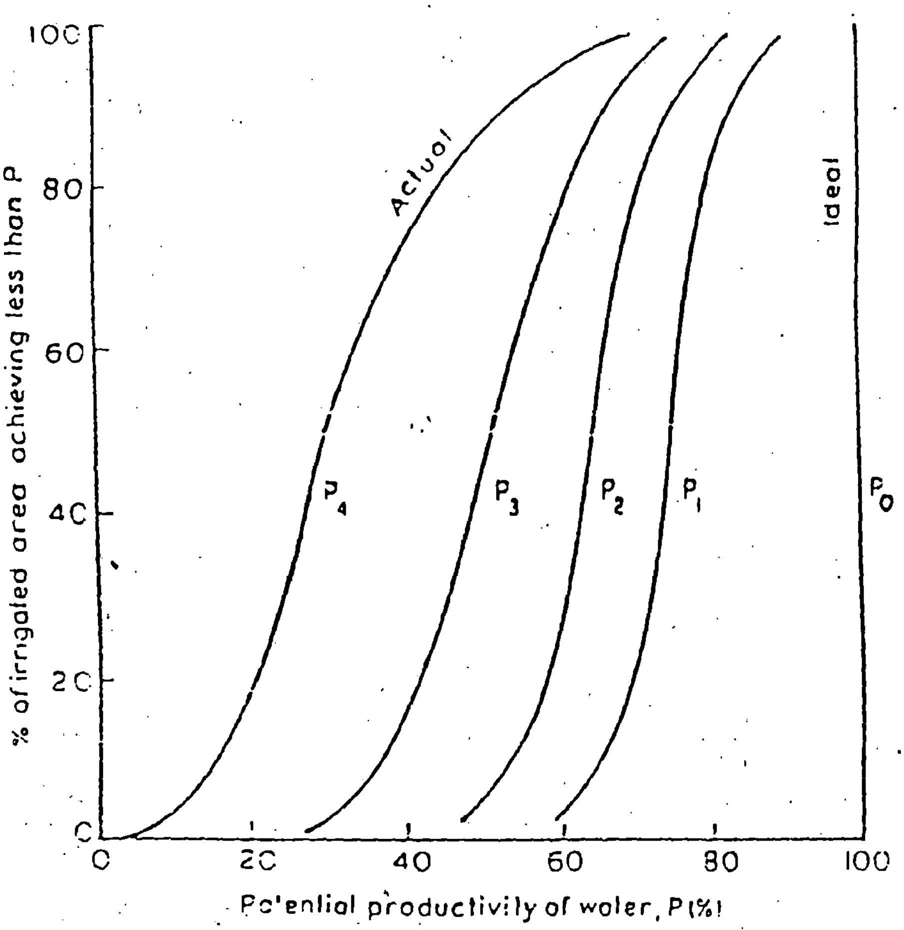

Fig. 2.3 Effects of different constraints upon the potential productivity of water

losses, which are one of principal constituents of irrigation efficiency. In a leaky system adequacy deteriorates as we move down stream, and equity also deteriorates, so we see these effects in lower P_{50} and higher Ip.

On the other hand, although P_{50} is designed to represent the effects of water supply on output, it avoids the problems that arise if we attempt to adopt actual out-put as a performance. The difficulties of doing that are well known, statistics of output are not highly reliable, and there are too many other influence upon output (pests, diseases, prices, equipment etc) among which it is difficult to isolate the influence of a single one. The use of potential productivity enables us to evade these difficulties.

Figure 2.2 illustrates one way in which we can use these concepts in diagnosis of management defects in a system. Here the single-S shaped distribution curve of figure 2.2 is replaced by a family of five such curves, Fig 2.3 labeled Po to P_4. Po. The extreme case, represents the ideal; water productivity under optimally controlled considerations, with uniform distribution of water, at times closely matched to crop need and with comprehensive lining for seepage control.

In any real system, the actual set of physical facilities for water delivery and control will be insufficient to enable us to manage water so perfectly. We have instead some maximum attainable performance level, which depends upon the available set to canals, regulators etc. This represented by the curve P_1, whose values can be determined by use of a numerical model of the irrigation network. As system age, we expect the curve P_1 to be regressing to the left, due to the deterioration of canals and structures.

The curve P_2, is the most difficult to determine at present, but it is useful to include it here as part of conceptual framework. Given a particular set of facilities, we cannot in practice operate them as perfectly as a mathematical model might assume, there are many practical constraints, the numbers of staff, their hours of working, the distances between structures and much else. These constraints will usually be reflected, more or less, in the operating rules that are supposed to guide field staff actions. So we can conceive of the curve P_2 as representing the potential productivity that could be achieved, if we operate the available facilities in full accordance with the operating rules.

Below this again is P_3, which is the curve that we find from direct measurement of the water distribution, as it actually occurs in the system. And below this again is P_4,

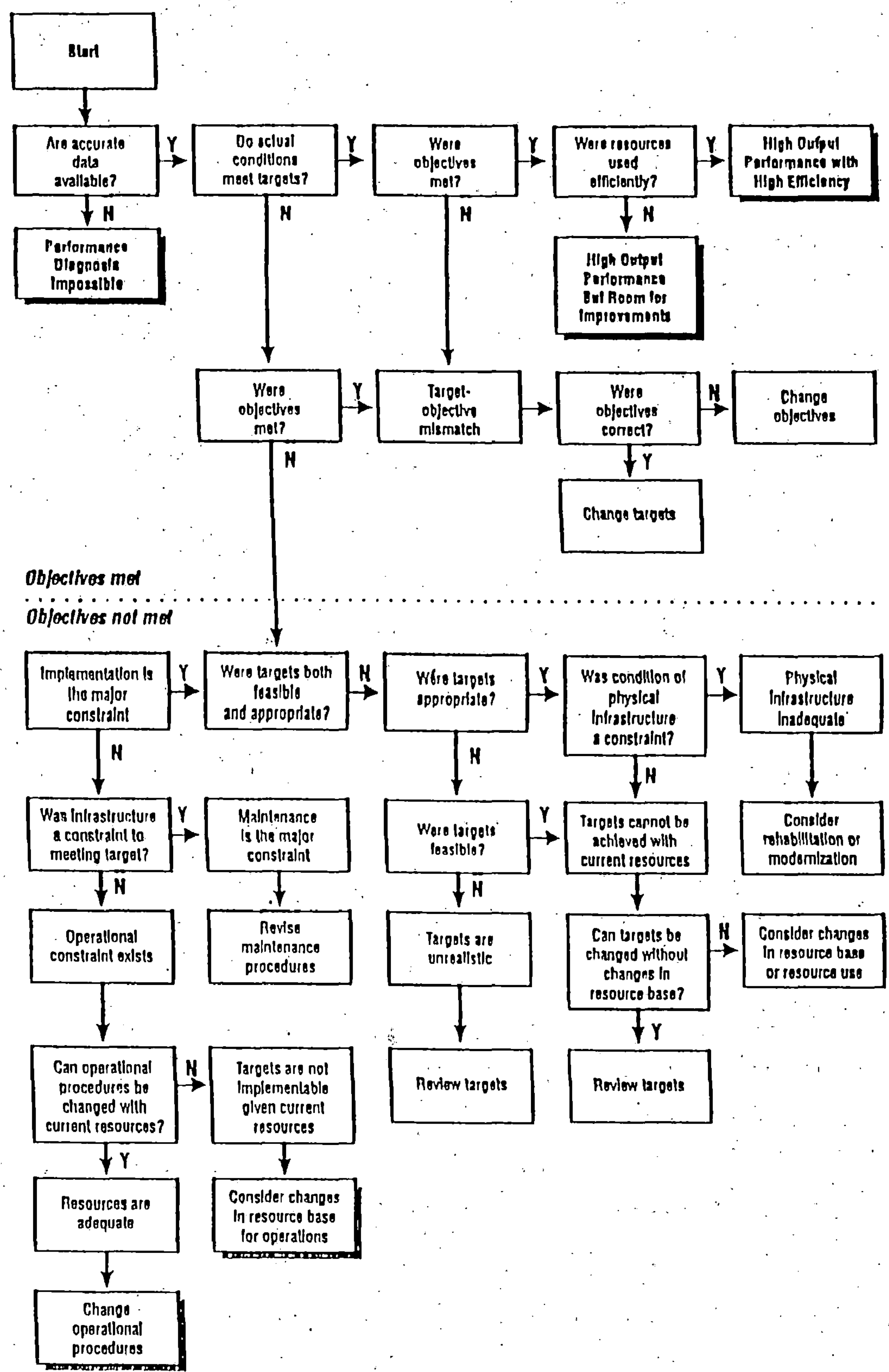

Fig. 2.4 Flow chart to show process of performance assessment and diagnosis

which represents, no longer a potential productivity but the actual crop production obtained in the field, as a proportion of the theoretically available output of the same crop(s), under the same levels of inputs and agricultural practices, but with perfect water supply.

The intercepts between these curves indicate the influences of the different aspects of management process. The area between P_4 and P_o represents the total gap between crop potential and achievement. The diagram enable as to this "loss" into four components. The area $P_o - P_1$ is attributable to the set of physical facilities; $P_1 - P_2$ to the constraints upon operational rules $P_2 - P_3$, to the execution of those rules in the field; and P_3-P_4 to the water application activities of individual farmers. Such information can be used diagnostically, especially in the case of projects that are candidates for rehabilitation of work. At that stage it is of high importance to distinguish the major cause of deficient performance, in order that rehabilitation funds can be applied to greatest effect.

D.H. Rust–Murry–Snellen state that an generic process of performance assessment can not be soley, out-put oriented. To be sure, outputs are integral to the assessment, but they are used to determine opportunities for improvement within the entire management cycle, not merely in raising the level of outputs as a single goal.

Fig.2.4 presents a summary of the paths by which a diagnosis could be undertaken by asking a series of questions that help to identify some of the causes of poor performance, possible ways in which management performance could be improved are identified. The diagnosis falls into two activities that require priority attention if performance is to be improved.

At the outset, it is obvious that elements of management control, the process by which the effectiveness of the various management functions of planning, organizing originating and implementing is reviewed and adjusted, relies on having good information. If good data are not available, then there is no possibility of making a careful analysis of the problem.

If, and only if the appropriate data are available, it is possible to undertaken a logical and analytical process of performance assessment. Personal experience at field and system level suggest that many irrigation agencies do not keep good record of field-level conditions; indeed, most of the case studies are based on research activities specially designed to measure real life performance.

A fundamental characteristic of process summarized in Fig. 24 is that information an output from the system is not used as the end result, but as the first step in assessing system management. There is no value judgement mode of level of output, but a clear analytical assessment made of whether the outputs are the same as those intended during the planning process. Put as simply as possible; if the desired targets and objectives were achieved, then the analysis of performance is concerned with whether the targets and objectives were ambitious enough, or whether they could have been accomplished with greater efficiency.

The deal level of performance can only be achieved when targets were achieved, objectives were fulfilled, and there was an efficient use of available resources. If targets and objectives are met but resources us is not efficient, then performance can be improved by institutional modifications that lead to better resource use. This can lead either to a reduction in resource utilization or a definition of a more ambitious set of objectives to make use of spare resource capacity.

As an example of the difficulties faced in undertaking performance assessment studies it is salutary to recall that Yudelman (1985), a former director at the World Bank's Agriculture and Rural Development programe, confirm that the irrigation projects often defy planners expectations.

Yet, in the case of investments in irrigation development, there are organizations that seem to be able to get away with unrealistic planning assumptions; by the time the construction of the irrigation system is completed, most of these organization's own objectives are already achieved and their direct involvement with the system comes to an end. In other words, long-term performance is for less important than generating the next cycle of projects.

In our perception, the above conditions present a serious constraint to achieving a performance oriented in irrigation system management; if the expectations are perceived as unrealistic by managers at the very outset, then there is little likelihood that they will make a serious effort to achieve them. To do so requires a clear definition of what the organization really is, and who are the different customers whose interests are, presumably taken into account by managers within the agencies or organizations responsible for irrigation.

2.2 SPECIFIC CASE STUDIES

These studies are not a full evaluation of performance at all levels of irrigation sector. It focuses on the issue of management of main system and, in particular on the allocation and distribution of water from source of system to the point where individuals or farmer groups take over responsibility of these takes. The organization will be the managers of main irrigation system, who are responsibility of these takes. The organization will be the managers of main irrigation system, who are responsible for supplying irrigation water and perhaps other services to farmers, whom we consider as their consumers. There are of course, also farmer-managed irrigation systems, in those cases farmers are the managers of the main system and at the same time they are their own customers. Planning and decisions on how to share water at system level are undertaken as a collective activity while individuals manage their share on their own farm.

Several case studies of performance evaluation of irrigation system has been carried out by different experts. These case studies demonstrate the importance of clearly understandings what users themselves feel to be equitable before on assessment can be made of distribution and supply of water.

2.2.1 Case Study 1

In case of six small systems in Nepal, studies carried by Rust-Murry and Sneller, the stated equity objective was an equal share of water per unit area of irrigable land.

The three systems in hills are Beretor, Bandarpa and Jamune and Terai are Tulsi, Parwanipur and Laxmipur. It has been found that there is little variation in average water availability between head and tail of the system. In the largest system (Parwanipur) there was a slight but insignificant decline in the water availability index (WAI) from head to tail of the system. In all other system no difference existed in terms of WAI between head and tail of the system. The interquartile ratios for the nearest and farthest 25 percent of sample plots are remarkably low.

Fixed over flow designs provide little opportunity to manage reliability below the head gate controlling flow into the canal. The systems are highly dependent on the water conditions upstream of the head gate. In the Nepal cases it is clear that weekly RWS at head of the system varies greatly (Fig. B-1(a) and (b)), so that in any week it is difficult for farmers to predict how much water they will obtain.

Because adjustments can not be made to flows in canal system, farmers have to either irrigate only a portion of their holding when water is in short supply or come to sharing arrangements with neighbors. None of the studies provided information on tertiary level management arrangement in this regard.

Adequacy in run-of river systems is dependent on river discharge. There is little farmers can do if the river discharge falls below total demand for water, although excess water can readily be passed down the river rather than being diverted into the system where it is not needed. In Nepal systems there are efforts to regulate discharge into the system to accommodate changes in both water availability and demand. Calculation of RWS at the intake into each system (Fig.B-1(a) and (b)) shows that supply and demand are well adjusted at system level, with weekly averages being normally in the range of 1 to 2.0. In none of the system is RWS very high; suggesting that over time the farmers have learned to estimate how much land can be irrigated with reasonable safety in a normal year and do not divert excess water into the canal.

Smaller systems in hills tend to have lower RWS values, suggesting that farmers are able to work together well to share scarce water supply. Although there is land available for potential expansion of the irrigated area the RWS levels suggest that farmers are unlikely to expand the total area for risk of water shortage in drier year.

Within the system, however adequacy shows a distinctly different pattern. The variation of WAI between adjacent farms, is high, irrespective of whether the plots are near to or far from head of the system. The inter quartile ratios for best 25% and worst 25% of sample plot were much higher than head-tail different.

Fig B-2(a) and (b) show that yields in all Terai systems are closely co-related with the actual value of WAI and it appears that there is potential for improving over all output from the system, and of individuals farmers, if water at tertiary level is shared more equally. In hills the same relationship is not found. It is not clear from the date presented whether WAI variations are due to unequal access to water or because of differences in soil-water requirements. Increases in agricultural output will only come from improvements to management of agricultural inputs, not from improvements in water distribution at system level.

2.2.2 Case Study 2

Cipasir system in West Java (Indonesia) has a completely different definition of equity. Each farmer is entitled to a share of water that is based on the length of time. The land has been developed; farmers in upper end areas whose ancestors built the original system are entitled to much water than those in newer additions to the system. The water rights can only be determined by a detailed analysis of the size of proportional dividers and the diameter of bamboo pipes serving each subsection of the system. This is a good example of a system that does not provide equality but is still seen as equitable by water users.

The result of the system of shares in ciparsir system is that upper-end landowners are able to cultivate rice three times a year. Farmer in middle area have sufficient shares for two rice seasons and, if they wish, a third season of non-rice crops. Farmers in the newer expansion areas can normally only cultivate rice during the wet season, but may risk one non-rice crop in the dry season if they feel there is sufficient water available.

2.2.3 Case Study –3 Fayoum irrigation system in Egypt

An effective design resulting good uniformity of water distribution is the Fayoum in Egypt. Measurements along the Bahr Seila subcommand of Bahr Wahby canal show that apart from the head end section, the water distribution is almost uniform. The upper 20% receives somewhat more than its fair share for the sub-command (but no more than the average for the entire Fayoum) both because of post-construction changes to fixed structures and use of pumps from the canal that cannot be easily controlled by irrigation agency. However, over the remaining 80% of the area water distribution is controlled by ungated division structures more or less in proportion to the command area. Tail-end areas actually benefit slightly more than the middle again partly as the result of modifications to division structures to allow more water to pass along the canal than was originally intended.

In Fayoun there is no intention to meet the total potential crop water demand. Water rights represent an allocation of a share of total water available; and is intended to be less than farmers might require to cultivate all their land under the most water demanding cropping pattern. With water effectively rationed by the system demand, adequacy is controlled by the farmer's cropping pattern choice and is not included in the system manager's set out operational objectives.

In this system, discharges into each subsystem will be reliable as long as discharges into the main canal are uniform.

2.2.4 Case Study 4 : Lower Chenab System (Pakistan)

In the secondaries included in the lower chenab system sedimentation is a major problem. In canals that have not under gone periodic desilting the changed cross section results in a failure to meet target discharges into the off takes. In head ends, the increased bed level means that the head upstream of orifices is higher than designed, even when the target discharge into the secondary is achieved; discharges through head-end orifices are typically 150-200 percent of design. As long as the discharge into the secondary is at design level, it is inevitable that tail-end it is inevitable that tail-end tertiaries will not have sufficient water. In extreme cases no water reaches the tail of the secondary even though the discharge at the head of the secondary met the target.

The importance of maintenance can be seen from similar measurement taken following desilting. In one case (khikhi) discharges into tail end tertiaries were above design following desilting of the top half of the canal. In second case (lager), where maintenance inputs were more modest but focused on the most silted sections, tail end water conditions improved significantly even though they did not achieve target discharges. Before desilting in lagar distributory, the IQR was 5.03 when discharges were at or close to design, a highly inequitable situation. Following desilting the IQR was reduced to 1.24.

Much of the variation in Lagar distributory following desilting appears to be the result of differences between the intended size and elevation of each orifice and the actual situation in the field. The differences can be attributed to deliberate tempering of orifice dimensions by farmers as well as to imprecision in the actual in installation of the orifice. In a system of this nature very precise installation is required to ensure that the operating head above the sill is the orifice, is as designed.

Data from Lagar distributory demonstrate the effect of operation of canal of lower than recommended discharge. When operated at 100% of full supply discharge (FSD) the IQR was 5.03 when incoming discharge were at 60% the IQR rose to 44.15 because the last 20% a canal received no water at al, while the upper half of the outlets still receive more than the designed discharge. In the worse case, when discharge were only 25% of FSD, no water passed the halfway point of the canal and no outlets received their design discharge.

The impact of maintenance can be seen on the relative IQR at different discharges. Immediate after maintenance had been completed; the IQR at 100 percent of FSD was 1.24 and only increase to 2.7 at 60 percent FSD. Fig B-4 and B-5 show the water distribution equity before and after desilting in lower Chenab canal system.

2.2.5 Case Study 5

Data from two similar distributaries in India (Mudki and Galewala) where sediment is not a problem and where operational factors do not seen to have significant influence, show much less variability between head and tail than was the case in Lagar, with in IQR value of 1.98 at Mudki and 1.35 at Galewala. The distribution of the variability is not related to distance along the canal and again appears to reflect differences between designed and actual installations at the outlets.

The impact of these operational inputs on reliability at tertiary level can be seen through an analysis of coefficient of monthly discharge into tertiary water course.

This is an enormous spatial variation in access to reliable canal supplies. Tail-end farmers get not only less water but less reliable water deliveries as well. The causes on this lake of reliability are the same as those for equity. Canals are poorly maintained so that tail-end areas are deprived of water, and there is weak management that permits discharge to be delivered far below the minimum stated in operational guidelines.

2.2.6 Case Study – 6

N.K.Tyagi principal scientist CSSRI Karnal, has conducted performance evaluation in the command of Fetahebad Branch Canal (FBC) which take off from Bhakra Main Branch (BMB) canal. Eight water courses in pairs of two (one lined and other unlined) taking off from Gorakhpur and Khjuri distributaries in the head reach, Adampur in the middle reach and Kutiyana and Sheronwalli in tail reach were selected for investigation. In addition, two watercourses on Fatehabad distributory in the tail reach near Fatehabad were also chose.

The performance indicators chose for evaluation were irrigation efficiencies at farm level and adequacy, equity and productivity at the water course level.

On-farm irrigation system performance, only hydraulic performance of field irrigation was evaluated. Graded borders are the most commonly used method of applying water to crops. The test border were specified along the entire length of Fatehabad Branch Canal, in the command of selected water course. In general three borders on each watercourse with locations in head, middle and tail reaches were selected.

Measurement taken were used for computing the efficiencies of water application, storage distribution. The application efficiency in most case is quite high whereas the storage efficiency is low. Because of higher unit stream size, water spreads quickly and the irrigation is terminated before the required quantity has been diverted into the border. The distribution uniformity is also poor (less than 60% in majority of cases). Thus the scope of improvement in design of water application practices exists.

For water delivery performance of watercourses, water supply to five water courses on different distributories was recorded. Delivery losses were measured along the water curse to estimate the water reaching the head, middle and tail reaches of water courses cropping pattern and irrigated area under different crops were taken from the records of irrigation department. Using data on climate, soil, crop and irrigation schedules, the daily values of evapotranspiration effective rainfall and irrigation requirements and the crop yield during the season were determined. These outputs were then used to compute equity, adequacy, relative water supply and water productivity of the water course system in the head, middle and tail reaches.

The conveyance losses at different points were measured to compute the water being supplied to different farms and the equity as represented by Christians uniformity coefficient (Cu), coefficient of variance (C_v) modified interquartile ratio (IQR) and their index (T) were computed.

The value of Cu ranges from 0.63 to 0.95 for different water courses with an average value of 0.8. If C_v were chose as a measure of equity then value of equity are apparently quite high, though there is a decrease in equity with increase in the size of watercourse. The distribution looks more non-uniform when one computes IQR which represents the ratio of the average least favoured quarter. The IQR value at the lowest discharge at 19.5 lps is 1.35 and it increases to 2.58 at the highest discharge of 68 lps with an average value at 1.85. In other words the farms located in the head reaches of the water courses were receiving nearly twice the water supply to the tail end farms.

Relative water supply of canal varied across the watercourses, season and reaches. RWS value during summer season, when crop water requirements are partly met by rainfall, were higher by 8-12% as compared to the winter season. There was marked variation in RWS along the watercourses with values at head exceeding those at tail by 25%. The average value at head of watercourses in winter season was 0.65 as against 0.5 in the tail reach. Such large differences obviously call for immediate remedial measures.

The productivity of water delivery was higher in the head reaches of all the water course, the average value during summer being 0.61 in head reach as against 0.48 in tail reach. The relative productivity potential is higher during winter season as compared to summer season. This may be due to occurrence at rain during supply periods in summer season. In such a cases, the supply is rendered surplus. Higher sensitivity of grown during summer to moisture stress could also be the reason for low water productivity. Important difference in RWS and productivity is that in general water productivity values are lower than RWS. It indicates that there is mismatch between supply and demand with respect to time.

The performance evaluation of water delivery using the currently available measures indicated that major shortcomings in the system are:-

(1) Lack of volumetric equity due to non-compensation of time for water lost in conveyance and larger size unit command areas.

(2) Temporal mismatch between supply and demand mainly due to system capacity constraint which makes it difficult to meet peak demand efficiently. Also fixed frequency schedule that is in vogue do not necessarily match with the demand for water.

These problems are amenable to solution with certain modifications in the existing system. Some of the suggested improvements are as fallow:-

(1) Provision of optimum unit command size.

(2) Provision of variable warabandi time schedule from head to tail to compensate for the conveyance losses.

(3) Provision of auxiliary storage at watercourse level during peak supply period for releasing the stored water during peak demand.

(4) Intra-seasonal change in water delivery schedule to provide irrigation at more critical stages.

2.2.7 Case Study – 7

Evaluation of water delivery system : some case studies from Haryana conducted by N.K. Tyagi and A.R. Mishra considered, the three important components of irrigation system water delivery, water application and water disposal system. The horizontal transport system conveying and distributing water through main canal, branches, distributories, minors and water courses is called water delivery system. The objective of delivery system is to distribute water in a appropriate amount at time and place where it can be profitably utilized for crop production. The operation of water delivery system is governed by a set of rules known as water delivery scheduling procedures.

The major emphasis in the studies in this area has been on investigating problem of water distribution in rotational water supply system, management of inadequate supply at farm level and effect on agricultural production. It has been established that the delivery system is faced with several problems which come in the way of improved management.

There are various parameters and indicators for performance evaluation of system. In present study adequacy and regularity were used to evaluate the performance of irrigation system in the command of Adampur distributory of Bhakra canal system and Gohan distributory of Western Yamuna canal system.

To calculate the adequacy the actual value of the water supply can be obtained from water supply hydrograph prepared from the records rotation period and discharge value maintained by canal department. The required value of water supply can be estimated from crop water requirement for established cropping pattern. The procedure was based on method given by Doorenbos and Pruiti.

Regularity defines the temporal match between demand and supply. It however, do not mean that water has to be supplied at regular interval of time. For crops, soil profile servers as a reservoir and this reservoir has to be replenished before it depletes to a level to cause reduction in crop yield. If the required moisture is always present, it is considered a high degree of regularity. The effect of irregularity on crop production varies with stage of growth.

The determination of irrigation requirement for attaining potential yield is done the way it is described in adequacy. If the management allows deficit as a matter of policy then the irrigation requirement should be worked out for that practice. It may be noted that for most of the month during the year the value of RWS is less than 1.0 in case of Gahana as well as Adampur though in the month of July and August RWS exceeds 1.0 in case of Gahana with an average value of 0.36 in Adampur (BCS) as compared to 28 Gahana (WYC), the former is better placed in respect of adequacy. In some months the relative water supply was as low as 10 percent making it a high tension system in which equitable distribution of water is difficult to accomplish. In such area equitable distribution and efficient use of water warrants an elaborate delivery system with a number of controls at different levels and a very high order of skill on the part of the irrigator.

Based on cropping pattern and the area under different crops, demand hydrographs are plotted. For the sake of brevity only average monthly value are taken. The area under supply and demand hydrograph were measured to compute the difference and hence the irregularity in water supply. On annual basis the irregularity in Gahana and Adampur distributories were 58 and 34 percent respectively. If values of only rabi season were considered, the regularity increased to 68.2 percent in Gahana and 40.7% in

Adampur. Fig B-6(a) shows the irregularity in water delivery and Fig B-6(b) shows the relative water supply in Gohana and Adampur distributaries.

The effect of irregularity on crop yield can be estimated if production function with dated water input were available. Such production was available only for wheat crop from Singh (1985). Using this production function, crop yield was calculated.

The average losses of yield in two distributaries were 53.7% (Gahana) and 24.96% (Adampur) respectively. In the both cases the impact of irregularity on yield loss was in the range of 60 – 70% of irregularity. The study leads to following conditions :

- Both the Adampur (BCS) and the Gahana (WYC) distributaries are high tension system with low RWS.
- The degree of irregularity in Gahana was more than 50% as compared to about 30% of Adampur.
- The yield reduction in case of wheat was of order of 60% of irregularity value.
- The regularity has shown improvement after lining of system in Adampur as well as in Gohana area.
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2.2.8 Case Study – 8

R.A.L. Brito, et.al., Brazil M.G. Bos DHU Netherlands in line with International Commission on Irrigation and Drainage's Research Program on Irrigation Performance (RPIP), a research program was initiated in Brazil (RPIP – Brazil) in 1997, under the responsibility of EMBRAPA (Brazilian Agency of Agricultural Research) with the major objective of developing a methodology to assess performance of irrigation scheme from a global, or integrated perspective, in the sense to consider a number of performance indicators within the analysis. These are parameters related to water tariff and distribution, crop return per unit of water, fee collection capacity in the schemes, to mention a few. ICID working group in irrigation performance as tentatively suggested a "minimum set" of performance indicators serve as starting point (Bos, 1997), but a general agreement is still to be achieved.

With the cope of RPIP – Brazil, three irrigation schemes were selected as pilot area, one of which is the Coelha irrigation system. Inspite of such restrictions, some data exists that permit a preliminary appraisal of the project performance, in terms of a few indicators that have been quantified, thus allowing a first over view of the scheme operation.

A preliminary assessment is attempt, based on parameters like irrigation area, water and energy consumption, cropping pattern and operation and maintenance costs. From those values, some indicators were calculated. These are sustainability of irrigation area, average water supply, water delivery ratio, overall consumption ratio, average energy consumption and demand per hector irrigation.

The project was originally conceived to irrigate a total of 15000 ha, for which goal a feasibility study was previously done and investments were made. Therefore, in order to justify the cost of project in term of original proposed, it should effectively maintain that full area in operation, otherwise the predicted goals number of users to be settled, physical production and economic return will not be match and, as a consequence, as shown in Table A-3, the indicator stated as a ratio in 1989, when the scheme was still under going implementation, and reached a value of 0.98 (nearly 1.0) in 1997, thus attained full operation. The expectation, from now on, is that this value should keep round the same.

Water requirement at Nilo Coelho is designed on the basis of a unit reference value of 3.6 m^3/h per ha and irrigation is done during day water supply, in terms of volume per ha gives an irrigation on how much water is being used to produce a hector of crop. The Table A-3 show an overall decrease, from 16650 m^3/ha in 1989, to roughly 7600 m^3/ha in 1997. In general terms, an average of 76000 m^3/ha for a large area may be considered quite satisfactory. The reasons that can explain this gradual change in Nilo Coelho are a combination of a shift in cropping pattern from traditional grain and food crops to "cash crops", like fruits; a gradual change from hand move sprinkler irrigation to localized system (micro – sprinkler and drip) and an improvement in water management by the irrigation, due to again "know how" by the farmers, with the help of technical assistant by district.

The scheme management lays out plan to deliver a certain amount of water, based on the irrigation area to be attended, the crop requirements to be matched and expected losses in the delivery network. After the water has been supplied, this indicator will provide information on how the actual results matched the intentions. The indicator was obtained by relating the volume that was actually delivered to the volume stored for irrigation.

From table A-3, it becomes evident that the predicted storage matched quite well the amount delivered, expect for 1998, when the ratio was 0.72, meaning that the supply was about 28% shot than expected. During the rest of the period water delivery ratio stayed between 0.89 and 1.05 which are quite satisfactory.

The water supplied should adequately match the crops need in the scheme. The figure from Table A-3 the over all consumption ratios for each year, varying from 0.63, in 1989 to 1.32 in 1997. The value for 1991 (1.18), 1993 (1.25), 1994 (1.17) and 1997 (1.32) indicate a deficit in water supply , where as for 1989 (0.63), 1990 (0.83) and 1992 (0.77), an excess in water supply is pointed out desirable value would be near 1.0 such as the case for 1995.

Energy consumption value in Table A-3 show the values of energy consumptions, in kwh/m^3, for stored and supplied water. The water stored value varies from 0.37 to 0.30 khw/m^3 and supplied water from 0.5 to 0.3 kwh/m^3. This observation reveals the inter-dependence among indicators and their trend to converge when intended goals of the schemes are met. That should be rationale behind performance indicators.

Energy demand is the power required (in kW) to operate the pumping station. Energy demand per hector irrigated (kW/ha) vary from 42.49 to 13.37, from 1989 to 1990. In the case of Nilo Coelha, pumps were first operated manually and only during the day. Improvements were obtained by gradual installation of automatic pumping devices associated with 24 hour operation. The indicator shows a more rational use of energy as the irrigated area approaches its original goal. Since electric power bills are composed by demand and consumption, this will have a positive benefit in decreasing expenses with energy for the project.

Water, as the main input for irrigated production, has not been charged for, that is, there is not a price for water. An in direct cost of water is calculated that has three composing actors :

(a) the infrastructure amortization, kl, charged by CODEVASF.

(b) Operation and maintenance called fixed cost, resulting from expenses required to operate the irrigation district.

(c) The energy costs to be paid to power company.

Table A-3 present import help farmers understanding how much the water represents in their cost composition for each cropping pattern and therefore serve as a guide for planning. From the presently available data and values obtained from the indicators, Nilo, Coelho scheme appear to be performing in a satisfactory level as compared to other schemes in Brazil.

2.2.9 Case Study - 9

Study of performance of irrigation system in respect of equity, reliability and availability of water by P.S. Kundu, Agricultural Finance Corporation Ltd. Bombay is carried out.

This is based on "Evaluation and Intervention Studies in Tawa Irrigation Project", conducted by P.S. Kundu as a team leader jointly funded by the Ford Foundation, New Delhi and Agricultural Finance Corporation Ltd. Bombay (1986). This study was carried out during a period of 2 years in 2 consecutive rabi irrigation seasons (October to March) of 1983-84 and 1984-85.

The command area of Tawa Irrigation Project was divided into three zones from the consideration of a gro-climatic conditions, soil characteristics and physical features. Zone B was selected for the study. Three minors in the head, middle and tail reaches in command areas of each of the above 2 distributories i.e. 6 minors were selected. Three outlets in head, middle and tail reaches in the command areas at each of 6 minors were selected. One direct outlet from Hoshangabad distributary were also selected. In all 20 outlets were selected for the studies.

The data on design discharge, length, full supply depth, velocity, bed slope, at the off-take points of Hoshangabad and Raigarh distributaries and 6 selected minors namely, Sankheda, Rasulia, Randhal, Nirkhi, Bisoni and Richi minors were collected from concerned Executive Engineer of Tawa I.P. The actual average daily discharges at the off-take points of both Hoshangabad and Raigarh distributaries for both rabi irrigation seasons were collected from the records of concerned irrigation officials. The daily reading of flow levels at off-taken points of 6 minors were taken by casual investigators engaged and trained for the purpose.

The discharges through 20 selected pipe outlets were measured by the casual investigators engaged and trained for the purpose daily at 2 hourly interval. Parshall flumes were installed just below outlets whenever possible, to measure the discharge from outlets.

Actual areas irrigated by each 20 outlets were measured during both the irrigation season. The design discharge and C.C.A. of each 20 outlets were collected from irrigation officials of the project.

The design discharges, monthly maximum and minimum discharges of Hoshangabad and Raigarh distributaries for both the irrigation season are given. From the data on status of flow levels in minors, the numbers of days in month under full, ¾th full, 1/2th to ¾th full, ¼ to ½th full and less than 1/4th full was computed and analysed during both the irrigation seasons. It was observed during the study period that the selected distributaries were never operated at full design capacity except for 2 days in November 1984 in respect of Hoshangabad distributory. During peak demands of water requirements of crops, the distributory was operated below 65.7 percent capacity and below 76.5% capacity irrespective years.

It was observed that Raigarh distributory was always operated less than 71% of design discharge.

None of the 20 outlets was operated at full capacity throughout the entire irrigation seasons. Their daily average maximum discharge were below 70% of design discharge ranging 47% to 68% of design capacity.

The equity of water delivery performance minor giving plot to plot variations in term of number of watering to a plot in relation to total number of irrigated plots.

There was no reliability of water as variation in fluctuations of discharge was random. Water supply was not reliable in distributories and minors even during peak demand of water requirement of crops. Availability of water from distributaries, minor and outlet was significantly below the design capacity during most part of the irrigation season.

The water distribution was not equitable in command areas eigher from one area to other or from plot to plot in the same area during both irrigation seasons under study. It has also be observed from the data on discharge and flow levels in 2 distributaries and 6 allowing 15 minutes between users to assure that each receives all the water he had paid for.

In stage II units, the process is complicated by the need to get an irrigation partner. If a partner in another loop can be found for all or part of the same time, the charge per unit of time to each is lowered. In these units, the pump is not turned off after each usage. The farmer goes to his field and opens his outlet at the appointed time. When he finishes his turns, he closes his outlet and walks up to the pump house to report that he has closed it. His appearance at the pump house is accepted as proof that he did indeed open and close his outlet as agreed. Walking time between pump house and field is deducted to determine the time the outlet was closed.

In April 1994, WUGs were charging their members between NRS 30 and NR 60 per hours of pump operation, in addition to the per ha charge. Some WUGs have decided to charge members a percentage above the sum calculated to cover electricity costs, in order to build up a fund for future repairs or other activities. Some WUGs are taking advantage of the 3% discount offered by NEA for early payment of the electricity bill.

Farmers are very cost conscious. They are using the pump much less them before Preliminary figures indicate that less than 50% of project consumptions but 18 months constitute too short a period in which to base conclusions. Much depends on the amount of rainfall, as well as on the natural caution of users unaccustomed to out-of-pocket expenditures. As they become more accustomed to paying and a they begin to observe the relationship between the volume of water and their yields, they may well increase their expenditure on water. In the meantime, they are pleased to find their costs lower than forecasted.

WUGs are insisting on conjunctive use where other sources exist, the WUGs are insisting that surface water systems be integrated with groundwater distribution scheme.

A clear benefit to the farmers has been the greater responsiveness of POs Previously, the POs were government employees some of these used to lock the pump house at the end of their shift, leaving farmers literally high and dry. As the farmers now pay the PO's salary and as he is usually a resident of the village and occasionally the son of one of the users, he is clearly sensitive to the needs of the users and is accountable to them.

minors under study that there was no equity in distribution of water from one distributary to another and from one minor to another as Hoshangabad distributary received higher percentage of design discharge as compared to that received by Raigarh distributory.

The performance of irrigation system in term of equity, reliability and availability in distribution of water was not satisfactory. Farmers also complained about non-availability of water in time; non-equitable distribution and unreliable supply of water.

It is recommended that

(i) The entire distribution system starting from the canal to outlet as also end of water course and field channel should be modernised.

(ii) Water supply as pre-determined schedule of water application in the field plots and outlets based on demand.

(iii) Equitable distribution of water by suitable method.

2.2.10 Case Study – 10

Manual Olin in his paper, "Transfer of management to water users in stage – I and stage – II of Bhairawa – Lumbini Ground Water Irrigation Project in Nepal", presented in 1997 seminar of IIMI states that the take-over process is well established and idea of managing the deep tubewell no longer frighten the farmers. The take-over endeavor has been a very intensive affair. There was never a full moment of the 80 DTWS originally scheduled for take-over, 69 are now fully managed by their members. They are all paying their electricity bill and in several, the salaries of their pump operators (P.O.) as well. Of the remaining DTWS very intensive activity is in progress to recover and to put them on track. Five WUGs are soon to start paying for M and R. The remaining 22 DTWS in stage II are well prepared to take over their DTWs as soon as they become operational. The experiences of stage I and of stage II phase I will not be repeated there.

WUGs are showing a great deal of caution. Farmers are required to pay in advance for water requested in most of cases. The pre-payment process is time – consuming. The farmer goes to the treasure and pays for the amount of time that he wants to irrigate. He receives a chit which he brings to the P.O. The latter assigns him a turn and the exact time. In some stage I units, the pump is turned on and off for each users, WUGs are ignoring rules of good operating practice. They turn the pump offs after every delivery; in stage II, they do not observe simultaneous distribution along all loops. These practices are hard on pump, wasteful of water and costly. The AOs are trying to make them aware of these problems and to organized the distribution differently.

Farmer interest in the working of their WUG appears to more active. Attendance in meeting is generally higher than what was reported in the socio-economic survey. Ignoring meeting of the Executive Committee alone, attendance has exceeded 50% of the membership in virtually all WUGs, in at least one of the last three meeting.

The management transfer is an interaction among many groups and within many groups. It is not limited to WUG and P.A in case of BLGP, the various participants were the WUGs individually and as a group, the project management as a policy – maker, the goverment as provider of budgets, the World Bank the NEA, the contractors and the employee of the P.A. The number of possible action and interactions among this long list indicates the potential for complications in take-over process.

In BLGWP, the farmers were not inclined to anticipate problems and to resolve them in advance. They faced the problems that confronted them, but were not willing to deal with those that just go away. Farmers were willing to test the limits. They waited till their power was cut and till the meter was removed. They withheld labour until they realized that the work would not be done for them by the contractor.

The farmer underestimate their own ability to handle new task and were fearful of untaking them. They also feared that the costs would be beyond their abilities. The AOs spent much time and effort to show them that none of this was beyond them.

The WUGs needed a lot of support at every stage of process. In a number of WUGs, they had to helped with simple things like issuing a receipt, calculating cost share or preparing a list of members so that it could easily be seen who had paid and who had not.

Following recommendation are made :

- In planning process, the list of potential actors must be identified, their likely reactions recognised and consideration given to these in the plan.

- Firmness is extremely but it must be mixed with a touch of reasonableness and fairness.
- Frankness and honesty in informing the farmers, what to except in terms of costs and responsibilities were very important.
- Where labour is to be contributed by farmers, it must be in complete self-contained package.
- The WUGs need help in administering their finances, in scheduling irrigation and recording water use by farmers in their different plots or scheduling pump operation without frequent stops and starts.
- The project authority must be ready to accept some adversity.
- The major calculation from the take-over exercise is that the need for take-over should be avoided in tune. Farmers should be involved in design and development from outset and at no time should, they be allowed to believe that they will be given hand outs.

The BLGWP believes in the speed for organizational support to WUGs after take-over. Support will be offered by only a given fixed time. Twelve months of support is estimated to be sufficient.

2.3 CONCLUSIONS AND RECOMMENDATIONS OF CASE STUDIES

After review of case studies following conclusions are drawn

(i) Lack of evidence of an effective performance assessment frame work :

None of the case studies contained any evidence of an effective assessment framework which would help managers to improve over the levels of performance. That does not mean to say that none of the systems have such a framework; it might be there, but is unreported.

Further, most of the case studies are reports of specific research activities that were themselves instrumental in collecting data presented except Nilo Coehlo of Brazil. This indicates that the operating personnel and managers do not have access to data of sufficient quantity or reliability to assess performance and diagnose ways of improving it.

Which of these two conditions needs to be addressed first, if performance is to be improved is difficult to determine; data collection program without a frame work appear doomed to die through lack of relevance : a frame work is of little value unless there are good data to be used.

(ii) Lack of Clearly Stated Objectives

Most of the case studies did not identify the objectives for which the system were being managed. This reflects in part the lack of a framework that stresses the importance of having clearly stated objectives, but it is also because outsiders impose their own understanding of what the objectives ought to be on the system being studies.

This highlights a particular dilemma for observers attempting to make judgements about performance. The most commonly cited objectives, including many of those used in this study, are more global in nature : equity, reliability, and adequacy are all seen to some extent an universal to the evaluation of water delivery performance. System managers may have an entirely different set of local objectives. Unfortunately, if they are not clearly expressed, they will be ignored in external assessment, and a different set of objectives used in any evaluation of the level of performance actually achieved.

The combination of the lack of an effective performance assessment framework and a set of relatively short-term research oriented case studies means that there is little information on the long term trends of performance in any of the system studies. Short-term studies give little opportunity to see if performance is improving or declining, and the lack of long term performance indicators in the assessment process means that adverse and even irreversible changes are simply not being monitored.

(iii) Target and Objectives Mismatches

In the majority of case studies some short fall is reported eighter in achieving targets, in fulfilling objectives or in both. It is obvious that without accurate data such shortfalls are inevitable, but it may be precisely because of adverse institutional pressures than system operators do not wish to report bad news.

It is essential to check whether appropriate data exists or not. Data collection be undertaken openly and objectively if realistic assessment of performance is to take place. The fact that shortfalls in meeting targets or objectives are reported should not initially be any cause for alarm or discrimination. It is when those shortfalls are viewed as persistent that evaluation must become more critical.

Assuming data exist and this is not the situation in all the case studies, then the diagnosis can proceed to assessing whether the defined targets, if met, would actually meet the objectives.

It is obvious that there is little concern with better matching the system level objectives with operational targets. At this stage of the diagnosis it may not be possible to say which should be modified in the future, but it is clear that the system is inherently out of synchrony and this can only perpetuate the situation where performance is lower than that it could be.

There is some evidence to suggest that operational targets are institutionalized and remain static even if external or system-level objectives change. Such rigidity is the hall mark of bureaucratically administered systems rather then of performance – oriented management systems.

The worst case, and regrettably the one that seems to typically most of the case studies is that neither objectives or targets were met to any great degree of precision. It may be that in most cases the managers are neither "doing things right" or "doing the right thing". This does not mean to say the system are catastrophes, but it does mean that there is tremendous potential to improve performance.

(iv) Assessment of Operational Performance

A management oriented approach does not rule out the need under some circumferences eigher to make physical changes in the system design or to increase the level of financial and human resources. What it does do, however, is to view these measures as necessary only when existing resources have been used to their full capacity. By improving objectives, implementation and monitoring through involvement of both agency staff and farmers, significant performance improvement resulted.

The case studies appear to suggest very strongly that management improvements, particularly the management of maintenance, are essential in improving overall water delivery performance. More complex technological solutions are less likely to be effective if the capacity to maintain simple infrastructure is inadequate.

Assessment of operational performance is in large measure a site specific activity. What is being assessed, is the degree of achievement of specific hydraulic and other targets, and their capacity to meet the system – specific objectives.

The primary motivation of a manager will be to increase performance in absolute terms for that system, based on a time series view of actually achieved performance. A good example would be improvement of equity of water distribution if this is a system objective and the manager consistently improves the achieved level of equity this is good performance irrespective of the situation encountered in any other system.

(v) Assessment of Performance Between Systems

It is more difficult and perhaps impossible to make many definite conclusion about the relative performance of different systems. Nevertheless, the overall environment in which an individual system is being operated must be taken into account when decisions have to be made in respect of where to invest for improved performance in future.

The case studies are too diverse in both physical design and managerial environment to indefinite. Nevertheless, in respect of certain objectives that concern decision makers at levels higher than the individual system, the equity, rehability and adequacy can be made based on the available evidence.

Following recommendation were made for improving performance :

(i) Objective Setting :

A fundamental component of a managed organization is that there is a process that sets objectives, determines who is responsible for achieving them and makes sure that all member of management team are fully aware of and committed to achieving these objectives. Objectives must be simple and clearly expressed, and the responsibilities for achieving them clearly defined.

The case studies show that high performance is only obtained in the systems where there are clearly stated, simple objectives for water allocation and delivery. In most of the case studies the objectives are unclear, let alone the operational rule. Thus, there is little or no opportunity for stabilization of management inputs.

System level objectives must be based eigher on past experience from that system, or from systems facing similar design and management conditions, rather than on assumptions about what ought to be achieved in more generic terms.

Performance of irrigation managers must initially be used on their fulfillment of specified set of objectives. At the same time, there must be parallel process of evaluation and review of the impact of current management actions.

Objectives must reflect the needs of all participants : policy makers, planners, managers and users, rather than only one or two groups.

One way of improving performance is by strengthening farmer participation in the annual or seasonal planning process and developing operational plans and targets. Performance assessment requires an evaluation not just of output but of the setting of objectives and of the management of available resources in attempting of fulfill those objectives.

(ii) Operational Management

Once objectives have been clearly defined the rest task is to transform these into clear quantitative operational targets that are required of each individual within the hierarchy. Operationalisation clearly includes both the structure of the decision-making process and the decisions themselves. It is therefore the dual task of managing the physical resources and individual within the system.

Each objective has to be transferred into a set of operational targets that match the responsibilities of each participant in the management process.

It is unrealistic to expect managers at system level to develop or modify operational targets unilaterally that will meet objectives developed in the external environment.

Targets must be quantified to facilitate monitoring and a set at standards developed to enable evaluation to be undertaken.

(iii) Information feedback and management control:-

Management system include mechanisms: These assess whether targets are being met, ensure that individuals are doing what they are supposed to do and provide feed back into the next phase of planning and objective setting. Although control is an essential condition for management, it is often weak or missing.

Without good and accurate information there can be no progress towards performance oriented management. Management cannot operate as a black box when either the internal or external environmental conditions are changing: It is essential that managers understand how to achieve particular targets under one set of conditions so that they can make appropriate operational change when other conditions change. If operations are based only on the assessment of outputs then a long-term managerial of strategy does not result.

The command tendency to report that targets have been achieved when in reality they have not is completely alien to the concept of performance oriented management.

Information on the levels of target achievement and the consequence for agricultural output must be directly integrated into the management structure.

(iv) Institutional and other management conditions

All the best management advice in the world will have little or no impact if the organization is not willing to adopt performance oriented management techniques. Performance oriented management requires a set of incentives and commensurate accountability throughout the management structure.

The case studies suggest however, that the decision-making process is largely static at system level because there are few rewards for improved performance and little accountability for failing to achieve a predetermined set of targets. Under these conditions the process of setting targets and them evaluating performance based on a assessment of the degree of achievement of those targets becomes on abstraction.

Evaluation of performance in respect of each objective requires an explicit statement of who is, and who is not, responsible for attending that objectives. Failure to clearly defined responsibilities for achieving objectives appears to lead almost inevitably to lower levels of performance.

In systems where there are more than one group of participants, then the definition of specific responsibilities is essential: the term "Joint management" might be better expressed as co-ordinated management. Planning can be undertaken jointly, with different groups expressing their desires and their constraints, but a necessary out come of this process is that each group knows where it has full responsibility for implementation to achieve certain objectives is not a satisfactory condition if there is no-parallel system of joint accountability or joint benefit.

Accountability requires that there be specified targets or contracts of points at transfer of management responsibility which enable all parties to determine whether the agreed level of service has actually been achieved and to assess causes of failures to meet the terms of contract.

A management approach should not, of course be used as an excuse to tolerate repeated failures indefinitely it has to incorporate learning as a process which will improve performance. The case studies suggest that the same errors are made repeatedly because the organizations involved cover up internally and blame other participants in management process.

CHPATER-3

THE PROJECT (ACASE STUDY)

3.1 GENERAL

Mahakali Irrigation Project is located in farwestern development region of Nepal on the left bank of Mahakali River in Kanchanpur district of Mahakali zone. The project area is being developed in three stage: stage I (4800 ha), stage II (6,800 ha) and stage III (2800ha, initially proposed 11,600 ha), stage I of the project was implemented in 1980 to 1987 and stage II started in 1990 and now they are in operation status. Stage III project is going to have its feasibility study. World Bank (IDA credit) financed both stage I and stage II project Stage I area falls under newly cleared forestland while most- of the stage II area falls under old flood plain of Mahakali River. The Mahakali irrigation project of stage I is under study.

3.2 LOCATION

Mahakali Irrigation Project is located in Kanchanpur district, the western most terai district of Nepal. The project area is bounded by the East-West Highway in North, Indo-Nepal boarder in South, Mahakali River in the west and Royal Shukla Phanta reserve Wild life forest in the east. The district head quarter, Mahendranagar is adjacent to the project area, which is linked through East West National Highway with other part of country. A grass airstrip at Mahendrangar is also served by Royal Nepal Airlines weekly Figure 3.1 and 3.2 show the location and general plan of project area.

3.3 TOPOGRAPHY AND SOIL

Topographically, the project area bears typical characteristics of terai plain of Nepal. It is generally flat and slopes gently from north to south with an average land slope of about 3%. The north part of project area is connected with foot hill area of Siwalik range and has rolling topography. The rivers in this area are deeply incised. Flatter lands are

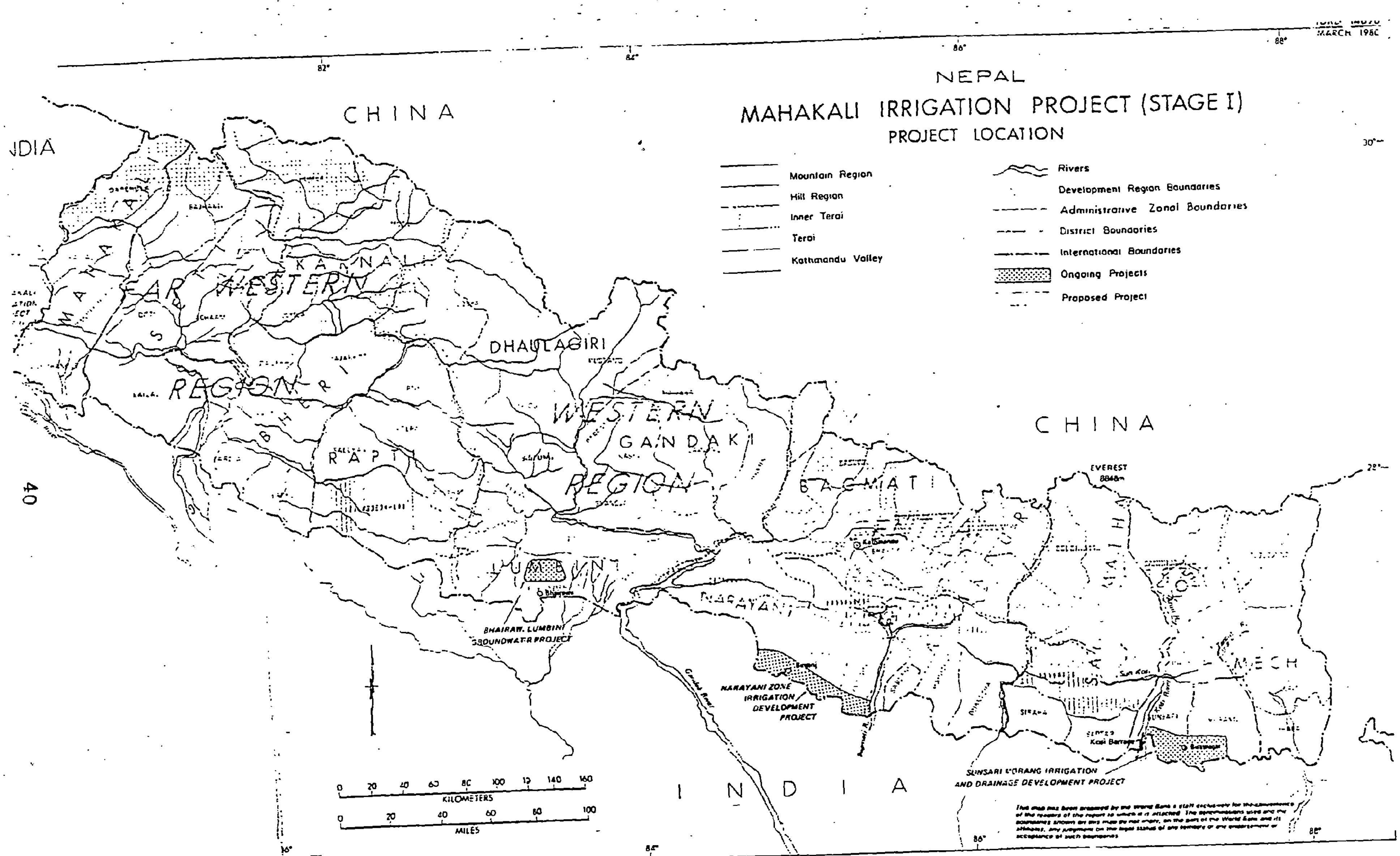


Fig. 3.1 Mahakali Irrigation Project(Stage I) project location map.

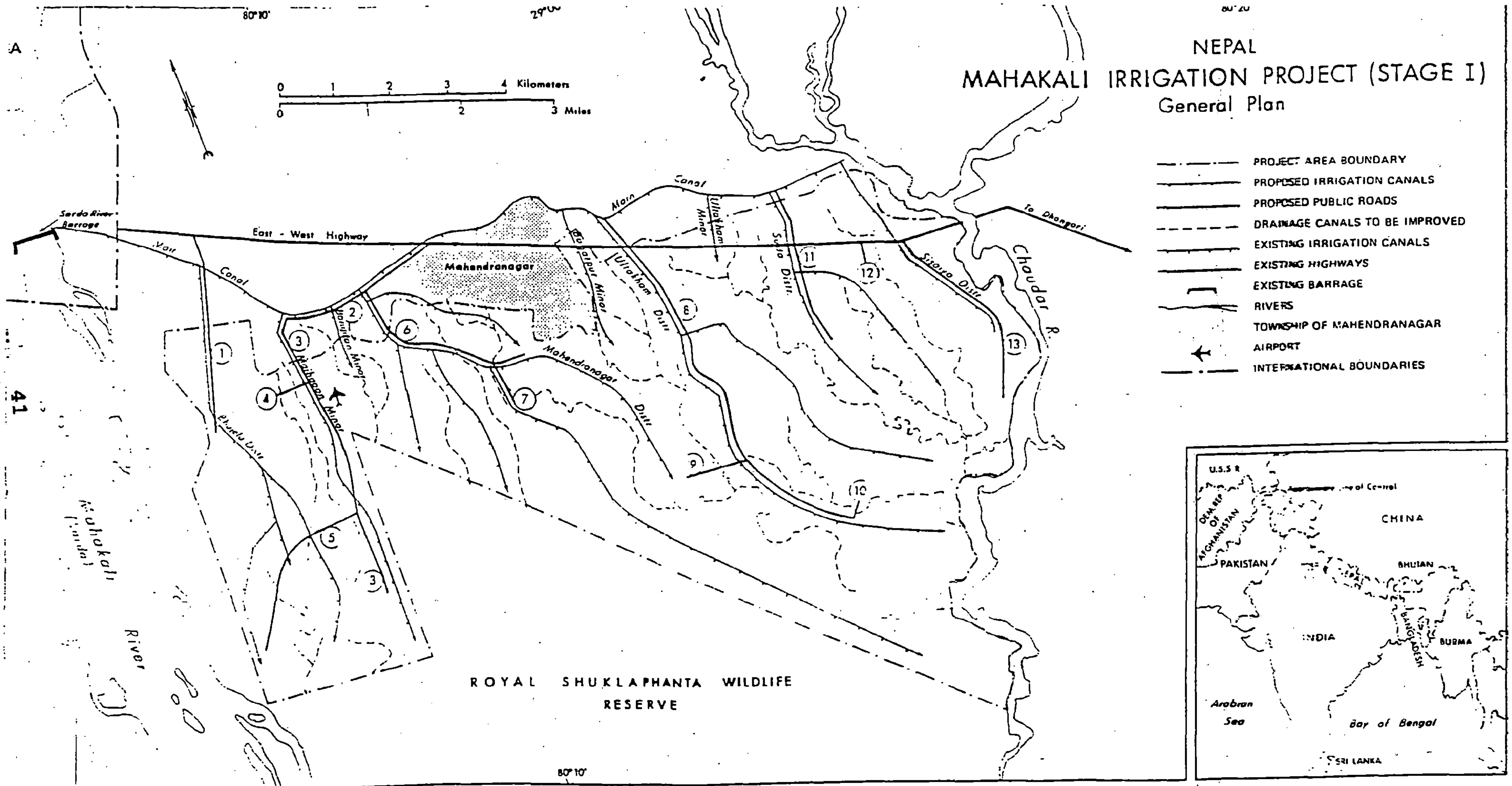


Fig. 3.2 Mahakali Irrigation Project (Stage I) project general plan.

encountered as one moves from north to south where rivers are shallow and spill over their banks causing inundation.

Soils in the project area are of alluvial and fall in to two main types

(i) Yellowish and grey brown soil coarse to moderately coarse texture and well drained.

(ii) Deep alluvial soil consisting mainly medium to moderate fine textured clay to silty loams, less permeable and poorly drained.

Over 95% of the area has been classified by USBR standards as class I and class II for irrigation Type (I) soils are suitable for irrigated farming of mainly upland crops such as wheat cotton maize and pulses because of their coarser structure and higher permeability. while type (ii) soil with proper drainage are suitable for both irrigated paddy and upland crops.

In general, the soil in the project area has good drainage capacity and therefore posses no problem for water logging and salinity. However some area laying on the southern part near Indo-Nepal boarder suffers form frequent inundation from over bank spillage of drained streams during monsoon where as the remaining area is well drained by a good network of natural and artificial surface drainage.

3.4 CLIMATE

The project area has humid-tropical monsoon type of climate. The annual rainfall with 50% probability of occurrence is 1751 mm and that of 80% probability is 1422mm. The class A pan evaporation is estimated to be about 1,9 15 m. The mean monthly humidity attains a maximum of 79% during July and August and a minimum of 37% during May. The maximum monthly temperature goes as high as 38.2^0 C in May and minimum as low as 7.3^0c in January. The maximum daily temperature occasionally exceeds 42^0c in the month of April and May. The minimum daily temperature touches as low as 6^0 C in month of December and January. Climatic data are presented in Appendix table A-6.

3.5 WATER RESOURCES

3.5.1 Surface water

The source of water supply for the project area is the Mahakali River which has monthly flows ranging from 130 m^3/sec in May upto 11,000 m^3/sec in wet season. Sediment concentration are high during monsoon period when mean monthly concentration of over 1,000 ppm are usual and some times exceed 4,000 pp m. Daily values may be as high as 16,000 pp m. The Chaudhar River bordering, the project area on the east carries considerable flashy flood in monsoon but its base flow is the dry season is a only bout 1.0 m^3/s. The four major drainage channels, crossing the main canal, carry flash floods in monsoon but are dry during the winter season.

The project is formulated on the bilateral treaty between Nepal and India in 1920 regarding the share of Mahakali (Sarda) River water. This agreement stipulates the following rights of Nepal:-

(a) From May 15 to October 15 a supply of 460 cusses (13.0 m^3/s) and provided a surplus in available, a supply upto 1000 cusses (28.3 m^3/s) and

(b) From October 15 to May 15, a supply of 150 cusses (4.25 m^3/sec). The agreement further stipulates that from October 15 to May 15 supply canal to Nepal would be alternatively closed and opened for 10 days at a time and then the canal could run at 300 cusses. (8.5 m^3/s) capacity whenever canal is open. These stipulated quantities are only minor portions of the flows in the Mahakali River, and India would have no difficulties in providing these flows.

3.5.2 Ground water

The ground water potential of Kanchanpur district has been studies since 1973 by DOI and United State Geological Survey in a study sponsored by USAID. A considerable portion of the project area over lies ground water aquifers. A phreatic alluvial zone located two to three metres below ground level and about 10 and 20m thicks, forms the upper aquifer its water table is 1.5 to 4m below ground water Numerous dugwells and hand pumped wells take water from this aquifer. A semiconfined and confined sub aquifer of new alluvial sediments underlies the pheatic alluvial zone descending to a depth of about 150m. In the eastern portion of project area this aquifer is artesian. The available supply of surface water is sufficient to meet the requirement of the project. However, when areas east of Chaudhar River are to be developed under stage II and III, the need for supplementary supply of ground water may arise. The water from all sub-aquifers in the project area is generally chemically suitable for domestic water supply, live stock and irrigation.

3.6 LAND RESOURCES

At the time of project formulation, data on distribution of operational handing i.e including those not owned by farmers is available at the district level only (census 1971) but is believed to be similar in the project area.

Table 3.1 : Farm Sze and Holdings

Farm size	% of all farms	% of total farm land	Average farm size.
Less then 1 ha	25.4	5.8	0.76
1-2 ha	27.4	13.2	1.63
2-5 ha	26.6	26.6	3.39
5-10 ha	15.7	32.7	7.09
10 ha and more	4.9	21.9	15.35

According to these date 21% of the largest farms occupied about 55% of farm land, where as 53% of smallest had only 19% of the total available. However this might overstate in equity since in this area large farms are often associated with large extended families as is the costoms of the Tharu caste. This might be also be reason for high average farm size (3.4 ha) in comparison with the average size for terai (1.7 ha). However continuing immigration and settlement after 1971 to 1980 have further reduced the average size to about 2.8-3 ha. However on the basis of data received in 1996 it has been found that the average farm size is approximately 1.3 ha in project area.

According to statistics from the department of land reform, 85% of registered land is being farmed by its owners. The remanding and is leased to tenants under various arrangement mostly share cropping.

The total area of Kanchanpur district is 161,000 ha and out of which the land area occupied by agricultural and human habitation is 46,8985.5 ha. and 95.3% of land is used for seasonal crops.

3.7 EXISTING CANAL, DRAINAGE AND ROAD SYSTEM

There are three components of irrigation development projects

(i) Canal improvement and extention the design capacities of irrigation distributaries system have been increased to enable extension of their command areas. Further more the design duty for these canals has been increased to meet the peak water demand. These increases in canal design capacity requires modification of existing structures, where required additional structures are built for improved water control. Additional tertiary, turnouts are constructed to reduce the size of tertiary to a maximum of 40 ha Existing turnouts are replaced by gated structures suitable for discharge measurement. The distribution system beyond tertiary outlets serving farm groups to 7.8 ha. All the existing and new tertiary canal is provided with outlet structures for each farm group and necessary division boxes check structures, drops and culverts for drainage channels and cart track crossing. In the existing system, the irrigation distribution system are also extended down to outlets serving farm groups of 7-8 ha

(ii) Drainage improvement

The capacity of the existing natural drainage channels was generally sufficient but increased where necessary to provide the required capacity to improve drainage within the tertiary units.

(iii) Roads

The roads components are encourage the production of marketable surpluses by providing all weather access to irrigated area. It has made the effective operation and maintenance, of canal system by providing quick access to all canals and control structures. All whether public road canal service road and road crossing structure are constructed.

As the irrigation works under project are relativity small hydraulic structures and canals, design of these works are not present any particular problem. The canals are designed for non-scour, nonsiltation situation on average.

Structures are generally built of mass concrete as bricks in project vicinity were of low quality.

Labour intensive methods of construction are adopted. However compaction of canal embankments earth works for roads and road pavement are executed by machinery under ensured quality.

3.8 ENGINEERING DESIGN CRITERIA

A. Irrigation Systems

1. The project area includes 36,00 ha of low lands suitable for paddy cultivation and 3,000 ha of uplands suitable only for growing field crops. The growing of paddy in upland areas would be discouraged as much as possible and inlet capacities of tertiary units would be limited to the growing of field crops only. The following design criteria are recommended:

2. Low Areas:- In lowland areas capacities for tertiary unit inlets distributaries have been determined with the formula:

$$I = \frac{Me^{\frac{MT}{S}}}{\frac{e^{\frac{MT}{S}}}{e-1}} \times \frac{0.1157}{ef \times et \times ed}$$

In which:

I = Supply (in 1/s/ha) required during presaturation period over the area to be irrigated;

M = supply (in mm) required for maintaining the water layer after presaturation is completed (2mm/day seepage losses plus 6.4 mm/day evaporation equals 8.4 mm/day).

T = duration of presaturation period (in days);

S = quantity in (in mm) of water required for presaturation and nurseries (140mm)

e_f = farm group efficiency (0.85);

e_t = tertiary canal efficiency (0.85);

e_d = conveyance efficiency of distributaries (0.80).

Design capacities thus become:

(a)	Inlet for tertiary unit	2.25 1/s/ha 1/
(b)	Distributary serving < 500 ha	2.00 1/s/ha2/
(c)	Distributary serving > 500 ha	1.80 1/s/ha/3/

3. Upland Areas. Required capacities have been calculated with the formula:

$$Q = \frac{0.1157D}{e_f \times e_t \times e_d}$$

In which:

Q = required supply (1/s/ha)

D = net irrigation requirement (58 mm for oilseeds in second half of October)

T = duration of supply (15 days)

e_f = farm group efficiency (0.70)

e_t = tertiary canal efficiency (0.85) \

e_d = conveyance efficiency of distributaries (0.75)

Design capacities thus become: 4/

(a)	Inlet for tertiary unit	0.75 1/s/ha
(b)	Distributary	1.00 1/s/ha

4. Mixed Areas. For mixed area>500 ha with A has lowland and and B ha upland the capacity of a distributary becomes:

$$\frac{1.8A + 1.0B}{A + B} \text{1/s/ha}$$

1/ for T = 15 days

2/ for I – 30 days

3/ for T = 45 days

4/ Based on requirement of 58 mm in 15 days (oilseeds in October).

B. Drainage Systems

1. Paddy areas. The 282 mm design rainfall adopted was the maximum cumulative rainfall occurring in three days with a probability of exceedence of 20% (one in five years). Such a rainfall generally ossuaries in July. The drainage criterion adopted was that the duration of flooding in the paddy fields to a depth over 20 cm should be less than three days. On the basis of these criteria project drains would be designed for a dischrge og 3.1/sec//ha

2. Upland areas. A design rainfall was adopted of 175 mm per day, being the maximum one-day rainfall with a probability of excedence of 20%. Adopting the

criterion that excess runoff should be drained in 40 hours and allowing for infiltration, the design modulus becomes 4.5 l/sec/ ha

C Roads

1. The road network would be designed to provide all weather access to within a distance of about 3 km from all parts of the areas to be irrigated. Design criteria would be as follows:

Item	Public Roads	Canal Service Roads
Formation: width Minimum height (to underside of pavement)	7.0m 0.7m	3.0m 0.7m
Pavement: Width Gravel base minimum thickness 1/ Waterbound Macadam top course minimum thickness Black top surfacing Bitumehdus seal coat	3.5m 200m 100mm 50 mm full grout on hard shoulders	2.4m 200m 75 m none on pavement
Hard shoulders, comprising 200mm gravel base and 75 mm Waterbound Macadam top course	2 x 1m wide	None
Passing places, 15m long x 4.0m wide built to canal service road pavement specification and identified by marker posts	None	About 500m spacing
Paved access ramps, 3.5m wide, maximum grade 1 in 6	On both sides 2/about 500m spacing	On landward side, about 500m spacing

1/ Thickness would be increased where necessary when CBR values of sub-soils are known.

2/ On landward side only for roads on canal banks.

3.9 PROJECT SALIENT FEATURES

The salient feature of Mahakali Irrigation project –(stage I and II) are presented are given in Table 3.2.

Table 3.2 : Salient Feature of Mahakali Irrigation Project

S. N.	Work scope	Unit	Stage 1	Sate II
1.	Command area	Ha.	4800	6,800
2.	Main-canal Rehablitation New Structures	 Km Km Nos	 13.7 - 64	 14.3 21.0 49
3.	Secondary canal Rehablitation New Structures	 Km Km Nos	 37.10 15.7 144	 - 93 257
4.	Tertiary canals Rehabilitation New Structure	 Km Km Nos	 34.80 171.20 1318.0	 352.0 40.0
5.	Drains Rehabilitation New Structures	 Km Km Nos	 102.30 121.8 827	 40.0 19
6.	Roads public roads/off canal roads service /on canal road	 Km Km	 15 55.6	 21.0 108.0
7.	River training Makakali river Rautela river Chaudhar diversion Flood bunds	 Km Km Km Km	 0.5 2.20 - -	 - - 5.75 2.0

Source :- MIP

3.10 ORGANIZATION AND MANAGEMENT-

In accordance with His Government of Nepal established policy and for effective project implementation, a governing board is created for executing the project under Development Board Act 1956. The project manger is the overall responsible for preparation of annual project work programme, budget and staffing schedules.

3.11 FARMERS PARTICIPATION

Farmer's participation and their active involvement in operation and maintenance not conceived in project design. However during the course of project implementation there are needs for farmers participation in all stages of project development and project started incorporating their participation. MIP stage I under went its operation and maintenance activities on joint irrigation management basis. According to which the project is responsible for O & M from main canal to the head of tertiary canals and the farmers are responsible for water allocation, distribution and maintenance within their tertiary canal and chak boundary except structures.

The design and construction of tertiary canals of stage II area incorporated active participation of beneficiary farmers. Farmers contribution as irrigation policy of Nepal to the capital cost of irrigation network consists of the cost of land for tertiary canals and cost of canal box cutting and grass sodding along with the construction and fixation of canal alignment.

3.12 CROPPING PATTERN AND YIELD

The crops grow in the project area are mainly paddy and maize during the wet season and wheat oilseeds & pulses and vegetables during dry season. Mostly common sequences are

(i) Paddy-wheat (ii) Paddy-pulses and (iii) Maize-oilseeds.

At time of project appraisal the present cropping intensity was 121% in rainfed area and 134% in irrigated area and was expected that after implementation of project the cropping intensity will rise to 165%.

The pre-project yield, SAR target yield, maximum yield of major crops are given in Table 3.3. Projected cropping pattern is given in Appendix A Table A-8.

Table 3.3 : Crops Yield

Crops	Pre-project yield in tone/ha	Staff appraisal Report Target yield in t/ha	Maximum yield achieved in tone/ha.	Remarks
Paddy	1.3	3.2	4.18	1994/95 year
Maize	1.20	2.0	2.10	1991/92 year
Wheat	1.10	2.10	2.8	1990/91 year
Potato	7.0	11.0	15.40	1991/92 year
Pulses	0.6	0.7	1.18	1994/95 year
Oilseeds	0.60	0.70	1.0	1994/95

The cropping intensity rises to 192% against the staff appraisal report target 165%. The agricultural activities of Mahakali Irrigation Project hinged on activities conducted by Agricultural pilot farm of the project.

Table 3.4 Cropping Pattern

Major crops	Present and Future project without project		Future with project as SAR	Present Existing Cropping intensity with project
	Rainfed %	Irrigated %		
Paddy	59	71	56	89
Maize	25	17	21	7
Wheat	10	17	24	68
Cotton,	-	-	10	-
Soyabean	-	-	3	-
Groundnut			4	
pulses		12	21	14
Oilseeds	14	16	23	12
Vegetable	-	1	3	2
Cropping intensity	121%	134%	165%	192.0%

Source:- MIP

CHAPTER-4

METHODOLOGY

4.1 GENERAL

During earlier work on performance assessment three level of organization, having different objectives, was distinguished.

- Irrigation and drainage system level
- Agency level and
- The planning and policy environment at sector level.

Despite the differences in objective sets for each level of organization, a common definition of performance was proposed

- The degree to which an organizations products and services respond to the needs of their customers or users and
- The efficiency with which the organization uses the resources at its disposal.

Recognizing that there are different customers or users, makes it easier to distinguish between objectives of such diverse group as donors, politicians, system managers and farmers.

Operational performance is concerned with the routine implementation of agreed level of service. It specially measures the extent to which intentions are being met at any moment in time, and thus requires that actual inputs and outputs are measured on a regular basis.

Strategic performance is a longer term activity that assesses the extent to which all available resources have been utilized to achieve the agreed service level efficiently, and whether achieving this service also needs the broader set of objectives. Available resources in this context refers not merely to financial resources; it also covers the natural resources base and human resources provided to operate, maintain and manage irrigation system. Strategic management involves not only the system manager, but also higher level staff in agencies and at national planning and policy level.

At all level, performance must be assessed using a combination of targets. Each all these targets have on acceptable range of value around that target. Neither targets nor the ranges are likely to the uniform.

4.2 KEY INDICATORS OF PERFORMANCE ASSESSMENT

The intended service being delivered by irrigation to its water users depend on the 'agreed service level'. Key elements to be taken into account are:-

1. An irrigation and drainage organization is service oriented if it ;
   - (i) Makes every effort to provide irrigation and drainage services that are well adopted to the farmers needs.
   - (ii) Aims to provide these services at the lowest possible cost to the farmers
   - (iii) It is accountable to farmers
2. A service agreement between an irrigation organization and its users specifies
   - (i) The service that will be provided
   - (ii) The payments or other resources that will be contributed by the users in return of these services
   - (iii) The procedure that will be used to check whether services are provided and payments are made as agreed.
   - (iv) The authority that will be address to settle conflicts and
   - (v) The procedure that will be used for updating and improving the agreement.
3. In large-scale irrigation system, irrigation water is often handled by an irrigation agency and by a water users association before it reaches the individual farmer. Such systems require a separate service agreement for each level where water is transferred from on organization to the next.
4. Organization needs to have the legal authority to make service agreement.
5. Service oriented management at an irrigation and drainage system is a process of identify designing and implementing the technical and institutional modification needed for sustained operation of system on the basis of an appropriate set of service agreements and organization charts.

4.2.1 General Features of Performance Indicators

A true performance indicator includes both an actual value and an intended value that enables the assessment of the amount of deviation. It is therefore desirable wherever possible to express indicators in forms of the ratio of the actually measured versus the intended situation. Hence

$$\text{Performance Indicator level} = \frac{\text{Actual level of DeliveredResources}}{\text{Intended level of Considered Resources}}.$$

It is important to ensure that indicators selected for a system will describe performance in respect of the objectives established for that system. It is this process that links the use of indicators to the overall performance assessment framework.

4.3 Use of Key Performance Indicators:

There are a number of indicators for performance assessment of a irrigation system. In general it is not recommended to use all described indicators under all circumstances. The number of indicators we should use depend on the level of detail with which we need to quantity performance (e.g. research, management, informant importance to public) and on the number of disciplines with which we need to look at irrigation and drainage (water balance, economics, environment, management). To compare the performance of system with the objective of the system we have selected following indicators: -

(a) **Water Balance Indicator**

Water balance performance indicators are concerned with the assessment of water supply function of irrigation system. They cover the volumetric components that is primarily concerned with matching water supplies to irrigation water demand, as well as reliability and equity. These three aspects all represent fact of concept of level of service being provided to water users.

(i) Water delivery performance: -

The simplest, and yet most important hydraulic performance indicator is the ratio of actually delivered volume of water to intended volume of delivered water.

$$\text{Water delivery performance} = \frac{\text{Actually Delivered Volume of water}}{\text{Intended volume of delivered water}}$$

Over a sufficiently long time frame (month, or over three or four rotational time periods) it can be assumed that if the Water Delivery Ratio is close to unity, then management inputs must be effective. If the water delivery performance ratios for different units within the considered command area have about same value, the uniformity of water delivery must (because of the concept of conservation of mass of the available water resources) be good.

(ii) Water Balance Ratio

In general, the water balance indicators deal with the volume of water delivered within a set time period (in m^3/period), rather than the instaneous flow rate (in m^3/s). The ratios quantify components of water balance in a spatial context over a unit ratio Ru (efficiency), is defined as (ICID 1978)

$$\text{Tertiary unit Ratio} = \frac{V_m + V_3}{V_d}$$

For practical purpose we may replace V_m by $E_{Tp} - P_e$ and assume negligible non-irrigation water deliveries from distribution system ($V_3=0$)

$$\therefore R_u = \frac{V_m}{V_d}$$

(iii) Overall Consumed Ratio:

The overall (or project) consumed ratio, R_P, quantities the fraction of irrigation water evapo-transpirated by the crops in water balance of irrigated area. Assuming negligible non-irrigation water deliveries, it is defined as

Overall consumed ratio $= \dfrac{E_{T_p} - P_e}{V_C + V_d}$

V_C = volume of irrigation water diverted or pumped from river or reservoir.

V_1= inflow from other sources to the conveyance system.

(iv) Conveyance Ratio:

The conveyance ratio, R_C quantifies, the water balance of the main specific time period.

(v) Tertiary Unit Ratio:

The irrigation water requirement of intake of a tertiary unit depends on the crop irrigation water requirement (E_{Tp}-P_e) in unit, on the water delivery performance in the unit, on canal seepage, and on (average) value of the above field application ratio. The tertiary lateral and sub-tutorial canals including related structures of the irrigation system. It is delivered as

Conveyance ratio $= \dfrac{V_d + V_2}{V_C + V_1}$

V_C= Vol. of irrigation water diverted pumped from river or resoir (sources of surface water)

V_d = volume of water actually delivered to the distribution system.

V_1 = inflow from other sources to the conveyance system.

V_2 = non-irrigation deliveries from the conveyance system.

The conveyance ratio should be calculated over a short (week, month) and a long (season) period. The rate of change of ratio is an indicator for e.g. the need of maintenance.

(vi) Distribution Ratio:

(R_u) is defined as $= \dfrac{V_f + V_3}{V_d}$

If the distribution ratio is determined for all tertiary units within the considered irrigated area, their uniformity of water delivery by WUA can be expressed by standard deviation of the distribution ratio values.

(b) Equity and Dependability

The primary indicators proposed for use in measuring dependability of water deliveries are concerned with the duration of water delivery compared to the plan and the time between deliveries compared to the plan. They are-

(i) $$\text{Dependability of duration} = \frac{\text{Actual Duration of water Delivery}}{\text{intended duration of water delivery}}$$

(ii) $$\text{Dependability of irrigation interval} = \frac{\text{Actual irrigation interval}}{\text{intended irrigation interval}}$$

In addition to dependability interm of timing, it is strongly recommended that the predictability of discharge or water level be included in this part of the assessment. For many irrigation activities the flow rate must be near the intended flow rate for water use to be effective.

(c) Sustainability of Irrigation

$$\text{Sustainability of irrigable area} = \frac{\text{current irrigable area}}{\text{initial total irrigable area}}$$

The initial area refers to the total irrigable area in the design of the system or in the last rehabilitation.

$$\text{Relative Ground Water depth} = \frac{\text{Actual Ground Water depth}}{\text{Critical Ground Water depth}}$$

The critical groundwater depth mostly depends on the (effective rooting depth) of the crop. If the actual groundwater depth is near the critical depth, the time interval between readings of the ratio should be near one month. One year is suitable for most other purposes.

(d) Maintenance Indicators:

Maintenance is designed to accomplish three main purpose; safety keeping canals in sufficiency good conditions to minimize losses and sustain designed discharge-head relationships and keeping water control infrastructure in working condition.

In irrigation systems the conveyance efficiency provides the best way of assessing whether canal maintenance is required. By tracking the charge in conveyance efficiencies over time it should be possible to establish criteria that will indicate when canal clearing or restoring is necessary. In many systems this undertaken subjectively on appearance rather than using a more analytical approach.

(i) Sustainability to Head-Discharge Relationship:

Indicators that gives practical information on the sustainability of the intended head discharge relation of flow division structure are:

$$\text{Relative change in head} = \frac{\text{Change of Head}}{\text{Intended Head}}$$

The effect of this ratio on the water distribution structure depends on the hydraulic flexibility of the division structure. A change of head (across) structures in irrigation canals is the single most important factor disrupting the intended delivery of irrigation water.

(ii) Maintenance Cost:

The cost of maintenance depends on the volume of silt and weeds that must be removed from the canal and by the size of the canal. An indicator that can be used to quantify thus cost per unit (meter) length of canal is

$$\text{Maintenance area ratio} = \frac{\text{Volume of (silt + weed) per unit length}}{\text{Constructed Area of canal}}$$

To quantify the maintenance performance: hence, to assess the extent to which (control) structures can be operated as intended, the following ratio will be used

$$\text{Effectivity of infrastructure} = \frac{\text{Number of Functioning Structures}}{\text{Total Number of Structures}}$$

This approach immediately indicates the extent to which the manager is able to control water. For analysis to the effective, however, it most divide structure up into their hierarchical importance (main, lateral, tertiary and quaternary) and the analysis completed for each level.

(e) Economic, Social and Environmental indicators:

The final set of indicators relates to longer term impacts of pursuing a particular set of operational and agricultural strategies. These indicators have been divided into three primary categories. Those relating to economic viability those relating to social viability and those associated with sustainability and the physical environment for irrigation.

(i) Financial viability of irrigation system

One set of indicators concerns with efforts to raise revenues from water users that help support management, operation and maintenance (M,O,&M) costs and often some or all of the capital costs of individual irrigation systems. The first of these indicator describes the over all financial viability of system.

$$\text{Total financial viability} = \frac{\text{Actual MO + M allocation}}{\text{Total M.O + M requirements}}$$

This indicator says nothing about the management, operation and maintenance (MO & M) allocation comes from; it may be from central government or from user fees. A modified indicator is proposed that looks at the extent to which a system generates sufficient income to be self supporting.

$$\text{Financial self sufficiency} = \frac{\text{Actual Income}}{\text{Total MO + M Requirement}}$$

Both these indicators are admittedly subjective because "requirements" greatly depends on the number of persons employed by the agency per unit irrigable area. However it gives an indication of the extent to which the agency is expected to be self financing. The above income of agency (user group, irrigation districts, irrigation department etc) may have different sources of income e.g. water charges, trees along canal, hydraulic energy etc.

To quantity the effectiveness of irrigation agency with respect to the actual delivery of water (operation) and maintenance of canal (or pipelines) and related structures, the O and M fraction is used.

$$\text{O + M fraction} = \frac{\text{Cost of Operation + Maintenance}}{\text{Total Agency Budget}}$$

This indicator deals with the salaries involved with the actual operation (gate men etc) plus maintenance cost and minor investment in the system. To quantify the O+M fraction, we need the annual budget as proposed by the irrigation authority (for its MO& M) and from the WUA of the selected command area (for its M, O &M), the budget as approved (allocation per item) and the actually realized income over the related year.

In many irrigated areas, water charges (irrigation fees) are collected from farmers. The fraction of annual fees (charges) due to be paid to the WUA and (or) the irrigation district, is an important inculcator for level of acceptance of irrigation water delivery as a public service to the customers (farmers). The indicator is defined as:

$$\text{Fee collection performance} = \frac{\text{Irrigation Fees Collected}}{\text{Irrigation Fee Due}}$$

The ratio should be quantified for all water users associations in the considered irrigated area.

(ii) Profitability of Irrigated Agriculture

Two indicators are proposed that address different aspects: profitability in term of land, and profitability interm of water delivered

$$\text{Yield VS Water Cost Ratio} = \frac{\text{Added Value of Crop}}{\text{Cost Applied Irrigation Water}}$$

This indicator requires evaluation of the value of the produced crop with irrigation minus the value of crop (that could be) produced without irrigation. The cost of applied water can be modified to include or exclude the discounted value of the capital cost of the system depending on whether or not capital is considered a sink cost.

Within most irrigated areas, however, water is the scarcer resource. Hence it is logical to substituted water for land in above equation:

$$\text{Yield vs Water Supply Ratio} = \frac{\text{Added Mass of Marketable Crop}}{\text{Mass of Irrigaation Water Delivered}}$$

Here, again the added mass at marketable crop should be determined. If viewed from the farmers perspective, the mass of water delivered is measured either at the farm inlet or at the head of field, depending on his views etc. From the perspective of farmer the (socio) economic of irrigation can also be quantified by relative cost of irrigation water:

$$\text{Relative Water Cost} = \frac{\text{Total cost of Irrigation Water}}{\text{Total production Cost of Major Crops}}$$

The total product cost includes cost of water (including fees, energy for pumping), seeds, fertilizer, pesticides, labors etc. it critical values of this ratio are exceeded, farmers tend to abandon irrigation.

(iii) Vialibility of Irrigation Investment:

The primary economic concern for planners and policy makers is the economic performance of investment, or the return to capital employed. A typical indicator used for this proposes is:

$$\text{Gross return} = \frac{\text{Gross value of output}}{\text{Investment on irrigation system}}$$

This indicator is calculated using the same basis data, but is used in slightly different ways in project evaluation. It helps to determine whether an investment in irrigation yields an overall profit, and also helps in deciding whether the investment might have been better made in another sector. Unless there are compelling social or political reasons, this indicator also helps to prioritize which particular investment opportunities should be pursued at the expenses of other, less beneficial alternatives.

(iv) Social viability:

Irrigation managers actions have direct social impact, though managers are often unware of these. This gap in perception leads many irrigation managers to feed that "Social viability" issues are not relevant to them. However, if the long term sustainability of irrigation is an objective, and it improving and maintaining social well being is ultimately important, then social viability is relevant, particularly from a strategic manager perspective.

Irrigation related labour:

In many countries, these are department of agriculture, labour or senses, which collect basic agricultural and economic data. These can be used by irrigation managers as sources of information on socio-economic impacts trends, such as employment, wages and poverty level. A possible indicator to quantity the social impact of a scheme is

$$\text{Irrigation employment generation} = \frac{\text{Annual day/ha labour by scheme}}{\text{Annual Number official working Days}}$$

For socio-political reasons a high value may be desirable for irrigation to be economically sustainable, however, this ratio has an upper limit. Less controversial ratios are:

$$\text{Irrigation wage generation} = \frac{\text{Average Annual Rural Income}}{\text{Average Annual National (regional) Income}}$$

Relative prosperity % of scheme population

$$= \frac{\text{\% of scheme population above poverty level}}{\text{\% of National population above poverty level}}$$

(v) Social capacity

Social capacity refers to the social (as distiquished from physical, biological or economic) capacity of people and organizations for managing and sustaining the irrigated agriculture system. There are two indicators.

$$\text{Technical knowledge of staff} = \frac{\text{knowledge needed for job}}{\text{actual technical knowledge of staff}}$$

and,

$$\text{Users stake of irrigation system} = \frac{\text{Active water users organzation}}{\text{Total Numbers of W.U.O}}$$

Actual technical knowledge of staff could be ascertained through tests, while required knowledge is intercept in the job description- "Activness" of WUA can be measured using acquired data, such as percentage of WUA's holding regular (or the minimum required) meetings percentage of water users participating in meeting or number of organizations fulfilling agreed upon the tasks such as fee collection, maintenance or distributing water. All these indicators are crude, and relatively untested; but they constitute useful and implementable first steps to begin paying greater attention to the social viability of irrigation.

(f) Crop productivity indicators:

The crops in irrigated area can be measured with the yield ratio. This indicators is defined as

$$\text{Yield Ratio} = \frac{\text{Actual Yield of Crop Achieved}}{\text{Intended Yield of crops}}$$

It is calculated for major crops. Its value greater than unity satisfy the performance, less value indicate the performance is not satisfactory. Other indicator is

$$\text{Cropping Intensity Ratio} = \frac{\text{Actual Cropping Intensity Achieved}}{\text{Intended Cropping Intensity}}$$

The value greater than unity indicate more coverage area of crops and less indicates low coverage of area.

4.4 Data collection and analysis :

The following procedure has been adopted to meet the requirement of data and information about the system for the performance study

(i) Documents related to Mahakali irrigation project such as feasibility study report and project appraisal report have been collected and reviewed. The aim of this exercise is to identify the areas which need careful observation and additional data collection so as to obtain information and establish a data base of the system at the end.

(ii) Assistance of key informants (Agency) shought to identify the issues concerning the project and access the cost and economic of the projects.

(iii) All the available information and data are collected from the project office as far as possible.

(iv) The data obtain and review of document are helpful for the performance assessment of the project and to identify whether the project is serving its defined objective or not for which it is created.

4.4.1 Water Resources Potential

The detailed information regarding the following are collected

(i) Data pertaining discharge at head regulator of the project.

(ii) Data pertaining information about the discharge of Mahakali river

(iii) Data pertaining history and development of the system.

(iv) Information about bilateral treaty between India and Nepal.

4.4.2 Irrigation Water demand and Supply

The detailed information and data regarding the following are collected.

(i) Climatic data pertaining rainfall, temperature, humidity etc. are collected.

(ii) Data and information of water supply at head of Mahakali river (Sarda) to the main canal of Nepal.

The water requirement of crops are calculate by pan-man modified method using the available data. Comparison is done with the crop water requirement and supply available to the system.

(iii) Data of area irrigated crop wise are collected.

(iv) Potential utilization v/s potential created is compare with the available data.

4.4.3 Cost of production and net return :

Data related to crop production are collected which includes

(i) Data pertaining types of crops grown by farmers in the command area and area of coverage.

(ii) Data pertaining use of seed, fertilizer human labour, animal labour, manure, pesticide.

(iii) Data regarding the yield of various crops.

Based on the above data the cost of production and net return from the agriculture is calculated.

4.4.4 Economic Analysis

The following data are collected for the economic analysis of project.

(i) The input side of economic crop budget has been taken from Nepal. The report for procedural guideline for implementation of NISP.

(ii) The output side of crop budget has derived from the record of cropping pattern yield and crop coverage.

(iii) Data pertaining annual O&M expenditure.

(iv) Border parity prices for traded agricultural outputs and inputs are taken from procedural guideline report of NISP.

The theme of economic analysis of irrigation projects has been prepared in view of the increasing costs of major and medium irrigation project with consequent social need to ensure benefit commensurate with the need for building infrastructure. Social capital have attracted the attention of economists who have focussed their concern on such aspects as scarcity of resources, their optimal utilization, risk of waste efficiency.

The economic analysis of project is carried out to general approach to economic appraisal of projects followed by the International Credit Agencies, commonly used discounted measures. The performance evaluation of project can be done by comparing the actually realised economic internal rate of return and that was projected before sanction.

Other detailed information and data regarding following are also collected.

- Information regarding existing O, M & M of system and its execution
- Basic socio-economic data
- Water users association, water users group and their detail information
- Agency organization and its functioning
- Water delivery and distribution practices.

It is imperative to analyze the information collected both qualitative quantitatively on different aspect of management of system in irrigation system which are concerned with effective use of water.

In view of scope of study and limitations, the more weightage is given to quantitative. The quantitative analysis is carried out for variable, which carried absolute value i.e. yield/ha, O&M/ha, discharge/ha etc.

The data analysis is done by adopting simple frequency counts, arithmetic mean and different key indicators. The performance study is concluded on the basis of the key indicator value.

CHAPTER-5

WATER USE

5.1 GENERAL

Return on investments in water development schemes for power, industry and urban uses can easily be determined because water is dealt with as a commodity with pre-determined sales values. In contrast to this, returns from investments in water development for agricultural are difficult to determine in advance because they entirely depend on the capability of farmers to use water as an input in agricultural production. The problem is aggravated by the great number of farmers in one water development scheme who all have to reach a certain relatively high level of efficiency in order to permit the required constant flow of returns on investments. It is this element of reliability on the capability of farmers to use the investments efficiently which makes the returns on investments in irrigation all too often slow and low.

Low efficiency of use of water is observed almost everywhere, even in more recently developed schemes. Estimates have shown that in many irrigation schemes only 40% of water diverted at head works finally reaches the fields. Leaving irrigated land fallow, failing to grow two or more crops per year, where this is possible, or growing crops of low value represents a waste of investments most understand that with the introduction. In the planning and design phase of water development project, proper attention should already be paid to the management of water as an input for production. Even the question of how many hectors can be irrigated with the available water is of less importance to the design engineer than the question of water needed quantitatively and time-wise of optimum production. Efficient project operation as well as the necessary maintenance and improvement of the system require close co-operation between the farmers and project. The farmer must learn and understand to use water as a production input i.e. to apply irrigation water at such times as will produce the desire crop growth and support the use of other inputs. He must know low to use water and soil wisely in order to protect this basic production means i.e. to provide water only in such amounts as will replace water lost from soil by evaporation and transpiration and will permit leaching of soil profile only to the extent required to maintain a favourable salt balance. Hence farmer of must understand that with the introduction irrigation, changes in farm operation might be required to optimize the use of all inputs and resources.

5.2 WATER RESOUCES POTENTIAL

5.2.1 General

The Sarda Barrage, the head-works of the project lies in India. The Indian authority control, operate and maintain the intake and the barrage system. The intake structure feeding MIP canal system consists of simple slid gate. The gates are in operational and in good condition. However, the Indian authority seems to have abandoned major maintenance work of barrage, which is evident from the damaged downstream floor of the barrage. At several places of d/s floor, the granit lining provided for resistance against abrasion of the structural part of the floor by rolling stones during flood have ripped off from their places.

The barrage is on operation sin 1928 and has already served for 72 years. The Indian authority has constructed Tanakpur Barrage, which lies u/s of Sarda Barrage. Tanakpur powerhouse utilizes water level difference between Tanakpur and Sarda Barrage of about 26m to generate hydropower. The tailrace canal of powerhouse meets the Mahakali River just upstream of Sarda Barrage. The Indian authority has planned to link the tailrace canal to the Sarda canal of about 800 m downstream of existing intake structure of Sarda Barrage. Immediately after the Sarda Barrage ceases to be functional, the Sarda canal would receive water from this link canal.

Similarly, in case of Sarda Barrage becomes non-functional, the link canal in Indian Territory feeding MIP main canal including part of MIP main canal will become redundant. In this case, the water would have to be diverted from Tanakpur Barrage to MIP canal system, which requires a new canal to be constructed in the Indian territory and additional canal system to link MIP system in Nepal territory. The new treaty on the integrated development of Mahakali River including Sarda and Tanakpur Barrage and Pancheswar multipurpose project has a provision of supply water to MIP system through Tanakpur Barrage. Indian authority has built an intake structure on the left afflux bund of Tanakpur Barrage for this purpose. The link canal in India as well as in Nepal has not yet been constructed.

5.2.2 Hydrology of Mahakali River

The Mahakali River has a total catchment area of 15,78 sq.km at Sarda Barrage which lie partly in India and remaining in Nepal.

The observed minimum monthly discharge of Mahakali (Sarda) river at Sarda Barrage is 140 m^3/sec where as the observed monthly maximum discharge is 2,523 m^3/sec (observed period 1989 to 1991). The monthly flow observed of Sarda Barrage has been given Table 5.1 and Fig. 5.1.

TABLE 5.1OBSERVED MONTHLY FLOWS AT SARDA BARRAGE (In Cumec)

Year/Month	1989	1990	1991
January	184	140	178
February	143	149	147
March	140	225	176
April	163	179	220
May	296	385	374
June	526	568	598
July	1248	1,870	1,207
August	2523	2,063	1,835
September	1176	1,257	1,045
October	392	426	338
November	251	254	227
December	184	194	176
December	184	194	176
Average	602	644	543

During master plan study for water resources development of upper Karnali and Mahakali River Basins conducted by Japan International Co-operation Agency in 1993; an estimated on the flow pattern at Banbasa (where the Sarda Barrage is located) has been made which indicate that two year flood of the Mahakali River at the headwork is 7,100 m^3/sec and hundred-year flood is 18,900 m^3/sec. The estimated floods of various frequencies are presented in Table 5.2. The frequency analysis has been performed by assuming Gumbel's distribution of annual maximum floods.

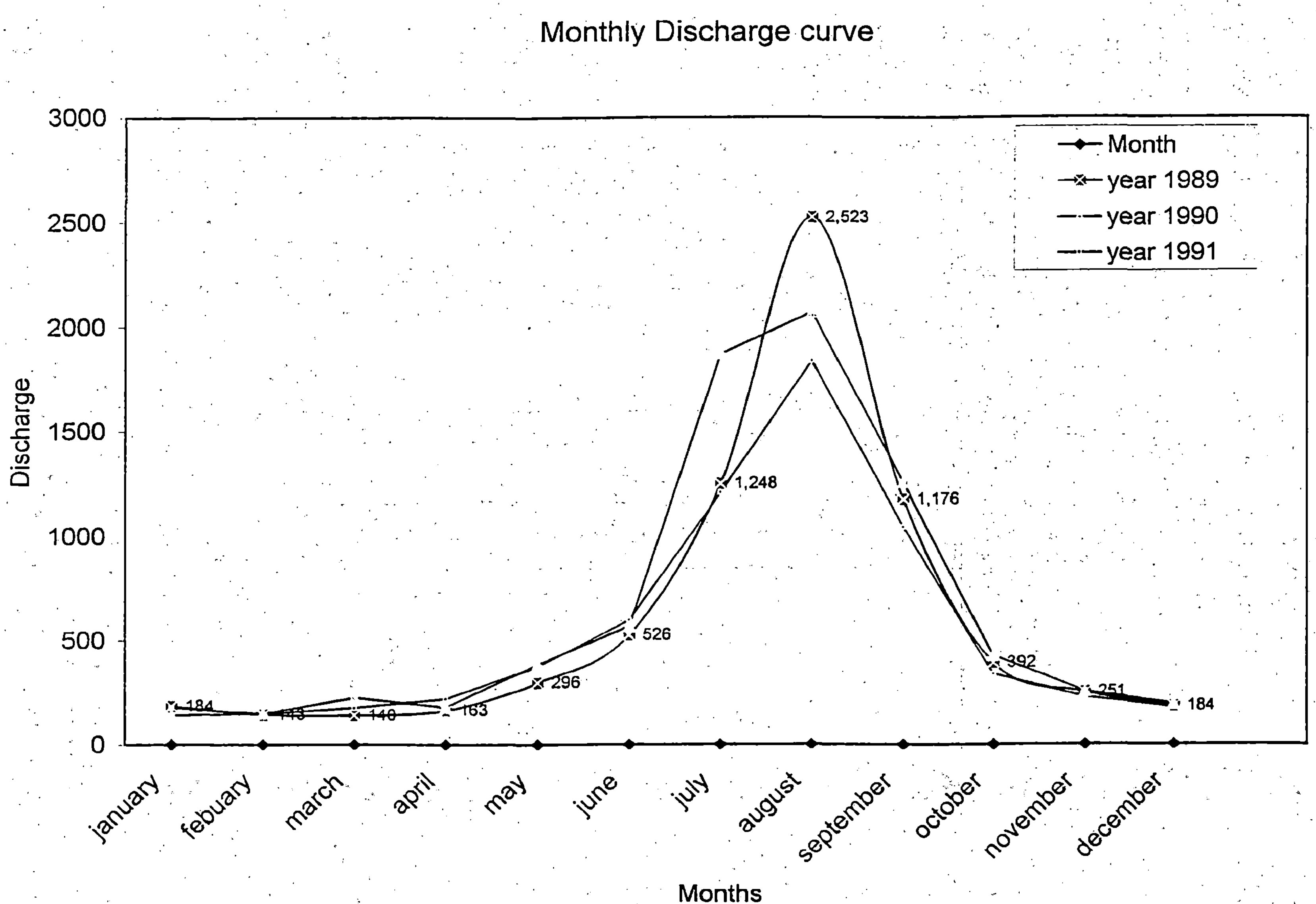


Fig. 5.1 Hydrograph of Mahakali River

TABLE 5.2: ESTIMATED FLOOD AT BANBASA, MAHAKALI RIVER CATCHMENT AREA =15,178 sq.km.

Return period	Flood in m^3/sec	Remarks
2	7100	
5	10,300	
10	12,400	
25	15,000	
50	17,000	
100	18,900	
200	20,800	
500	23,300	
1000	25,300	
5000	29,700	
10,000	31,600	

5.2.3 Sediment Load

The sedimentation data of Mahakali River of Sarda Barrage are not available. Similarly, sediment data of the inflow to the main canal of MIP at Indo-Nepal Border are also not available. The master plan study of water resources development of Upper Karnali and Mahakali River Basin conducted by JICA has estimated the annual sediment flow at the Pancheswar Dam site (catchment area 12,600 sq.km) to be about 60 million tons/year. The figure, if extended linearly on the basis of catchment area, comes out to be 72.3 million tons/year at Sarda Barrage. It is worth to note that if Pancheswar Dam is constructed in the near future, the sediment flow of the Barrage will reduce considerable, which would change the flow regime of the river.

The Mahakali River is one of the big border river carrying a large quantity of flow ranging from 140 m^3/sec to 2523 m^3/sec. The stipulated quantities are only minor partions of the flows in the Mahakali River, and Hence India have no difficulties in providing these flows. Therefore, there is no problem of water in the source river.

5.3 THE SYSTEM

5.3.1 General

MIP does not have head works facilities under its own control. At present it draws water from the Sarda Barrage which lies in India and being operated by the Indian authority. The MIP main canal receives water at Indo-Nepal border through a 1.1 km long link canal.

The canal system for stage I area starts from the Indo-Nepal border, which is linked with Sarda Barrage. The length of main canal serving stage I area is 13.70 km having a design capacity of 28.2 m^3/s at the head reach which reduces to 10.97 m^3/s at the tail and given below

Canal stretch	Design Discharge m^3/s
0+00 km to 1+300 km	28.20
1+500 km to 3+100 km	27.40
3+100 km 4+580 km	26.99
4+580 km 8+325 km	26.20
8+325 km 10+830 km	11.80
10+830 km 13+700 km	10.97

The stage I area has been divided into four blocks namely blocks A, B, C, and D having service area 1,100 ha. 1,200 ha, 1,218 ha and 1282 ha respectively the division of block at present has been made almost equal in area to facilitate water distribution.

5.3.2 Performance of Physical System

In general, the main and secondary canals in MIP stage I area are in good shape. They are maintained by project in consultation with water user organization. A part of main canal in the vicinity of East-West Highway crossing Mahendra Nagar municipality gets silted up frequently. As a result it cannot carry the required discharge. There is increased urbanization in this area in recent years. Local people used to dispose their household garbage into the canal thus enhancing the silting process. But these garbage are usual cleared off before running the canal.

The regulatory structures such as head regulators and cross regulators are all gated with simple slide gates. These gates are simple to operate and maintain and are in good working condition.

The territory canals in stage I area was constructed by MIP during stage I implementation. Some of then have renovated to suit the local requirement before handing them over to the water users organization. All the tertiary canals in stage are now handed over to the respective WUOs, they operate and maintain the system on their own. The tertiary canals are regularly maintained by the WUOs and are in good operating conditions.

The field channels are used to deliver canal water from the tertiary outlets to individual farms. Each one of them serves about 4 ha of land. The farmers were expected to construct that channel on their own. With some exceptions the farmers have not constructed the field channels. They still practice field to field irrigation, which requires inundating the upstream land before irrigating the downstream land before irrigating the downstream adjacent farm. Recently the farmer has increasingly felt the need to construct field channels which can deliver the water right at the point of requirement. Some farmers have started constructing channels. However, development of complete field channel systems is likely to be hundred due to land fragmentation and large number of small farmers.

5.4 PLANNING AND DESIGN

5.4.1 General

The Far Western Region is relatively under developed compared to other regions of Nepal. Of the Kanchampur district in 1980, 58%, area was under forest. The district has a good potential for agricultural development, especially irrigated agricultural. Since it is bordered by Mahakali (Sarda) River which is one of Nepal's major rivers. Although India constructed a barrage across this river in 1928, Nepal has so far only utilized a small portion of the river flow that it is entitled to use. As population pressure from hill is becoming accurate in Far Western region, HMGN has given high priority to irrigation development.

In December 1979, HMGN approved a comprehensive master plan for development of Kanchanpur district. This project was a key element in that plan,. The development plan delineates areas to be maintained as commercial forest, wild life reserve, areas to be reforested and areas to be developed for rainfed and irrigated agriculture including resettlement and settlement of land less farm families. The plan anticipated the MIP (34,00 ha net) ultimately be extended to 23000 ha. Development would be in stages; under MIP stage I, the proposed project, the existing irrigation scheme would be extended to 6,600 ha net. The MIP II (6,600 ha net) and MIP stage III (11,800 ha). The division of stage is mainly based on two factors; that is the availability of water and the sequence of construction.

Implementation of MIP (state I) was involve the clearing of 1,700 ha of commercial forest and 500 ha of forest partly occupied by encroachers.

The objective of the project is to provide the necessary irrigation, drainage and road infrastructure to increase the agricultural production.

The project has been designed to the standards of modern irrigation scheme in which a high level of operational efficiency can be achieved.

5.4.2 Performance Evaluation Parameter

Planning and design consists of critical evaluation of

- Water availability in system
- Water utilization
- Losses in conveyance and distribution system
- Cropping pattern

Comparison of these with the existing system based on actual available data and with project planning and design consideration. This can be done by using suitable performance indicator.

5.5 WATER AVAILABILITY IN SYSTEM

Mahakali (Sarda) river is a major border river of India and Nepal. It carries large quantity of discharge varying from 140 m^3/sec to 2523 m^3/sec (measured flow in 1989).

Water for the MIP is supplied from the Sarda Barrage on the Indian side of the border under bilateral agreement, which dates back to 1920:

(a) From May 15 to October 15 a supply of 460 cusecs (13.0 m^3/s) and, provided a surplus is available, a supply of upto 1,000 cusecs (28.3 m^3/s) and

(b) From October 15 to May 15, a supply of 150 cusecs (4.25 m^3/s).

The agreement further stipulates that from October 15 to May 15, the supply canal to Nepal would be alternately closed and opened for ten days at a time and that could run at 300 cusecs (8.5 m^3/s) capacity whenever the canal is open. These stipulated quantities are only minor portion of the flows in the Mahakali River, and India would have no difficulties in providing these. flows. Table A-7 in Appendix shows the demand and supply of water.

TABLE 5.3 : WATER AVAILABILITY

Month	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Guaranted supply	4.25	4.25	4.25	4.25	4.25/ 13,.0	13	13	13/4.25	13	13/ 4.25	4.25	4.25

5.6 WATER UTILIZATION

MIP does not have head works facilities under its own control. At present it draw water from the Sarda Barrage which lies in India and is being operates and maintained by the Indian authority.

The partial daily discharge record for the years taken of the weir locates at border has been presented in Appendix A Table A-5. The table provides the information on the quantity of water Nepal has received as per bilateral agreement. It further provides information on the duty of the diversion point used in stage I area.

In kharif (wet) season crops grown is paddy; which is grown over 89 percent of command covering 4272 ha, uses the diverted water starting from the period of June to November which amounts 157.73 million cubic metre. Though at the time of planning and design of the project, the area covered by paddy was estimated to be 3696 ha but presently change in cropping pattern and also reduction in area of Ist stage the paddy area increase to 4272 ha. Even though the duty of head is 3.68 m for paddy. This figure is very high indicating abundance of water availability. Normally, the appropriate duty of the diversion point in server climatic condition for paddy is about 1.2 m i.e. 1200 mm which means that stage I area is using at least 3 times more water than required.

Similarly when utilization of water for winter crops is considered, the total amount of water in stage 1 area is utilizing at the present comes out 3655 million cubic metres. (From mid November to mid-March). 4272 ha use this water ha (existing crop coverage being 96 %). Employing duty at the diversion point it comes 1.20 m i.e. 1200 mm. The normal duty for winter (wheat crop) is 0.6m. So this figure is also about 2:0 times higher.

This indicates that the water availability is satisfying for stage I but it would be shortage of water for irrigating both stage I and stage II area during winter if current trend of water availability and utilization persist in future.

As per Bilateral Agreement of 1920 between India and Nepal the volume of water should be available for the period for the period of monsoon, winter and summer crops comes to 172.638, 39.474 and 27.728 million cubic metre respectively. The actual present utilization are about 87.93 and 97.83 percent during monsoon and winter season respectively where as water utilization in summer is very low and in general canal closure is observed.

The primary task of the manager of the irrigation system and of the managers of sub-systems (The WUA) is to deliver water in accordance with the plan (as intended). Indicators in this regard therefor those that guide managers in respect to water delivery performance. The simplest and yet probably the most important, hydraulic performance indicator is

$$\text{Water delivery performance} = \frac{\text{Actual delivered vol. of water}}{\text{Intended volume of water requirement}}$$

Table 5.7 shows the monthly water delivery performance ratio. This measure enables a manager to determine the extent to which water is delivered as intended during a selected period (monthly) and at any location of the system. The primary utility of water delivery ratio is that it allows for checking the flow at any location in the system is more or less than intended (planned or required). It is obvious that if actually delivered volume of water is based on frequent flow measurement greater the like-hood that managers can match actual to intended flow.

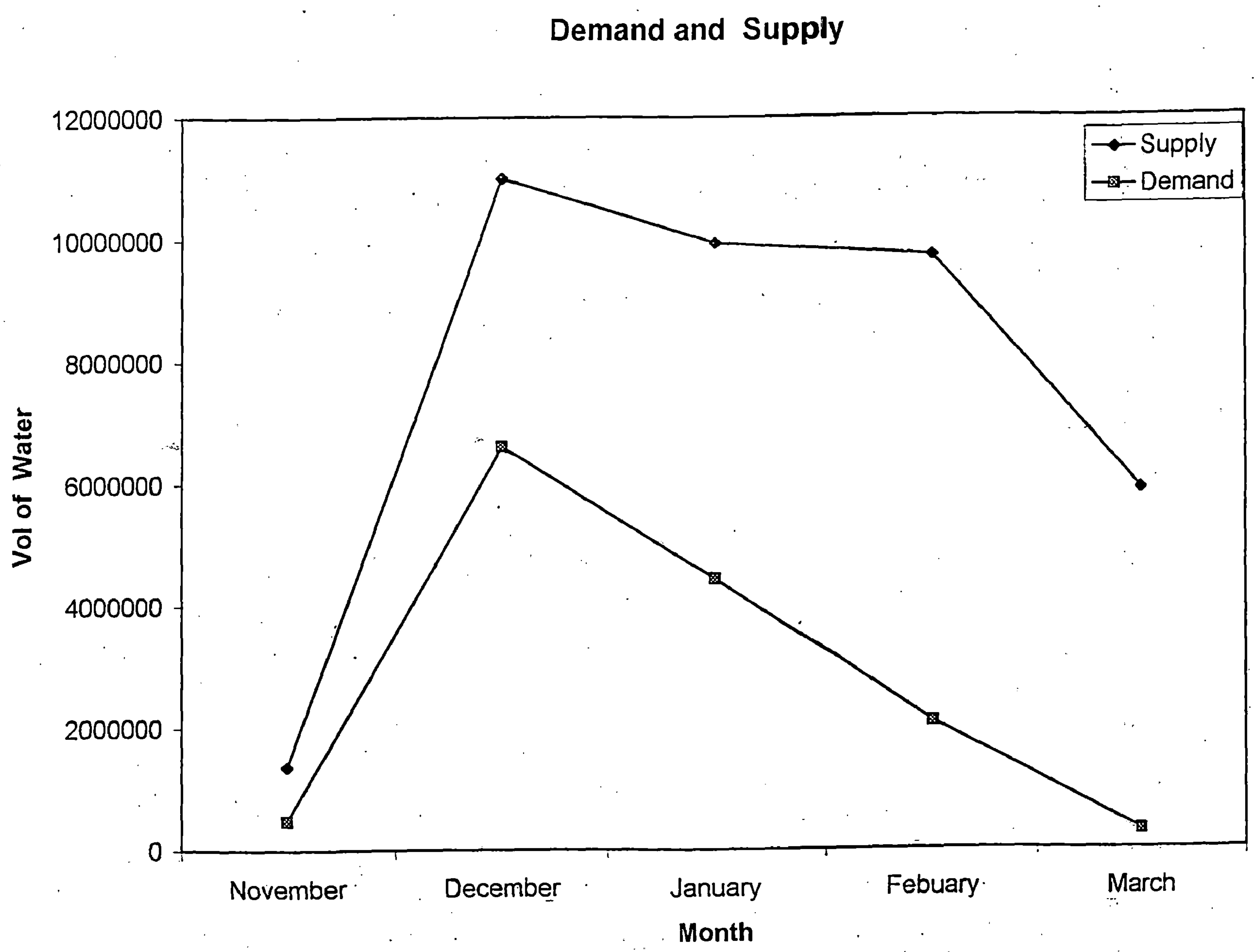


Fig. 5.2(a) Water demand and supply dry season

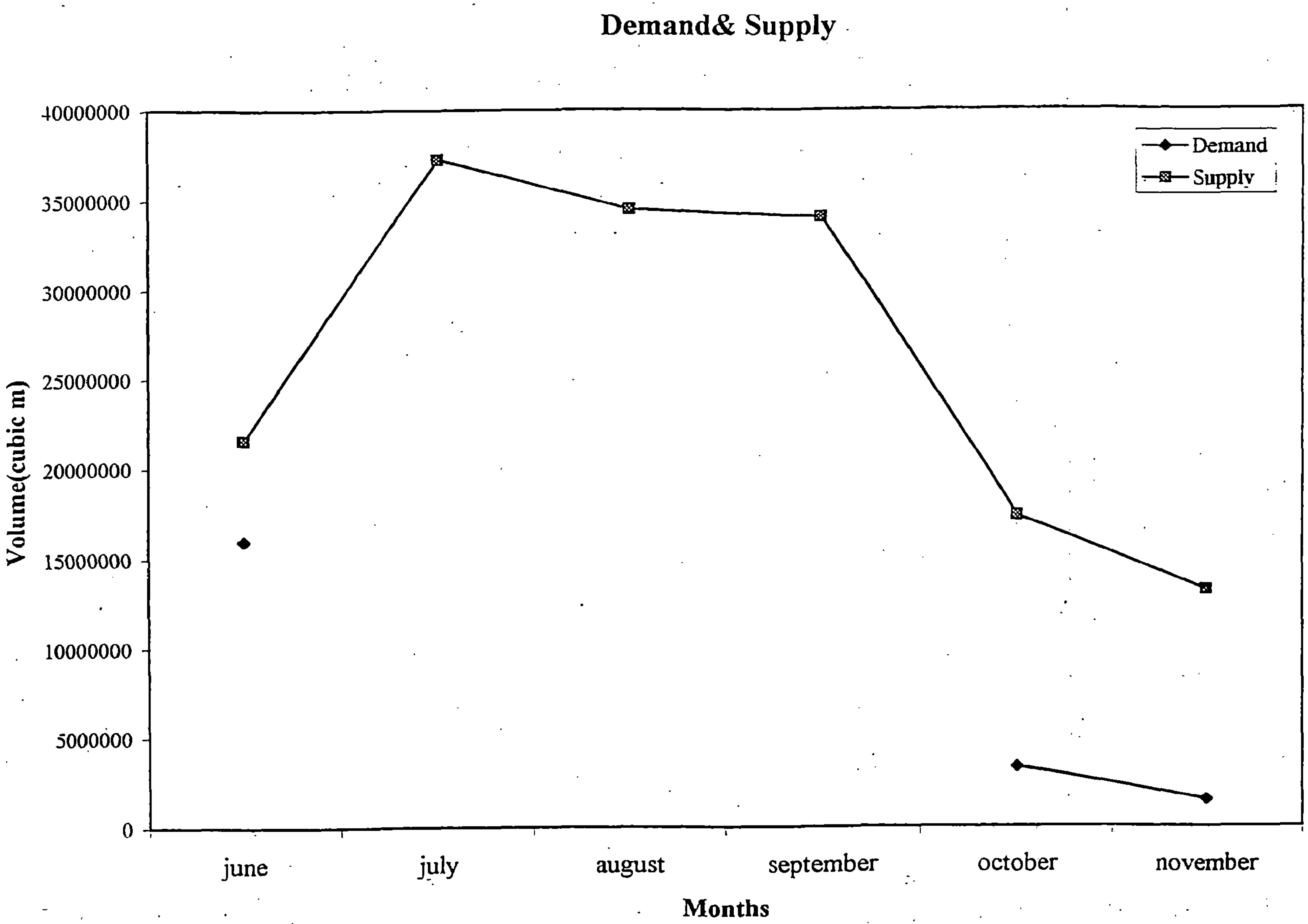


Fig. 5.2(b) Water demand and supply wet season

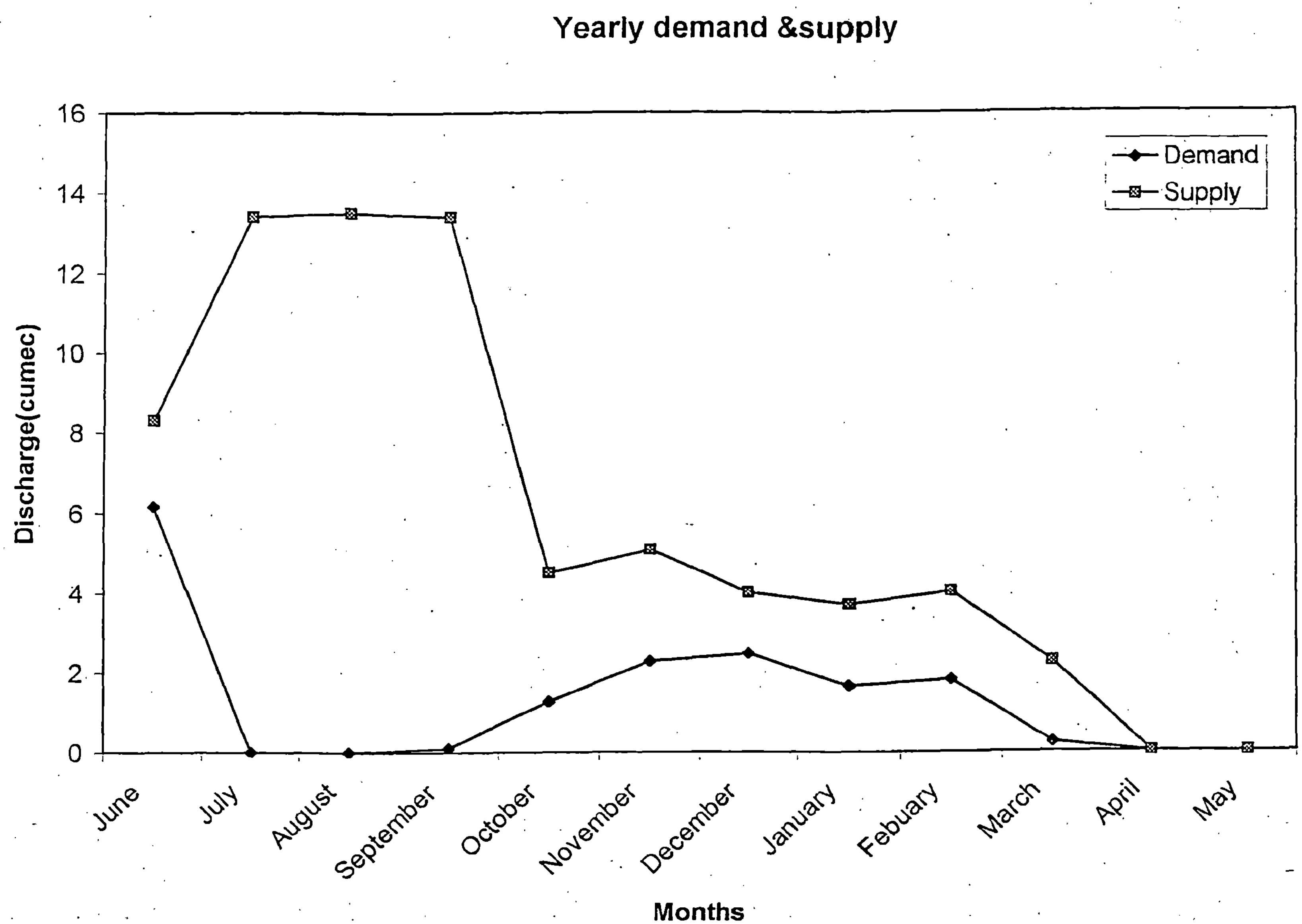


Fig. 5.3 Water demand and supply (yearly)

Over a sufficient longtime frame (monthly or over seasonal or over three or four rational time) it can be assumed that, if the water delivery performance is close to unity, then management inputs must be effective. It W.D.P ratio for different units within the considered command area have about the same volume. The uniformity of water delivery must be good (because of available water resources).

The Table 5.4 shows that supply of water of intake point of canal in all the month is more than the required. Hence the water delivery performance ratio is greater than unity in all of month e.g. It indicates that the farmer s are utilizing the available water in time as the requirement of crops. Hence there is increase in cropping intensity and crops yield. So delivery performance is satisfactory.

Table 5.4 : Monthly Water Supplied and Demand at Head of Main Canal

Month	Volume of Water Delivered	Volume of Water required
January	9942000	4435776
Feburary	972700	2076192
March	5882000	298080
April	-	-
May	-	-
June	21554000	15992640
July	37249000	-
August	34444000	-
September	34018000	-
October	17307000	3304800
November	1371000	1487800
December	11003000	6602688

Table 5.5 : Half Monthly Water Suppli ed and Demand at Head of Main Canal

Month	Volume of supplied water		Volume of water Required	
	Ist half month	2nd half month	Ist half of month	2nd half of month
January	5155000	4791000	2099520	2336256
February	4841000	4886000	2799360	1778112
March	5882000	-	298080	-
April	-	-	-	-
May	-	-	401760	2293920
June	6934000	14616000	8994240	6998400
July	16063000	21186000	-	-
August	17299000	17145000	-	-
September	17370000	34018000	-	-
October	11253000	6054000	401760	2903040
November	6631000	6540000	997920	489880
December	5467000	5536000	3395520	3207168

Table 5.6 : Seasonal Water Supplied and Demand at Head of Main Canal

Sl. No.	Season	Supply of water in m^3	Duty at head
1.	Wet season	157.743×10^6	$3.68\ m^4 = 3680$ mm
2.	Dry season	36.554×10^6	$1.22\ m^6 = 1220$ mm

Table 5.7 : Monthly Water Delivery Performance

Month	Water requirement at head in m³	Water delivered at head in m³ Year 1994-95	Water delivery performance ratio	Water delivered at head in m³ 1993-94	Delivery performance ratio
January	4435776	9942000	2.24	9425000	2.12
Feburary	2076192	9727000	4.68	9525000	4.58
March	298080	5882000	1.97	5750000	1.93
April	-	-	-	-	-
May	2695680	-	0	-	-
June	15992640	21554000	1.35	21050000	1.30
July	-	37249000	-	34256000	-
August	-	34444000	-	32430000	-
September	-	34018000	-	30580000	-
October	3304800	17307000	5.24	16505000	4.99
November	1487800	1371000	8.85	12572000	8.45
December	6602688	11003000	1.67	12015000	1.8

5.7 LOSSES IN CONVEYANCE AND DISTRIBUTION SYSTEM

5.7.1 General

Substantial water is lost in transmission in a canal system from its head to delivery point at the outlet in conveyance and distribution channels. All these losses are termedas transmission losses and these constitute mainly following type of losses :

(a) Evaporation losses :

These include all the evaporation losses from surface by evaporation in reservoir, surface of flowing water in canal in long conveyance and distribution network. They primarily depend upon climatic conditions and range of temperature.

(b) Transpiration losses :

These are caused by vegetative along the water surface on canal banks and berms and primarily depend upon the climatic conditions as well as over all maintenance of channels.

(c) Seepage losses in the system :

These constitute the seepage as well as percolation losses from the canal cross-section and vary from system to system and also on different network of the system. They also depend upon design, alignment and maintenance of the channels along with type of soil, ground water tables and many other factors related to the canal system and the irrigated command.

(d) Operation losses :

These depend upon the status of engineering infrastructure needed for operating and regulating the canal system.

It has been observed that evaporation and transpiration losses in Upper Ganga Canal System in Western U.P., one of the oldest major canal system of the country are nearly to 1% of the head discharge of the system.

The seepage losses which constitute the major part of transmission losses; on Upper Ganga Canal could be found on measurement from time to time by various methods; of the order of 45% of head discharge of the system from its head up to delivery point to the field including losses on main canal, branch canal, distribution channels and water courses carrying water from outlets to the fields.

The operational losses vary from system to system and from time to time but on broad assessment. These losses on UGC system could be observed normally on an average 10 to 15 % of head discharge of these system. These losses can be substantially reduced by proper maintenance and improvement in the regulating structures, alongwith careful operation and maintenance.

The distribution of seepage losses in Upper Ganga Canal system can be recorded as follows and these losses represent the normal losses in unlined canal system in alluvial plain in Northern India.

(i) Losses on Main Canal and Branches - 17% of head discharge

(ii) Losses on distributory and minors - 8% of head discharge.

(iii) Losses in water course - 20% of head discharge.

Total losses works out to 45% of head discharge of main canal in the system. There are different design practices for adopting the losses in design of canal system in different states in the India. These losses on unlined canals vary from 0.91 to 3.96 $m^3/sec/10^6 \times m^2$ and on lined canals from 0 to 1.83 $m^3/sec/10^6 x m^2$. However, other observing the losses on different canal system a uniform practice for preliminary design of canal, all over the India has been followed and the losses adopted on unlined and lined canals are as follows :

Unlined canal - 2.5 $m^3/sec/10^6 x m^2$ of wetted perimeter.

Lined canal - 0.8 $m^3/sec/10^6 x m^2$ of wetted perimeter.

5.7.2 Factors Affecting the Canal Seepage

The seepage of water from irrigation canals is a complex process and it depends on the following factors :

- Soil characteristics of canal bed and slopes
- Depth of water in canal
- Velocity of flow in canal
- Wetted area or shape of canal
- Position of ground water table in relation to canal.
- Position of impermeable layer in relation to canal.
- Drainage level of nearby drain and its location.
- Temperature of water and soil
- Intrained air in the soil
- Soil moisture tension
- Age of the canal
- Amount of sediment and its grade
- Salt concentration in canal water and soil.
- Surrounding vegetation of canal
- Ground slope at right angle to canal.
- Velocity of flow of underground water
- Other biological factors.
- Frequency of canal discharges.

All or many of the above factors may affect the seepage from canal system depending upon its location and use.

5.7.3 Methods of Seepage Estimation

The seepage losses can be estimated by following methods :

(i) Empirical formulae

(ii) Theoretical methods

(iii) Experimental measurements.

Several different empirical formulae have been in use in different countries and also sometimes in different parts of the same country as in India. Some of the commonly used formulae are given as follows :

(i) Punjab Formula (India).

Seepage losses are assessed:

$P = 5 \times \quad 0^{0.0625}$ (unlined canal)

Where P = Seepage loss in cusecs/million sq.ft. of wetted perimeter

Q = discharge in canal in cusecs

For lined canal; seepage loss

$P^1 = 1.25\,(Q)^{.0625}$

P^1 = The seepage loss in cusecs/million Sq.ft of wetted perimeter and Q is the discharge in canal in cusecs.

The above formulate have been used in Bhakra Canal system in Punjab and also used in U.S.A and Pakistan.

(ii) Uttar Pradesh India

$dq = c/8\,(B+D)^{2/3}$ F.P.S unit

where dq = loss in cusecs per mile of canal

B = Bed width of canal in feet

D = Depth of water in canal feet

C = Constant which is taken normally equal to 1.0 for all channels running in rotation and as 0.75 for main canal and Branch canals running continuously.

Also the following losses are also taken in general in India seepage losses of 6 cusecs per M.sft for channels upto 120 cusecs discharge. In India the following formula is also used.

S = C a d

Where S = total loss in cusecs

a = wetted perimeter area

d = depth of flow

c = A constant (range 1.1 to 1.8).

5.7.4 Tertiary Unit Ratio

The irrigation water requirement of the intake of a tertiary unit depends in the crop. Irrigation water requirement in the unit depend on the water delivery performance in the unit, on canal seepage and on the average value of above field application ratio. The tertiary unit ratio R_v (efficiency) is defined as (ICID 1978)

$$\text{Tertiary unit Ratio} = \frac{V_m + V_3}{V_d}$$

For practical purpose V_m = water requirement of crop (ET_p-P_e) and assume reliable non-irrigation water deliveries from distribution system (V_3 =0). Thus the tertiary unit ratio is the volume of water required at the head of tertiary to the volume of water delivered of head of tertiary canal.

Thus the performance can be indicated as the volume of water delivered to tertiary and volume of water required to the tertiary during required period of time (monthly or seasonally).

This measure enables a manager to determine the extent to which water is delivered as intended during a selected period. Its primary utility is to check of water the flow at tertiary is more or less than intended. If this value is close to unity or greater than unity then it is obvious that the crop water requirement is matching with the supply of water. Table 5.8 and 5.9 indicates the monthly tertiary with ratio and season tertiary unit ratio respectively. which give the satisfactory value.

TABLE 5.8 : MONTHLY TERTIARY UNIT RATIO

Month	Volume of water delivered	Losses upto head of tertiary	Volume of water delivered of head of tertiary	Designed water required of head of tertiary	Tertiary unit ratio
January	9942000	4473900	5468100	2661466	2.05
February	9727000	4377150	5349850	1245715	4.29
March	5882000	2646900	3235100	178848	1.8
April	-	-	-	-	-
May	-	-	-	-	-
June	21554000	9699300	11854700	9595584	1.23
July	37249000	16762050	20486950	-	-
August	34444000	15499800	18944200	-	-
September	34018000	15308100	18709900	-	-
October	17307000	7788150	9518850	1982880	4.8
November	13171000	5926950	7244050	892680	8.1
December	11003000	4951350	6051650	3902688	1.55

TABLE 5.9 : SEASONAL TERTIARY UNIT RATIO

Season	Water required of head of tertiary	Water delivered of head of tertiary	Tertiary ratio
Wet (kharif)	14.1×10^6	86.76×10^6	6.15
Dry (Rabi)	8.1×10^6	20.10×10^6	2.48

5.7.5 Over All Consumed Ratio

The over all (or project) consumed ratio, R_p quantities the fraction of the irrigation water evapotranpirated by the crops in water balance of the irrigated area assuming negligible non-irrigation water deliveries, it is defined as

$$\frac{E_{T_p} - P_e}{V_C + V_1}$$ where,

$E_{Tp} - P_e$ = crop water requirement value of which is entirely determined by the crops of which the climate and interval of water application

V_C = volume of irrigation water diverted or pumped from river or to the conveyance system

V_1 = inflow from other source to the conveyance system = 0 (our case)

The volume of the inflows V_C and V_1 are among the very first value that should be measured together with cropped area, the cropping pattern and climatological data. The overall consumed ratio is first water balance indicator that should be available for each irrigated area.

Conveyance ratio R_C quantities the water balance of main, laterals and sub-laterals, including related structures of the system it is defined as

$$\text{Conveyance Ratio} = \frac{V_d + V_2}{V_C + V_1}$$

V_d = volume of water actually delivered to distribution system

V_1 = inflow from other sources to conveyance system = 0(in our case)

V_2 = non-irrigation deliveries from conveyance system = 0

The conveyance ratio should be calculated over a short (weak, month) and along (season) period. The rate of charge of the ratio is an indicator for e.g. the need of maintenance.

For large irrigation system it is common to consider the conveyance ratio of parts of system. Hence consider

(i) The conveyance ratio of the upstream part of the system as managed by irrigation authority and

(ii) At the WUA managed canal.

Here we have consider the conveyance ratio of the U/S part of the system as managed by irrigation authority.

Table 5.10 shows the overall consumed and conveyance ratio of system. and indicate satisfactory value.

TABLE 5.10: MONTHLY OVERALL CONSUMED RATIO AND CONVEYANCE RATIO

Months	Vol. of water diverted from river	Vol. of required by crops	Over all consumed ratio R_p	Conveyance ratio R_c
January	9942000	4435776	0.45	0.89
February	9727000	2076192	0.21	0.89
March	5882000	298080	0.50	0.89
April	-	-	-	-
May	-	-	-	-
June	21554000	15992640	0.74	0.89
July	37249000	-	-	-
August	34444000	-	-	-
September	34018000	-	-	-
October	17307000	3304800	0.19	0.89
November	13171000	1487800	0.11	0.89
December	11003000	6602688	0.6	0.89

5.8 CROPPING PATTERN

5.8.1 General

Cropping pattern means the proportion of area under different crops at a particular period of time. A change in cropping pattern means a change in proportion f area under different crops.

Development of realistic cropping pattern needs no emphasis, with introduction of irrigation water, farmers go for their own selection of crops.

Cropping pattern in command area forms the basis for yearly and seasonal water budget and to work out irrigation schedules, the objective of crop planning is to evaluate a cropping pattern, which maximizes the socio-economic benefits of irrigation correct evaluation of economic, social and ecological factors (rainfall, temperature, soil etc) is necessary to make the crop planning realistic. A designed cropping pattern should have a fair change of being implemented in field. A too ambitious or pessimistic design can throw the planning machinery into dis-arrow and cause a lot of confusion and manipulations of the implementation stage.

5.8.2 Cropping Pattern

The out standing features of cropping pattern in India and Nepal are

(i) Amazing variety of crops and

(ii) The pre-dominance of food crops over non-food crops.

The most important crops produce in Nepal are : Rice, Paize, Wheat, Pulses and Oil Seeds.

With assured irrigation, farmers tend to adopt commercial crops (cash crops). Wide discrepancies has been observed in design cropping pattern and actual cropping pattern. Designed and actual cropping pattern in command areas are shown in table 5.11.

TABLE 5.11 : BEFORE, PROJECT DESIGNED AND ACTUAL CROPPING PATTERN

Crops	Present and future cropping pattern without project in % of area		Designed cropping pattern with project in % of area	Actual cropping pattern in % of area
Wet-season	Rainfed	Irrigated	Irrigated	Irrigated
Paddy				
Local	48	57	15	
HYV	-	4	37	89
Upland	11	10	4	
Maize	25	17	21	7
Cotton	-	-	10	-
Soybean	-	-	3	-
Groundnut	-	-	4	-
Vegetables	-	-	1	-
Subtotal	**84**	**88**	**95**	**96**
Dry season				
Wheat	10	17	24	68
Oil seeds	14	16	23	12
Pulses	13	12	21	14
Vegetables	-	1	2	2
Subtotal	**37**	**46**	**70**	**96**
Cropping intensity	121	134	165	192

5.8.3 Water Availability and its Allocation

Long transition period taken in implementation of project provides more water in the beginning to farmers in head reaches who thus try to adopt intensive cropping pattern and later on when irrigation networks is fully operational, the head reach farmers exert social pressure to allow them to continue with the intensive cropping pattern.

In general the availability of irrigation during each of the growing season largely determines the cropping patterns. Where water is available year round, farmers favour the best economic return crops. Also for limited irrigation those cropping pattern are selected which provide the best economic return such as wheat during Rabi.

Irrigation water availability increases, the cropping intensity. Assured irrigation provides more management control by farmers.

Here ratio of achievement to the intended cropping pattern is greater than unity. It indicates that the cropping pattern is satisfactory in stage I of Mahakali Irrigation Project.

TABLE 5.12 : CROPPING INTENSITY RATIO

Crops	Design cropping intensity in % of area	Actual cropping intensity in % of area	Ratio
Kharif	95	96	1.01
Rabi	70	96	1.37

5.9 IRRIGATION POTENTIAL

5.9.1 General

MIP is located in Kanchanpur district. This district has a good potential for agricultural development, especially irrigated agriculture, since it is bordered by Mahakali River (Sarda River) which is one of the major River. In December 1979, HMGN approved a comprehensive master plan for development of Kanchanpur district. The proposed project (MIP) was a key part in that plan. The development plan delineates areas to be maintained as commercial forest, wild life reserves, areas to be reforested and areas to be reforested and areas to be developed for rainfed and irrigated agriculture, including resettlement and settlement of landless farm families. The plan anticipated that the MIP (3,400 ha net) ultimately extended to 2300 ha. development would be in stages.

Under stage I, the existing irrigation system (3400 ha net) will be improved and extent it 6600 ha net. The extended area would in value the clearing of 1,700 ha of commercial forest and 500 ha of forest partly occupied by encroachers. Forest leaning was an going activity being under taken by forest Product Development Board. The total command area of the project planned in MIP stage was 6,600 ha net.

The gross area of this stage is 8,000 ha and net area is 4,800 ha net. The feasibility study of the stage I was carries out in 1979 under UNDP financing and IDA subsequently appraised the project in June 1980. The appraised led to an IDA credit of US$ 16.0 million. This stage was to completed in 1985. The project comprised of

(a) Improvement to the existing irrigation system in 3,400 ha.
(b) Extension of the system to an additional 3,200 ha.
(c) Construction of a network of public and service roads.
(d) Agricultural extension and training
(e) Consulting services and
(f) Fellowship for Nepali students.

The detail study of the project revealed that the actual area of stage I is less than the targeted area for the following reasons:-

- Fully controlled project mapping (which was not available at the time of appraisal) showed that there was about 14% less area within the physical, boundary of the stage I area resulting a reduction of about 1,100 ha net in command area.
- A government ban on the proposed clearing of part of Sukla Phanta Reserved Forest for settlement and irrigation development reduced the area about 900 ha.

Consequently, a project area at 4800 ha net, instead of original area of 6,600 ha, was considered for irrigation development, the other part of project scope remaining unchanged.

The aspects of physical sustainability that can be affected by irrigation managers relate primarily to over-or under supply of irrigation water leading to water logging or salinity. The simplest measure of sustainability is therefore

$$\text{Sustainability of area} = \frac{\text{Current Irrigation area}}{\text{Initial Total Irrigable area}}$$

The initial area refers to the total irrigable area in the design of the system or in the lastest rehabilitation. Where it is appropriate, this ratio can be modified to specifically refer to water logged or salin areas as a percentage of the total irrigable area. Due to the above mention reason the new area can bot be extended hence the lastest rehabilitation area is 4800 ha only. Therefore

$$\text{Sustainability of irrigable area} = \frac{4800}{4800} = 1$$

Hence irrigation is sustainable.

5.9.2 Irrigation Achieved Year Wise and Crop Wise

It ahs been found that all the command area is getting water there is no problem of water in MIP stage I area. Table 5.13 shows the irrigated area year-wise and crop-wise.

Table 5.13 Irrigation Achieved year wise and crop wise

Crops	Year 1994/95 Area irrigated	Year 1995/96 Area irrigated
1. Rainy season	4705 (ha)	4689 (ha)
Paddy	4284	4270
Maize	406	400
Pulses	13.0	12.0
Others	2.5	2.0
2. Winter season	**4473**	**4491**
Wheat	3255.0 (ha)	**3250**
Rapeseed	398.0	400
Lentil	340	340
Potato	60	60
Fodder	60	60
Chickpea	120	100
Linseed	100	90
Vegetables	90	81
Others	90	110

Cropping intensity is more than the proposed at the time of project appraisal.

5.10 DELIVERY OF WATER

5.10.1 General

The most important service that the irrigation system provides to farmers is the delivery of the irrigation water to users. From users point of view the service in term of delivery of water to him should ensure:-

- Timing of delivery
- Flow rate as per allocation
- Duration of water flow for irrigation application.

In major canal system commanding extensive irrigable areas with large number of farmers receiving irrigation service, fulfillment of above requirement does need the higher order of efficiency from the system. In the India and many developing countries like Nepal for the major canal system deliveries and distribution is primarily the responsibility of irrigation department upto outlet level on minors (tertiary canals). Below the outlets the water is divided among users themselves without any formal water users communities or associations. Quite often, the travel distance for water from pleas of canal to trail reaches in the system covers upto 500 km as ever more. The supplies are in most of cases drawn directly by river supplies specially when there is no storage support. In these conditions we really need a very dependable delivery line good, network of distribution channel and water courses, functional organization for correct assessment of irrigation requirement and after resource an deliver the water as per preceded schedule of delivery.

5.10.2 Principle of Water Distribution

In most of the large canal systems projected in India specially in northern plans, the available water resources at the head of canal was required to be spread on larger areas to benefit largest number of users as a protection to their crop against deficiency of moisture and drought conditions. The concept of maximum yield or largest benefit per unit of water was never applied. Inspite of the change in agricultural practices from extensive to intensive and with new technological development with large improvement of seeds and facility, the principle of use of available water in surface irrigation system to extensive large areas and delivery to largest number of users still hold good. The remaining need of irrigation water is now normally met out by supplement use of ground water mainly by farmers private means of shallow wells and tubewells. This is a sustainable and quite appropriate system of irrigation practices over large irrigable commands and concepts of better use is already in built in it. This also controls the objectionable rise of ground water table in agriculture command with constant addition of canal water over along period as substantial nearly two third of volume available of the zero point of unlined canal system is normally lost through seepage and operational loses upto the time, the water is applied in the field to crops.

5.10.3 Conveyance of Water Through Main Lines

The water in major surface irrigation system is conveyed through the command by main canal and Branch Canal. In India the canal with head discharge greater than 14 cunecs is normally rated either branch or main canal. The main canal normally runs continuously throughout the year except those, which are taken off from non-perennial rivers or tanks and reservoirs.

The branch canal normally run in roaster with two to four weeks running and few weeks closure depending upon availability of supplied. Normally the total capacity of branch canal is higher than the capacity of main canal and some time branch canals are made to run even with partial discharge capacity.

5.10.4 Distribution of Water on Irrigable Command

The distribution of water to users is carried out by distributions and minor channel through outlets.

As given in table the water quantity is meeting the requirement of MIP stage I and stage II in kharif (wet) season. The water requirement only for stage I is being met by the delivery of water in Rabi (dry) season. But when the MIP II stage will be also in fully operation and the water from Sarda barrage will delivered as bilateral agreement of 1928 then there will be scarce of water in Rabi season. At that time the canal has to run in rotation.

Normally roaster of supply delivery from Indian authority is fixed as 10 days closure and 10 days running i.e. roaster at that time the water delivery will be twice the normal delivery i.e. 8.5 cumec.

In actual practice the delivery efficiency as related to availability of water, is normally more than 90% upper and middle reaches of commands, which in last 1/3 rd of the area in command, the delivery efficiency varies from 60 to 80% percent.

5.10.5 Water Allocation and Distribution

Before formation of legally registered WUOS, water allocation and distribution in command area was fully managed by MIP. The project now takes into its confidence the WUAS and WUGS under its umbrella for water allocation and distribution. The stage I area is enjoying the whole source of available water from the canal and there is in fact abundance of water for the area only. The water allocation in such condition is much easier and can be said to be non-existent. After completion and fully operation of stage II areas, the same source has to serve an area 2.42 times the area covered by stage I. In this situation, the water allocation will be very critical. The distribution of water would also become critical when stage II will be fully ready for receiving water. The effectiveness of WUOs can be judged only after water is delivered to the total area of two stages.

5.10.6 Rotational Supply of Water

Rotational supply of water is adopted when there is scarce of water in source. When the available supply is not meeting the water requirement of crops, then a rotational delivery of water is unavoidable. This method envisages canal running in full terms with full supply discharge and the duration of flow is regulated. There are two types of rotational delivery system in vogue.

(i) Flexible rotational system

(ii) Rigid rotational delivery.

In northern Indian plain the second method is normally followed and it is suitable for water scarce areas or large commands with limited river supplies.

The MIP has made efforts to introduce rotational water supply system in Stage-I area but the abundance water has proved this exercise a futile one. At present no rotational water supply is practiced.

5.10.7 Rostering or Rotation

During the period of keen demand, when MIP stage I and stage II both will be in full operation ., all the off-taking channels of the canal system it is not possible to run all the channels simultaneously as the supplied needed by the all the off-taking channels put together, generally exceed the full supply discharge of the main canal in winter season. Running of the channels of reduce discharge is generally not resorted to on account of following reasons :

- It leads to silting of channels and subsequent weed growth.
- It may result in low head over the outlets, which would lead to indicate discharge, this would be resented by cultivators.

Under these circumstances, it becomes necessary to run a group of channels at a time and keep the remaining channels closed. This process of rotation is rostering. When the off-taking channels are run for one week in every two week they are said to be running with roster 1 in 2 and when they are run for one week in every three weeks they are said to be running with roaster 1 in 3 and so on.

Some channels are unable to feed all their outlets during the period of keen demand. This may be due to fixing of larger number of outlets on channel than it can cater for or due to the outlets in the upper reaches drawing more than their due stage. In such a case group of outlets on the channel may be kept closed while other are allowed to run and during the next running of channel, the process may be reversal. Closure of a group of outlets in this manner is called 'Tatil'.

5.10.8 Water Requirement and Running of Channels

Water requirement based on present cropping pattern has been calculated and given in appendix A Table A-9. For the monsoon period (crops) there is no problem of water even the stage II will run in full operation. But in dry season (Rabi crops) there will be water scarcity when both stage I and stage II will run simultaneously. To meet the crop water requirement, and in this season the canal has to be run in rotation. Hence a rotational planning is needs to satisfied the need.

There are four blocks in stage I and fours blocks and Daiji in stage II having the net command area of 4800 ha and 6600 ha respectively.

The existing cropping pattern is 96% of stage I area in dry season (Rabi) so it is assumed that farmers will adopt the same cropping intensity in stage II area.

Rotational planning of running the off-taking channel has been done to met the crops need in scarce period. Three proposals have been prepared for running the canal in roaster.

CASE 1 – 7 DAYS RUNNING OF CHANNELS AND 21 DAYS CLOSURE

In this case, channels are divided in four groups and at a time only one canal will run will full supply and other two will run in balance. Planning is given in Table 5.14.

Table 5.14 : Groups of Channels and Supply Condition for 7-Days on & 21 Days off Rotation

Week No.	Groups	Full supply discharge	Partially supply discharge	Remarks
1.	I(A, D, H)	A	D, H	
2.	II (C, D, H)	C	D, H	
3.	III (B, E, G)	B	E,G	
4.	IV (E, F, G) and Daiji	Daiji	E,F,G	

CASE II – 10 DAYS RUNNING OF CHANNELS AND 20 DAYS CLOSRUE

In this case channels are divided in three groups and two channels will run in full supply and other are in balance. No channel will be remain closed more than 20 days. Planning is given in Table 5.16.

Table 5.15 : Groups of Channels and Supply Condition for 10 Days on and 20 Days off Rotation

Rotation No.	Groups	Full supply discharge	Partially supply discharge	Remarks
1.	I(A, D, H)	A, D	F	
2.	II (B, F, G and Daiji))	B, Daiji	F,G	
3.	III (C, G, E, H)	C	E, H	No channel will remain fully close more than 20 days

CASE III – 10 DAYS RUNNING OF MAIN CANAL

According to the bilateral treaty between India and Nepal, in scarce period i.e. from 15 October to 15 May the supply from Sarda Barrage may be alternately closed and opened for ten days of a time and the main canal could run of 8.5 m^3/sec capacity whenever the canal is open.

In this case the channels are divided into two groups only as four blocks and Daiji area in one group and remaining 4 blocks in another group and planning is given in Table 5.16.

Table 5.16 : Groups of Channels and Supply Condition for 10 days Alternate Closure and Open of Main Canal

Rotation No.	Groups	Full supply discharge	Partially supply discharge	Remarks
1.	I(A, D, F, H)	A,D,F,H & Daiji	-	
2.	II (B,C,E,G)	B,C,E,G	-	

Running of channel of all three cases are given in appendix A Table 11(a), 11(b) and 11(c).Table A-12 in appendix A shows the roaster for Rabi crops for both stage I and II area.

5.10.9 Equity and Timeliness of Irrigation Water

The pattern, in which water is delivered over time, is directly related to the overall consumed ratio of delivered water, and hence has a direct impact on crop production. The rationale for this is that water users may apply more irrigation water, it there is an unpredictable variation in volume or timing of delivered water, and they may not use other inputs such as fertilizer in optimal quantities if they are more concerned with crop survival than crop production.

The primary indicators proposed for use in measuring dependability of water deliveries are concerned with the duration of water delivery compared to the plan, and the time between deliveries compared to the plan.

$$\text{Dependability duration} = \frac{\text{Actual duration of water delvery}}{\text{Intendd duration of water delivery}}$$ and

$$\text{Dependability of irrigation interval} = \frac{\text{Actual irrigation of interval}}{\text{Intended irrigation interval}}.$$

In addition to dependability in term of timing, it is strongly recommended that the predictability of discharge or water level be included in this part of assessment. For many irrigation activities the flow rate must be near the intended flow rate for water use to be effective.

In MIP stage I and flow rate is even higher than intended hence there is dependability of duration.

Observations are compared on monthly basis because there is continuous supply form June to third March. Hence due to continues supply of water with more than required there is dependability in both duration and irrigation interval as required.

A rapid appraisal survey was conducted in 1996, taking sample area from head, middle and tail reaches of each block, A, B, C and D the crops yield and cropping intensity (Stage – I) has been given in Table 5.17.

Table 5.17 : Cropping Intensity and Yield

Season	Crop	Head			Middle			Tail			Av.	Av.
		Sample area	% of area covered	Yield t/ha	Sample area	% of area covered	Yield t/ha	Sample area	% of area covered	Yield t/ha	Yield	Intensity
Block A												
Monsoon	Rice	100	80.0	4.0	66	100	4.5	40	100	4	4.18	223.88
	Maize		20.0	0.9		0.0	0	0				
Winter	Wheat		80.0	2.4		86.7	2.3		100	2.3	2.32	
	Oilseed		20.0	0.5		13.3	0.6		0	0.0	0.52	
	Others		30.0	5.0		20	5		15.0	4.5	4.94	
Block B												
Monsoon	Rice	43	100.0		50	100	4.5	22	90	2.9	4.21	218.37
	Maize		0			0.0	0		10	0.5	0.48	
Winter	Wheat		77.0	2.3		85	2.3		81	1.9	2.17	
	Oilseed		20.0	0.0		5.0	0.6		10	1.4	0.34	
	Others		32.0	0.0		26	0.6		12	0.5	0.31	
Block C												
Monsoon	Rice	25	100.0	2.5	39	76.9	2.9	108	94	2.3	2.45	211.9
	Maize		0	0		23.1	1.4		6.0	0.6	1.07	
Winter	Wheat		68	1.7		76.9	2.1		68.0	1.7	1.75	
	Oilseed		19	0.5		23.1	0.6		10.0	0.6	0.59	
	Others		25	0.7		0	0		38.0	0.7	0.69	

Source:- CMS Kathmandu

From the table, it is observed that in monsoon season the cropping intensity in all blocks and head; middle and tail reaches of each block is 100%. That is to say there is no problem of water distribution. All the farmers are receiving there required share of water in time-yield is also nearly same for each crops.

But in winter season it is found that the cropping intensity decreases in tail reaches and also yield of crops are low as compared to head reach field.

Now if we consider the equity parameter delivered by C.L. Abernethy in head reach and tail reach area; then we will find that there is no equity even there is availability of water in canal system.

It indicates that tail reach farmers always suffer form unequal distribution of water. It is observed in all most all the irrigation projects of developing countries that the head reach farmers use more water than tail reach farmers.

Table 5.18: Inter-Quartile Ratio

Blocks	% area (A) upper reach	% of area (B) tail reach	Inter-quartile ratio	Remarks
Rabi Season				
Block A	130	115	130/115 = 1.13	
Block B	129	103	1.25	
Block C	112	106	1.056	

5.10.10 Conjunctive Use of Surface and Ground Water

The ground water potential of Kanchanpur district has been studies. It is found numerous dug wells and hand pumped wells take water from this aquifer. In the eastern portion of the project area this aquifer is artesian. The available supply of surface water is sufficient to meet the requirement of the project. However, when areas east of the Chaudhar river are to be developed under stage II and III, the need of a supplementary supply of ground water may arise. The water from all the aquifers in the project area is generally chemically suitable for domestic water supply, live stock and irrigation.

There is no use of groundwater as a supplementary source of water presently.

CHAPTER-6

SOCIO-ECONOMIC ASPECTS

6.1 GENERAL

Irrigation development plays an important role in uplift of people in developing countries like Nepal where 86% of the population are engaged in agriculture. Water is a scarce commodity in relation to its demand for several uses of plants and animal life. Being scarce and having immerse alternative uses, it has got economic value. The way in which water available as the gift of nature, is harnessed, developed, managed and utilized, has its impacts on users, past, present and future. The impacts get reflected in objectives of planning for alternatives user of water in ex-ante form, in monitoring for present situation, in evaluation for its past performance.

The socio-economic impact from the three major angles of planning, monitoring and evaluation and the related factors that crop up while executing these three functions in the process of water resources development and management are analyzed.

There are many input like fertilizer, seeds, cultivation practices, extension services and irrigation water for crop production. Out of all inputs irrigation water is one of the important and critical input for crop production. It must include not only engineering aspects to divert water from sources to the canal but also agricultural, social, political infrastructure facilities, legal and environmental should also be given due consideration. The farmers involvement is an important and adjunct role in proper utilization of available water. Since the farmers are ultimate users of the irrigation water hence they must be included right from the planning to O & M of irrigation system.

The objective of socio-economic study in a broad sense is to identify the socio-economic change, pattern of use of farm resources land, labour and capital and how are they allocated for cultivation of different crops and effect and strength of water users group in water management. However the main objective of socio-economic study relates to longer-term impact of pursuing a particular set of operational and agricultural strategies. It includes study of

- The social setting composition of family, level of education and standard of living
- The existing cropping pattern, production and productivity and extent of farm resources. Comparison with the objective set of the project formulation time is carried out to evaluate the performance of project.
- To analyze the input-output and profitability of important crops grown in the project command.
- The performance of extension services in the project area.

6.2 SOCIAL COMPOSITION AND LAND HOLDING

Before 1950's, Kanchanpur district was inhabited mainly by Tharus and a large part of district was under forest. People from hilly area began to migrate into the area only in the late 1950's after malaria had been brought under control. The rate of migration increased subsequently as government started clearing forest under a planned resettlement program to accommodate the influx of Nepali citizens displaced from Burma in early 1970's along with large scale migration of population from adjoining hill districts. Now their settlers in Kanchnapur district from almost all the district of Nepal. The ethnic composition in the project area has been are found to be Brahmin (35%) Tharu (29.40%) and Chhetri 23.9% and ST/SC 10.6% and others 1.1%.

TABLE - 6.1 SOCIAL COMPOSITION AND LAND HOLDING

S.No.	Ethnic group	Percentage of ethnic group	Land holding capacity
1.	Brahmin	35	24.1
2.	Chhetri	23.9	40.1
3.	Tharu	29.4	17.1
4.	SC/ST	10.6	18.5
5.	Others	1.1	0.2

6.3 LAND DISTRIBUTION

The land distribution in the project area is uneven. Table 6.2 show the farm size and percentage of all farms holding by farmers.

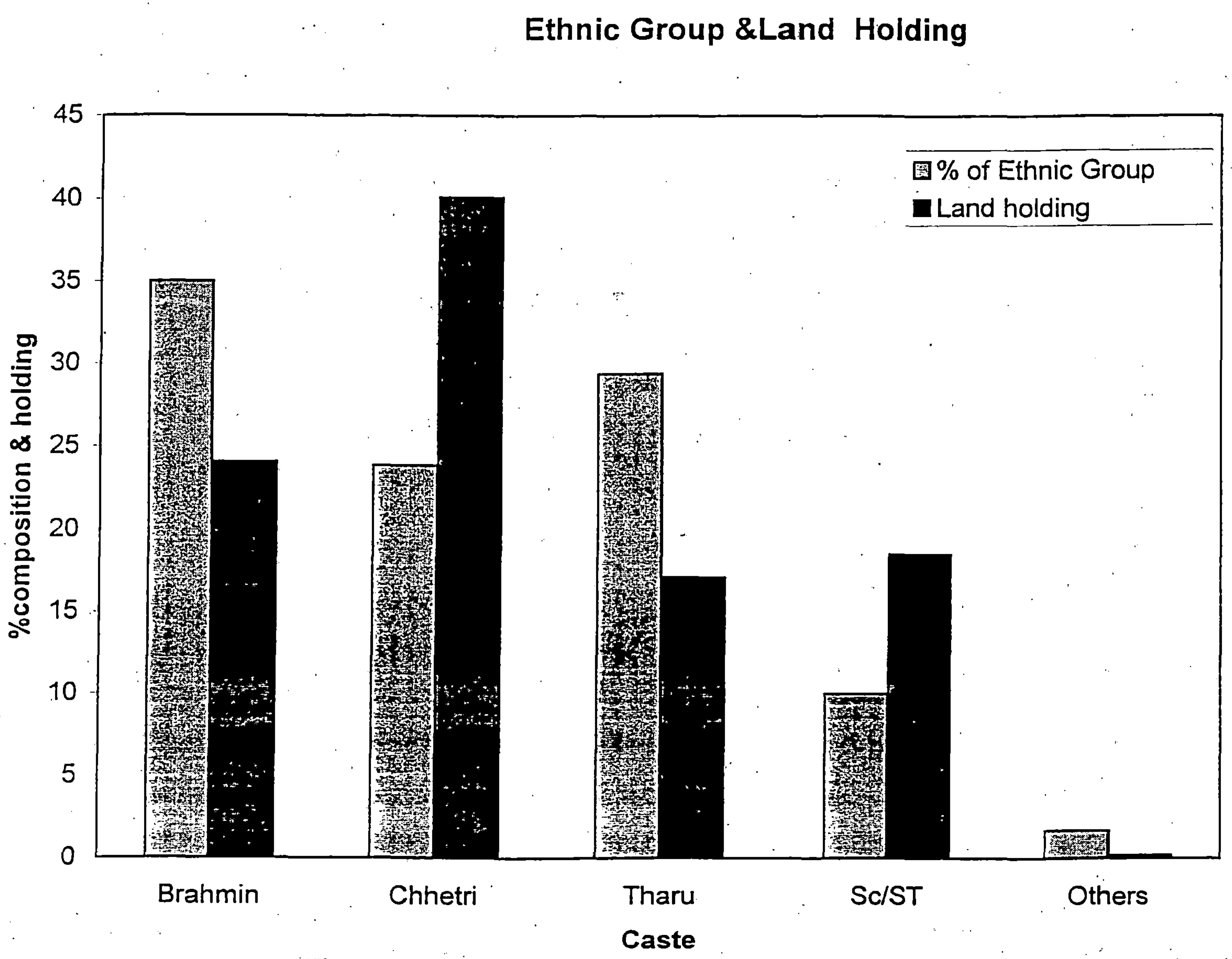


Fig. 6.1 Ethnic group composition and land holding

Table 6.2 **Land Distribution.**

Farm size	% of all farms	% of total farm land	Average farm size
Less than 1 ha.	43.5	15.3	0.64
1-2 ha	35.6	33.6	1.27
2 – 5 ha	17.9	35.5	5.60
5 – 10 ha	2.6	12.6	6.47
10 ha and more	0.4	3	13.1

According to these data 3% of the largest farmer occupied about 15.6% of all the farm land where as 79% of small and marginal farm occupied about 49% of land. However the 18 % medium farmer occupied nearly 35% of the land. However this might be stated as inequity since in this area large farms are often associated with large number of families. The average land holding of family in project area is presently 1.3 ha.

According to the data of district level, the Kanchanpur district has 46,990 ha of agricultural land with about 35,237 number of land holdings.

6.4 LAND USE AND CROPPING PATERN

Out of the total area at 161,000 ha, at Kanchanpur district, the land area occupied by agriculture and human habitation is 46,985.5 ha of which 95.3 percent has been used for seasonal crops. Project area land capability and cropping pattern are given in table 6.3 & 6.4.

TABLE – 6.3 PROJECT AREA LAND USE CAPABILITY

S l. No.	Land use class	4 Rsd	3 Sd	2Sd	2S	Total
1.	Drainage conditions	Poorly drained lowland	Imperfectly drained lowland	Moderately well-drained lowland	Well-drained upland	
2.	Soil type	Fine textured clay loam or silty clay loam	Medium to fine-textured loam to silty loam	Moderately course to fine textured loam to silty loam	Moderately course sandy loam	
3.	Crops recommended wet season	Paddy	Paddy	Paddy, cotton, soyabean, vegetables,	Paddy, maize, groundnut, cotton, vegetables,	
	Dry season	Pulses	Wheat, pulses	Wheat, oilseeds, pulses, vegetables,		

4.	Cultivated area (ha)	140	1,580	1,380	1,100	4200
5.(a)	To be developed (ha) under project	120	210	200	1,870	2400
(b)	Developed under project	120	210	200	70	600
6.	Total cultivable area (ha)	260	1790	1580	1170	4800

TABLE – 6.4 PRESENT LAND USE UNDER PROJECT AREA

Sl. No.	Particulars	Gross area in (ha)	Net area in (ha)
1.	Forests	300	-
2.	Deforested	-	-
3.	Cultivated (rainfed)	-	-
4.	Cultivated (irrigable)	7700	4800
5.	Others (Airport, Swamps, Villages)	500	-
6.	Sub total	8500	4800
7.	Mahendre Nagar Town	1,200	-
	Total	9,700	4800

The area is flat and forms a gently slope from north to south about 3%. The soils of the project area are alluvial and falls into two main types:

(i) Yellowish and grey brown soils, develop under forest cover coarse to moderately coarse texture and well drained and are suited for irrigated farming of mainly upland crops such as wheat, cotton, maize and pulses because of their coarse structure and higher permeability.

(ii) Deep alluvial soils consisting mainly of medium to moderately fine textures clay to silty loams, less permeable and poorly drained. This type of soils is suitable for both irrigated paddy and upland crops with proper drainage.

However, it has observed that practically the farmers used about 89% of land for paddy and 7% of land for maize in monsoon season and about 68% of land for wheat, 12% for pulses, vegetables, peases and 14% for oilseeds, potato and others. Farmer used the land to get the maximum benefit of available water in the sources.

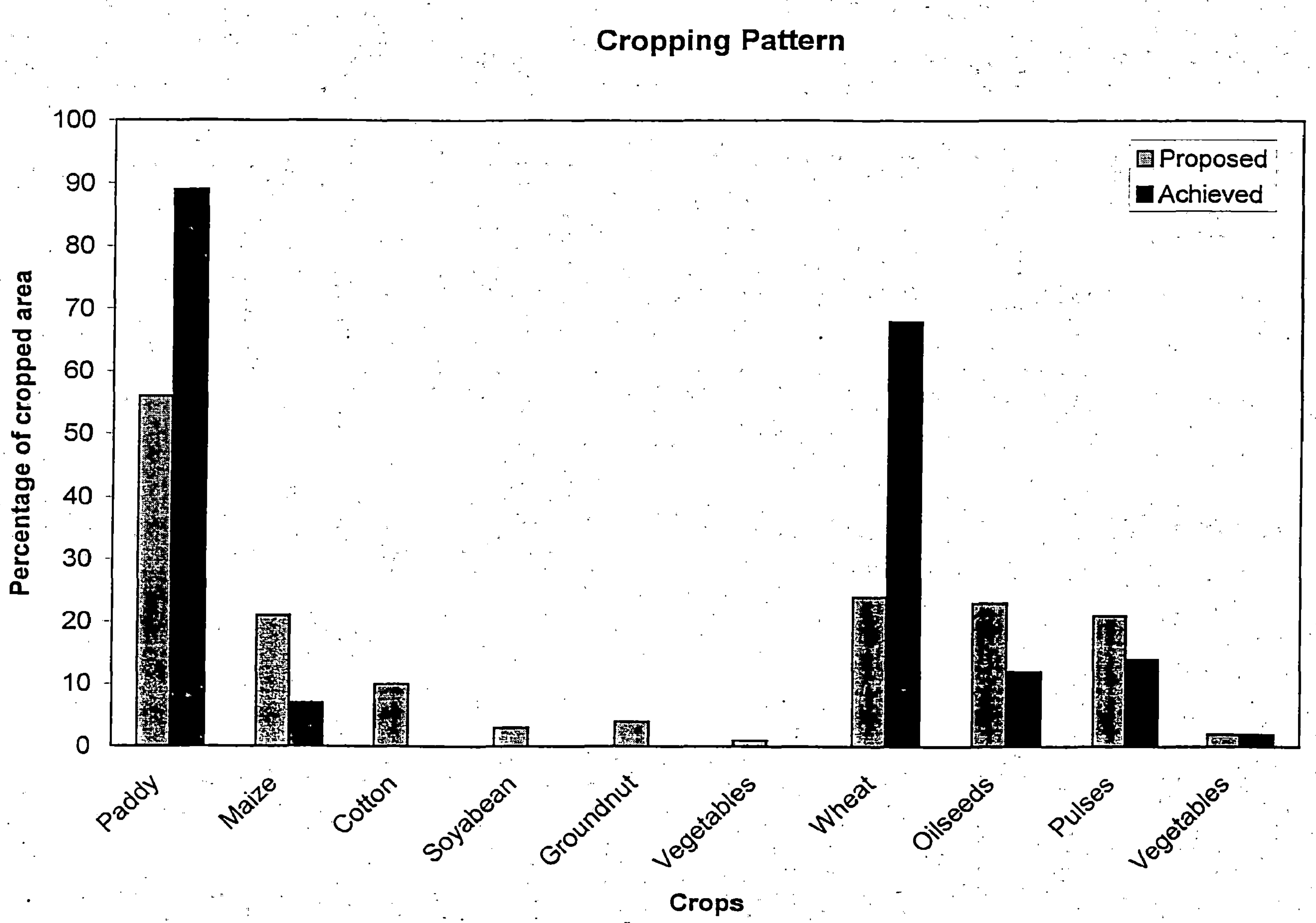


Fig. 6.2 Actual and proposed cropping pattern

Table 6.5 **Cropping Intensity**

Crops	Proposed % of area to be covered	Actual % of area covered	Remarks
Wet Seasons (Kharif)			There is increase in cropping intensity
Paddy			
Local	15	3	
HYU	37	86.0	
U pland	4	1	
Maize	21	7	
Cotton	10		
Soyabeen	3		
Groundnut	4		
Vegetables	1	1	
Others	-	-	
Subtotal	95	96	
Dry Season (Rabi)			
Wheat	24	68	
Oilseeds	23	12	
Pulses	21	14	
Vegetables	2	2	
Subtotal	70	96	
Cropping intensity	165	192	

6.5 PRODUCTION OF CROPS

6.5.1 General

Invariably in planning and developing a water resources project there is over optimism about the productivity achievable possibility. This possibility is some times not based on any facts or figures and even worse than guesstimate. It is not advisable controlled conditions. There is need to think whether we should so in for such projections in benefits so as to get the projects cleared on the basis of over inflated benefit cost ratio, or should be concentrate on a more realistic projections of benefit based on the socio-economic and administrative management setup obtaining in respective water resources development project.

The area that needs attention is the choice that the authorities have to make about the criteria to be followed in taking a decision, the projections to be made in respect of physical inputs and outputs and the prices at which the respective inputs and outputs are to be evaluated. But inspire of all the emphasis on water development and management, the role of associated disciplines has yet be appreciated and acknowledged in water resources and irrigation development project. The role which the economists, sociologists agronomists, agriculturists are to play in effective planning, development and management of irrigation projects, have to be clearly defined and emphasized Unfortunately, till today water resources planning, development and management have been the job of engineers and the last minute contribution from other disciplines, where they exist, is only marginal and strictly to aid the engineers to get a project cleared.

The performance of a management system can only be measured in term of its objectives. If we limit our discussion to technical performance at the hydraulic level of water distribution system, then the success of an irrigation system can be measured by how it supplied the required quantity of water at the right time in an equitable manner to users served by the system. The delivery system can have many objectives but there is a broad agreement that most of them can be included in adequacy equity and timeliness. Water delivery management is not an end in itself but is a means of increasing agricultural productivity in sustainable manner and ultimately improving the quality of life of water users. Hence it is necessary to establish linkage between intermediate objective and ultimate objective i.e. productivity of crops.

6.5.2 Potential Productivity

Let us consider the effect of timeliness on production. There is now a days a substantial amount of information enabling us to estimate the effect of water deficiencies on crop yield and in particular to differentiate between effects, on ultimate yield, of water storage that may be occur at different stages in crops history.

From the data of water deliveries and out put achieved can calculated the ratio at potential productivity. We can define potential productivity as the ratio of the output that can be achieved under water region, and the output that would have been according the matched needs at the crops. The yields of different crops at proposed in project appraisal report and actual yield achieved in different years in given in appendix A table A-13.

Productivity means production per unit of input we may have a land productivity (t/ha), which is usually called yield or we may have a water productivity (kg of crop/m^3 of water), which in the United State literature is usually called water use efficiency. In some circumstances labour productivity will be a more important feature and so on. The land productivity tends to receive the greatest emphass in literature, but incases where management of water is a focus of concern there is at least a prima facie where management of water may be dominant costraint on output, and that water productivity ought to be our primary criteria for good performance.

A way of resolving the point is to ask whether, in case any water is saved by good management, it can be put to alternative use, or whether it will simply be wasted. If there is not alternative demand for it, then water productivity is not an important objective.

From the fig. 6.2 There is excess of water in rainy season (wet season) even the cropping intensity is 96% in stage I. Also if we consider the command area of stage II even in the rainy season, water is sufficient to meet the crops water needs and also quit excess in month of July, August, and September. But we can not store this supply and use it in scarce period incase of run off river project,. During this season there is no alternate use of that water. So the productivity per unit water has less meaning. In this case the value of potential productivity will be very low.

In the winter season (dry season) if we consider only stage I area of MIP, then it is now meeting the crop water requirement and also matching the time with crops need. The potential productivity is really 0.158 t/m^3. But when state II will be in full operation then the crop water requirement in a particular time will exceed the available supply in month of November and January. During this period a rotation water supply is required to meet the crops need. In this case a proper management of water supply is required so that there should not be loss of yield of crops which farmers are getting then. Even through excess water of other month except deficient have no alternative use. We are in conditions of over all water deficiency in particular irrigation system and the saved water can be used also where then we must regard water productivity as an important factor of good management of performance.

Using the data of table A-13 of appendix we see that the most of years the crops yield is more than the expected in stage I but after full operation stage II if requires again performance study to increase substantially more is also important crops in wet season.

In dry season, wheat is a major cereal crop. The area under oil seeds and pulses are also grown. Some vegetables are grown in small portion of area. The project was designed to achieve a cropping intensity at 165% and now the actual cropping intensity is about 192%.

6.5.3 Production Impact Performance

Production impact is assessed to cropped area, cropping systems, cropping intensities and yields and the over all adoption of improved management practices as compare with staff appraisal report target.

Present cropping pattern shows that crop coverage has already exceeded the SAR target 165%. It is worth to mention that the adaptation of HYV crop become more popular to over Local to get maximum yield.

The agricultural pilot farm has continuously monitoring the average yield of crops in stage I area since 1986/87. The average yield of crops in stage I area have persistently increased over years. The average yield of all the crops exceeded SAR targets. The yield of paddy is significant as it has reached a level of 4.0 t /ha compared to SAR target 3.2 t/ha.

6.6 INPUT USE

Agriculture at present facing two conflicting issues :

- The increasing population of the world and the prevailing malnutrition of people in advancing countries demand greater production of food. As the area of potentially cultivable land is limited, it is essential that the yield of crops per unit area be increased. To achieve this more fertilizer must be used.
- The raw materials for fertilizer manufactured are becoming scarce and more expensive. Farmers, especially in the advancing countries, cannot use as much fertilizer as they should.

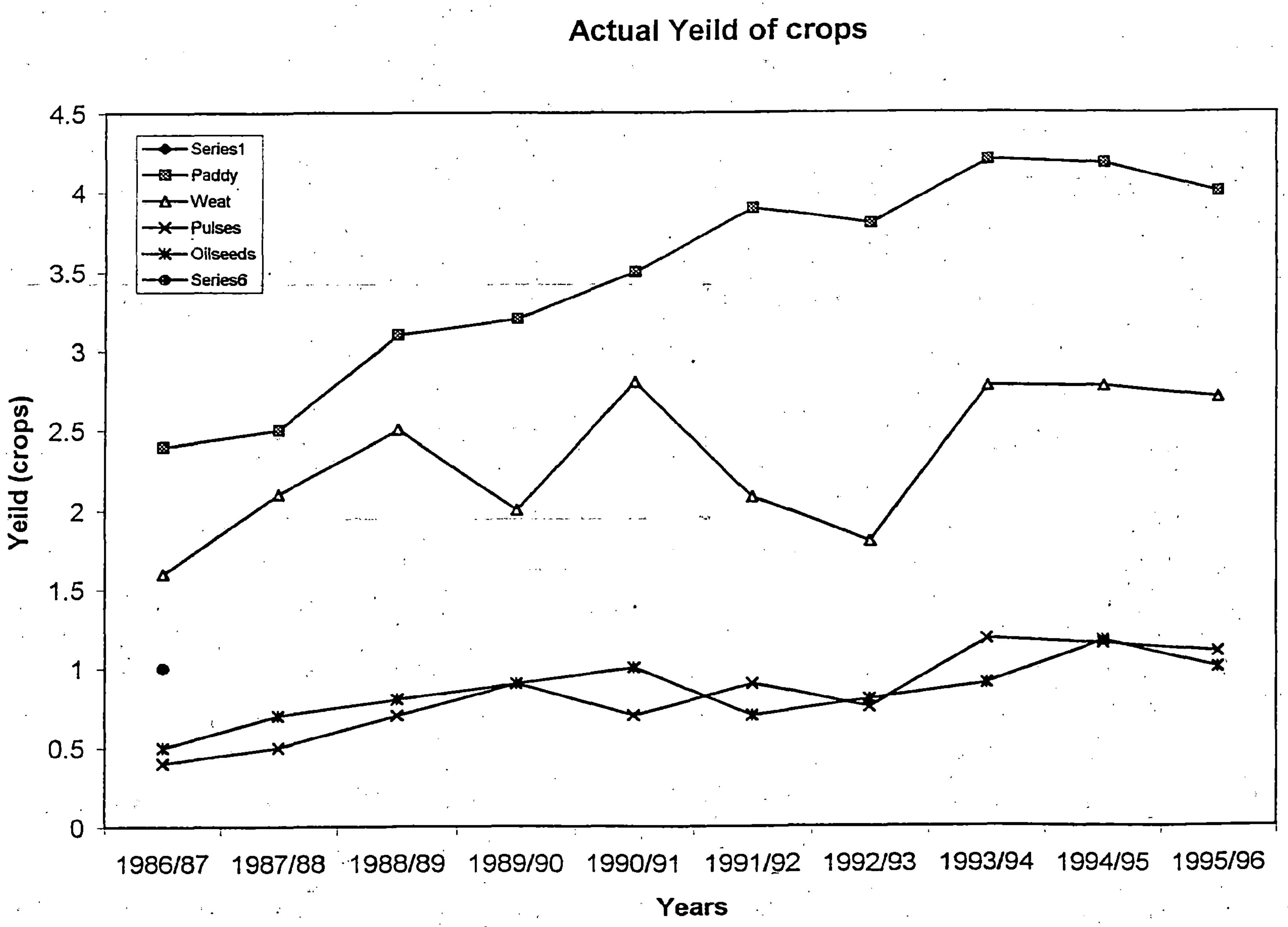


Fig. 6.3 Yields of major corps in different year

Our limited resources must therefore be used at maximum efficiency and yields kept at the highest possible level. In this context some aspects of increasing the efficiency of fertilizers while maintaining high yields of grain crops are necessary.

The use of fertilizer depends on the availability of water. The irrigation water is a one of the most important input used for the crop production. The overall use of fertilizer in stage I area is about 103.2 kg/ha. It is observed that the farmers tend to use more chemical fertilizers for high value and cash crops. There is still sufficient scope to increase the fertilizer use in stage I area and there by to increase the crop yield, if the water will be available in sufficient quantity and in time.

Before the project was launched no fertilizer and plant protection chemicals are used for crops grown under rainfed conditions, The use of fertilizers and agro-chemicals was mostly limited to HYV paddy, wheat and vegetables grown by some progressive farmers. Average amounts used, however, were very low. Only about 10% of the farmers in project area were using certified from their previous harvests or fellow-farmers. There were about 2,800 pairs of draft animals; they provided adequate farm power for land preparation and other cropping operations.

The input used rate by farmer in MIP stage I is shown in of appendix A-15. Intensified cropping patterns, improved farming practices and intensive in-service training for farmers have been considerably increase the use of better seeds, fertilizers and plant protection chemicals.

AIC and Sajha have been providing these input increased demand. As a result of project, labour requirement have been also increased. During the month of June and July the peak labour demand for hired labour is covered by local landless laborers and migrant labour from hills and neighboring Indian State of Uttar Pradesh. Securing agricultural short-term credit from ADBN has been facilitated through formation of WUGS, which are obtain such credit collectively as "Joint liability groups".

6.7 ECONOMIC CONCEPTS

6.7.1 General

Economic analysis is generally concerned with assessing the real cost of using resource in order to establish priorities between competing proposals. Resources include land (soil fertility and the presence of useful minerals), water, climate, and human skill and labour, supported by man-made capital resources (which are the result of previous productive effort). It is emphasized that economic analysis concerns resources and not money. In this context money should be seen as nothing more then convenient way of measuring resources. Economic evaluation is only one of the criteria against which decisions about a project will be made. Technical, financial, social and institutional criteria will also generally be used.

Financial evaluation is concern with determining the costs of using resources form the Point of View of an individual or small corporation. The evaluation is only concerned with those costs, which have a direct bearing on financial performance.

Economic evaluation is concerned with determine the costs of using resources an seen from the point of view of the community as a whole. However the economic evaluation does need to take into account all the cost of the community, irrespective of whether they are borne by households, a corporation, an administrative authority or national government.

6.7.2 With And Without Project Comparison

The aim of economic analysis is to assess the net incremental benefits arising from a project. To assess this incremental benefit, it is necessary to identify the costs and benefits that will arise with project and to compose them with the costs of benefits that would have arisen without the project.

This is not the same as comparing the situation before and after the project, which assumes that the situation would remain static in the absence of a project. In the analysis of most irrigation projects it is unlikely that agricultural output from within the proposed area would be stagnating, and in most cases it is likely to be growing, albeit at slower rate than would be achieved with. The project- in some cases, it is possible that agricultural out put would fall in absence of a project (e.g. a project to reduce soil salinisation, in addition to providing more irrigation water). The benefit with the project and without the project is given in Appendix A-1'.7

6.7.3 Adjustment of Financial Prices

a) Transfer-

In adjusting financial prices to showdow prices, direct transfers on inputs and outputs to be eliminated. A port 'tax' may in practice be a charge of port services such as handling and administration.

b) Traded goods

Distributions in the market prices of goods which are internationally traded (rice, wheat, maize, fertilizer etc) also need to be allowed for. The approach is to allow for the domestic costs of transport and marketing between border and the project site and for export; If the project produces goods (rice, wheat) which can be used in place of imports, then the value is the foreign exchange saved by using domestic product rather than imported product, valued at the border price, in this case the C.I.F price.

For direct imports, which are used to as a project input (fertilizer), the price at the project site is calculated by adding the costs of local transport, storage, handling etc. To the border price, since, these costs will be incurred in getting the input to the site.

The calculation of economic prices for major crops and fertilizers are shown in appendix A-14 and are as follows

Table 6.6 Economic prices of crops and fertilizers

Sl.No.	Crops	Economics price NRs/ tone	Fertilizer	Economics Prices NRs Price/ tone
1.	Paddy	11815	Urea	25146

2.	Wheat	21698	TSP	25062
3.	Maize	16023	DAP	24894
4.	Oilseeds	20586	Potash	26237
5.	Pulses	41400		

C) Non-Traded Goods

For goods which are not internationally traded (construction material, transportation, vegetables), there are no world price and thus no basis for estimating border prices. However, there may still be a need to make price adjustments to remove distortions causal by Taxes or market imperfections.

6.7.4 Standardized components of Benefit Matrix

In formulating the benefit matrix the objective has been to standardize and precalcualted as many of the components as possible without reducing accuracy too much through over generalization.

Crop yields

Crop yields in the presents and future "with project situations" have been obtained. The present and past with project situation yields, as obtained from office, are used. The crop yields without project situation as given in the project appraisal report are also used for calculation of benefit in each year.

Agriculture inputs

The level of agricultural inputs (seed fertilizer, agro-chemicals, labour and bullock power) per hector for each crop in the future "with project" situation at given yields have been used as given in design manual.

In "without" project situation a standard seed rate has been used for each crop and standard labour and bullock inputs have also been calculated for each of three situations.

Crop Budgets

Where possible, by using the standardized yield, agricultural inputs and economic prices, crop budgets showing the net returns for each crop have been calculated, (Table A-16).

6.8 COST OF PRODUCTION AND NET INCOMES FROM FARM OPERATION

The project has changed the condition under which agriculture in the project is traditionally operating. Improved irrigation and drainage in the existing scheme have provided farmers with a more reliable supply of water, reduced dependence on the erratic monsoon rainfalls and thus increase the incentives for higher input application and adoption of advanced farming practices.

At the full development of project, the production of paddy and wheat have been increased rapidly

The net return from a farm operation is given in appendix A-16. The economic farm budget has been prepared. The rate of out puts and input of traded community is taken as world market rate on projected for year 2000 this basis the net benefit from the major crops are given in table 6.7.

Table 6.7 Net return from farm operation

S.No.	Crops	Net- return (NRS/ha)
1	Paddy (H.Y.V.)	23,213.0
2.	Wheat	25867.0
3.	Maize	19608.0
4.	Oilseeds	6520.0
5.	Pulses	22607.0
6.	Vegetables	28152.0

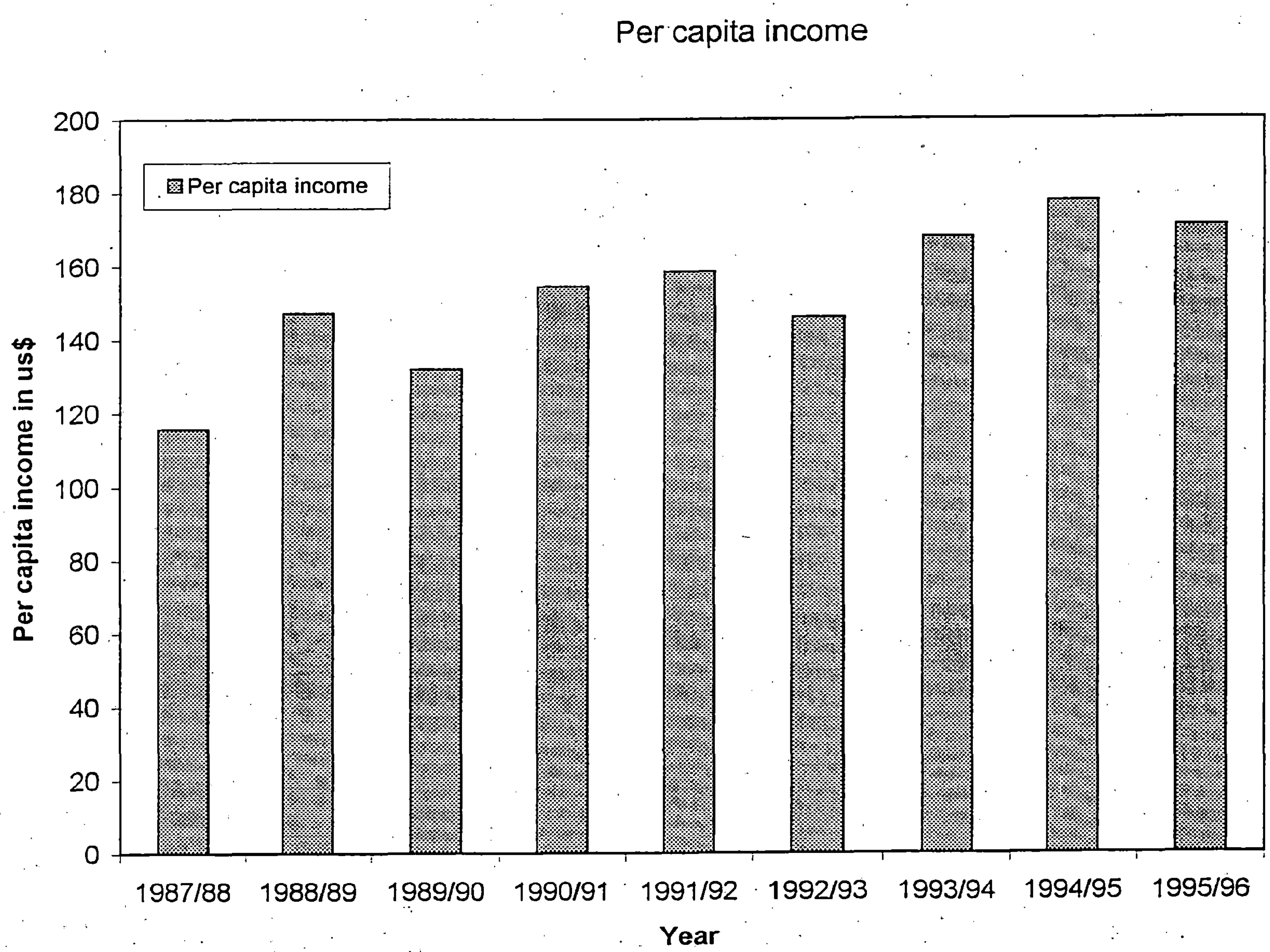


Fig. 6.4 Per capita incomes

Table 6.8 Per Capita Incomı Of Farmers

particular	1988/89	1989/90	1990/91	1991/92	1992/93	1993/94	1994/95	1995/96
Net return in NRS	347691	314590	373868	389071	363498	424705	444637	427874
croping intensity	181	182.8	185.6	188.3	191	193.9	192	192
Cropped area	8688	8774.4	8908.8	9038.4	9168	9307.2	9216	9216
Net return in NRS per hactor	40.02	35.85	41.97	43.05	39.65	45.63	48.26	46.42
Net return in NRS per family	52	46.6	54.56	55.96	51.55	59.32	62.74	60.35
Net return in US$ per family	736	659.6	772.26	792.1	729.65	839.6	88.04	854.2
Net return in US$ per capita	147.2	131.92	154.4	158.4	145.93	167.92	177.6	170.8
Note: NRS ' 000								

On the basis of cropping intensity and crop yield the per capital incomes from the farm operation has been calculated and given in table 6.8. The average family have landholding capacity of 1.3 ha in project area and 5 members in a family. The percapita incomes has increase as a result of project.

6.9 PROFITABILITY OF IRRIGATED AGRICULTURE

Independently of economic viability of a particular investment or the viability of the agencies supplying water and other inputs, farmers must primarily be concerned with the profitability of their actions of the level of their individual farm. It is quit possible for sector or system level economic analysis to show negative returns, largely through the high cost of capital and yet find farmers in those systems consistently making profits. Two indicators are propose that address different aspects. Profitability in terms of land, and profitability in terms of water delivery.

$$\text{Yield VS water cost Ratio} = \frac{\text{Added value of crop}}{\text{Cost of applied irrigation water}}$$

This indicator requires evaluation of the value of the produced crop with irrigation minus the value of crop (that could be) produced without irrigation. The cost of applied water can be modified to include or exclude the discounted value of capital cost of the system depending on whether or not capital cost is considered a sunk cost.

Within most irrigated areas, however, water is the scarcer resource. Hence it is logical to substitute water for land in above equation.

$$\text{Yield VS water supply Ratio} = \frac{\text{Added Mass of Marketable Crop}}{\text{Mass of Irrigation Water Delivered}}$$

Table 6.9 Yeild vs Water Cost Ratio

particular/year	1988/89	1989/90	1990/91	1991/92	1992/93	1993/94	1994/95	1995/96
net return in NRS after project	347693.7	314589.8	373867.6	389070.8	363498.2	424704.7	444637.1	427874
net return in NRS, without project	60067	60067	60067	60067	60067	60067	60067	.60067
added value of crops	287626.7	254522.8	313800.6	329003.8	303431.2	364637.7	384570.1	367807
present value of invesment in NRS	1125027.4	1022752.2	929774.7	845249.7	768408.8	698553.5	63048.6	524833.6
O&M cost in NRS	.5084.2	5706.2	6484.5	15326.6	10374.9	10717.9	6372.3	2737.8
Total investment in NRS	1130111.6	1028458.4	936259.8	860576.3	778783.7	709271.4	641420.6	527571.4
Discount factor	0.909	0.528	0.751	0.683	0.62	0.564	0.513	0.424
Discounted investment	1007271.4	849506.6	703131.1	587773.6	483624.7	400029.1	329048.7	223690.3
Yeil vs water cost	0.28	0.3	0.446	0.56	0.627	0.911	1.17	1.64

NOTE: Amout in NRS' 000

Table 6.10 Yelld vs Water supply Ratio

S.N.	particular/year	1988/89	1989/90	1990/91	1991/92	1992/93	1993/94	1994/95	1995/96
1	Added mass of Marketable crops in kgs	14779200	12883600	19555200	18652300	17512500	20536100	21528000	21528000
2	Mass of irrigation water delivered in cum	193000000	192500000	190000000	186000000	189000000	191000000	194290000	190000000
	Yelld vs water supply ratio	0.076	0.067	0.103	0.1	0.093	0.107	0.111	0.113

Table 6.11 Relative Water Cost

particular/year	1988/89	1989/90	1990/91	1991/92	1992/93	1993/94	1994/95	1995/96
Total production cost in NRS '000	170644.1	171587	174980.9	177526.4	180071.9	182806	181014.7	181014.7
Total cost of irrigatio water	1027271.4	849506.6	703131	587773.8	483624.7	400029	329048.7	223690.3
Relative water cost	6.02	4.95	4.02	3.311	2.686	2.19	1.8	1.236

Here again the added mass of marketable crop should be determined. If viewed from farmers perspective the mass of water delivered is measured either at the farm inlet or at the head of field, depending on this views.

From the perspective of the farmer the (scio-) economics of irrigation can also be quantified by the relative cost of irrigation.

$$\text{Relative water cost} = \frac{\text{Total Cost of Irrigion Water}}{\text{Total production Cost of Major crop}}$$

The total production cost includes cost of water (including fees, energy for pumping seeds, fertilizers, pesticides, labour, etc). If critical values of this ratio are exceeded, farmers tend to abandon irrigation.

The value of yield VS water cost ratio, yield VS water supply ratio and Relative water cost is calculated for years and given table 6.9, 6.10 and 6.11 respectively. These indicators indicate that yield VS water cost and relative water cost is satisfactory but yield VS water supply ratio is low. This is due to excess water supply and excess water has no alternate use so that another benefit can be achieved.

6.10 SOCIAL VIABILITY

6.10.1 General

Irrigation managers actions have direct social impacts, though managers are often unaware of these. This gap in perception leads many irrigation mangers to feel the social "viability" issues are not relevant to them. However, if the long term sustainability of irrigation is an objective, and if improving and maintaining social well being is ultimately important, then social viability is relevant, particularly from a strategic management perspective.

Table 6.12 Irrigation Employment Generation

S.N	Employee	Rate of empyment per	command area in ha	No. of employee required	Annual working days	Employment Generation	Remarks
							As SAR
1	Dich Rider	500ha	4800	10	283	12.9	
2	Gate Operator	100ha	4800	48	283	61.9	
	Total			58		74.8	

Table 6.13 Irrigation Wage Generation

year particular	1993/94	1994/95	1995/96	1996/97	Remarks
Av.Annual Rural incom(	167.67	177.6	170.8	170.8	incomes in US$
Av.Annual National incom(	190.2	200	220.21	234.17	
Irrigation wage genera	0.881	0.888	0.775	0.729	

Table 6.14 Relative Prosperity

year	1993/94	1994/95	1995/96	1996/97	Remarks
%of scheme Population above povert	38	40	39	41	
% of natuional Population above povert	40	41	43	42	
Relati\ Prosprity	0.95	0.976	0.91	0.976	

6.10.2 Irrigation Related Labour

In many countries, there are departments of agriculture, labour or census, which collect basic agricultural and economized data. These can be used by irrigation managers as sources of information and socio- economic impacts and trends such as employment, wages and poverty levels. A possible indicator to quantify the social impact of a scheme is

Irrigation Employment Generation =

$$\frac{\text{irrigation Employment Annuaday/ha Labour by scheme}}{\text{Annual Number official working Days}}$$

Because of the cost of labour this ratio is related to the self-sufficiency, of the irrigation agency for socio-political reasons, a high value may be desirable; for irrigation to be economically sustainable; this ratio has an upper limit.

Less controversial ratio are:

a) $$\text{Irrigation wage Generation} = \frac{\text{Average Annual Rural Income}}{\text{Average Annual National (Regional) Incomes}}$$

b) $$\text{Relative prosperity} = \frac{\text{\% of scheme population above povety level}}{\text{\% of National population above poverty level}}$$

These indicators can also be modified to compare within-scheme levels to adjacent non-irrigated areas, or to other irrigation system. The irrigation employment generation, irrigation wage generation ratio and relative prosperity are calculated and table 6.12, 6.13 and 6.14. From these tables it reveals that due to the project employment has been created, irrigation wage generation has increased and the farmers life of the project area is relatively prosperious than other part of this region.

Table 6.15 Tertiary Level Users Stake of Irrrigation System

S.N.	Particulars/Years	1993/94	1994/95	1995/96	1996/97
1	Active WUGS	1276	1318	1318	1300
2	Total number of WUGS	1276	1318	1318	1318
3	Users stake of Irrigation System	1	1	1	0.986

6.10.3 Social Capacity

Social capacity refers to the social (as distinguished form physical biological or economic) capacity if people and organizations for managing and sustaining the irrigated agriculture system. It is suggested to use two indicators:

$$\text{Technical knowledge staff} = \frac{\text{Knowledge Needed for job}}{\text{Actual Technical Knowledge of Staff}}$$

$$\text{Users Stake of irrigation system} = \frac{\text{Active water users organization}}{\text{Total number pf W.U. organization}}$$

Actual technical knowledge of staff could be ascertained through tests, while required knowledge is inherent in the job description. 'Activness" of water user associations can be measured using acquired data, such as percentage of WUA's holding regular minimum required) meeting. Or percentage water users participating in meeting, or number of organizations fulfilling agreed upon tasks, such as fee collection, maintenance or distributing water. All of these indicators are crude and relatively untested; but they constitute useful and implement able first steps to begin paying greater attention to the social viability of irrigation. In the MIP the water users are active and have social capacity to deal the project. Users stake of irrigation has been shown in table 6.15.

6.11 EMPLOYMENT

6.11.1 General

It was expected at the time of project appraisal that overall, labour requirements in agricultural will rise from about 0.7 M to about 1M mandays per year at full development. This is due to higher cropping intensities requiring more labor. Taking into account the expected population growth, it was estimated that the rate of (male) farm labor utilization would increased from approximately 30% at that time to about 48%.

Presently due to higher cropping intensities as expected at the time of project appraisal the labour requirement has increased to 1.2 M mandays per year. The labour required is fulfilled by the labour migrated from hilly region and near by state of India (U.P) at peak demand. The most of the employment benefit is self-employed family labour on their own farms, to a certain extend also land less labourers. The employment in the rural and urban non-farm sector has been increased corresponding as additional demands for marketing, transport and processing facilities.

During the implementation period of the project construction works temporally employment was also about 4M man-days. If has been observed that the project authority has also employed some additional staffs temporality for the different job like gate operators, canal inspectors. J.T.A. Chaukdars etc.

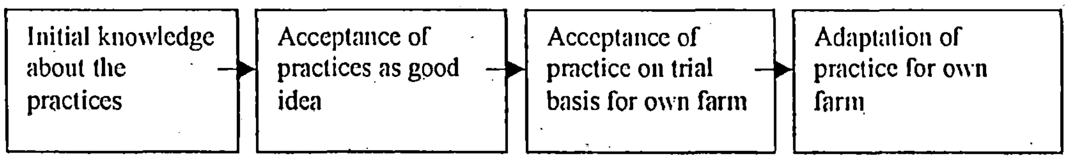
6.12 EXTENSION SERVICES

6.12.1 General

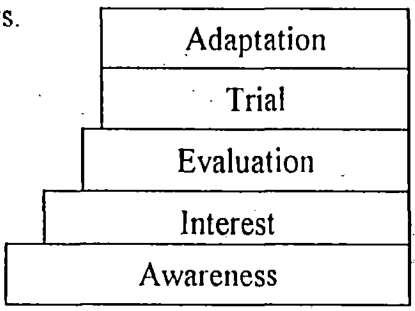
The relative advantage of innovations like improved seeds, fertilizer, insecticides etc. as compared with the old practices constitutes a condition-affecting acceptance of changes. In economic terms this is the comparision of output per unit of input (inform of fertilizer, pesticides, improved seeds etc) on the relative efficiency of new items. It has been observed that the greater the efficiency of new technology in farming, the producing returns or in forms of economic or consumption goods, the greater the likely hood of its acceptance. An important qualifying condition of this principle is the relative ease with which the new technique can be demonstrated and the amount of time it takes to do this.

This is affected by various socio-economic and cultural factors like: size of holding of the farmer, his educational level, availability of capital, exigenous forces (like transport, communication, change agents like block staff and subject matter specialists) social status of farmers, cultural practices etc.

The adoptation of a new practice is the decision of an individual farmer and his family and this is influenced by a series of event or activities bearing upon the decision process.



When a developing country like Nepal launches an agricultural development program in the beginning, the rate of acceptance is slow, then the commutative effect brings the rapid acceptance until almost all the potential adopters have accepted the change. Some of the practices are accepted more quickly as compared to others. In some of these farmer wants to see the results at other farm. The steps of adaptation are as follows.



5. Adaptation
4. Trial
3. Evaluation
2. Interest
1. Awareness

6.12.2 Technology Transfer

The agricultural activities of MIP hing on the activities conducted by agriculture pilot farm of the project. The pilot farm was established in 1982 as training cum demonstration farm and is located at 9 km of project office. The net cultivable area of the farm is 13.2 ha. The farm is used to undertake four programme.

- Cropping system model program
- Adaptive trials
- Seed multiplication program
- Year round vegetable demonstration

The pilot farm has been the local point of all agricultural activities in MIP command area. The major components of the agricultural program in the command area are:-

- To educate the farmers of command area about irrigated agricultural technology
- To launch extension activities through extension tools such as demonstration, field visits, field day meeting and distribution of high yielding improve seeds to the farmers
- To operate the pilot farm for production of high quality improved seeds, conduct crop demonstrations and conduct rotational irrigation management system and
- To assess agriculture production parameters of the project on regular basis.

An important function of the farm is to provide in service training for extension workers and farmers.

The farm has conducted several impressive activities.

- It has so far distributed 8,072 number of mini-kits consisting high yielding seeds of a wide varieties of crops. (Appendix A table A-19).
- It has introduced a large number of improved crop varieties from Pantnagar Agricultural University in India and other research stations in Nepal.
- It has conducted total number of 452 crop production and 1,198 number of result demonstration in farmers fields.

Table 6.16 : Crops demonstration in Farmers Fields

Year	1987	1988	1989	1990	1991	1992	1993	1994	1995	Total
Result	12	48	51	52	180	190	195	220	250	1198
Production	14	17	12	17	30	47	96	104	115	452

6.12.3 Organization of pilot farm

The pilot farm is guided by the agricultural division of MIP through the district agriculture development office. It guides the pilot farms and at initial stages, it was supported by consultants. It consists of one agriculture officer two subject matter specialist and 3-J.T, J.T.A 3PLA as a frontline technician. The MIP has provided offices, transportation facilities and staff quarter as well as low cost farm equipment such as power tillers, thresher and sprayers training facilities including quarter for trainees and audiovisual aids has also provided. The pilot farm is performing its job satisfactory.

The organization of pilot farm consists of following personnel.

Agriculture officer	-	1
SMS	-	2
JT/JTA	-	3
PLAS	-	8

6.12.4 Credit Service

Agricultural Development Bank of Nepal has established a branch office in Mahandranagar, serving the entire project area. Credit is distributed mainly through co-operatives, who in turn administer individual credits to farmers. Most of the credit is for short-term production purposes. The cooperative is now in poor position. For individual credit, land is virtually always the collateral, favoring the larger farmers, whereas loans from co-operative need only the standing crops security. ADBN in tends to promote "joint liability groups" of farmers as borrowers, e.g. water users group (WUG), in order to facilitate credit in a more expedient way, either through co-operatives or ADBN directly. Besides, there are two commercial banks in the area, but their involvement in agricultural lending has been limited. Lending from private source is still wide spread but no reliable data on this are available. The main source of supply for certified seeds n the project area is AIC which has its Branch office at Mahandranagar. As areas cultivated with these crops are high even the AIC is meeting the requirement of seeds AIC also supplies fertilizer and plant protection in chemicals through its branch office in project area. The co-operatives are responsible for its distribution in farm level but now a day the co-operatives are inactive, so the farmers directly purchase from AIC or through dealers. Although supply of fertilizers is generally adequate and available Government has also provided licensed to private agency to meet the fertilizer in keen demand period. To support farmers practice to proper pest control, AIC rents simple sprayers to farmers of a nominal fees.

6.12.5 Education and Skill

MIP area covers the Mahendranagar municipality and near by villages. Mahendranagar being the district headquarter, all level of secondary education, boarding school and public schools are existing there. There are also degree, 10+2 educational and technical institutes for producing low level technical as needed in village development levels at Mahendranagar.

For development of skill to poor farmer in village area and low level educated people of town area there is a cottage industries development board office which trained the people. This office develops the skill to the people to be a self-dependent. There is no data available so it can be not predict how many persons are trained. But this office conduct training as a annual programme. The impact of this to farmers is very good.

Total literacy of Nepal is 39.6% but in project area the literacy is nearly 42% as it is located near the town.

6.12.6 Health Services Facilities

There is a district hospital located at Mahendranagar which provides health services to people. There is also a primary health centre to near by village. The health centers are located within the constituency of Member of Parliament. But these health centers are not operating properly due to lack of posting of qualified doctors. The service of district hospital is also not appreciable as the farmer / people have to go to nearby U.P. state of India for serious disease.

6.12.7 Market Facilities

Due to growing food grain deficits within Nepal, no difficulty has been seen to market surpluses at rice, wheat or maize from the project Nepal food corporation has strengthened its capacity to transport food grains to deficit areas and increased in food grain storage in Mahendranagar.

In addition, HMGN'S intention is to give wheat a priority for home consumption, while releasing additional surpluses of rice for expert through re-orientation of the population's consumption habits. The near and open border to India, together with lifted export restriction for private traders, has been also provided a residual outlet for surpluses. Crops such as oil-seeds, pulses and vegetables are still deficit in Nepal and the amount generated in the project is relatively small. Mahendranagar as the regional urban centre has benefit from the project.

Construction of a network of public roads in project area has been greatly faciliated marketing of the produce to Mahendranagar.

CHAPTER 7

JOINT IRRIGATION MANAGEMENT

7.1 GENERAL

In the last decade, management transfer becomes an important topic in irrigation, especially in the developing countries. The concept of irrigation management transfer to their respective users was born mainly to bridge the widely recognized gap between investments to and return from irrigation systems. This concept rests in the premise that an irrigation system can not be managed best without full participactation of its users, and considers farmers as the major actor in both turnover and joint management of agency built irrigation system. In this background several approaches and process adopted in different developing countries depending on their socio-political settings.

In Nepal as in other developing countries, irrigation management-transfer has been a policy tool since last few years. Accordingly, the government is trying to transfer the management of agency built irrigation systems to their respective users, which were earlier managed independently by the government. At present, in Nepal, diverse forms of irrigation management transfer have been initiated at different levels by different projects under Department of Irrigation (DOI) Nepal, now started gaining some experience of irrigation management transfer through a process of learning by doing, with the growing understanding there are still much more to be learned in this regard.

World wide, international water management institute (IWMI) is conducting research on process and performance of irrigation management transfer to understand its impact and to assist the concerned governments in formulating their policies and refining the process of irrigation management transfer. It is widely recognized that success of management transfer program rests in the regular evaluation of its process and performance.

The importance of farmer participation was not realized in past and was no clear Government vision in this regard in Nepal .As a result, the level of farmers participation in agency managed irrigation systems remained much low compared to farmer managed irrigation system-However at present, recognizing its importance, farmers participation has remained one of the main government policy tools for the sustainable development of the country's irrigated agriculture.

In the context of promoting former's participation in irrigation system management, the capability of promoting farmer's participation in irrigation system management the capability of farmers be improved so that they could manage the agency constructed modern irrigation infrastructure and farmers be made aware of the efficient use of valuable water resources.

The main objective of farmer's involvement should be:-

- How can the farmer's participation be maximized;
- How can owner ship feeling of the farmers be developed.
- What are the genuine problems of farmers in the managing irrigation systems.
- How can irrigation management transfer improve agriculture and irrigation technology in the farmer's fields
- Capability of farmers to understand and manage irrigation technologies introduced by engineers and
- How could the irrigation infrastructures be designed and constructed so that former could manage them.

The above objective can be achieved if farmers are involved from initial stage of project survey, planning, design and construction. However in the large irrigation project it is not possible to involve farmers during planning, design and construct stage of main canal and branch canals but however while planing minors, tertiary and quarterly canal it is possible even essential to involve farmers from initial stage.

In the MIP stage I, initially no farmers involvement was there. While project was completed then it became problem for operation and maintenance of system. The necessity of farmers participation was realised and WUA was formed.

7.2 IRRIGATION MANAGEMENT AND ACTIVITIES

Earlier irrigation was looked from only engineering technology point of view. It is now world wide accepted that irrigation management involves not only engineering aspects but other aspects also. Irrigation management has now become a "Socio-

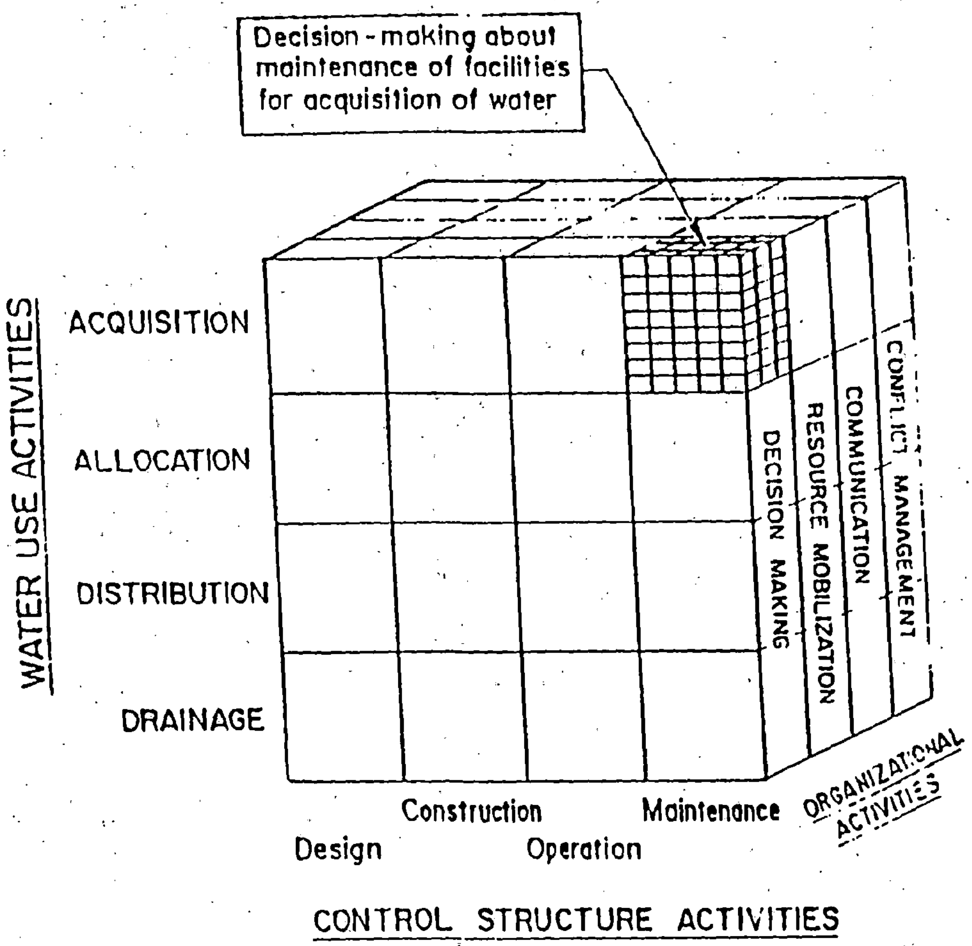


Fig. 7.1 Matrix of irrigation management activity (adopted from Uphoff, 1980)

Technical" process. An irrigation system can be broadly divided into four sub-system, viz., physical, agricultural, social and organization and economic systems.

All the four sub-system are equally important but for better irrigation management now a days more emphasis is given to the social processes in the from of co-operation, accommodation, competition and conflict resolution in continuing forever. Therefore irrigation management be defined as:

The process that institutes or individuals employ in order to set objectives for irrigation system; establish appropriate conditions and identify mobile and use resources to attain these objective while resuming that these objectives are performed without adverse effects. This definition goes for beyond irrigation technology straight forward water delivery function and incorporates a variety of human, agricultural and economic aspects of irrigation "(I I M I 1989).

We should also keep in mind the sustainable value of management. So management is something to be optimized, not maximized. The cost of maximum management are unlikely to produce enough incremental benefits to justify an all out effect by Government staff/or water users, and such efforts any way are not likely to be sustainable simply in human terms. So trade off must always be considered.

Although building physical infrastructures is an essential part of irrigation development, it has been realised that this alone will not. An irrigation system, whether it achieved the goals of irrigated agriculture be an agency managed or farmer managed needs an effective management to carry out various tasks of which water allocation, distribution O & M and conflict management, are importance. Ophoff (1986) has expressed three sets of irrigation management activities which are show in fig.7.1 are as follows:

I Water Use Activities Acquisition, allocation, Distribution and Drainage

II Control structure activities:- Design, construction, operation and maintenance

III Organizational activities: - Decision making, communication, resource mobilization and conflict management.

The first set of management activities focus on the water itself and include acquisition, allocation (Supply management); distribution and drainage (control management) of water. The second sets of activities are related with the structures required for water. The third sets of activities are the organizational activities necessary to sustain human effects.

7.3 NEED OF FARMER'S INVOLVEMENT IN IRRIGATION MANAGEMENT:

Irrigation sector has three major stages of development. The first is where the systems are primarily hydrologic and hydraulic second in which there is greater concern for the use to which the water is put, with a shift from a primary focus on physical system development to concern for agricultural the social. Third where there is maximum efficiency in the entire system of hydraulic and the agriculture Nepal could correctly be put in stage two of irrigation development.

To move toward the third stage the role and responsibility of farmers with active participation in irrigation management is not only desire but urgently essential because of the following reason:-

- The failure of Government to finance or recover the cost of irrigation management from users
- Poor performance of agency management large irrigation system with sub-stantial gap between actual and expected performance level.
- Loss of faith and respect towards the capability and dependability of the government with growing dissatisfaction and low ownership feeling among the users; for proper irrigation development and management.

  There it is essential to develop a management system that would ensure sufficient accountability officials to farmer, farmer leaders to members of WUAS and WUAS to the government. The large number of relatively small system spread throughout the country with poor communications and transport, compounded by shortage of funds and institutional weakness, make it also difficult to envisage how the department of irrigation can ever manage along. These systems effectively and improve their performance.

7.4 OBJECTIVE OF JOINT MANAGEMENT

Realizing the potential of irrigated agriculture to cope, up with the ever – increasing population pressure coming into this area from hills, HMG/N gave high priority to irrigation development in Kanchanpur district. The main. objectives of

Makakali irrigation project, is to increase the agricultural production and farm income through the improvement and extension of the existing irrigation and drainage system and efficient utilization of the available resources. The primary rationale for IDA involvement, was to advance, the rehabilitation and development of irrigation and drainage system and to improve operation and maintenance through farmers participation right from the implementation of the project. Farmers participation and their active involvement in O & M were not conceived in the project design. However, during the course of the project implementation, there were need for farmer's participation in all stage of project development and the project started in corporating their participation. MIP stage I underwent its O & M activities on joint Management basis according to which the project is responsible for O and M from main canal to head of tertiary canals and the farmers are responsible for water allocation, distribution and maintenance within their tertiary canals and chalk boundaries. The design and construction of tertiary canals of stage-II area incorporated active participation of beneficiary farmers. Farmer's contribution to the capital cost of irrigation network constists of the cost of land for tertiary canals and cost of canal box cutting and grass sodding along with the contribution fixation of the canal alignment.

To assess the impact of joint irrigation Management and farmer's system participation in improving system through reduction in operation and maintenance cost, increased in collection of rate of irrigation fee and overall impact in Economic performance. The extent and quality of farmers participation in project management is, therefore, a subject of analysis based on the performance of actual implementation and not only from the planning perspective.

7.5 OPERATIONAL PRACTICES IN MIP

Due to growing demand in scarce water resources, a need for efficient irrigation systems with higher degree of water delivery performance is realised. Consequently a new management practice has yielded and is defined in term of equity and reliability in water distribution. Although adequancy is an important system, it has not much importance in comparison to equity and reliability evolving a sustainable irrigation system in long run.

There are several factors influencing the performance of a system among which operation of flow control structure plays dominant role in maintaining equity and reliability. A widely accepted irrigation system is the conventional upstream control system. All old canal system and most of large project in developing countries are the designed for upstream control irrigation system. Operational flexibility is constricted in an u/s control system because at low flows the gate will be almost closed and at the maximum design flow rates the gate may be raised out of the water to maintain a constant level, regardless of the flow through structures. Operation of flow controlling structures is guided by a set of rules but in fact the rules are applicable in design flow condition only, which seldom prevails in any system.

Design, placement and operation of flow controlling structures are inter-related from managerial point of view. Since water control devices are provided in all irrigation of water distribution relationship between choice of technology and management ability of the system and the decision to choose a certain, technology should be made in the light of the local situation (horst, 1990). It is because the modernization option will be more costly than the simplification option. Still in developing countries manually or mechanically operated technology is in use because of financial, technical and social problems. A large room for farmer's involvement in decision making process exists in contrast to a modern computer guided system. So a precise set of rules is required for the operation of a system to yield a higher performance.

In most of the river diversion schemes fluctuations in river flow exist. Due to such fluctuations, the preset rules can not work in absence of efficient and effective in formation transfer and communication facilities. Also due to some natural problems such a sedimentation and weeds, the hydraulic regime of canal changes, changing the flow conditions. Gate operators get confused and operate gates as per the schedule (Idle rule) provided by the management or follow the self made rule resulting in inequity and unreliability in water distribution throughout the system.

The hydraulic flexibility of the canal bifurcation is one of major factor influencing the operational procedure. A set of rules regarding the extent of flexibility to be allowed in gate operation depends on the changing of great importance for improved water delivery performance. The rules may vary with site conditions but system having a similar set of conditions can be generalized. For this, a co-relation between control structures and flow condition exists.

7.6 MAINTENANCE AND REPAIR SYSTEM IN MIP

7.6.1 General

The structures and the systems created through massive investment should be properly maintained in good health. Annual provision should be made for this purpose in the budget.

Maintenance refers to operation performed to preserving system and facilities in good or near original conditions without increasing, their capital cost. Repairs are essential parts of maintenance. Maintenance of the system should be aimed at preventing deterioration rather than waiting until it has reached major proportions, seriously reducing the efficiency with consequent losses fanancially to the community as a whole.

The works in irrigation system are put to contineuos stress and stain, being functional with varying amount of flow in different conditions, exposed to diversified wheather adversity, interferences by human being, cattles and other natural factors over a long period. The above factors are bound to cause different type of damages. Unforeseen natural calamities such as floods, cloud boosts and severe drought further add to the serious strains to these works.

7.6.2 Essential Normal Maintenance

The maintenance as routine round the year varies in nature for main canal to smaller channels.

(i) Routine Maintenance on Main canal and Branch canals

Main canal as well as Branch canals are normally designed with cross-section where velocities are such that normally, no desilting is needed on them at any time. The internal repairs to earthen section are also not frequent except checking local severe erosion or falling of banks in deep cutting reaches and repairs and restoration to embankment sections. The external repairs are carried out as and when needed but internal repairs are only possible normally in planned closure periods. Damages to hydraulic structures on main canal are examined and analyzed during such closure periods and essential repairs are carried out in emergent conditions. All the damage as well as restoration are recorded in log book/closure registers and remarks are recorded for any further planning for repairs. These documents encompasses the history of performance of these major structures and provides valuable information on their restoration and improvement.

(ii) Routine Maintenance on Distributary Canals

Although the distributaries and minors, the distribution channels carry small amount of flow but quit often they are run with even more than designed capacity to meet out keen irrigation demands and normally run with full capacity with repeated running round the year. These channels passes though the most interior of irrigable command and are cattle population. The banks and service roads need annual normal repairs for maintaining in proper condition.

Most of the distribution channels are silted up substantially, especially in head reaches during monsoon running of channels. The tail reaches of distributary and also of minors are specially either silted up on damaged by over growth of berms checking, the provided cross-section and reducing the carrying capacity.

As these channels requires repeated desilting every year after monsoon and covering quite large kilometers in length, special attention is needed to plan the work with utmost economy and utility consideration. Normally most of the canal system were provided by bed bar along their length which reveals the designed profile of channel and their x-section.

(iii) Repairs to Masonary works

These are large numbers of Masonary works such as bridges, falls, cross-regulators, escapes etc on distribution channels in all the irrigation system. These are used continuously for a long time for carrying the discharge through the channel and for communication by large population. Frequent unforeseen damages to these works cannot be avoided Normally inadequacy of Maintenance budget or neglect of maintenance, staff continue with increase or defer the essential maintenance causing further increase in the extent of damages. This is a fact that repair to all these damages is more painstaking than normal construction especially in view of their locations.

An appropriate solution of this problem appears to allocation of certain amount of annual maintenance budget for regular maintenance masonary structures and restoration the damaged portions.

(iv) Erosion control of bank

Erosion by canal flow will be minimized by good design and construction but it can rapidly initiated by obstructions such as logs a unauthorized structures, washing ghats etc. at canal water edge and by permitting buffaloes and cattle to enter the canal. Maintenance should for the major part be 'preventive maintenance' where by as much as possible, the cause of major damage are reduced to a minimum. Regular patrolling of the canals are required however to answer that it is flowing and discharging smoothly intrusion and for observing where obstruction may occur or where erosion is developing etc. so that, if necessary, maintenance gangs can promptly take prectifying action.

A major protection against canal bank erosion above water level is carpet grass and this should be encouraged by pre-planting areas damaged and reducing excessive grazing by cattle animals and wild-life. On the other hand tall grasses should be regularly cut to encourage denser rooting and to discourage such pests as rats and snakes which barrow into the canal banks.

If canal bank erosion develops seriously then it is best to repair it by stabilizing the toe of the banks where the erosion has occurred by driving in bamboo or hardwood timber piles (about 10cm diameter) along the correct toe-line of bank, leaving the piles about 30cm above the bed level.

(v) Maintenance of water control structures

These are fixed weir structures but for most part they are of concrete and steel structures with movable gates for controlling the levels of canals water or the rates of flow as much as possible and to reduce turbulence round the structures. When the canal deliveries are stopped between crop seasons, careful inspections should be made to see if there is any bed erosion around the structure or damage to the soffit and wings that need repair. The gates, gate guides and lifting mechanisms also requires detailed inspection for rust, wear and damage.

Lubrication of moving parts of gate should be done regularly at intervals no greater than are month but the seasonal break should be used to check for any wear or tear in the gears, shafts and pulleys ropes etc. Gears and gate lifting shafts should be kept clean with only a light but frequent application of oil. Gate super-structures should be painted, preferably in a bright departmental colour. This helps to develop a sense pride among the gate operators and other staff in the functioning of the project which leads to higher efficiency.

(vi) Maintenance of Transmission Structures

The main canal crosses several rivers by syphons passing under the bed of river. These structures are built principally of reinforced concrete. They should be protected particularly on the u/p stream side by grids across the syphons opening to prevent entrance of animals (such as buffaloes) or floating timber that may get jammed down the syphon so reducing the flow down the canal. With reduced flows at the end of the season or during the rabi season, velocities may not be great enough to prevent large silt deposition collecting the bottom of the syphon.

Maintenance staff should take immediate action to remove any obstruction held up by the grids on the syphons. During the off season and zero canal flows, inspections should be made of interior of the syphons and if necessary, arrangements made for repairs to be carried out. Also, if silt desposits in the syphon are excessive then removal of the silt should be under taken.

(vii) Maintenance of Supper Passage and Bridges

Supper-passage conveying drainage across the canals and bridges conveying pedestrians, animals and vehicles, are provided at various location along the main canal and bridges are also located across secondary and sometimes tertiary canals.

These structures re made of reinforced concrete and should normally require little maintenance. Supper passages can sometimes become particulate blocked with heavy desposits of silt making them highly inefficient as drainage channels. In such cases removal of the such deposits should be carried out before the following monsoon period. Bridges may be damaged by vehicles misusing them in which case warning signs should be erected if the structures becomes dangerous and repair should be carried out as soon as convenient.

7.7. MAINTENANCE OF DRAINAGE

Drainage from the quaternary chaks, is the responsibility of the chak farmers and it will be up to them to come to an amicable a greement for sharing the responsibility of digging and maintaining their farm and chak drains.

The secondary and tertiary drain gradients if where is too steep, are rectified by with gabion type drops. These structures normally require little maintenance but during the periodic inspections careful check should be made that the wire mesh has been turn thus weakening the distorting the structures.

Where there are tree, lining the drain or stream banks check must be made that they have not fallen into the waterway, thus causing erosion of the banks by the diverted drain flow. All obstruction in the drainage system should be removed as soon as possible after occurrence.

The growth of weeds in the channels and on channels banks is likely to increase due to near continuous discharge at surplus water from irrigated chaks. It is necessary to cut or pull put all such weed prior to both the Rabi and Kharif (wet season) and if possible to burn them is dispose of them where they will not be germinate in the water ways.

River channels into which the drainage flows are frequently partially blocked by fallen branches or whole trees which trap the movement of silt and further obstruct flood flows consequently the minor obstructions have resulted from fallen timber etc. then these should be moved.

7.8. MAINTENANCE OF ROADS

The roads in the scheme other than the east west highway are for the greater part to be gravel surfaced. The remainder are earth roads. The greater length of roads are located on the canal banks and as such should have good drainage and consequently foundation stability.

The principal concern with the maintenance of the roads is maintaining high efficiency of road drainage both of the surface and the foundation. Next that is the maintenance of the surface, filling potholes and maintaining a good surface chamber.

Roads side drains should be regularly kept clear of weeds and siltation and culverts also should be free of obstruction.

7.9. MAINTENANCE RESPONSIBILITIES OF O & M UNIT OF MIP

The responsibility of O & M unit of MIP includes the irrigation system down to tertiary canal intake-structures, primary and secondary canals and drainages and on canal roads. The tertiary and quaternary canal, and drainage structures including the division boxes (chak outlets) and culverts are also maintained by O & M unit. Operation within the tertiary and quaternary blocks are done by farmers water users group. Although the O & M staff have no operational responsibilities in tertiary and quaternary systems it is necessary that they have to take a close interest in standards of maintenance and also in the productivity of farms. They have in fact, good communication and co-operation with farmers and the agriculture extension officers right down to field level.

7.10. MAINTENANCE RESPONSIBILITIES OF WUA

The water user association is responsible for all operation within the tertiary units and maintenance of tertiary and quaternary canals and drains earthworks.

The division of responsibility above are intended to broadly define. The responsible duties, O & M staff also need to play a part in overall planning of each seasons agricultural activities and in this respect, they should meet regularly as an executive committee of district co-ordination committee together with District Agricultural Officer and farmers representatives from each of four main irrigation blocks.

Maintenance aspect place much emphasis on the concept of preventive maintenance, which it self is a year round activity.

7.11 PRIORITIES OF MAINTENANCE PRACTICES

MIP has undergone to joint Management so to maintain the irrigation system in sustainable operational order and to protect the command area from harsh regime of river, Mahakali are the main targets of system activities. Moreover, the siltation in main and secondary canals and increasing demands for communication structures (canal, drain and road crossings) are in priorities of maintenance practices.

7.11.1 Tertiary Maintenance

As the responsibility of tertiary maintenance lies with the tertiary canal committee, farmer desilt their canals before transplanting the paddy crop. In practice the desilting work is carried by volunteer labour based on number of house holds or by labour tired by land owners. Due to the encroachment on canal toes by adjacent farmers and cultivation of dry root crops on the banks and slopes, seepage in some tertiary canals is frequent resulting in increasing demand for lining.

7.11.2. Block Maintenance

The desilting of main and secondary canals is usually carried in alternate years. Block maintenance (secondary canal to the head of the tertiary) is carried out on the basis of priority fixed by respective WUAs.

7.11.3 Procedure of Priority Fixation of Maintenance

Soon after the start of new fiscal year and stoppage of the monsoon rain, maintenance demands from the farmers come to the WUA of each block. Tertiary chairman eigher certifies, these demands or the outlet leader or individual farmer may put forth the demand directly. All demands should come in written form, addressed to the chairman of the WUA and these demands are collected and complies by the office bearer of WUA. Moreover, a meeting held in the beginning of the fiscal year, will fix priority through a sub-committee headed by executive member of WUA. In practice, this meeting falls during September to October. Based on the maintenance demands collected and compiled in the office, the sub-committee has to verify the sites and submit its report with a list of respective priority works. After the submission of all priority lists, a meeting is held to discuss and make a consensus. In case of disputes, executive members jointly inspect the site to identity the necessity of the works to be done. In the mean time, WUAs hold a meeting to know the proposed budget ceiling of their block. Project manager or his representative (Usually Executive Engineer of O & M Division) should attend this meeting depending upon the proposed budget and nature of the problem WUA unanimously makes priority of works to be carried out in the near future and sends it to the MIP requesting execution of all these genuine demands.

After the arrival of priority from all four blocks, MIP starts survey works and prepares estimate of these works. In practice, the survey is carried out with a walk-through with respective WUA members and concerned farmers. Depending up on the nature of work and budget provision, construction management activities proceed in consultation with WUA members.

These priority fixation activities reflect the farmers active participation in their system improvement and management through their decision making process and feeling of ownership towards the system. However, increasing demands of communication and lining. Structures may lead to dependency syndrome among the farmers. A typical is of priority works are given in Table 7.1

Table 7.1 typical priority lists
Group A Fiscal Year 1996/97 Proposed Budget 15 lacks

S.N.	Description of work	Budget in lacks
1.	Mahakali Rive bank protection & Spurs	4
2.	Gadda tail escape maintenance	2.0
3.	BJR'/1 Tertiary maintenance	1.0
4.	Desilting of Bhujela distributory and other branch canals and minors including following lists of 44 tertiary canals.	8.0 lacks
(a)	Road crossing culvert	43 Nos
(b)	Foot bridge with crate abutment and precast slab	91 Nos
(c)	Tertiary crossing pre-cost slabs	180 Nos
(d)	Gabion Crate works in all drains of this block	27 Nos
(e)	Additional outlet	185
(f)	Check gates and check plates	15
(g)	Himpipes 600 mmϕ 900mmϕ 300mmϕ	 15 10 Nos 200 Nos
(h)	Maintenance of non-canal gravel roads, Pipariay branch Bankatti branch , Gadda minor	

Group B Fiscalyear 1996/97 Proposed Budget – 15 Lakhs

S.N.	Description of work	Budgeting in lacks
1.	Desilting works of mahaenlonarger brach from kalopool of khair batti	
2.	Pre cast slab for tertiary crossing	12 Nos
3.	Pipe culvert 900 mm dia near Ram-Janki temple and skill development and training center	1 No.
4.	Drainage protection works with gabions	1
5.	Hcm pipes 900 mm dia 600 mm dia 300 mm dia	 5 Nos 1 Nos 65 Nos
6.	Tertiary lining MNL 1/1 and BS 3/2	
7.	On canal road repair Basantapur minor Mahandranagar branch	
8.	Levelling on ground by MIP Dodger	
9.	Drain crossing with gabion crate and pre-cast slab	
10.	Contingencies	NRS 50,000.00

7.12 INSTITUTIONAL DEVELOPMENT

After the promulgation of irrigation Regulation 1989 farmers participation became mandatory, at all levels of irrigation development, from the project Identification, design and construction, to operation and maintenance of he completed system. According to the policy in public irrigation system, the farmer will carry out the operation maintenance of the cands commanding less than 25 ha area and will also do the construction themselves.

To implement the policy guideline in the field, a program was set to hand over all the tertiary canals of stage I area to farmers who use the water. The handing over of these tertiary canals was a historic event in the sustainable development of MIP, which was performed in a series of institutional development activities. They involved:

- Listing of users in each tertiary canal.
- Confirming chak boundaries
- fixing outlet group and its leader
- Electing or selecting tertiary committee and its chairman.
- Electing Block committee.

After completing all basic institutional development activities, a walk. through program was set up to verify the physical system and to make a list of structures to be repaired or added. The walk through team comprised of an engineer and his subordinates including farmer representatives and institutional development staff. After repairing, the verified system handover process was launched. Association organizers of project played a vital role in the handing over process.

The case of stage II is different. The construction of all tertiary canals by the farmers became impossible after conducting a series of meeting with the farmers. As the tertiary canals are crucial part of large irrigation system without which water can not be delivered to the field, the construction of these tertiary canals became the prime concern of the project management. Inspite of several meeting held with beneficiary farmers and development of association organizer and consultants, farmers of the area expressed their inability to construct tertiary canals by themselves. At first, the project decided to construct the required structures and to ask the farmers for earthworks. But farmers refused to support this arrangement also. At last realising the seriousness of the issue, the project decided to construct the tertiary canals on the basis of following cost sharing arrangements. The farmers participation included the cost of land for tertiary canals, barrow area along the canals, canal box cutting and grass saddling where as project bore the cost of all construction including, the cost of standing crop compensation.

In order to materialize the above-mentioned participatory approach in tertiary canal construction, several activities were carried out during pre-construction period: Preparation of farms holding register based on hydrological boundary and commanding capacity of the outlet.

- Fixation of canal alignment based on farm boundary.
- Determination of technical feasibility
- Formation of tertiary committee
- Construction agreement.

In construction agreement farmer were informed about their entailing operation and maintenance responsibility of tertiary canals after their successful completion.

Table 7.2 Institutional Development Activity stage II

Period	Users list Nos of Tertiary canals	Water user groups	Tertiary committee	Construction Agreement
Target	262	1,834	262	252
July-Dec 1995	40	231	27	16
Jan-June 1996	9	70	10	10
July-Dec 1996	143	979	147	131
Jan-June 1997	62	386	52	60
July-Nov 1997	5	109	14	20
Total	260	11,775	250	237

7.13 ORGANIZATIONAL SET UP

The organizational setup of WUAs is designed as per the structural system of canal and the rotational water supply principle. The canals of MIP are divided into four main categories: -

- Main and distributary canal

- Branch and distributary canal (Minors also)
- Tertiary canal
- Field channel.

Accordingly, the water user associations are also organized into four tiers at the bottom tier is the outlet group, above it, is the water users group (WUG-tertiary committee) and above WUG lies water users associations (WUA-Block committee) at the open, there is one water users association co-ordination committee (WUACC) which was farmed in December 1993, initially representing farmers of stage I area and latter following the formation of all origination in stage II, representing farmers of both stage I and stage II.

7.14 COMPOSITION OF COMMITTEE

The water users of one outlet have to constitute one outlet group consisting of one outlet leader. A leader of an outlet is elected from all user of that outlet command area and all user are group members. There is one water users group for each area covered by a tertiary canal. All leaders of outlet group will become automatically members of water uses group and they elect one chairman and one secretary from among the selves. Similary, one water users association is farmed for each block area covered by respective branch and distributary canals. All chairmen of WUG assembly, will become members of WUA assembly. The executive committee of WUA comprised five members from WUG representatives, operation and maintenance chief of MIP and chief of Agriculture pilot farm and from these five farmers representative, are chairman and one secretary are elected. The representation of WUA from WUG is based on following principles: -

Table 7.3 : Composition of Committee

Group	Representation in WUA (Assembles of Representative)		Minimum representation in executives of WUA	
A	Gadda minor	2	Bhujela distributory	3
	Bhujela distributory	36	Gadda Minor and main canal direct tertiary	1
	Main can direct territory	6	Women	1
	Total	44		5
B	Basantpur minor	5	Majgaon Minor	1
	Mahendranagar branch	19	Mahendranagar branch	2
	Majgaon Minor	13	Basantpur minor and main canal territory	1
	Main canal direct tertiary	6	Women reservation	1
	Total	43		5
C	Ultakham distributory	33	Ultakham distributary	3
	Bhagatpur minor	5	Bhagatpur minor and main canal direct tertiary	1
	Main canal direct tertiary	6	Women reservation	1
	Total	44		5
D	Churaria minor	3	Suda branch	2
	Suda branch	23	Sisaiya branch	1
	Sisaiya branch	11	Women reservation	1
	Canal direct tertiary	8	Main canal direct tertiary	1
	Total	45		5

The woman members must be chairpersons of outlet leaders of respective block. At the central level there will be a co-ordination committee, all executive members WUA will be represented in central committee and elect 15 members executive committee including chairman and secretary from among them selves. The chairmen and secretories of WUA will not be elected or nominated in executive committee of WUACC. The composition of WACC is as follows: -

Chairman	-	1
Vice chairman	-	1
Secretary	-	1
Joint secretary	-	1
Members	-	8
Project manager of MIP	-	1
Chief of pilot farm	-	1
Woman reservation	-	1
Total	-	15

The tenure of WUA members is of 3 years

7.15 FUNCTIONS OF WUAs AND WUGs

Each tier of organization has its own rules and regulations, which are clearly mentioned in their constitution 1989 and corresponding amendments. Other than in operation and maintenance of tertiary canal, the organization is responsible for assisting in irrigation service fee collection, water allocation and distribution, conflict management in water issues and maintenance of main canal. As the system is not operated on rotational basis, there are no problems regarding the water allocation and its distribution.

7.16 TRAINING

The training is an effective means for imparting, the latest technical information and precise meaning of comprehensive and integrated water management there by improving their capacity to manage water. The objective of the training programmer is to increase agricultural production and farm incomes through improved irrigation efficiency. It's aim is

- To help professional to understand the principles, process and specific field problems and to appraise, them on how the system presently works.

- To provide field experiences and knowledge and develop skills in menotoring methodologies and procedures, to inter disciplinary responsibilities and action.
- To understand process of team work.
- To prepare them for their role as project manager.

The farmer should be apprised of weakness in the procedure and implementation of prevailing water system in the large irrigation networks, the problems and uncertainties and authoritarian attitude to lower functionaries. Lack of monitoring at project level in respect of equity in supply and punctuality in water deliveries must be emphasized.

As the training is instrumental in strengthening institutional activities of an organization. MIP conducted several training programs since the introduction of join irrigation management. Training programs were organized for farmers as well as for association organizers. Farmer to farmer interaction of completed irrigation projects and observation tour of farmer-managed and agency-managed irrigation systems are conducted each year.

The pilot farm is the focal point of all agricultural activities in MIP command area. The major function of pilot farm is to educate the farmers of command area about the irrigated agriculture technology.

The farms has conducted several impressive activities from 1984, the farms has provided 373 number of training programmers to 9,030 farmers of which 740 were woman participates.

Table 7.4 Farmer Organization Activities Stage-I

Period	Tertiary cleaning		Upper level meeting					No. of participants
	Length in km	Mandays	Group A	Group B	Group C	Group D	WUA CC	
1990	51.69	14,38	-	-	-	-	-	165
1991	70.81	3,620	-	-	-	-	-	132
1992	36.59	8,059	2	3	5	7	7	46
1993	21.52	5,141	3	2	2	2	4	164
1994	6.85	331	3	2	7	2	4	176
1995	81.24	2,512	5	6	4	2	12	50
1996	84.44	5,789	2	4	3	3	12	176
1997	19.4	1,124	5	5	5	5	11	50

7.17 OPERATION AND MAINTENANCE AND BUDGET OF THE SYTEM

7.17.1 Maintenance Indicators

In irrigation systems the conveyance efficiency provides the best way of assessing whether canal maintenance is required. By using the following indicators as manager can decide whether a canal clearing is restoring is necessary or not. In many systems this undertaken subjecting on appearance rather than using a more analytical approach.

(i) Sustainability to Head-Discharge Relationship

This indicator gives practical information on the sustainability of intended head discharge relation of flow division structure are:

$$\text{Relative change in head} = \frac{\text{Change of Head}}{\text{Intended Head}}$$

Table 7.5 : Effectivity of Infrastructure

Year / Canal	Year 1990-91			1991-92			1992-93			1993-94			1994-95			1995-96		
	Total no. of structure	No. of functioning strs.	Effectivity of strs.	Total no. of strs.	No. of functioning strs.	Effectivity of str.	Total no. of strs.	No. of functioning strs.	Effectivity of strs.	Total no. of strs.	No. of functioning of str.	Effectivity of str.	Total no. of strs.	No. of functioning str.	Effectivity of strs.	Total no of strs.	No. of funtioning strs.	Effectivity of strs.
Main Canal	64	64	1	64	64	1	64	64	1	64	64	1	64	64	1	64	64	1
Secon-dary canal	144	144	1	144	144	1	144	144	1	144	144	1	144	144	1	144	142	0.99
Tertiary canal	1318	1318	1	1318	1318	1	1318	1318	1	1318	1318	1	1318	1318	1	1318	1300	0.96

Table 7.6 : Maintenance Area Ratio

Sl. No	Particulars	Year 1993 94					Year 1994/95					Year 1995/96				
		M.C	Block A	Block B	Block C	Block D	M.C	Block A	Block B	Block C	Block D	M.C	Block A	Block B	Block C	Block D
1.	Volume of (silty weed)/unit	13	1.0	1	0.9	0.8	10	0.9	0.8	0.7	0.9	8	0.8	0.75	0.5	0.6
2.	Constructed area of canal	52	4.2	4.0	4.10	4.15	52	4.2	4.0	4.1	4.15	52	4.2	4.0	4.1	4.15
3.	Maintenance area ratio	0.25	0.238	0.25	0.22	0.193	0.192	0.214	0.20	0.17	0.217	0.154	0.19	0.187	0.122	0.14

Table 7.7 : Relative Change of Head

Sl. No.	Year 1993 94	Bhujela Dy	Bankati Branch	Popariya Branch	Basantpur minor	Majgaon Minor	Malendra Nagar Dy	Bhagatpur minor	Utakham Dy	Suda Dy	Sisaiya Branch
1.	Intended Headover weir in (cm)	33	30	18	18	20	35	24	45	26	12
2.	Change of head in (cm)	30	28	15	16	18	30	22	42	23	10
3.	Reative change of Head	0.91	0.93	0.83	0.89	0.9	0.86	0.92	0.93	0.96	0.83
4.	Year 94/95										
5.	Change in head in cm	31	29	16	15	17	31	23	43	24	11
6.	Relative change of head in cm	0.94	0.97	0.89	0.833	0.85	0.886	0.96	0.95	0.92	0.92
7.	Year 95/96										
8.	Change in head in can	32	29	17	16	18	32	23	44	25	11
9.	Relative change of head	0.97	0.967	0.94	0.89	0.9	0.91	0.958	0.978	0.96	0.92

The table 7.6 shows that the relative change is head in all cases are greater than 0.89 and less than 0.97. Hence it indicates that a low maintenance is required.

(ii) Maintenance Cost

The maintenance cost depends on the volume of silt weeds that must be removed from the canal and by the size of canal. The maintenance area ratio can used to quantify the cost per unit (meter) length of canal.

$$\text{Maintenance Area Ratio} = \frac{\text{Volume of (silt + weed) per unit length}}{\text{Constructed area of canal}}$$

The table 7.7 shows that the maintenance area ratio is very low. Hence a low amount of budget is required to maintain the canal system.

(iii) Effectivity of Infrastructure

To quantify the maintenance performance, and to assess the extent to which control structures can be operated as intended, the effectively of infrastructure is used. It is judged by the number of structure which are not functioning

$$\text{Effectively of Infrastructure} = \frac{\text{Number of Functioning Sructure}}{\text{Total Number of Structures}}$$

The table 7-5 indicates that the effectivity of infrastructure is nearly 1 in all the years. Hence it reveals that no heavy maintenance is required in main and branch canal but a small number of structures are required to maintain in tertiary canal.

7.17.2 Operation and Maintenance Budget

The MIP is responsible for the maintenance of main canal and secondary canals. The operation and maintenance expenditures include two components

(i) For physical works carried out for maintenance and repair and for (small) new construction.

(ii) For salaries and wage's ("establishment") of the Government personnel.

According to Nepalese practices this personnel can be dealing with the operational matter or with maintenance activities. It is not possible to give separate figure for maintenance alone although the expenditure on works might largely concern maintenance activities.

Table 7.8: operation and maintenance budget and expenditure

Fiscal year	Total Budget in NRS' 000	Total expenditure in NRS' 000	Expenditure perha.
1988/89	1700	1620	337.5
1989/90	2000	2000	416.7
1990/91	2550	2500	520.83
1991/92	7200	6500	1354.2
1992/93	4500	4400	916.7
1993/94	5100	5000	1041.7
1994/95	3500	3270	681.0
1995/96	1800	1700	354.2

The average O&M cost in NRS 702.85 (without considering inflation rate) per to before.

7.18 IRRIGATION SERVICE FEE AND COLLECTION

7.18.1 General

To meet the operation and maintenance cost of the system users are expected to pay irrigation service fee(ISF). It is always said that the water rates besides being based on the area of the value of crop, this is not reflected by the figures. Some times the rate for rice and wheat is the same and some time the rate for wheat is even higher. In fact the norms are much more complicated. Firstly water rates for major and medium systems usually differ from those for minor schemes. Secondly, there are wide variation between the projects. Sometimes it has been advocated to base the water rates on volume of water delivered. However, this will probably not be feasible of the inability of most of the agencies to accurately measure water consumption by farmers; due to absence of the required water measuring devices and other practical complications involved.

7.18.2 Collection of ISF

Generally ISF are not sufficient to cover the actual O and M costs. Moreover, they are not always fully collected. In MIP rate of irrigation service fee is NRS 200 per hector per year irrespective of crops grown and water actually received since 1985.

In general, farmers come to project office to pay ISF. They are expected to pay levied caressed by the end of mid April (chaitra month) of each fiscal year. If a farmer pays this charges a month a head of the deadline i.e. end of mid March (end of falgun month), he can have a rebate of 5%. Notice to the farmers is sent through the official staff or through water user associations. Some times the staff also go to the farmers door to collect the previous delayed charges. In tertiary committee meeting formers usually discuss on ISF and encourage the late payers to pay.

MIP also requests the co-operation of District- Land Revenue Office and District Agriculture Development Bank in ISF collection. Farmers who come to buy and sell their land or to ask for credit should clear ISF fee also. But in practice it is not yet satisfactory happened due to lack of legel procedure. The collection of ISF is presented in Table 7.9 and shown in fig 7.2.

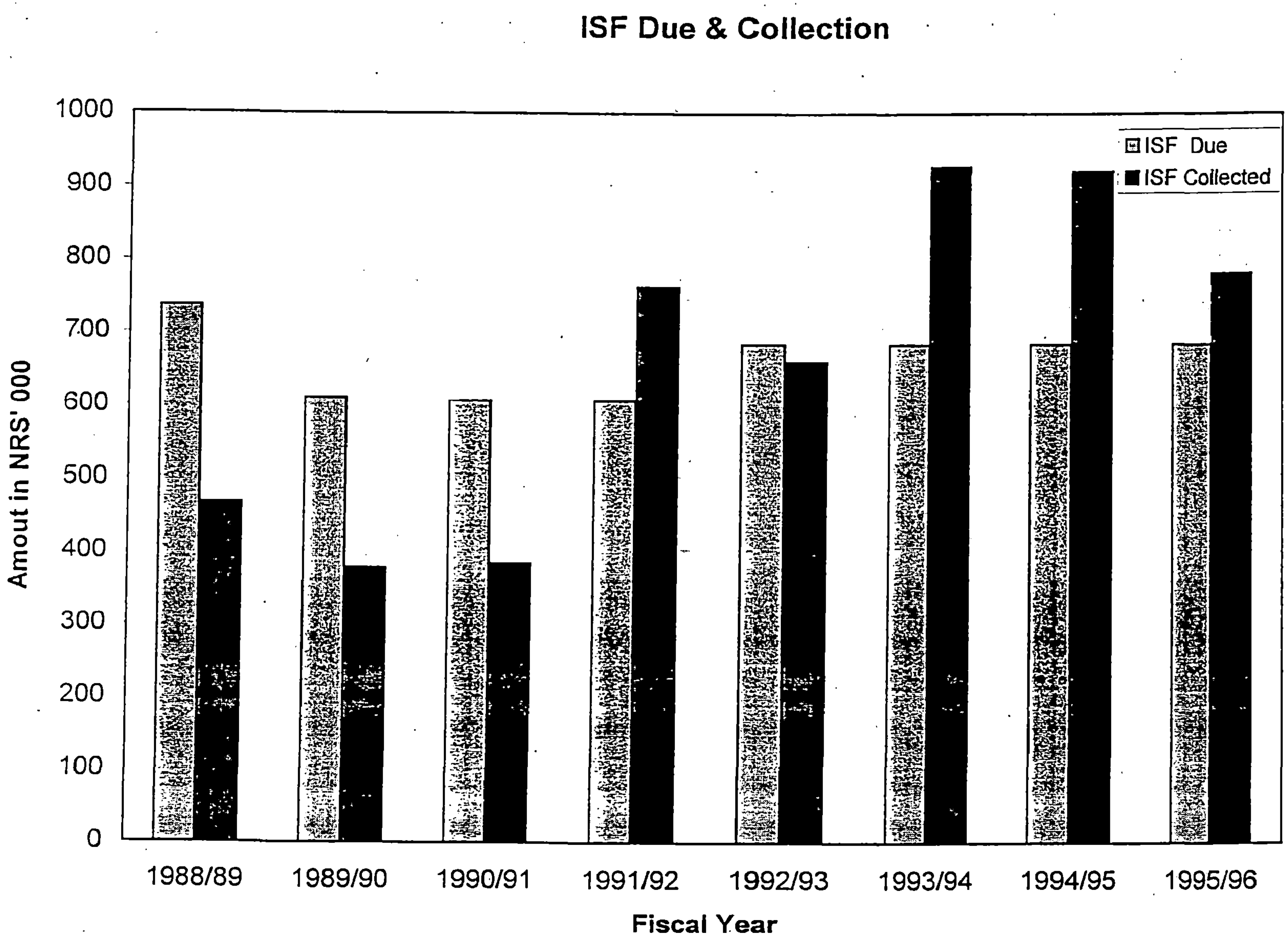


Fig. 7.2 Irrigation service fee collection and due.

The rate of ISF collection has significantly increase since the introduction of joint management in stage I area. However the collection results show yearly fluctuations in the rate of collection, which are probably governed by the effort devoted to ISF collection water revenue section of MIP, which is responsible for ISF collection, comprises of 5 staff.

Table 7.9 Irrigation Service fee Collection and Due

Fiscal year	Amount Due NRS	Amount Collected NRS		Percentage of Collection
		Current years	Last years	
1985/86	399,486.0	110,171.00	-	28
1986/87	546,0413.00	1120,606.0	-	21
1987/88	544,000.00	425,600.0	-	78
1988/89	736200.00	468,123.0	-	63
1989/90	610112.00	3,78,504.0	-	62
1990/91	606,569.0	304,364.0	-	63
1991/92	606,569.0	534,898.0	-	88
1992/93	684,418.0	3,88,264.0	2,28,437.00	64
1993/94	684,418.0	436,335.0	2,72,449.00	64
1994/95	684,418.0	509,455.0	4,91,094.00	74
1995/96	684,418.0	5,18,815.0	4,11,644.00	76
1996/97	684,418.0	509,529.0	2,63,125.0	74
1997/98	684,418.0	-	-	-

7.18.3 WUA Share in ISF

MIP has undergone to joint management. The farmers are responsible for operation and maintenance for territory canal below and rest by the Government.

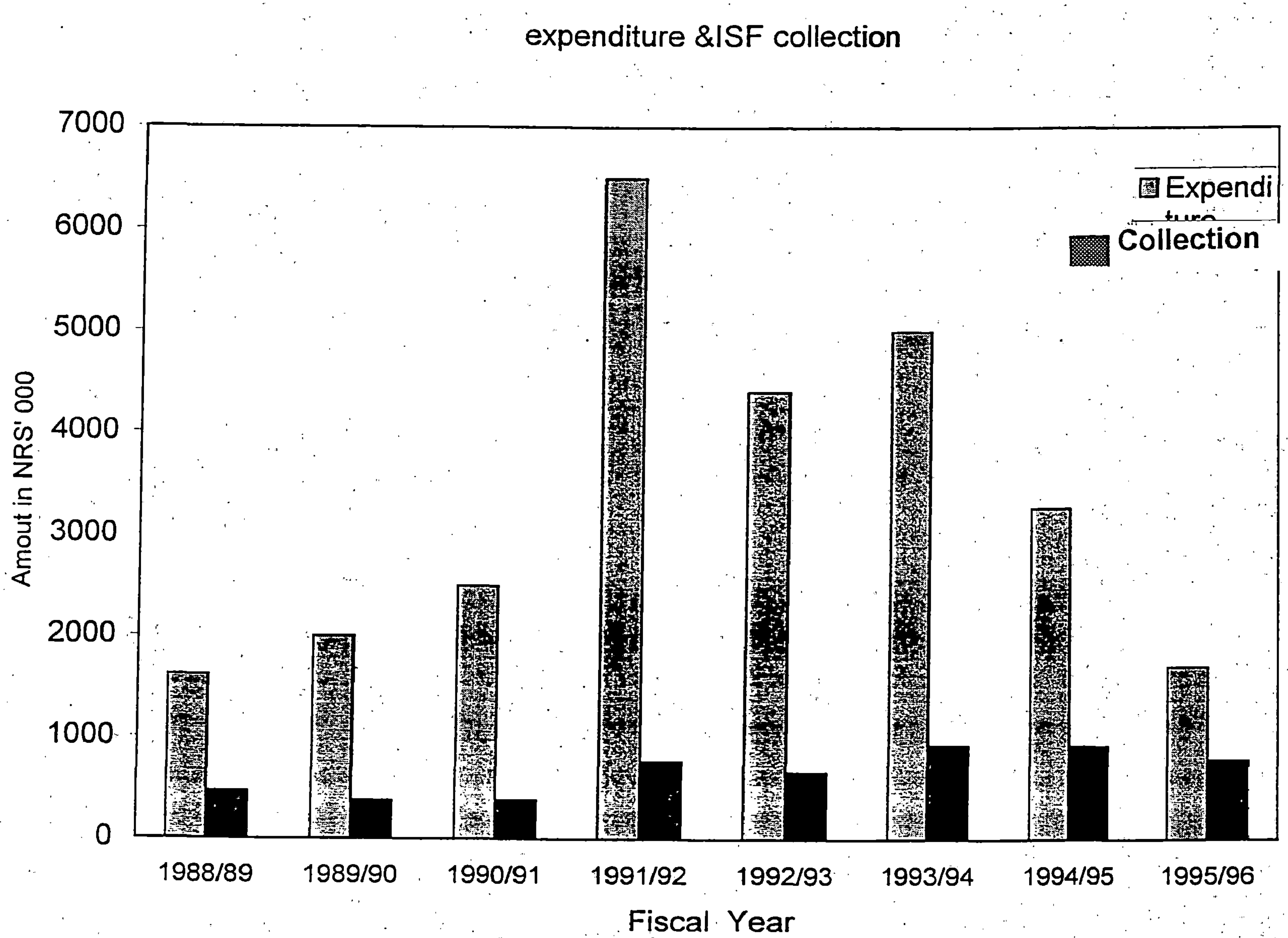


Fig. 7.3 Irrigation service fee collection and expenditure

According to the arrangement made in irrigation policy schedule-2 provision relating to irrigation service fee, the share received WUA is 25% and Government will keep only 75%. This provision encourse the WUA to help in collection of ISF.

7.18.4 Comparison of Expenditure and ISF Collection

To compare O & M expenditure and ISF collection are given in Table 7.7. the column 4 gives an indication of annual losses in the irrigation sector without considering the capital cost, when coastal cost are added, this would indicate that the irrigation sector would be a heavy burden to Government.

Table 7.10 Comparison of Expenditure and ISF Collection

Fiscal year	Expenditure	Collected	Difference	% of recovery
1	2	3	4	5
1988/89	16.20,000	4,68,123.0	11,21877.0	28.9
1989/90	20,00,000	3,78,3040.0	16,21,496.0	18.93
1990/91	25,00,000	3,84,564.0	21,15,436.0	15.38
1991/92	65,00,000	7,63,335.0	57,36,665.0	11.75
1992/93	44,00,000	6,60,713.0	37,72,987.0	15.0
1993/94	50,00,000	9,27,429.0	40,72,371.0	18.55
1994/1995	32,70,000	9,21,099.0	23,48,901.0	28.17
1995/1996	17,00,000	7,81,940.0	91,80,600.0	46.0

In all developing countries including Nepal, it is frequently heard opinions that water rate are insufficient to cover expenditure. It is usually advocated to increase. The water rates. But it will be more appropriate to increase first, the rate of collection of existing fees and then increase the ISF.

Table 7.11(a) **Financial Self Sufficiency(on actua budget)**

particular	1988/89	1989/90	1990/91	1991/92	1992/93	1993/94	1994/95	1995/96	1996/97
Actual Income	425600	468123	378504	384564	763335	660713	927429	921099	781940
Actual O&M	1620000	2000000	2500000	6500000	4400000	5000000	3270000	1700000	2000000
Financial self sufficiency	0.263	0.234	0.151	0.059	0.174	0.133	0.284	0.542	0.223

Table 7.11(b) Financial Self Sufficiency(based on proposed budget)

particular	1988/89	1989/90	1990/91	1991/92	1992/93	1993/94	1994/95	1995/96	1996/97
Actual Income	425600	468123	378504	384564	763335	660713	927429	921099	781940
cost of O&M	3500000	3500000	5000000	8000000	9000000	7500000	5000000	3500000	3500000
Financial self sufficiency	0.122	0.134	0.076	0.048	0.0851	0.088	0.186	0.263	0.223

Table 7.1.2 Irrigation Service fee collection Performance

particular	1988/89	1989/90	1990/91	1991/92	1992/93	1993/94	1994/95	1995/96	1996/97
ISF Due	736200	610112	606256.9	606569	684418	684418	684418	684418	684418
ISFcollected	425600	468123	378504	384564	763335	660713	927429	921099	781940
ISF Collection Performance	0.64	0.60.62	0.63	0.88	0.64	0.64	0.74	0.76	0.74

Table 7.1.3 O&M Fraction Based on actual expenditure

particular	1988/89	1989/90	1990/91	1991/92	1992/93	1993/94	1994/95	1995/96	1996/97
cost of o&m	1620000	2000000	2500000	6500000	4400000	5000000	3270000	1700000	2000000
Total Agency budget	1700000	2000000	2550000	7200000	4500000	5100000	3500000	1800000	2100000
O+M Fraction	0.953	1	0.98	0.9	0.978	0.98	0.93	0.94	0.952

O & M Fraction (based on proposed budget

particular	1988/89	1989/90	1990/91	1991/92	1992/93	1993/94	1994/95	1995/96	1996/97
cost of O&M	3500000	3500000	5000000	8000000	9000000	7500000	5000000	3500000	3500000
Total budget	1700000	2000000	2550000	7200000	4500000	5100000	3500000	1800000	2100000
O+M Fraction	2.05	1.75	1.96	1.11	2	1.47	1.43	1.94	1.67

From the Table 7.10 and Fig 7.2 conclude that the maximum recover of O & M cost is 46% and minimum recovery in 11.75 percent. Hence a step should be taken at least to recover the O & M cost.

7.18.5 Financial Viability of Irrigation System

For sustainable irrigation system, financial viability is essential. Following indicators are used to looks at the extent to which a system generates sufficient income to be self supporting.

(i) Financial self sufficiency = $\dfrac{\text{Actual income}}{\text{Total MO + M Required}}$

The tables 7.11 a. ·l 7.11 show that if we consider the actual maintenance expenditure even though only a small part is fulfilled by the of own source of project, which is irrigation service fee. If we consider the proposed budget for maintenance and income of project then only a very small part is fulfilled by project actual income.

(ii) Irrigation Service Fee Collection Performance

In many irrigated areas, water charges (irrigation fees) are collected from the farmers. Similarly MIP also collects ISF. A indicator is used to measure the fee collection performance defined as the ratio of irrigation fees due. Table 7.12 shows that fee collection performance in some year each 100% but as comparison to other project, it may say that fee collection is more or less satisfactory. An effort is required to increase the ISF collection.

(iii) O+M Fraction

This indicator deals with the salaries involved with actual operation (gate men etc.) plus maintenance cost and minor investment in system. The table 7.13 reveals that O+M fraction is double in most of the years. This may be due to lack of availability of fund with the government and it may be to make the project financially sufficiency.

7.19 RESOURCES MOBILIZATION AND MANAGEMENT

According to the construction of WUA, each tier has its own rules and Regulation regarding, the resource mobilization. The main forms are labour contribution in canal cleaning and share of collected ISF. Toll collection from canal roads of each block is also a source. The 25% of ISF collection is distributed among three tier of organization of which 80% goes to tertiary committee, 15% goes to block committee and the remaining 5% goes to co-ordination committee. Each organization has its own bank account and the expenditures are to be approved by general meeting. Till date, about 100 tertiary canal committee have their own bank accounts and other are in process. In practices expenditures are made on maintaining, their offices and sometimes to pay for hired labours in tertiary canal cleaning.

Joint management programme in MIP shown positive indications to turnover all branch and secondary canals to respective farmers organizations.

7.20 ECONOMIC PERFORMANCE OF IRRIGATION PROJECT

An evaluation can be attempted by comparing the actually realised internal rate return actually realised with that was projected before sanction. Unfortunately, the arrangements for monitoring agricultural performance in most of the irrigation projects, are a very deficient and data on yields, prices, costs of cultivation' etc as actually realised are just not accurately available. The two critical factors which determiners, the realized internal rate of return are the cost of project, the crop yields realised and differential impact of inflation on projects costs and value of output.

Basically in any economic appraisal of a project, some kind of comparison is involved between the projected benefits on the one hand projected cost for achieving that benefit on the other. In case of irrigation projects cost are incurred to evaluate both public and private investment projects. It's use is especially prevalent in large corporations and among International lending institutions like International Development Agency (IDA) and United States Agency for International, Development Corporation. However in case of individual firm, company or corporation, the rate of return is not called IRR, but the financial rate of return (FRR). The rate of return calculated for a public sector project such as irrigation project using economic prices is called the economic rate of return or economic internal rate of return.

The IRR criterion has an important advantage that it does not depend, at least in initial stages of calculation, on an externally given rate of discount. It does not on its own provide a decision rule for choosing a project. It requires a standard for comparison at a predetermined social rate of discount or rate of interest at which social investment fund is available.

7.20.1 MIP Economic Performance

An economic analysis has been performed to arrived at the economical parameter of the project. The input side of economic crop budged has been calculated in appendix A.

The output side of the crop budget has been derived from the records of cropping pattern, yields and crop coverage recorded by MIP. It has been assumed that after providing irrigation service to stage II will attain the some level of crop coverage and yields as that of as stage I by year 2002. The economic prices of agricultural outputs, the border parity prices for the traded agricultural out put and input, and the year-wise agricultural outputs, have been projected for 2000 and given in Appendix A.

The O and M cost for stage I area has been obtained from the actual investment records of MIP and presented in Table 7.7. Based on these records, the O & M cost for future has been assumed. Net benefits start only after completion of projects and continue till the last year of the project life. The comparison in such a case has to be made between a projected schedule of annual benefits and a projected schedule of annual costs. The schedules of annual cost and benefits are not comparable. As it is not possible to compare two different kinds of commodities without a common base in terms of value, it is also not proper to compose projected annual streams of costs and benefits without relating the future values to present time. The technique by which the future value of costs and benefits can be reduced to present level is called discounting, which is reverse to the process of the compounding i.e. relating present value to future values while discounting looks from future to present values. The compounding formula is expressed as $(1+r)^n$

where 'r' is the rate of interest and n is the time in years. As such the interest rate and discount rate are the same: Normally the present value of future money is worked out with the use of discount factor which is a decimal fraction between 0 to 1 and expressed as $(1+r)^{-n}$. The sum of the discounted future annual cost is equal to the present value of the cost stream and the sum of the discounted future annual net income is equal to the present value of the benefit stream.

7.20.2 The Internal Rate of Return Criterion (IRR)

The IRR is that rate of discount at which the net present value (NPV) of a project becomes zero, expressed as that rate at which

$$\sum_{n=0}^{n} \frac{B_n - C_n}{(1+r)^n} = 0$$

The IRR is calculated by trial and error. The costs are deducted from the benefits for each year and the net benefit is indicated with signs after plus or minuses the case may be. The net benefit is discounted at two such rates of which the lower rate provides the some of discounted net cash flow with minimum possible positive figure and the higher rate of discount with a minimum possible negative value. Such two rates are obtained by iteration. The IRR is there after interpolated between these two rates.

The internal rate of return (IRR) is commonly used, has been converted in base year 2000 by assuming a discount rate of 10 present. Project life has been taken as 30 year of completion of project.

Based upon the assumption mentioned above, economic analysis of stage I has been performed. The investment cost and benefits up to the project life has been taken for analysis, the Table 7.8 in appendix A-20 shows the details of calculation of EIRR. The table indicated that the EIRR value of the project is 29% percent.

The EIRR value of the MIP project stage I at the time of appraisal is 14 percent. The actual achieved EIRR is 29 percent. Hence it surely indicated the high performance of the project. This is attributed to high agricultural yields and coverage of project area. In consideration with rapid agricultural transformation of stage I it can reasonably assumed that stage II area will also under go similar transformation.

CHAPTER-8

DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

8.1 DISCUSSION

The exploitation and utilization of water for irrigation require that there are periodic assessment of its utility and efficiency of use. Any enterprise requires feedback on the management of resources and the result interm of increased output. The performance of an irrigation system is a measure both, degree of fulfillment of output objectives and management of available resources in accomplishing this. Performance indicators are used to provide information on past activities and their result help in making informed judgments that may guide our decision making about future activities. Deviation from the quick provide feedback to manger as to the extent to which the overall objective is being fulfilled through the use of performance indicators.

In MIP discharge targets are given to the gatekeepers but no parallel information is readily available to indicate the permissible level of deviation. Such a lack of standards immediately makes the process of operational control much more difficult because all deviation are treated as an equal error irrespective of actual value of deviations and little effort is made to rectify management at these locations where deviations are first encountered.

The upstream discharge or water level is control by gates and operation of gates further does not affect the upstream condition. Gated division systems have been provided at each off take along the main and branch canals allowing water to be manually controlled at every bifurcation in the system. The design of tertiary structures are fixed division system, where water can only be managed at the head of tertiary canals; discharge into the water coursed field channel are achieved through fixed division structure that does not have gates.

MIP stage I area is getting abundance of water but when the stage II area will be in full operation then there will be shortage of water availability. When there is insufficient water to meet all demand then there has to be some clearly understood planning process before start of each season that determines whether some rights will be suspended or modified. In this case some blocks receive their full right and other receive a reduced share and temporary rotational system irrigation will be adopted, where access to water by groups of users is regulated by time.

At system level, current water allocation and distribution practices result in unequal access to benefits. Tail enders almost always suffer a disapropriate burden when water is in short supply. This often results in conflicts and disruption of management. If a long term objective of the system is to provide equal access to water to all beneficiaries, then allocation plans and distribution practices must reflect this objective.

The returns are related to the investment made at national level to the society. The level of income of the farmer has been increased considerable and the percentage of population above the property level has been increased as compared to other rural area due to increase in percapita incomes. There is also employment generation for the population living in the area which automatic provide opportunity to solve unemployment problem to some extent.

The introduction of joint irrigation management in canal operation and maintenance by establishing farmers organization; MIP enables farmers to participate in water allocation, decision at tertiary levels in Engineers operating system, both before and after the establishment of farmer organization report that conflicts were reduced dramatically. Water distribution is more equitable, increase in collection of irrigation service fee. There is also reduction in operation and maintenance expenditure. Overall there is also increase in cropping intensity and crops yields. The extension services provided by Agriculture pilot farm, Agriculture Development Bank and Agriculture input corporation is appreciable. The Agriculture pilot farm established linkes with, the Pantnagar Agriculture University of India which resulted introduction of several high yield crop varieties.

The water availability from Sarda Barrage to MIP canal system is also reliable. This has produced positive effect on the farming activities in project area.

Most of the field project staff are on contract basis for project period. A radical reduction in field staff especially A.Os and Agriculture support staff, will reduce the intensive activities taking place in the field regarding WUO's strengthening and extension services. This will adversely affect the project performance in future.

The Agriculture pilot farm is planned to be handed over to Ministry of Agriculture is suspected that the hand over will not be in favour of supporting increased extension service required. The project does not have any plan to provide extension services to area it is serving.

8.2 CONCLUSIONS AND RECOMMENDATIONS

The art and science of evaluating the performance of irrigation system is still in evolving stage. There is lack of field, studies to correctly assess the usefulness of performance indicator. It is important to ensure that indicators selected for a system will describe performance in respect of the objectives set for that system. There are many indicators but we have used only those indicators on the level of detail which we need to quantify performance and on the number of disciplines with which we need to look at irrigation system. To compare the performance of system with the objective of system set at the project appraisal time, the required indicators are selected accordingly.

- Water delivery performance is good for both Rabi and Kharif season for stage I area but a rotational supply of water is required for both stage I and stage II area to meet the water requirement of crops.
- The project is serving whole the command area for which it is developed to irrigate. Hence irrigation is sustainable.
- The relative change in head is low and its is maintained in every year.
- All the infrastructures are functioning well and maintenance area ratio is low.
- Performance of overall irrigation season (dry) is also satisfactory with regard to the actual yield of crops and expected yield per unit area. If we consider yield of crops with respect to per unit volume of water then the performance is poor. Since there is no alternate use of water so it is not required to consider.
- The project is not financial self sufficient to meet its O & M expenditure. To increase the O & M budget. It is recommended to
  - Increase irrigation service fee and degree of collection
  - Increase farmers participation step-wise from tertiary level to distributory and Branch canal levels.
  - and increase the responsibilities of O & M to WuA.

- To avoid deterioration of system in long turn-run, considerable amount of O & M budget is required to keep the system in proper order, which is only possible by joint management.
- The per capita income of farmers has increase and a large number of employment has been generated in project area.
- The social capacity of people and organization for managing and sustaining the irrigated agriculture has been increased.
- After introduction of joint management in MIP in 1992 accordance with the irrigation policy of Nepal, the overall assessment of O & M has revealed that the project had been successfully in attending its major goals of raising agricultural production and farm income. The crop yield survey indicates that the improved irrigation facilities has helped to adopt multiple cropping pattern as a result cropping intensity has increased to 192 percent in stage I.
- Farmers has positive acceptance on the system improvements as it insures reliable supply of water in all fields from head to tail.
- With regard to the extend and quality of farmer's participation in O & M, the project has positive impact on water allocation, distribution and conflicts resolution of system. However with regards to reduction in O & M cost through mobilization of local resources, only marginal success has been achieved.
- The project has been able to hand over almost all tertiary canals of stage I area and has not yet formulated any programs to hand over secondary and distributory canals. It is required to make a action plan for this also and the make the system more suitable.
- The indicators of organizational effectiveness i.e. no of times meetings. held in a year, participation of members in the meeting, settlements of disputes, implementation of decisions, and changes in farming system show optimistic result
- Comparing the magnitude of maintenance work, within and outside of tertiary canal, per unit maintenance cost is less than 5 percent ever not considering the main canal's maintenance cost. There is not record of maintenance of tertiary canals. In practice, tertiary committee used to spend the fund received from MIP

as a share of water cess collection in desilting the canals rather than doing it by volunteer labors. Moreover, the procurement of construction material and tools and plants to be used in maintenance to tertiary canals and field channels, is not practices by the organizations. This is so because most of such demands are fulfilled by MIP block maintenance budget.

To avoid all these joint management consequences, the project should monitor the farmers, and should limit fulfilling ever-increasing demands for maintenance work.

- After all, the reliability of water supply is most governing factor in a attaining farmers participation eigher in construction phase or into its operation and maintenance. Once farmers see water in the parent canal, they will start forgetting the misunderstanding if any created during the course of participation approach and will proceed towards getting water to their fields.
- All project activities and the attitude of working personnel should be focused only in the direction of supplying water to the field within the targeted time.
- System improvement is needed to link MIP main canal to Tanak Barrage, where Indian authority has built up the intake structure on the afflux bound to supply water incase the Sarda Barrage, become non-functional.
- Agriculture division in the MIP organization should be continued and pilot farm activities should be maintained from MIP itself for supporting farmers of stage I and stage II area.
- The activities of pilot farm should now be concentrated on increasing the water use efficiency in the project area with adequate emphasis being given to encouraging the farmers to build the field channels.
- The project-should make every effort to replicate the transformation process of stage I to the stage I area.

8.3 OVERALL PERFORMANCE OF MIP SYSTEM

8.3.1 Performance of System in Regard to Proposed Objective

The summary of proposed objective at time of project appraisal and actual achievement in stage I is given in Table 8.1.

Table 8.1 : Objective and Achievement

S.No.	Particulars	Original before project	Proposed objective	Achievement (of objective)	Performance
1.	Cropping intensity major	134	165	192	Very Good
2.	Crops yield				
	paddy	2.4	3.2	4.0	Very good
	wheat	1.1	2.10	2.10	Good
	maize	1.0	2.0	2.0	Good
	potato	7.0	11.0	13.5	Good
	oilseeds	0.5	0.60	0.70	Good
	pulses	0.6	0.70	0.8	Good
3.	Per capital in comes	65	118	177.1	Good
4.	Economic internal rate of return	-	14%	29. %	Good
5.	Irrigable area in (ha)	3400	4800	4800	Good

8.3.2 Performance Evaluation of Irrigation Management Actives

Logical performance evaluations of different management actives are carries out and are given in Table 8.2.

Table 8.2: Logical Performance Evaluation

S.No.	Activities	Performance
1.	Design	Simple
2.	Construction	Simple
3.	Operation	Co-operative
4.	Water delivery	Reliable
5.	Water distribution	Equitable
6.	Water application	Appropriate
7.	Wastage of water	Low
8.	Complicit management	Good and prompt
9.	Communication	Good
10.	Resource mobilization	Good
11.	Decision making	Quick
12.	ISF (collection)	More
13.	Operation and maintenance share	High
14.	Overall efficiency	High
15.	Productivity	High
16.	Cropping intensity	High
17.	Owner ship feeling	Good
18.	Willingness to pay	Good
19.	Overall performance	Good

8.3 SUGGESTIONS FOR FURTHER STUDY AND RESEARCH

The use of secondary data that contain insufficient information will, in long run, need to be replaced by a set of more focused in depth studies that address the management process, and identify more precisely, the complex relations between the system design, planning implementation, control, O & M and water users relationship. It is always difficult to use secondary data, particularly where the objectives of those studies may be quite diverse. A systematic approach to measurement of output and management-performance, taking into the consideration institutional and resources conditions; likely to result in a much clearer understanding of the factors that affect performance.

Further studies need to more well beyond the main focus reported here of water delivery to canal system, canal operation and maintenance, Agricultural, or socio-economic aspect. Similarly future studies have to include greater concern for environmental effect of both irrigation and drainage system which have the capacity to undermine agricultural stability, if they are not made part of the objective set for system mangers.

The report has attempted to address the short falls that exists in current irrigation system and management practices in relation to water delivery and its proper management and farmer's participation in the canal systems.

There can be little doubt that what is required in the future is the implementations of performance-responsive framework that managers and planners can use consistent and more focused performance case studies in a range of physical and institutional environments.

Appropriate ways and means to replicate the extensions activities of pilot farm to other large irrigation project under joint management should be sough at policy level. The information on the use of high yield crop vanities of the farm should be disseminated to other irrigated areas in Nepal. The DOI in close co-ordination with DOA, can modify the mandate of pilot farm to carry out similar activities in some other projects.

If this combination of intervention and knowledge improvement can be taken, then I am confident that this will be the basis for more sustainable, performance-oriented irrigation management in the future.

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APPENDIX – A (TABLES)

Table A-1 Inter ratio (IQR) of water availability index (WAI) in six small schemes of Nepal

Name of system	Hills			Terai		
	Barctar	**Bandarpa**	**Jamune**	**Tulsi**	**Parwanlpur**	**Laxmipur**
Average	161	146	144	146	144	179
(a) By distance form head of system						
Head 25%	160	134	168	153	154	186
Trail 25%	151	154	141	149	135	162
IQR	1.06	1.15	1.19	1.15	1.10	1.15
(b) Independent of distance S						
WAI heighest 25%	195	173	177	162	170	199
WAI lowest 25%	124	127	130	138	120	158
IQR	1.57	1.36	1.36	1.17	1.40	1.26

A-2 Water supply along Wahby and Bahr Seilarelative to total Fayoum water supply

Area	Discharge (m^3 /S)	Gross command area (ha)	Supply (%)
Fayoum System total	77.1	151,865	100
Bahr Yusuf at Lahun	50.0	102,181	96
Bahr Hasan Wasef	27.1	49,685	107
Bahr Wahby total area	13.6	30,660	107
Bahr Wahby d/s of Nasria	9.0	23,100	77
Bahr Wahby u/s Nasria total	4.6	7,560	120
Bahr Wahr Wahby u/s Nasria excluding Bahr Seila	3.0	3,405	173
Bahr Seilat total area	1.6	4,155	75
Area B	0.35	685	101
Area C	0.37	1,094	66
Area D	0.33	943	68
Area E	0.26	705	71
Area F	0.29	730	79

A--3 **Operation and managbement descriptors and performance indicators. Nilo Coelho Irrigation Scheme (1989-1997).**

Description	1989	1990	1991	1992	1993	1994	1995	1996	1997
Annual Eto (Penman-Monteith)-mm	1767	1718	1772	1726	1970	1950	1705	1712	1635
Annual Precipitation	720	318	475	678	188	47	681	460	629
1. Area									
-Irrigable	14787	15392	15255	15248	15230	15247	14729	14789	15341
-Sustainability of Irrigated Area	0.29	0.33	0.57	0.49	0.69	0.72	0.78	0.85	0.98
2. Water									
-Stored for irrigation (1000 m^3)	100818	82568	86674	96477	149701	141526	122543	125437	116342
-Annual supply (1000 m^3)	72492	85392	91333	101710	149635	139073	109566	130437	114212
-Average supply (1000 m^3/ha)	16.65	16.89	10.59	13.63	14.29	12.69	9.53	10.3	7.6
-Water Delivery Ratio	0.72	1.03	1005	1.05	1.00	0.98	0.89	1.04	0.98
-Overall Consumption Ratio	0.63	0.83	1.18	0.77	1.25	1.17	1.07	1.22	1.32
3. Energy									
-Annual consumption –1000kwh	36016	34529	29997	33824	53204	42341	35.515	41725	34919
-Annual ave.kwh/m^3 stored	0.36	0.42	0.35	0.35	0.36	0.3	0.29	0.33	0.3
-Annual ave.kwh/m^3 supplied	0.5	0.4	0.33	0.33	0.36	3	0.32	0.32	0.031
-Total demand –1000kwh	185	169	224	182	270	196	217	216	201
-Demand-kW/ha irrigated	42.490	33.34	25.97	24.39	25.79	17.88	18.87	17.09	13.37

A-4 Impact of more costs productivity on equivalent (kg) and as % crop revenue per ha.

Crop	Minimum Price		Average Price		Maximum Price	
	Prod (kg)	% Revenue	Prod (kg)	% Revenue	Prod (kg)	% Revenue
Pumpkin	2422	9.69	1211	4.48	757	3.03
Cowpea	287	23.93	188	45.68	130	10.83
Beans	206	11.44	146	8.08	103	5.72
Watermelon	1556	6.22	1037	4.15	778	3.11
Maize	910	22 .75	670	16.76	490	12.25
Tomato-indicatory	1721	3.84	1721	3.82	1721	3.82
Tomato-salad	2804	14.02	1519	7.59	911	4.58
Banana	2052	5.13	1319	3.30	947	2.37
Coconut	1823	3.41	1458	2.73	467	0.88
Guava	1581	5.27	977	3.26	664	2.21
Mango	1673	8.37	558	2.79	167	0.84
Grape	753	1.88	565	1.41	365	0.91

Tabl(A-5 Discharge Record at Sarada Barrage Broad Weir to Main Cana Year 1994/95 Volume(cubic m)'000

Day/M	May	june	july	ugust	ember	tober	ember	ember	nuary	ebuar	narch	april
1	0	1158	1417	1158	1158	1158	436	363	346	276	346	
2	0	994	1158	1054	1158	1158	436	363	346	276	346	
3	0	1054	1054	37	1158	1158	436	363	346	276	346	
4	0	1054	1054	994	1158	899	436	363	346	380	346	
5	0	1417	1037	1417	1158	899	436	363	346	380	346	
6	0	1054	994	1417	1158	346	436	363	346	380	346	
7	0	1054	1417	1417	1158	346	436	363	346	380	346	
8	0	544	1417	1417	1158	363	397	363	346	333	346	
9	1417	1158	1417	899	1158	363	397	346	333	333	346	
10	436	1158	1417	899	1158	363	436	346	333	333	346	
11	1158	1158	899	994	1158	363	436	346	333	333	346	
12	708	994	899	994	1158	363	436	346	333	333	346	
13	1158	1158	994	994	1158	346	436	346	333	333	346	
14	1158	1054	994	1158	1158	346	436	346	333	333	346	
15	899	1054	994	1158	1158	346	436	346	333	333	346	
16	899	1158	1158	760	1158	346	436	346	333	480		
17	899	1158	1158	760	1158	346	436	346	285	480		
18	708	1158	760	899	1158	346	436	346	285	346		
19	544	1417	760	1158	1158	346	436	346	285	346		
20	1158	1417	899	1158	1158	346	436	346	285	333		
22	1158	1417	1158	1158	1158	346	436	346	285	333		
23	1158	1417	1158	1158	1158	346	436	346	285	333		
24	708	1417	1158	1158	1158	346	436	346	285	333		
25	436	708	1158	1158	1158	346	436	346	285	333		
26	1158	1417	1158	1158	1158	605	436	346	285	285		
27	1158	1417	1158	1158	1158	605	436	346	276	285		
28	1158	1417	1158	1158	1158	605	436	346	276	285		
29	1158	1417	1158	1158	1158	436	363	346	276			
30	1158	1417	1158	1158	1158	436	363	346	276			
31	1158		1158		1158		363	346	276			

A-6 Climatic data

NEPAL

MAHAKALI IRRIGATION PROJECT (STAGE I)

CLIMATIC DATA 1/

Latitude : 29°N
Longitude : 80°E
Elevation : 200 metres

Item	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Mean daily temperature (°C)													
- Max	22.0	25.0	31.2	37.2	38.2	36.6	33.0	32.2	31.5	30.9	27.6	23.9	
- Min	7.3	7.9	12.1	18.0	23.0	24.7	24.9	24.8	24.2	20.6	12.5	8.8	
- Mean	14.7	16.5	21.6	27.6	30.6	30.3	29.0	28.5	27.9	25.8	20.1	16.4	
Relative humidity at noon (%)													
- Range of monthly means	45-86	43-74	30-58	24-76	24-54	42-77	68-95	73-90	60-97	60-76	57-69	64-87	
- Mean	67	59	41	40	37	60	79	79	74	70	63	70	
Duration of bright sunshine 2/	0.65	0.75	0.73	0.76	0.66	0.60	0.39	0.44	0.46	0.69	0.81	0.83	
Wind speed at 2 m above ground (M/sec)	0.34	0.38	0.53	0.66	0.56	0.84	0.93	0.46	0.38	0.35	0.32	0.27	
Rainfall (mm)													
- 50% probability	27	22	21	14	42	272	554	404	294	87	5	9	1,751
- 80% probability	9	16	24	17	29	133	479	356	299	55	3	8	1,422
Class A pan evaporation (mm/month)	69	92	181	264	291	272	180	171	125	112	91	67	1,915
Water use by reference crop 3/ (ETO); (mm/month)	63	82	129	171	192	184	152	140	119	111	77	58	1,448

1/ Climatic data for Nepalganj (since 1968); rainfall data for Dhangarhi Station (since 1956)

2/ Expressed as a fraction of the maximum possible duration of bright sunshine

3/ Estimated by empirical formula using pan evaporation and climatic data.

A-7 Water supply and demand of SAR

MAHAKALI IRRIGATION PROJECT (STAGE I)

Water Supply and Demand

A. **Net Water Requirements**

(i) **Basic Assumptions:**

(a) Potential Evapotranspiration (ET_o) : calculated by modified Penman method (see T-1)

(b) **Lowland Paddy:**

- Land preparation 100 mm (net of evaporation and on-farm losses)
- Nursery 40 mm
- Percolation losses : 2 mm/day

(c) Field Crops: 60 mm pre-irrigation for upland paddy, maize, cotton, soybean, summer vegetables, groundnut, wheat, oilseeds and winter vegetables.

(d) Design Rainfall : rainfall with 80% probability of exceedance.

(ii) **Net Farm Water Requirements** (mm)

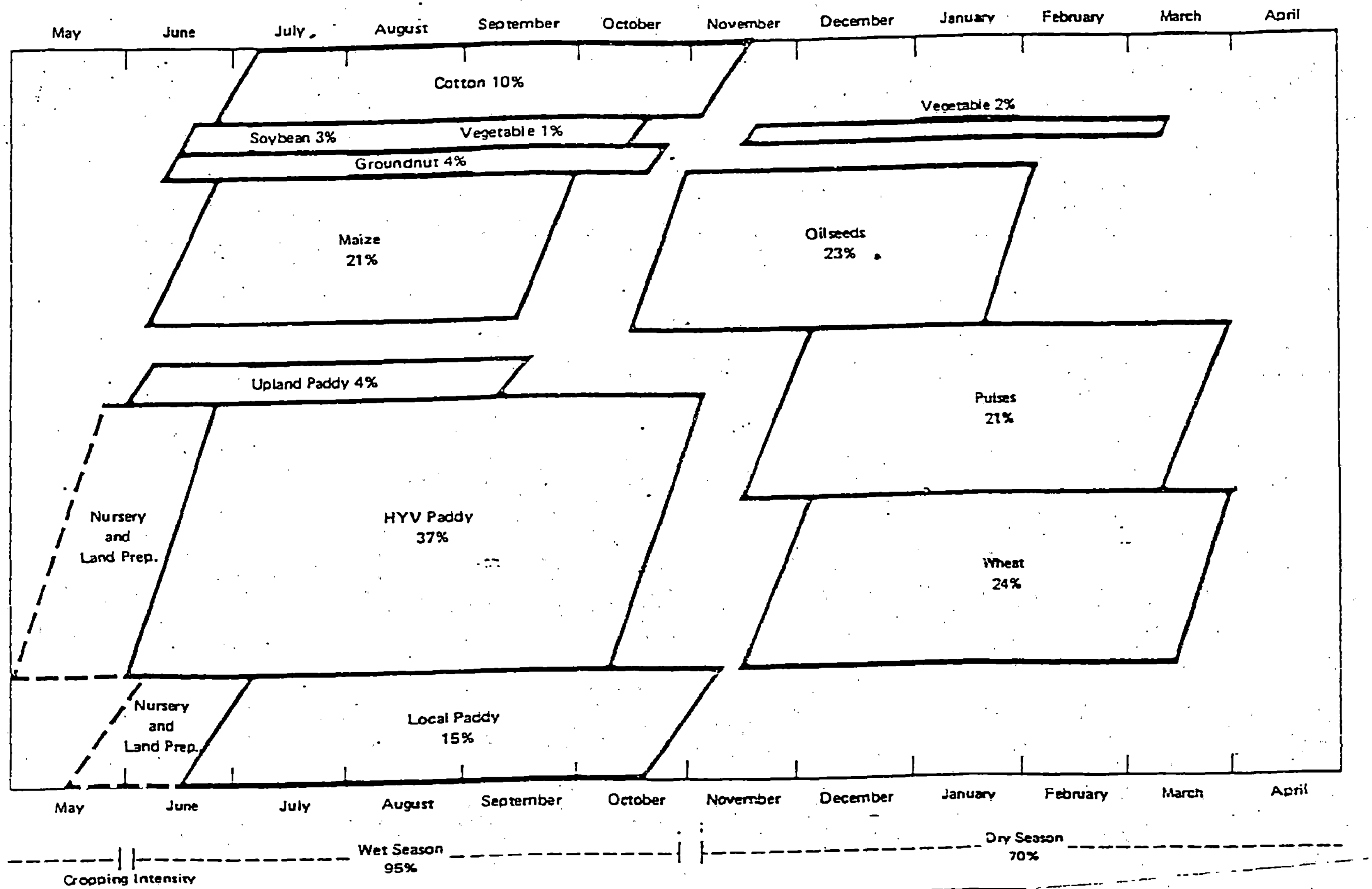
Crop	Planting Period	Area Planted %	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
			half month periods																							
1. HYV Paddy	June 1-15	22	-	-	-	-	-	-	-	-	10	52	195	-	-	-	-	-	-	-	-	-	-	-	-	-
2. HYV Paddy	June 15-30	15	-	-	-	-	-	-	-	-	-	10	2	138	-	-	-	-	-	-	-	-	-	-	-	-
3. Local Paddy	June 15-30	15	-	-	-	-	-	-	-	-	-	10	2	138	-	-	-	-	-	-	-	-	-	-	-	-
4. Upland Paddy	June 1-15	4	-	-	-	-	-	-	-	-	-	-	77	-	-	-	-	-	-	-	-	-	-	-	-	-
5. Maize	June 1-15	10	-	-	-	-	-	-	-	-	-	-	49	-	-	-	-	-	-	-	-	-	-	-	-	-
6. Maize	June 15-30	11	-	-	-	-	-	-	-	-	-	-	-	12	-	-	-	-	-	-	-	-	-	-	-	-
7. Cotton	June 15-30	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	16	-	-	-	-	-
8. Cotton	July 1-15	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	23	27		-	-	-
9. Soybean	June 15-30	3	-	-	-	-	-	-	-	-	-	-	-	12	-	-	-	-	-	-	-	-		-	-	-
10. Vegetables	June 15-30	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-
11. Groundnuts	June 1-15	4	-	-	-	-	-	-	-	-	-	-	49	-	-	-	-	-	-	-	-	-		-	-	-
12. Wheat	Nov 15-30	18	25	25	31	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	69	15	25
13. Wheat	Dec 1-15	6	22	25	31	42	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	67	12
14. Pulses	Nov 15-30	16	22	24	28	28	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	16	16	21
15. Pulses	Dec 1-15	5	18	23	30	38	35	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	13	13
16. Oilseeds	Oct 15-31	23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	58	23	37	31	26
17. Vegetables	Nov 15-30	2	18	21	26	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	69	8	12
B. **Diversion Requirement** (m^3/sec) 1/			1.62	1.69	2.16	1.47	0.23	-	-	-	0.31	1.77	6.94	5.40	-	-	-	-	-	-	0.31	2.24	0.77	3.78	2.62	2.32
C. **Available Supply** (m^3/sec)			4.25	4.25	4.25	4.25	4.25	4.25	4.25	4.25	4.25	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	4.25	4.25	4.25	4.25	4.25

1/ Irrigation Efficiencies assumed:

- On-farm efficiency 85% for paddy, 70% for upland crops; tertiary canal efficiency 80%; tertiary unit efficiency 68% for paddy, 56% for upland crops.

A-8 Projected cropping pattern

NEPAL
MAHAKALI IRRIGATION PROJECT (STAGE I)
Projected Cropping Pattern



MAHAKALI IRRIGATION PROJECT (STAGE I)

A-9 **CROP WATER REQUIREMENT**

1. Water-1 Requirement for Rabi Crops

(i) Wheat-1 period 15th Nov. to 15th March total days 120 (Sunflower, Linseed, lentil, garlic)

Sl.No.	Item	October	November	December	January	February	March
1.	No. of days	-	15	31	31	28	15
2.	Mid point	-	8	31	62	81	113
3.	% of growing season	-	6.7	25.8	51.7	75.8	94.2
4.	CU coefficient	-	0.1	0.28	0.61	0.88	0.62
5.	Pan evaporation losses Ep	-	45.5	67	69	92	90.5
6.	Consumptive use CU	-	4.55	18.76	42.1	80.1	56.11
7.	Effective rainfall	-	1.5	8	9	16	12
8.	Presowing	-	30	30	-	-	-
9.	NIR= 6-7+8	-	33.05	40.76	33.1	64.1	44.11
10.	NIR= NIR/0.75	-	44.1	54.33	44.13	85.47	51.89

(ii) Wheat-2 period Ist November to 28th February total days – 120

Sl. No.	Item	October	November	December	January	February	March
1.	No. of days	-	30	31	31	28	
2.	Mid point	-	15	46	77	106	
3.	% of growing season	-	12.5	38.3	64.33	88.3	
4.	CU coefficient (k)	-	0.17	0.44	0.76	0.733	
5.	Pan evaporation losses Ep	-	91	67	69	92	
6.	Consumptive use CU	-	15.47	29.49	52.49	69.44	
7.	Effective rainfall	-	3	8	9	16	
8.	Presowing	-	60	-	-	-	-
9.	NIR= 6-7+8	-	72.47	21.49	43.44	51.44	
10.	NIR= NIR/0.75	-	96.53	28.6	57.92	68.63	

(iii) Gram, Mustard, Onion, Vegetables period 16/10 to 28/02 Total Period 136 Days

Sl. No.	Item	October	November	December	January	February	March
1.	No. of days	16	30	31	31	28	
2.	Mid point	8	31	62	93	115	
3.	% of growing season	6	25.41	50.82	76.23	94.26	
4.	CU coefficient (k)	0.1	0.28	0.59	0.88	0.6	
5.	Pan evaporation losses Ep	56	91	67	69	92	
6.	Consumptive use CU	5.6	25.48	39.53	60.72	55.2	
7.	Effective rainfall	29	3	8	9	16	
8.	Presowing	30	30	-	-	-	-
9.	NIR= 6-7+8	6.8	52.58	31.53	51.72	39.2	
10.	NIR= NIR/0.75	8.25	65.72	39.4	49	48.12	

(iv) Peas, Pulses Potato Period 1st Nov. to 28 Feb Total Period =120 days

Sl. No.	Item	October	November	December	January	February	March
1.	No. of days		30	31	31	14	
2.	Mid point		15	46	77	99	
3.	% of growing season		12.50	38.33	64.17	88.33	
4.	CU coefficient (k)		0.43	0.98	0.93	0.55	
5.	Pan evaporation losses Ep		91	67	69	72	
6.	Consumptive use CU		39.13	65.66	64.17	39.6	
7.	Effective rainfall		3	8	9	16	
8.	Presowing		60	-	-	-	-
9.	NIR= 6-7+8		90.13	57.66	55.17	23.6	
10.	NIR= NIR/0.75		120.16	72	68.96	29.5	

2. Water Requirement for Kharif

(i) Paddy Period 15/06 to 15/10 Total Period 120 Days

Sl. No.	Item	June	July	August	September	October
1.	No. of days	15	31	31	30	15
2.	Mid point	8	31	62	92	115
3.	% of growing season	6.7	25.8	51.6	76.67	95.8
4.	CU coefficient (k)	0.92	1.11	1.3	1.14	0.7
5.	Pan evaporation losses Ep	146	180	171	125	58
6.	Consumptive use CU	134.3	199.8	222.3	142.5	39.2
7.	Nursery 5% of col.	6.7	-	-	-	-
8.	Total CU= 6+7	141	199.8	222.3	142.5	39.2
9.	Effective rainfall	66	470	358	299	29
10.	Presowing	38	37	-	-	-
11.	Land Preparation	100	50		-	-
12.	Pecolation losses	30	62	62	60	30
13.	NIR= 8-9+10+11+12	243	0	0	0	40.2
14.	FIR= NIR/0.90	270	0	0	0	44.87

(ii) Maize: Period 15 June to 15 Oct. Total 120 days

Sl. No.	Item	June	July	August	September	October
1.	Growing days	15	31	31	30	15
2.	Mid point	8	23	62	92	115
3.	% of growing season	6.6	19.18	51.6	76.7	95.8
4.	CU coefficient (k)	0.25	0.61	1	0.818	0.27
5.	Pan evaporation losses Ep	136	180	171	125	56
6.	Consumptive use (Cu)	34	109.8	171	102	15.12
7.	Effective rainfall	92	152	140	119	56
8.	Presowing	30	30	-	-	-
9.	NIR= 6-7+8	0	0	31	0	0
10.	FIR= NIR/0.85	0	0	36.47	0	0

GROSS IRRIGATION REQUIRMENT

1. Rabi Crop

Sl. No.	Item	Oct.	Nov.	Dec.	Jan.	Feb.	March
1.	Wheat –1, Area 45% FIR in mm Discharge in cubic m	- - -	2180 96.53 0.804	2180 28.64 0.231	2180 57.94 0.467	2180 68.63 0.613	
2.	Wheat = 2 Area 25% FIR in mm Discharge in cumec	- - -	1200 44.1 0.204	1200 54.33 0.243	1200 44.13 0.198	1200 85.47 0.424	1200 58.47 0.265
3.	Pulses, peas, potato 14% Area FIR in mm Discharge in cumec	 - - -	 672 120.10 0.312	 672 72.1 0.181	 672 63.96 0.173	 672 29.5 0.002	 - - -
4.	Gram, Mustard, Onion/ Vegetable						
	12% Area FIR in mm Discharge in cumec	570 8.25 0.083	570 65.72 0.146	570 39.4 0.085	570 64.65 0.139	570 49 0.117	570 - -

B. Kharif a Crops

Sl. No.		June	July	August	Sept.	Oct.	Nov.
1.	Paddy AREA 89% in ha FIR in mm discharge	 4272 270 4.45	 4272 0 0	 4272 0 0	 4272 0 0	 4272 44.7 0.712	
2.	Maize Area 7.1 FIR in mm Discharge in cumec	 336 0 0	 336 0 0	 336 36.47 0.047	 336 0 0	 336 0 0	 - - -

2. Total discharge of stage 1 for Rabi crops

Items	Nov.	Dec.	Jan.	Feb.	March
Wheat -1	0.804	0.231	0.467	0.613	0
Wheat-2	8.204	0.243	0.198	0.424	0.265
Pulses, pea, gram,	0.312	0.181	0.173	0.002	0
mustard, vegetable	0.146	0.085	0.139	0.117	
Total discharge for stage I area	1.5	0.76	0.996	1.25	0.265
Taking 75% conveyance efficiency	2	1.01	1.328	1.67	0.487
For Stage II area discharge in cumec	2.75	1.4	1.83	2.29	0.674
Total Required discharge at head	4.75	2.41	3.16	3.96	1.16

B. Total discharge for kharif Crop. (in m^3/Sce)

	June	July	August	September	October
Stage I area.	4.45	0	0	0.047	0.71
Stage II area	5.50	0	0	0.070	0.976
Total Discharge required	9.95	0	0	0.117	1.686
Taking 75% conveyance efficiency total discharge at head	13.0	0	0	0.13	2.26

A-10 Demand supply of water for stage I and II area (calculated)

Table 2(a): Demand (SAR) and Actual Supply of Water for Rabi Crops (Stage I)

Sl. No.	Month	Demand in m^3/sec	Supply in m^3/ sec
1	November	2.28	5.08
2.	December	2.47	4.0
3.	January	1.65	3.70
4.	February	1.81	4.42
5.	March	0.23	2.25

(b) Demand (SAR) and actual Supply of Water for Kharif (Stage-I)

Sl. No.	Month	Demand in m^3/sec	Supply in m^3/ sec	Remark
1	June	6.17	8.30	
2.	July	-	13.4	
3.	Aug	-	13.5	
4.	September	-	13.4	
5	October	1.27	4.5	

(c) Demand and Supply estimated for Stage I and II Area for Kharif Crops

Sl. No.	Month	Demand in m^3/sec	Supply in m^3/ sec	Remark
1	June	13.00	13.0	Just meet the demand
2.	July	0	13	
3.	Aug	0	13	
4.	September	0.120	13	
5	October	2.26	13	

(d) Demand and Supply for (estimated) Stage I and II Area for Rabi Season

Sl. No.	Month	Demand in m^3/sec	Supply in m^3/ sec	Remark
1	November	4.75	4.25	Deficit
2.	December	2.41	4.25	Exceed
3.	January	3.16	4.25	Exceed
4.	February	3.96	4.25	Exceed
5	March	1.16	4.25	Exceed

(e) Demand and Supply of water (estimated) for Stage I and II Area for Rabi Season

Sl. No.	Months	Demand in m³	Supply in m³	Remark
1	November	487800	137100	Exceed
2.	December	6602688	11003000	Exceed
3.	January	4435776	9942000	Exceed
4.	February	2076192	9727000	Exceed
5	March	298080	5882000	Exceed

(f) Demand and Actual Supply for Kharif Crops (Stage I)

Sl. No.	Month	Demand in m^3	Actual Supply of water m^3	Remark
1	June	15992640	21554000	Exceed
2.	July	-	37249000	
3.	August	-	34444000	
4.	September	-	34018000	
5	October	3304800	173071000	

(g) Actual Demand and Actual Supply of Water for Kharif Stage I

Sl. No.	Month	Actual Demand of water in m^3/sce	Actual Supply of water in m^3/sec.	Remark
1	June	5.90	8.30	Exceed
2.	July	0	13.40	
3.	August	0	13.5	
4.	September	0.067	13.2	
5	October	0.95	4.50	

(h) Actual Demand and Supply of Water for Rabi Crops Stage I

Sl. No.	Month	Actual Demand of water in m^3/Sce	Actual Supply of water in m^3/Sec.	Remark
1	November	2.0	5.08	Exceed
2.	December	1.01	4.10	
3.	January	1.328	3.70	
4.	February	1.67	4.02	
5	March	0.487	2.25	

Table A- .11(a) Channel Roaster for 7 days(one week) on and 21 days off

Blocks	N.C.A. in ha	Irrigate Area ha	Reqd head discharge cumec	Canal Capacity cumec	Vol. Of Water Reqd Cu.m	Group I (A,D, H) Cumec	Group II(C,D, H)	Group III (B,E,G)	Group IV (E,F,G ,Daiji)
A	1100	1056	0.344	2.25	891648	2.0			
B	1200	1152	0.375	2.05	972000			2.15	
C	1218	1169	0.381	2.057	987552		2.1		
D	1282	1230	0.4	2.17	1036800	1.25	1		
E	1610	1542	0.50	2.59	1296000			1.1	1.8
F	1525	1464	0.477	2.75	1236384				1.0
G	1675	1608	0.523	3.01	1356616			1.0	.75
H	1390	1334	0.434	2.5	1124928	1	1.15		
Daiji	400	384	0.125	0.72	324000				0.7

Table A- .1 1(b) Channel Roaster for 10 days on and 20days off

Blocks	N.C.A. in ha	Irrigate Area ha	Reqd head discharge cumec	Canal Capacity cumec	Vol. Of Water Reqd Cu.m	Group I (A,D, F) Cumec	Group II(BFG Daiji,)	Group III (C,G,,E, F)	
A	1100	1056	0.344	2.25	891648	1.40			
B	1200	1152	0.375	2.05	972000		1.45		
C	1218	1169	0.381	2.057	987552			1.6	
D	1282	1230	0.4	2.17	1036800	1.6			
E	1610	1542	0.50	2.59	1296000			1.075	
F	1525	1464	0.477	2.75	1236384	1.25	0.65		
G	1675	1608	0.523	3.01	1356616		1.65	0.5	
H	1390	1334	0.434	2.5	1124928			1.075	
Daiji	400	384	0.125	0.72	324000		0.5		

Table A- . .11(c) Channel Roaster for 10 days on and 20days off

Blocks	N.C.A. in ha	Irrigate Area ha	Reqd head discharge cumec	Canal Capacity cumec	Vol. Of Water Reqd Cu.m	Group (A,D, F,H) Daiji cumec	Group II(B,C, E,G Daiji,)	Group III (C,G,,E, F)	
A	1100	1056	0.344	2.25	891648	1.5			
B	1200	1152	0.375	2.05	972000		1.45		
C	1218	1169	0.381	2.057	987552		1.6		
D	1282	1230	0.4	2.17	1036800	1.6			
E	1610	1542	0.50	2.59	1296000		2.0		
F	1525	1464	0.477	2.75	1236384	2.15			
G	1675	1608	0.523	3.01	1356616		2.1		
H	1390	1334	0.434	2.5	1124928	2.1			
Daiji	400	384	0.125	0.72	324000	0.5			

Table A-12 Roaster for Rabi crops

Roaster for Rabi Crops from November to March (Proposed)

Blocks	N.C.A in (ha)	Irrigated area in (ha)	Canal capacity in cumec	Total discharge delivered	October		November			December			January			February			March	
							4.25	4.25	4.25	3.82	2.0	2.45	2.04	3.74	4.0	4.22	3.5	4.1	3.64	
				-	10	20	30	10	20	1	10	20	1	10	20	1	10	20	2	12
A	**1100**	1056	1.98				1.4			0.35		0.35		0.47	0.47	1.58		0.58	0.35	
B	**1200**	1152	2.16					1.45		0.4		0.4		0.50	0.52	0.64		0.64	0.38	
C	**1218**	1169	2.19						1.6	0.4		0.40		0.52	0.52	0.65		0.65	0.39	
D	**1282**	1230	2.3				1.6			0.4	0.90		0.54		0.54		0.68	0.68	0.40	
E	**1610**	1542	2.59							0.5	0.6			0.7	0.7	0.85		0.85	0.51	
F	**1525**	1464	2.75				1.25	0.65	1.075	0.5		0.50		0.65	0.65	0.80	0.82	-	0.49	
G	**1675**	1608	3.01					1.65	0.5	0.5		0.5	0.7	0.7			1.0	0.7	0.53	
H	**1390**	1334	2.5						1.075	0.5	0.5		0.6		0.6	0.70	0.8	-	0.44	
Daiji	**400**	384	0.72					0.5		0.26		0.2	0.2	0.2			0.02	-	0.15	

A-13 Average crop yields in stage I area

Crop	Pre-Project	SAR Target	1986/87	1987/88	1988/89	1989/90	1990/91	1991/92	1992/93	1993/94	1994/95
Paddy	1.40	2.30	2.40	2.50	3.40	3.10	4.10	4.20	4.10	3.95	4.18
Maize	1.20	2.00	1.10	1.50	1.60	1.80	2.00	2.10	2.00	1.28	1.10
Groundnut		1.40					0.90	1.10	1.10		
Greengram			0.60	0.60	0.30						
Redgram	0.60	0.70				0.80	0.90	1.20		1.09	1.16
Soybean		1.00					0.80	1.00	1.00		
Wheat	1.10	2.10	1.60	2.10	2.50	2.00	2.80	2.08	1.80	2.77	2.77
Rapeseed	0.60	0.70	0.40	0.50	0.70	0.90	0.70	0.90	0.75	1.18	1.15
Potato	7.00	11.00	5.60	6.30	7.20	9.00	13.50	15.40	12.00	11.90	11.13
Chichpea			0.70	1.10	1.00	0.70	0.70	1.17	0.78	1.53	1.10
Lentil			0.80	0.90	1.00	0.70	0.80	0.93	0.60	1.77	1.04
S. Maize											1.59
S. Greengram						0.50					
S. Balckgram			0.60	0.60	0.40	0.50					
Sunflower											1.58
Cowpea											1.03

Table A-14 **Derivation of Economic prices for traded outputs and inputs**

World prices (US$/t)	Paddy	Wheat	Maize	Olseeds	Urea	TSP	DAP	Muriat potash
projected 2000 prices (1995 contant)	291	189	120	271	165	143	163	122
Nepal adjusted world prices	218	189	120	271	165	143	163	122
Shipping and handling	67	147	119	46	91	112	90	147
CIF Calcutta prices	285	336	239	317	256	255	253	269
Trasportation &handling to Nepal border	40	40	40	40	40	40	40	40
CIF at Biratnagar	325	376	279	357	296	295	293	309
Equivalent (NRS)	22961	26564	19711.4	25222	20912	20842	20700.4	21831
Transportation &marketing cost from border to whole sale market	-2066.5	-2391	1774	2270	1882.1	1875.7	1863	1964.7
Wholesale price	20894.5	24174	17937.4	22952	22795	22717	22563.4	23796
Trasportation&marketing from wholesale market to project area	1880.5	2176	1614.3	2065.7	2051.5	2044.6	2030.7	2141.5
price at project area	19014	21998	16323.1	20886	24846	24762	24594.1	25937
proccessing ratio	62%	100%	100	100				
Eqvilent raw product	11788.7	21998	16323.1	20886	24846	24762	24594.1	25937
proccessing charge	657							
By product	984							
Transportation from project area to farmgate	300	300	300	300	300	300	300	300
Farm gate price (NRS/Tone)	11815.7	21698	16023	20586	25146	25062	24894	26237
Pulses	41355							

NOTE
a. Prices based on World Bank, price Prospects fo Mojor primary Commodities 1993-2005,November2 1993
bProjected 2000 prices are adjusted to 1995 constant prices by World Bank Manufacturing Unit Value Index
.cWord prices adjusted for c quality differences
d. Since curret data was unavailiable at the time of calculation ,the Master plan 1988 cost was inflated by 40% to allow for the increase in shipping & handling costs
e. 10% of CIF at Biratnagar with converted by scf. 0.9 from border to wholesale market
f. US$ 1=NRS 70.65
I.C. RS 1=NRS 1.6
g. Marketing& transportation fromm wholesale market to project area is taken as 10% with scf 0.9
g NRS 30/KM is taken for transportation from project area to Farm Gate and distance is assumed to 10 km

A-15 Input Use Rate (Stage I Area)

Input	Head				Middle				Tail				Average of the Block			
	Paddy	Maize	Wheat	Mustard	Paddy	Maize	Wheat	Mustard	Paddy	Maize	Wheat	Mustard	Paddy	Maize	Wheat	Mustard
Bullock A																
Bullock (pairs)	18.5	10.5	28.5	10.5	22.5	0.0	29.0	21.0	17.5	0.0	23.8	0.0	19.5	3.5	27.1	10.5
Labour (mandays)	49.0	22.5	28.5	21.8	76.5	0.0	36.3	21.3	75.0	0.0	36.3	0.0	66.5	7.5	33.7	14.3
Seeds (kg)	45.0	28.5	122.3	13.5	45.0	0.0	120.0	10.5	55.0	0.0	120.0	0.0	48.3	9.5	120.8	8.0
Chemical - Fenlizers (k	285.0	0.0	155.0	60.0	375.0	0.0	375.0	150.0	187.5	0.0	262.0	0.0	282.5	0.0	264.2	70.0
Farm Manure (kg)	150.0	155.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0	51.7	0.0	0.0
Bullock B																
Bullock	22.3	0.0	29.5	0.0	21.0	12.0	27.0	27.0	18.0	11.0	24.0	22.0	20.4	7.7	26.8	16.3
Labour	105.0	0.0	44.5	0.0	112.5	30.0	52.5	37.5	77.5	27.5	40.5	23.0	98.0	19.2	45.8	20.2
Seeds	26.3	0.0	150.0	0.0	82.5	27.0	120.0	8.0	60.0	30.0	120.0	18.3	56.3	19.0	130.0	8.8
Chemical-Fenlizers	150.0	0.0	150.0	0.0	120.0	0.0	150.0	150.0	150.0	0.0	225.0	0.0	140.0	0.0	175.0	50.0
Farm Manure	0.0	0.0	0.0	0.0	150.0	150.0	150.0	225.0	0.0	90.0	0.0	0.0	50.0	80.0	50.0	75.0
Bullock A																
Bullock	28.0	13.5	34.5	33.0	21.8	17.8	27.0	18.8	8.3	10.5	27.0	14.5	19.3	13.9	29.5	22.1
Labour	72.5	13.0	27.5	30.5	75.0	17.0	42.5	23.0	61.5	22.5	21.5	24.5	69.7	17.5	30.5	26.0
Seeds	45.0	22.3	90.0	11.0	42.5	21.3	150.0	14.0	60.0	16.5	112.5	13.8	49.2	20.0	117.5	12.9
Chemical-Fenlizers	375.0	0.0	375.0	150.0	9.0	0.0	120.0	120.0	150.0	0.0	112.5	165.0	178.0	0.0	202.5	145.0
Farm Manure	90.0	120.0	120.0	120.0	225.0	200.0	300.0	450.0	300.0	150.0	225.0	225.0	205.0	156.7	215.0	265.0
Stage I																
Bullock													15.0	6.3	2.14	12.2
Labour Seeds													56.3	10.3	26.5	15.2
Chemical													38.3	11.6	92.88	7.7
Fertilizers													166.3	0.0	172.1	72.8
Farm Manure													83.6	74.1	69.7	87.7

A – 16 - CROP BUDGET FORM
PROJECT : Mahakali Irrigation Project
COST STATUS : Economic (with Irrigation)

	Particulars	Unit	Paddy (sp)	Paddy (m)	Wheat	Maize	Oilseed	Pulse	Vegetable
I.	YIELD	(t/ha)		4.0	2.10	2.0	0.6	0.70	11
	Price	(NRs/ha)		118200	21700	16023	20586	41355	4000
	Value	(NRs/ha)		11.82	21.70	16.023			
	Value	(NRs/ha)							-
	GROSS RETURN	(NRs/ha)		47280	45570	32046	12352	28949	44000
II.	SEED	(kg/ha)		25	90	20	9	25	2
	Price	(NRs/ha)		14.25	26.5	9.5	25	50	2
	Value	(NRs/ha)		356.25	2385	390	225	1250	1000
	DAP.	(t/ha)		220	120	50	0	-	250
	Price	(NRs/kg)		24.9	24.9	24.9	24.9	24.9	24.9
	Value	(NRs)		5478	2988	1245.0	0	-	6225
	CHEMICAL N	(Kg/ha)		60	60	50	0	15	70
	Price	(NRs/Kg)		25.2	25.2	25.2	0	25.2	25.2
	Value	(NRs)		1512.0	1512	1260		378	1764
	P	(Kg/ha)		30	30	30	-	15	30
	Price	(NRs/Kg)		26.3	26.3	26.3	-	26.3	26.3
	Value	(NRs)		789	789	789		395	789
	K	(Kg/ha)		20	20	15	-	10	20
	Price	(NRs/ha)		25	25	25	-	25	25
	Value	(NRs)		500	500	375		2500	500
	PESTICIDES	(NRs/ha)		500	500	250		100	400
	LABOUR	(md/ha)		135	105	83	49	39	30
	Price	(NRs/ha)		63	63	63	63	63	63
	Value	(NRs/ha)		8505	6615	5229	3087	2457	1890
	ANIMAL LABOUR	(md/ha)		51	39	25	20	12	30
	Price	(NRs/ha)		126	126	126	126	126	126
	Value	(NRs/ha)		6426	4914	3150	2520	1512	3780
III.	COST	(NRs/ha)		2406725	19703	12438	5832	6342	15848
IV.	NET RETURN	(NRs/ha)		23213.75	25867	19608	6520	22607	28152

A – 16 - CROP BUDGET FORM
PROJECT : Mahakali Irrigation Project
COST STATUS : Economic (Future without project)

	Particulars	Unit	Paddy (sp)	Paddy (m)	Wheat	Maize	Oilseed	Pulse	Vegetable
I.	YIELD	(t/ha)		2.20	1.30	1.30	0.5	0.60	7.0
	Price	(NRs ha)		118200	21700	16202	20586	41355	4000
	Value	(NRs/ha)		26004	28210	21063	10293	24813	28000
	GROSS RETURN	(NRs/ha)		26004	28210	21063	10293	24813	28000
II.	SEED	(kg/ha)		25	100	20	9	25	2
	Price	(NRs/ha)		14.25	26.5	19.5	25	50	500
	Value	(NRs/ha)		356	26.50	390	225	1250	1000
	ORG.	(t/ha)		50	50	-	-	-	80
	Price	(NRs/kg)		24.9	24.9				24.9
	Value	(NRs)		661	661				1992
	CHEMICAL N	(Kg/ha)		20	15	10	-	-	30
	Price	(NRs/Kg)		25.2	25.2	25.2	-	-	25.2
	Value	(NRs)		504	378	252	-	-	756
	P	(Kg/ha)		10	10	5		-	-
	Price	(NRs/Kg)		26.3	26.3	26.3	-	-	-
	Value	(NRs)		263	263	132	-	-	-
	K	(Kg/ha)		10	10	2	-	-	-
	Price	(NRs/ha)		25	25	25	-	-	-
	Value	(NRs)		250	250	50	-	-	-
	PESTICIDES	(NRs/ha)		250	200		-	-	-
	LABOUR	(md/ha)		120	88	67	54	33	97
	Price	(NRs/ha)		63	63	63	63	63	63
	Value	(NRs/ha)		7560	5544	4221	3402	2079	6111
	ANIMAL LABOUR	(md/ha)		49	31	10	20	10	20
	Price	(NRs/ha)		126	126	126	126	126	126
	Value	(NRs/ha)		6174	3906	1260	2520	1260	2520
III.	COST	(NRs/ha)		16018	13852	6305	6147	4589	12379
IV.	NET RETURN	(NRs/ha)		9986	14358	14758	4146	20224	15621

A – 16 - CROP BUDGET FORM
PROJECT : Mahakali Irrigation Project
COST STATUS : Economic (Future with rainfed)

	Particulars	Unit	Paddy (sp)	Paddy (m)	Wheat	Maize	Oilseed	Pulse
I.	YIELD	(t/ha)		1.0	1.0	1.1	0.4	0.5
	Price	118200		118200	21700	16023	20586	41355
	Value	(NRs/ha)						
	GROSS RETURN	(NRs/ha)		11820	21700	17025	8235	20675
II.	SEED	(kg/ha)		35	100	20	9	25
	Price	(NRs/ha)		14.25	26.5	19.5	25	50
	Value	(NRs/ha)		499	2650	390	225	1250
	ORG	(t/ha)		-	-	-		-
	Price	(NRs/kg)		-	-	-		-
	Value	(NRs)		-	-	-		-
	CHEMICAL N	(Kg/ha)		-	-	-		-
	Price	(NRs/Kg)		-	-	-		-
	Value	(NRs)		-	-	-		-
	P	(Kg/ha)		-	-	-		-
	Price	(NRs/Kg)		-	-	-		-
	Value	(NRs)		-	-	-		-
	K	(Kg/ha)		-	-	-		-
	Price	(NRs/ha)		-	-	-		-
	Value	(NRs)		-	-	-		-
	PESTICIDES	(NRs/ha)		-	-	-	-	-
	LABOUR	(md/ha)		90	78	65	49	29
	Price	(NRs/ha)		63	63	63	63	63
	Value	(NRs/ha)		3670	4914	4095	3087	1827
	ANIMAL LABOUR	(md/ha)		35	30	10	20	10
	Price	(NRs/ha)		126	126	126	126	126
	Value	(NRs/ha)		4410	3780	1260	2520	1260
III.	COST	(NRs/ha)		10578	11344	5745	5832	4337
IV.	NET RETURN	(NRs/ha)		1241	10356	11880	2403	16341

A – 16 - CROP BUDGET FORM
PROJECT : Mahakali Irrigation Project
COST STATUS : Economic

Future Without Project (irrigated)				Future with Project			
Crop-Name	Crop-Area (ha)	Yield (t/ha)	Production	Crop-Name	Crop-Area	Yield (ha)	Total Crop production
Paddy	2414	2.2	5310.8	Paddy	4272	4	17088
Maize	578	1.3	6751.4	Maize	336	2.1	7056
Wheat	578	1.3	751.4	Wheat	3264	2.0	6528.0
Oilseed	544	0.5	272.0	Oilseed	576	0.6	342.0
Pulses	408	0.6	244.8	Pulses	672	0.7	470.4
Vegetable	34	7	238	Vegetable	96	11	7056
Paddy	826	1	826				
Maize	350	1	350				
Wheat	140	1.1	154				
Oilseed	196	0.4	78.5				
Pulses	182	0.5	91				
Total (A)			9087.8 t	Total (B)		26190 t	26190 t

Net Incremental Project Benefit (B-A): NRs. 26190-9088 = 17102. T

Future without Project (irrigated)					Future with Project				
Crop-Name	Crop-Area (ha)	Yield (t/ha)	Benefit/ha (NRs)	Total Crop Benefit (NRs)	Crop-Name	Crop-Area (ha)	Yield (ha)	Benefit/ha (NRs)	Benefit.ha (NRs
Paddy	2414	2.2	9986	241606.2	Paddy	4272	4.0	23214	99170.21
Maize	578	1.3	14758	8530.1	Maize	336	2.0	19608	65882
Wheat	578	1.3	143658	8298.9	Wheat	3264	2.1	25867	84429.9
Oilseed	544	0.5	4146	2255.4	Oilseed	576	0.6	6520	3755.52
Pulses	408	0.6	20224	8251.4	Pulses	672	0.7	22607	15191.9
Vegetable	34	7	156210	531.1	Vegetable	96	11	28152	2702.6
		Sub total	-	51973.1					
		Rainfed	-	8093.7					
Total (A)				60066.8 (Sav 60067.0	Total (B)				212138.4

Net Incremental Project Benefit (B-A): NRs. 212138.4-60068.8 = 152071.4 thousand

Future Without Project (Rainfed)				
Crop-Name	Crop-Area (ha)	Yield (t/ha)	Benefit (NRs)	Total Crop Benefit (NRs)
Paddy	826	1	12111.0	1024.2
Maize	350	1	10356	3624.6
Wheat	140	1.1	11880	1663.2
Oilseeds	196	0.4	240.3	470.98
Pulses	182	.5	16341	2974.0
Total (A)				8093.7

A – 16 - CROP BUDGET FORM
PROJECT : Mahakali Irrigation Project
COST STATUS : Economic (Future with rainfed)

	Particulars	Unit	Paddy (sp)	Paddy (m)	Wheat	Maize	Oilseed	Pulse
I.	YIELD	(t/ha)		1.0	1.0	1.1	0.4	0.5
	Price	118200		118200	21700	16023	20586	41355
	Value	(NRs/ha)						
	GROSS RETURN	(NRs/ha)		11820	21700	17025	8235	20675
II.	SEED	(kg/ha)		35	100	20	9	25
	Price	(NRs/ha)		14.25	26.5	19.5	25	50
	Value	(NRs/ha)		499	2650	390	225	1250
	ORG	(t/ha)		-	-	-		-
	Price	(NRs/kg)		-	-	-		-
	Value	(NRs)		-	-	-		-
	CHEMICAL N	(Kg/ha)		-	-	-		-
	Price	(NRs/Kg)		-	-	-		-
	Value	(NRs)		-	-	-		-
	P	(Kg/ha)		-	-	-		-
	Price	(NRs/Kg)		-	-	-		-
	Value	(NRs)		-	-	-		-
	K	(Kg/ha)		-	-	-		-
	Price	(NRs/ha)		-	-	-		-
	Value	(NRs)		-	-	-		-
	PESTICIDES	(NRs/ha)		-	-	-	-	-
	LABOUR	(md/ha)		90	78	65	49	29
	Price	(NRs/ha)		63	63	63	63	63
	Value	(NRs/ha)		3670	4914	4095	3087	1827
	ANIMAL LABOUR	(md/ha)		35	30	10	20	10
	Price	(NRs/ha)		126	126	126	126	126
	Value	(NRs/ha)		4410	3780	1260	2520	1260
III.	COST	(NRs/ha)		10578	11344	5745	5832	4337
IV.	NET RETURN	(NRs/ha)		1241	10356	11880	2403	16341

A – 16 - CROP BUDGET FORM
PROJECT : Mahakali Irrigation Project
COST STATUS : Economic (Future without project)

	Particulars	Unit	Paddy (sp)	Paddy (m)	Wheat	Maize	Oilseed	Pulse	Vegetable
I.	YIELD	(t/ha)		2.20	1.30	1.30	0.5	0.60	7.0
	Price	(NRs ha)		118200	21700	16202	20586	41355	4000
	Value	(NRs/ha)		26004	28210	21063	10293	24813	28000
	GROSS RETURN	(NRs/ha)		26004	28210	21063	10293	24813	28000
II.	SEED	(kg/ha)		25	100	20	9	25	2
	Price	(NRs/ha)		14.25	26.5	19.5	25	50	500
	Value	(NRs/ha)		356	26.50	390	225	1250	1000
	ORG.	(t/ha)		50	50	-	-	-	80
	Price	(NRs/kg)		24.9	24.9				24.9
	Value	(NRs)		661	661				1992
	CHEMICAL N	(Kg/ha)		20	15	10	-	-	30
	Price	(NRs/Kg)		25.2	25.2	25.2	-	-	25.2
	Value	(NRs)		504	378	252	-	-	756
	P	(Kg/ha)		10	10	5		-	-
	Price	(NRs/Kg)		26.3	26.3	26.3	-	-	-
	Value	(NRs)		263	263	132	-	-	-
	K	(Kg/ha)		10	10	2	-	-	-
	Price	(NRs/ha)		25	25	25	-	-	-
	Value	(NRs)		250	250	50	-	-	-
	PESTICIDES	(NRs/ha)		250	200		-	-	-
	LABOUR	(md/ha)		120	88	67	54	33	97
	Price	(NRs/ha)		63	63	63	63	63	63
	Value	(NRs/ha)		7560	5544	4221	3402	2079	6111
	ANIMAL LABOUR	(md/ha)		49	31	10	20	10	20
	Price	(NRs/ha)		126	126	126	126	126	126
	Value	(NRs/ha)		6174	3906	1260	2520	1260	2520
III.	COST	(NRs/ha)		16018	13852	6305	6147	4589	12379
IV.	NET RETURN	(NRs/ha)		9986	14358	14758	4146	20224	15621

A – 16 - CROP BUDGET FORM
PROJECT : Mahakali Irrigation Project
COST STATUS : Economic (with Irrigation)

	Particulars	Unit	Paddy (sp)	Paddy (m)	Wheat	Maize	Oilseed	Pulse	Vegetable
I.	YIELD	(t/ha)		4.0	2.10	2.0	0.6	0.70	11
	Price	(NRs/ha)		118200	21700	16023	20586	41355	4000
	Value	(NRs/ha)		11.82	21.70	16.023			
	Value	(NRs/ha)							-
	GROSS RETURN	(NRs/ha)		47280	45570	32046	12352	28949	44000
II.	SEED	(kg/ha)		25	90	20	9	25	2
	Price	(NRs/ha)		14.25	26.5	9.5	25	50	2
	Value	(NRs/ha)		356.25	2385	390	225	1250	1000
	DAP.	(t/ha)		220	120	50	0	-	250
	Price	(NRs/kg)		24.9	24.9	24.9	24.9	24.9	24.9
	Value	(NRs)		5478	2988	1245.0	0	-	6225
	CHEMICAL N	(Kg/ha)		60	60	50	0	15	70
	Price	(NRs/Kg)		25.2	25.2	25.2	0	25.2	25.2
	Value	(NRs)		1512.0	1512	1260		378	1764
	P	(Kg/ha)		30	30	30	-	15	30
	Price	(NRs/Kg)		26.3	26.3	26.3	-	26.3	26.3
	Value	(NRs)		789	789	789		395	789
	K	(Kg/ha)		20	20	15	-	10	20
	Price	(NRs/ha)		25	25	25	-	25	25
	Value	(NRs)		500	500	375		2500	500
	PESTICIDES	(NRs/ha)		500	500	250		100	400
	LABOUR	(md/ha)		135	105	83	49	39	30
	Price	(NRs/ha)		63	63	63	63	63	63
	Value	(NRs/ha)		8505	6615	5229	3087	2457	1890
	ANIMAL LABOUR	(md/ha)		51	39	25	20	12	30
	Price	(NRs/ha)		126	126	126	126	126	126
	Value	(NRs/ha)		6426	4914	3150	2520	1512	3780
III.	COST	(NRs/ha)		2406725	19703	12438	5832	6342	15848
IV.	NET RETURN	(NRs/ha)		23213.75	25867	19608	6520	22607	28152

A-17 Benefit with and without project

PROJECT : Mahakali Irrigation Project
COST STATUS : Economic

Future Without Project (irrigated)				Future with Project			
Crop-Name	Crop-Area (ha)	Yield (t ha)	Production	Crop-Name	Crop-Area	Yield (ha)	Total Crop production
Paddy	2414	2.2	5310.8	Paddy	4272	4	17088
Maize	578	1.3	6751.4	Maize	336	2.1	7056
Wheat	578	1.3	751.4	Wheat	3264	2.0	6528.0
Oilseed	544	0.5	272.0	Oilseed	576	0.6	342.0
Pulses	408	0.6	244.8	Pulses	672	0.7	470.4
Vegetable	34	7	238	Vegetable	96	11	7056
Paddy	826	1	826				
Maize	350	1	350				
Wheat	140	1.1	154				
Oilseed	196	0.4	78.5				
Pulses	182	0.5	91				
Total (A)			9087.8 t	Total (B)		26190 t	26190 t

Net Incremental Project Benefit (B-A): NRs. 26190-9088 = 17102. T

Future without Project (irrigated)					Future with Project				
Crop-Name	Crop-Area (ha)	Yield (t/ha)	Benefit/ha (NRs)	Total Crop Benefit (NRs)	Crop-Name	Crop-Area (ha)	Yield (ha)	Benefit/ha (NRs)	Benefit.ha (NRs
Paddy	2414	2.2	9986	241606.2	Paddy	4272	4.0	23214	99170.21
Maize	578	1.3	14758	8530.1	Maize	336	2.0	19608	65882
Wheat	578	1.3	143658	8298.9	Wheat	3264	2.1	25867	84429.9
Oilseed	544	0.5	4146	2255.4	Oilseed	576	0.6	6520	3755.52
Pulses	408	0.6	20224	8251.4	Pulses	672	0.7	22607	15191.9
Vegetable	34	7	156210	531.1	Vegetable	96	11	28152	2702.6
		Sub total	-	51973.1					
		Rainfed	-	8093.7					
Total (A)				60066.8 (Say 60067.0	Total (B)				212138.4

Net Incremental Project Benefit (B-A): NRs. 212138.4-60068.8 = 152071.4 thousand

Future Without Project (Rainfed)				
Crop-Name	Crop-Area (ha)	Yield (t/ha)	Benefit (NRs)	Total Crop Benefit (NRs)
Paddy	826	1	12111.0	1024.2
Maize	350	1	10356	3624.6
Wheat	140	1.1	11880	1663.2
Oilseeds	196	0.4	240.3	470.98
Pulses	182	.5	16341	2974.0
Total (A)				8093.7

A-18 Yearly gross production and value of outputs

nr s ? 000

Crop	82.83				83/84				84/85				85/86			
	Cr. Cover	Yield t	Produ-ction	Gr. Value	Cr. cover	Yield	Produ-ction	Gr. Value	Cr. Cover	Yield	Produ-ction	Gr. Value	Cr cover	Yield	Produ-ction	Gr. Value
Paddy	68.0	1.40	4,569.6	53989.8	70.3	1.65	5.570.4	65841.3	72.7	1.90	6.627.2	78300.4	75.0	2.15	7.740.0	91448.1
Wheat	16.0	1.10	844.8	18336.5	22.5	1.23	1323.0	28706.5	29.0	1.35	1.879.2	40774.9	35.5	1.18	2.513.4	54535.8
Maize	19.0	1.20	1,094.4	17535.6	18.2	1.18	1024.6	164174.2	17.3	1.15	956.8	15330.8	16.5	1.13	891.0	14276.5
Pulses	12.0	0.60	345.6	14307.3	12.0	0.62	355.2	14705.3	12.0	0.63	364.8	151021.7	12.0	0.65	374.4	15500.2
Oilseeds	15.0	0.60	432.0	88.37	15.5	0.55	499.2	8428.8	16.0	0.50	384.0	7905.0	16.5	0.45	356.4	7336.8
Total	130		7.286.4	113056.9			8.682.4	134067			10.212.0	157413.8			11875.2	183007.4

86/87

Cr. cover	Yield	Produ-ction	Gr. Value
77.3	2.40	8,908.33	105257.5
42.0	1.60	.225.6	69989.1
15.7	1.10	827.2	13254.2
12.0	0.67	384.0	15894.6
17.0	0.40	326.4	6719.3
		13672.0	21147.7

Crop	87/88				88/89				89/90				90/91			
	Cr. Cover	Yiel d	Produ-ction	Gr. Value	Cr. cover	Yield	Produ-ction	Gr. Value	Cr. Cover	Yield	Produ-ction	Gr. Value	Cr cover	Yield	Produ-ction	Gr. Value
Paddy	79.7	2.50	9,560.0	11295.4	82	3.40	13382.4	158119.1	83.2	3.10	12381.6	146288.6	84.4	4.10	16613.9	196293.2
Wheat	47.2	2.10	4,757.8	103234.7	55	2.50	6600.0	143206.8	57.1	2.00	5485	119013.5	59.3	2.80	7965.9	172844.0
Maize	15.7	1.50	1.128.0	18.079.9	14	1.60	1075.2	17257.9	13.1	1.80	11297	181011.2	13.1	2.00	1255.2	201120.0
Pulses	12.0	0.68	393.6	16295.0	12	0.70	403.2	16692.5	10.0	0.70	357.5	13972.5	8.1	0.80	310.7	12862.9
Oilseeds	17.1	0.50	410.0	8440.3	18	0.70	604.8	12450.4	19.4	0.90	836.2	17214.0	20.7	0.70	696.0	14327.8
Total			16.249.4	258995.3			22065.6	347690.4			20170.0	314589.8			26841.6	373867.6

91/92

Cr. cover	Yield	Produ-ction	Gr. Value
85.6	4.20	17263.0	203962.3
61.4	2.08	6130.7	133024.0
13.1	2.10	1318.0	21118.3
6.1	0.93	273.9	11335.5
22.1	0.90	953.4	19626.7
		25938.9	385070.8

Crop	92/93				93/94				94-95				95/96			
	Cr. Cover	Yield	Produ-ction	Gr. Value	Cr. cover	Yield	Produ-ction	Gr. Value	Cr. Cover	Yield	Produ-ction	Gr. Value	Cr cover	Yield	Produ-ction	Gr. Value
Paddy	86.8	4.10	17090.1	201919.5	88.1	4	16694.3	197243.1	89	4.2	17909.1	211596.2	89	4.0	17088	201894.7
Wheat	63.5	1.80	5489.9	119119.8	65.7	2.8	8732.1	189469.1	68	2.8	9016.0	195629.2	68	2.7	8812.8	19020.1
Maize	13.1	2.00	1255.2	20112.7	13.1	1.3	803.3	12811.3	7	1.1	446.2	7149.5	7	2.0	672.0	10767.5
Pulses	4.2	0.60	120.4	4984.6	2.2	1.8	189.0	7824.6	14	1.0	140	558.9	14	0.6	672.0	14307.8
Oilseeds	23.4	0.75	843.4	17362.2	24.8	1.2	1403.7	28896.6	12	1.2	1442.9	29705.5	12	0.7	346.6	96836.0
															470.4	
Total			24798.9	363498.2			27822.5	424704.7				444634.1			26841.6	427374.0

Cr. Cover = Crop coverage in percentage of area.
Gr. Value = Gross value .. in thousand.
Yield = in tons. / ha.
Production = tons.

A-19 **Minikits distribution from 1987 to1995**

	Crops	1987	1988	1989	1990	1991	1992	1993	1994	1995	Total
1	Wheat	80	36	100	181	224	300	200	200	250	1571
2	Chickpea	30	29	12	26	20	30	92	70	80	389
3	Lentil	22	30	12	32	44	40	96	70	100	446
4	Paddy	100	125	100	150	260	200	175	275	200	1585
5	Ground nut		20	0	7	8	16	25	40	40	156
6	Maize			28	0	20	40	50	20	90	248
7	Greengram				0	8	0	5	0	50	75
8	Rapeseed				40	40	40	120	120	140	504
9	Blackgram				8	32	0	10	30	30	118
10	Vegetable					21	128	589	875	707	2320
11	Pigeonpea					16	30	41	80	50	217
12	Soyabean					12	30	20	40	20	122
13	Sesbania					0		100		31	131
14	Cowpea									40	40
15	Sunflower									105	105
	Total	232	240	276	444	705	854	1523	1820	1933	8027

Table A-20 Calculation of EconomicInternal Rate Of Return

Year	F/Y	Invetment NRS' 000	Net Increamental Benefit in '000	Discount Rate 20%	30%	Net Present Value at 20%	30%
1	1982/83	103799.5	-103799.5	0.833	0.769	-86464.98	-79821.8155
2	1983/84	24404.1	28586	0.694	0.592	19838.684	16922.912
3	1984/85	144522.5	-70522.4	0.579	0.455	-40832.47	-32087.692
4	1985/86	216340	-118993.2	0.482	0.35	-57354.72	-41647.62
5	1986/87	345870	-222839.6	0.402	0.269	-89581.52	-59943.8524
6	1987/88	14422.1	136628.6	0.335	0.207	45770.581	28282.1202
7	1988/89	161213.2	177151	0.279	0.159	49425.129	28167.009
8	1989/90	5706.2	248038.5	0.233	0.122	57792.971	30260.697
9	1990/91	6484.3	298474	0.194	0.094	57903.956	28056.556
10	1991/92	15326.6	318628.9	0.162	0.055	51617.882	17524.5895
11	1992/93	10374.9	292713	0.132	0.043	38638.116	12586.659
12	1993/94	6372.3	358265.4	0.112	0.033	40125.725	11822.7582
13	1994/95	57757.1	331813	0.093	0.025	30858.609	8295.325
14	1995/96	52757.1	315050.7	0.078	0.019	24573.955	5985.9633
15	1996/97	5275701	315050.7	0.065	0.015	20478.296	4725.7605
	to			0.318	0.0578		
37	2017/18	52757.1	315050.7			100186.12	18209.93046
						262976.33	-2660.69974

Economic Internal Rate Of Return=20+ 10:/262976.3/265637 =29.8
Say =29 %

APPENDIX –B (FIGURES)

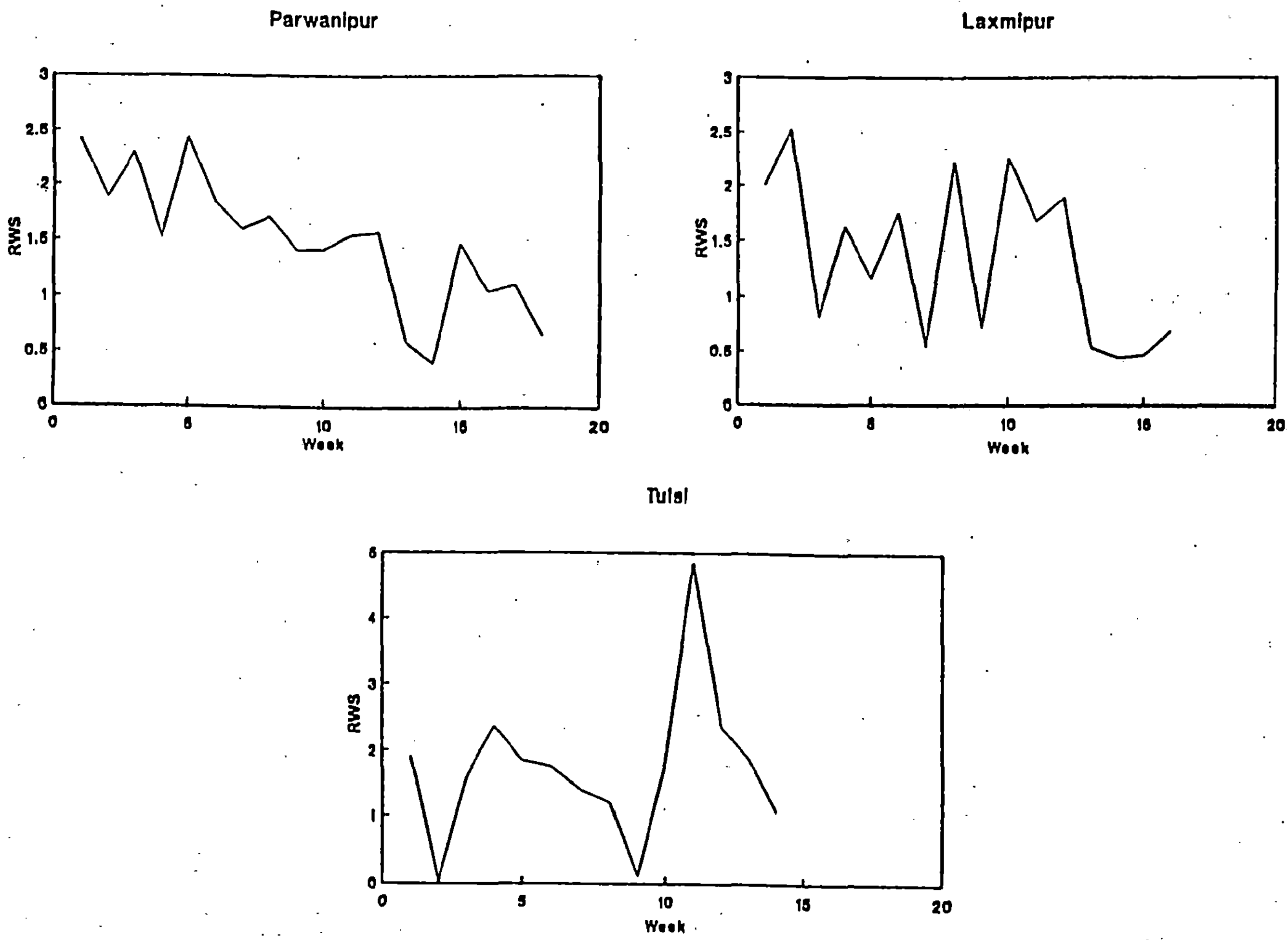
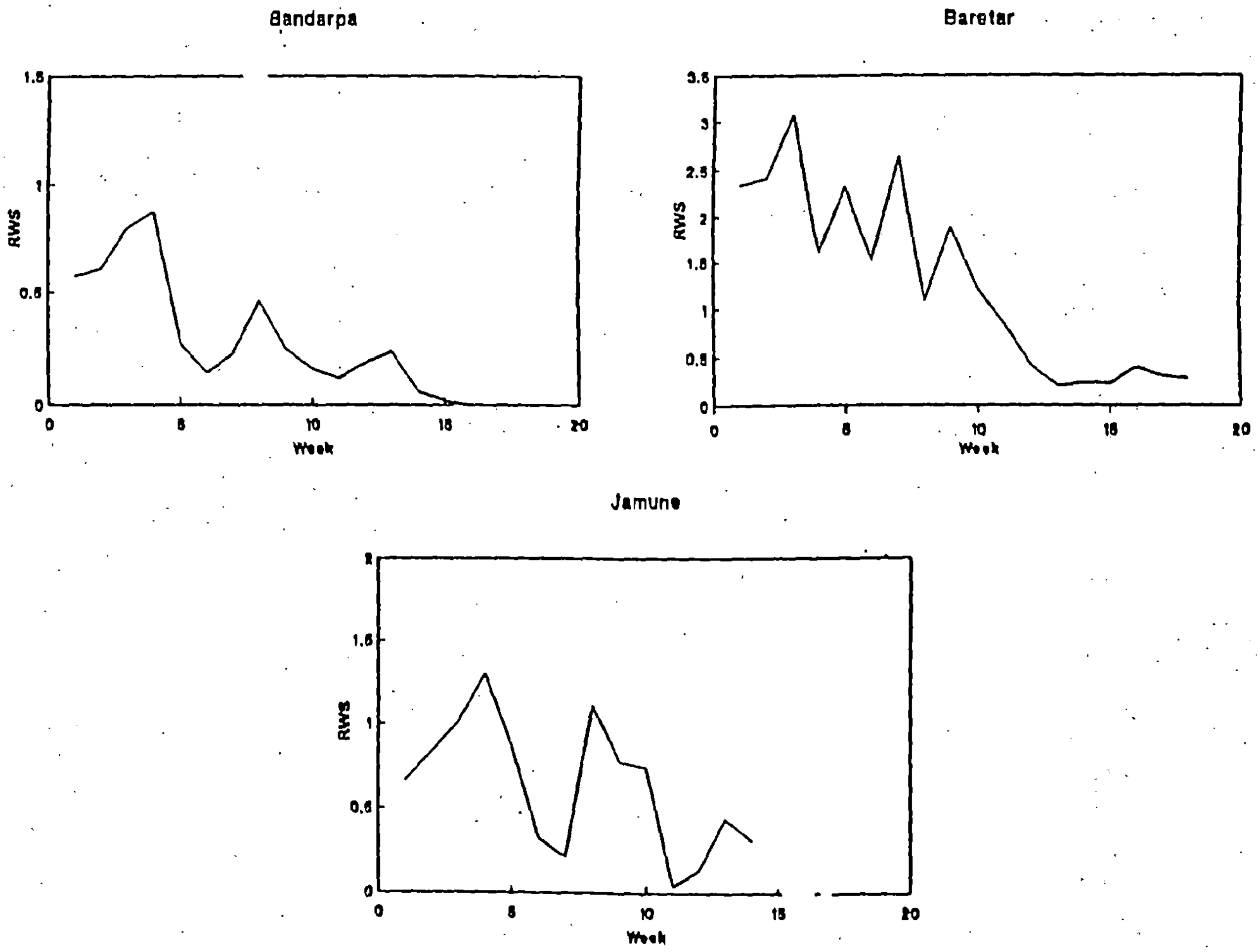


Fig. B-1 (a) Weekly relative water supply (RWS) in three Terai system in Nepal.



(b) Weekly relative water supply (RWS) in three hill system in Nepal.

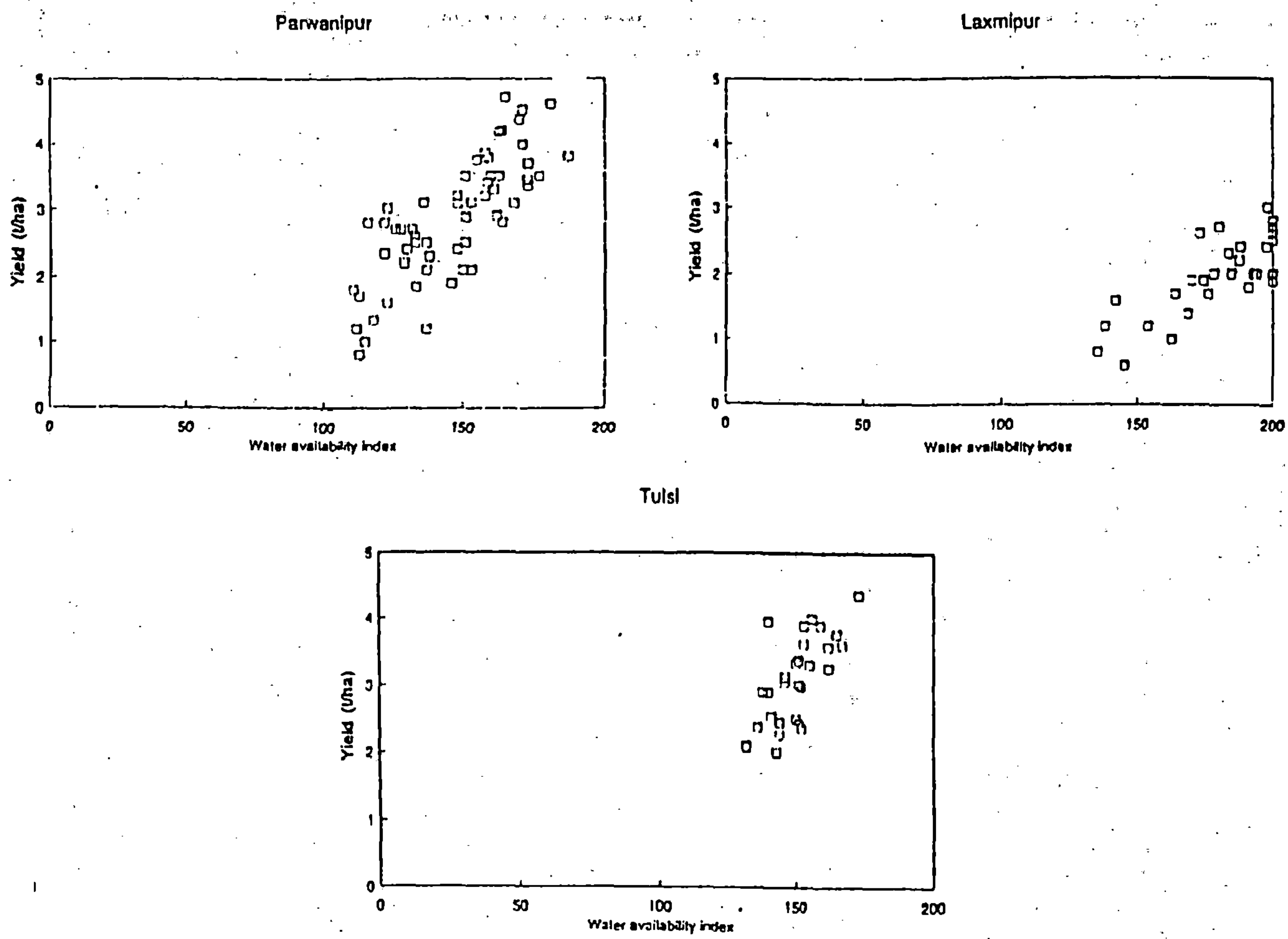
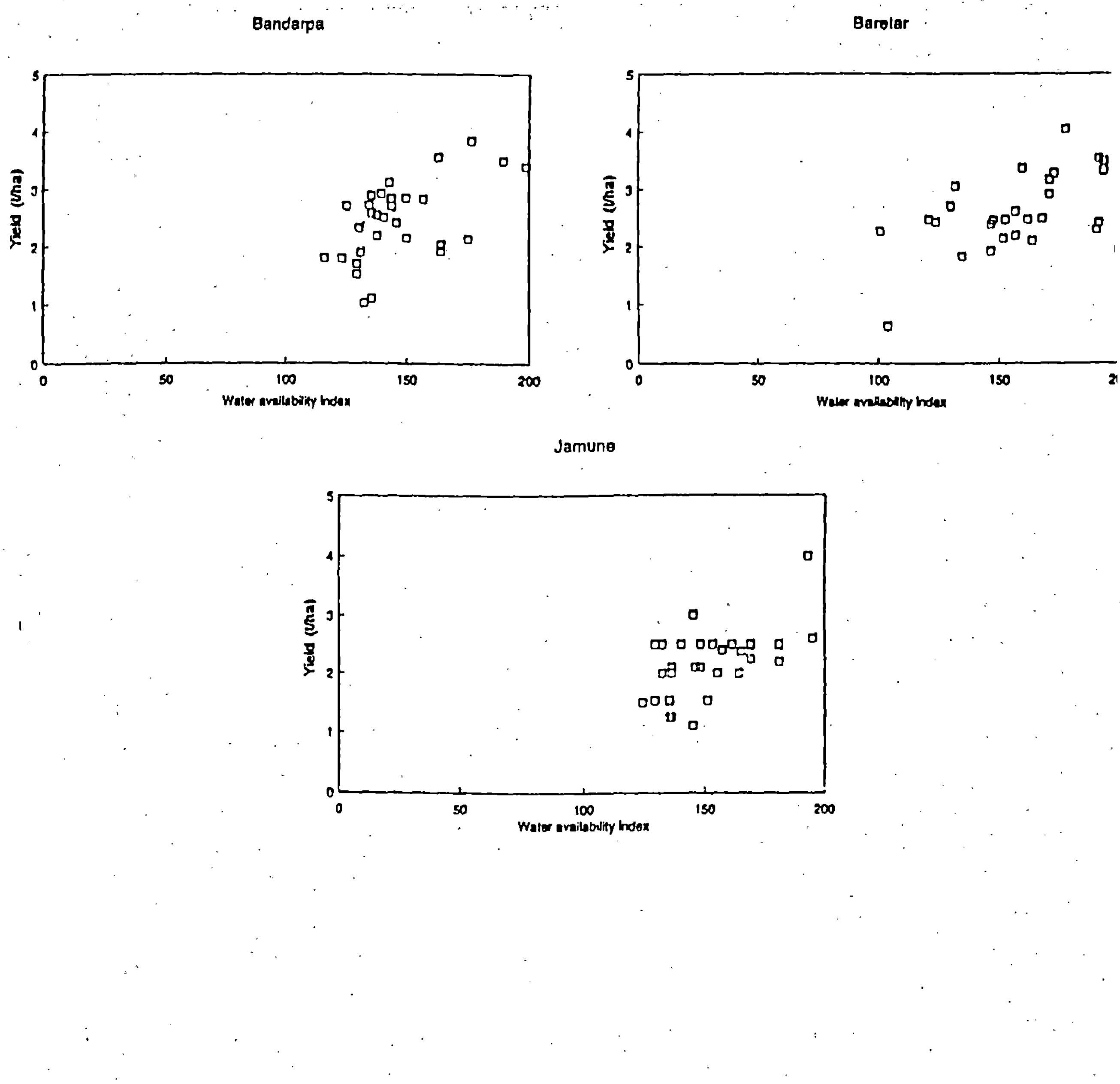


Fig. B-2 (a) Water availability index and yield in three Terai system in Nepal.



(b) Water availability index and yield in three hill system in Nepal.

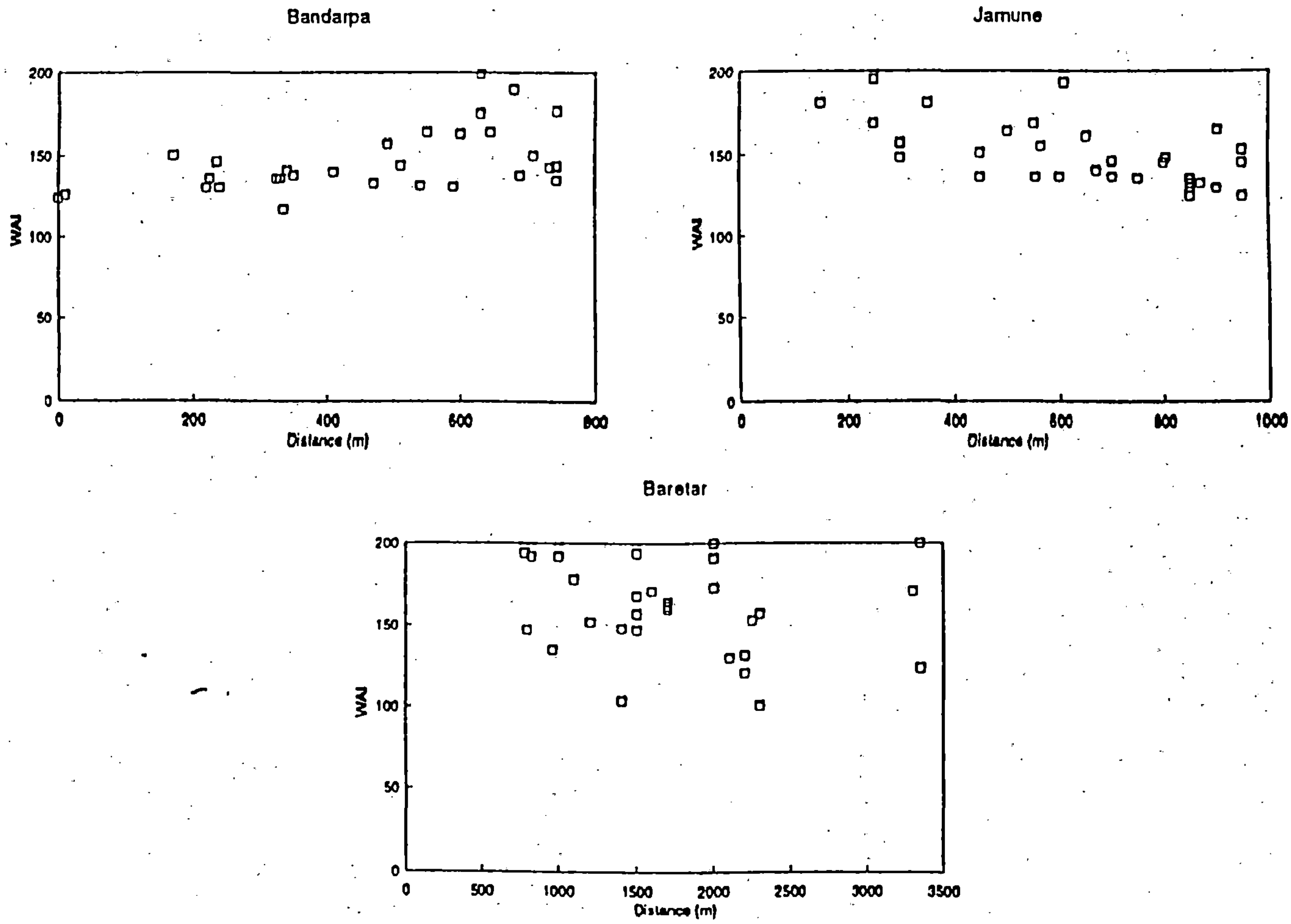
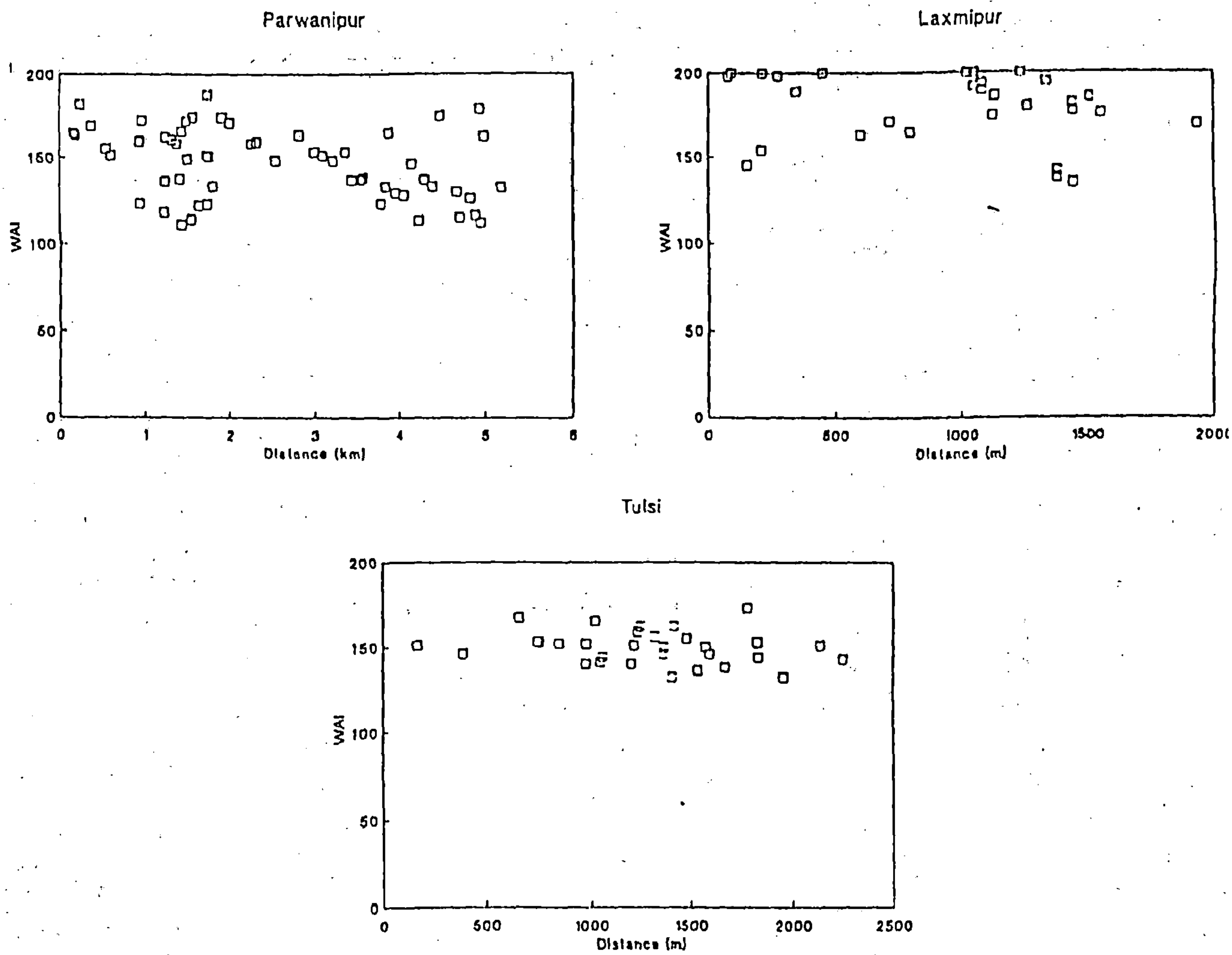


Fig. B-3(a) Relationship between distance and water availability index in hills.



(b) Relation ship between distance and water availability index in Terai

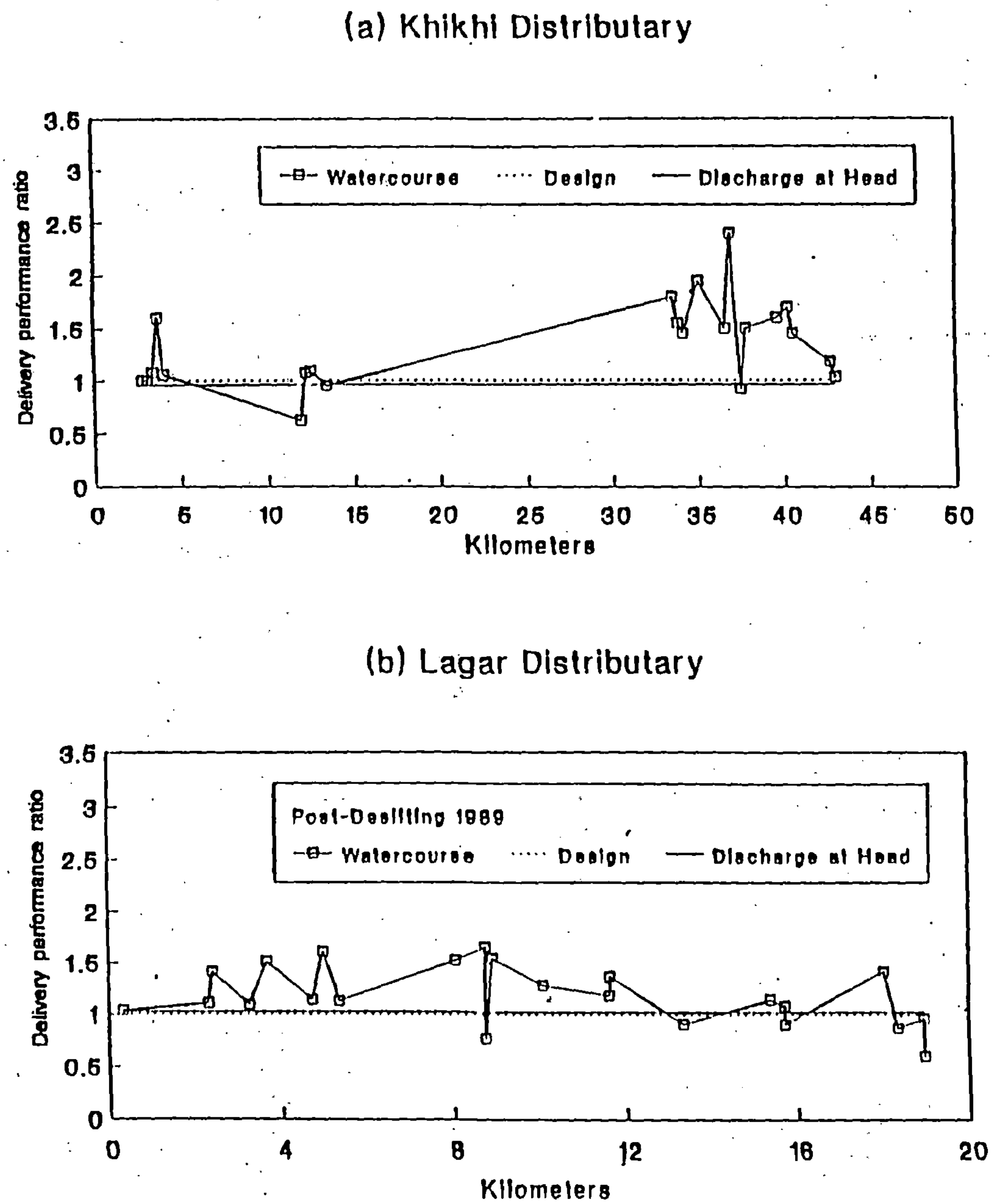


Fig. B-4 Water distribution equity, lower Chenab canal (Pakistan).

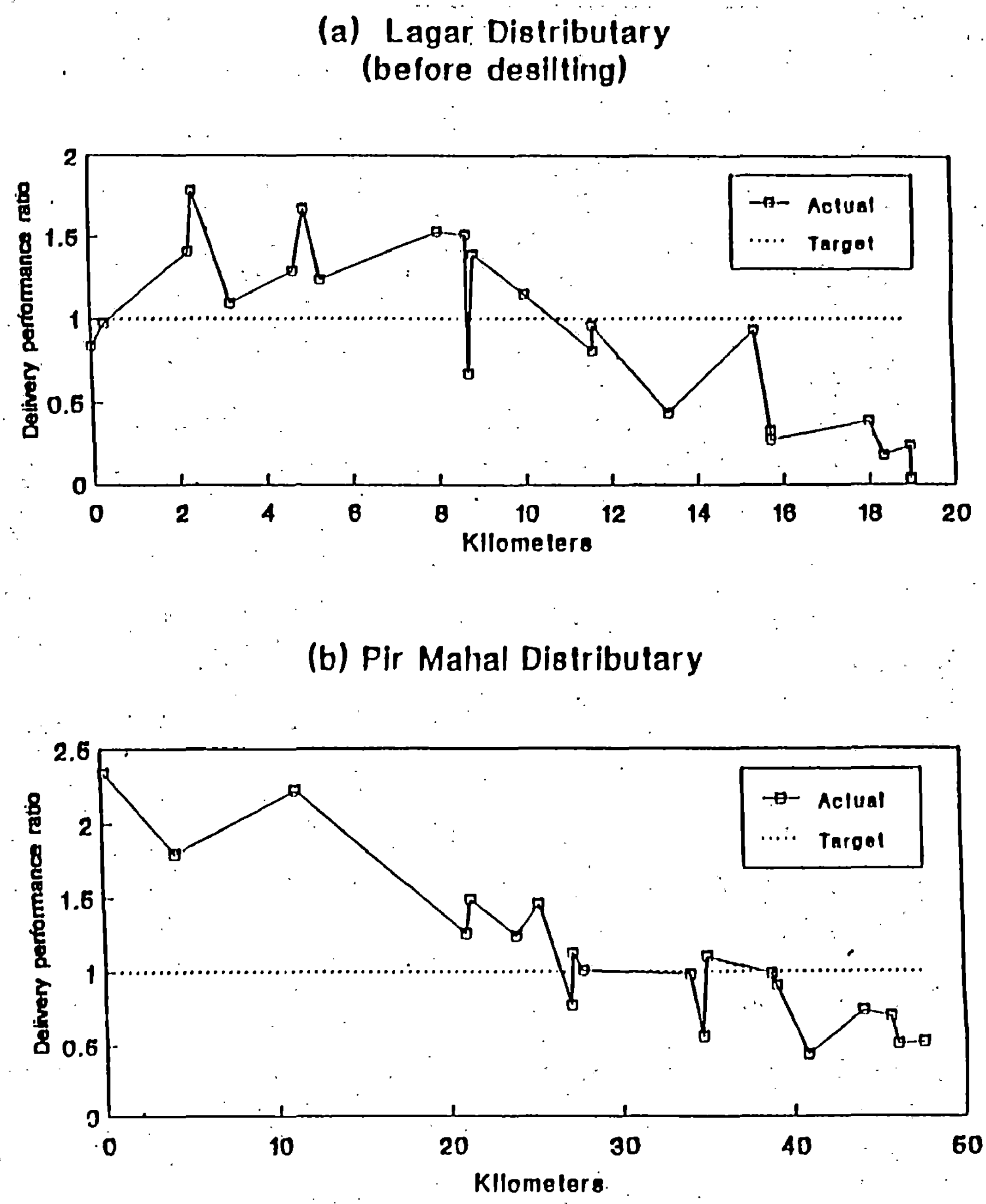


Fig. B-5 Water distribution equity after desilting in lower Chenab canal (Pakistan).

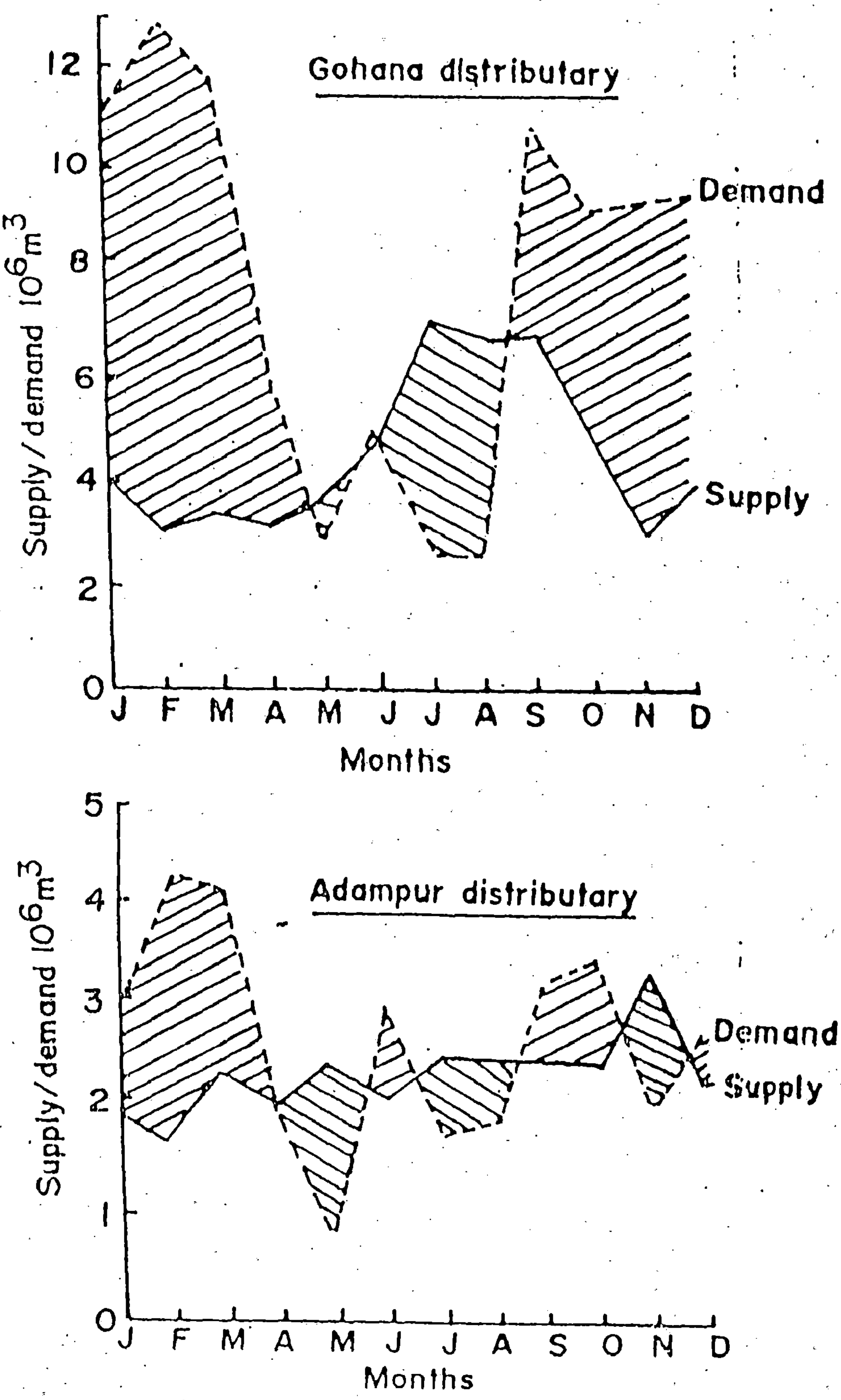
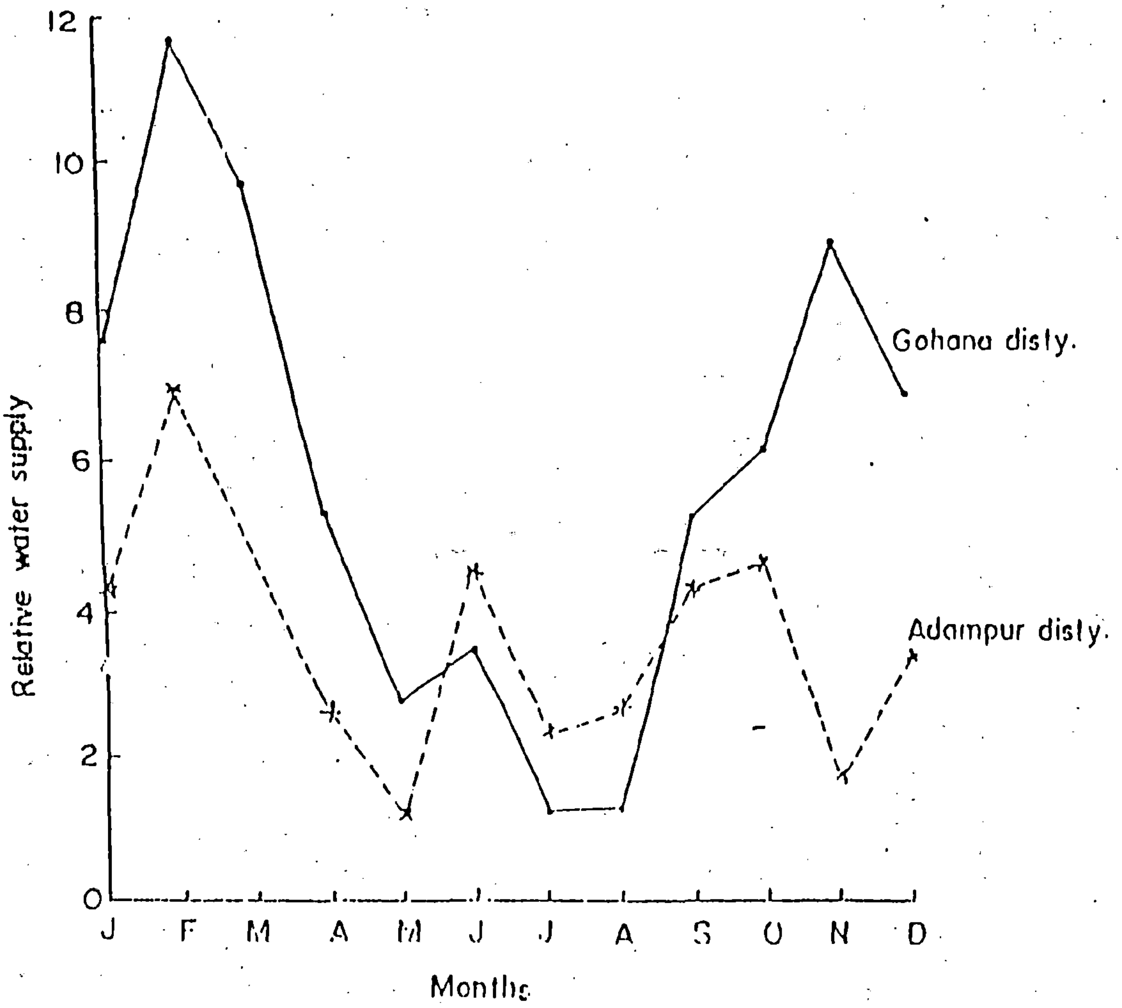


Fig. B-6(a) Irregularity in water delivery in Gohana and Adampur distributries.



(b) Relative water supply in Gohana and Adampur distributries

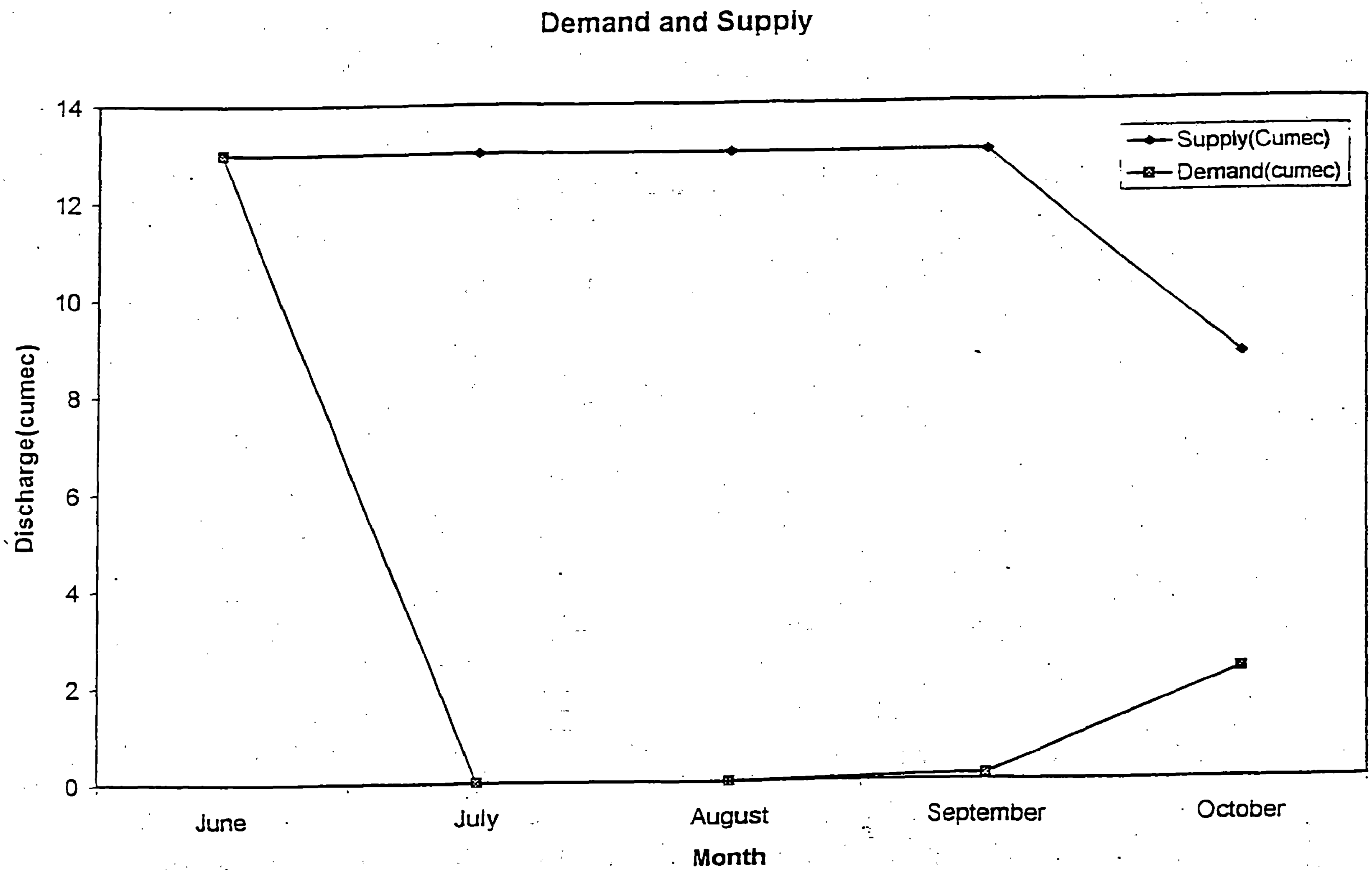
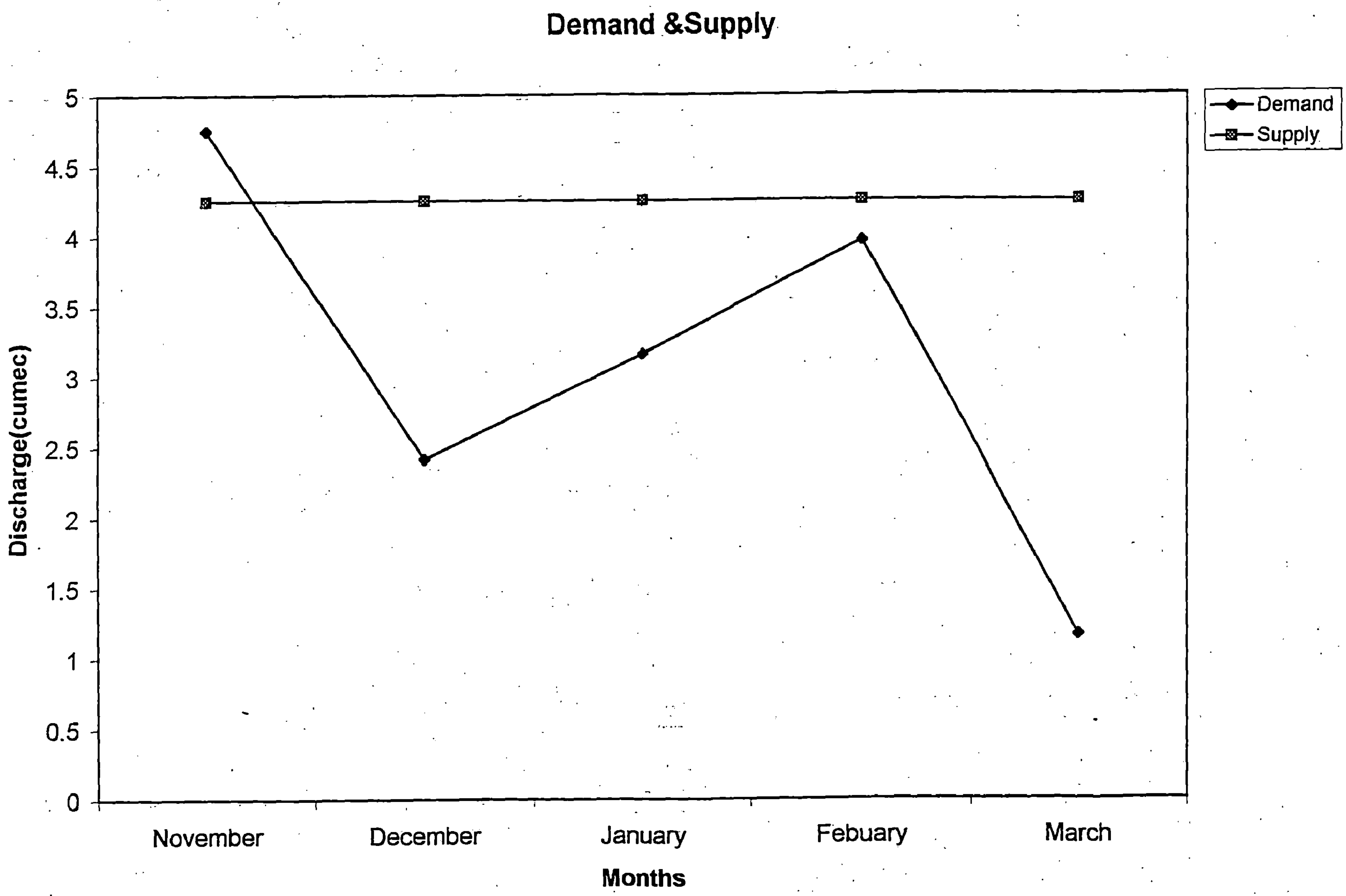


Fig. B-(a) Demand and supply for both stage I and II area for kharif.


Demand &Supply
Demand
Supply
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Discharge(cumec)
November
December
January
Febuary
March
Months