GOLDEN JUBILEE SEMINAR
ON
FIVE DECADES OF PLANNED IRRIGATION DEVELOPMENT: ACHIEVEMENTS AND FUTURE CHALLENGES

Proceedings of the Seminar

held in Kathmandu, Nepal
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editors

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FOREWORD

The Department of Irrigation (DOI) in Nepal came into being in 1952 and its establishment marks the planned irrigation development in the country. The DOI is the principal government agency involved in the planning, designing, construction and management of irrigation schemes in Nepal.

On April 7 and 8 2003, the Department celebrated 50 years of establishment in the form of its Golden Jubilee and various programs were organized during the occasion. The key features of these programs focused on the importance of water for the increased agricultural production. The Department took this opportunity to review critically its past performance and work out a vision for the coming years. For this a seminar entitled **Five Decades of Planned Irrigation Development: Achievements and Future Challenges** was organized and many researchers and scholars, both within and outside the Department made interesting remarks through their papers presented in the occasion. This proceedings is an outcome of the seminar. The seminar provided a forum for sharing experiences and for exchanging ideas about improving the assistance to the farmers in developing and managing irrigation schemes. I hope that the proceedings of this seminar, presented in this volume will contribute to advancing the effectiveness of assistance to irrigation systems and raise the awareness of this important production input to all who are involved in the irrigated agriculture sector of Nepal.

I take the opportunity to thank the editors of this proceedings for their hard work. I thank the International Water Management Institute (IWMI) for providing the financial assistance for the publication of this proceedings.

Jitendra Ghimire
Director General
Department of Irrigation

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We are deeply indebted to all the paper presenters and all other participants for their active participation in the seminar. We would like to extend our appreciation to all those who worked as the rapporteurs during the paper presentations. Our sincere appreciation also goes to Ms. Nira Sharma and Ms. Ranjana Shrestha for their assistance in the publication of this proceedings.

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- Editors

ACRONYMS

ADB	Asian Development Bank
B.S.	Bikram Samsat
CAFT	Center for Agro Forestry Technology
CBO	Community Based Organization
DOI	Department of Irrigation
DG	Director General
DDG	Deputy Director General
DAD	Depth Area Duration
DHM	Department of Hydrology and Meteorology
DL/AP	Diagnostic Learning and Action Plan
DIO	District/Divisional Irrigation Office
EPR	Environment Production Regulation
EIA	Environmental Impact Assessment
ERIP	East Rapti Irrigation Project
FMIS	Farmer Managed Irrigation System
FORWARD	Forum for Rural Women Ardency Development
GIS	Geographical Information System
GLOF	Glacial Lake Outburst Flood
GOI	Government of India
GCA	Gross Command Area
GGG	Guideline for Good Governance
HMG/N	His Majesty's Government of Nepal
IWMI	International Water Management Institute
IMTP	Irrigation Management Transfer Project
ILC	Irrigation Line of Credit
IMP	Irrigation Management Project
ISP	Irrigation Sector Project
MDMS	Multipurpose Development and Management Services
NISP	Nepal Irrigation Sector Project
NGO	Non-Governmental Organization
O&M	Operational and Maintenance
PMP	Probable Maximum Precipitation
PMF	Probable Maximum Flood
PLA	Participatory Learning and Action

PTD	Participatory Technology Development
PCPS	Problem Census and Problem solving
RCNP	Royal Chitwan National Park
SMTP	Sunsari Morang Irrigation Project
SISP	Second Irrigation Sector Project
SIREN	Society of Irrigation Engineers, Nepal
SMHP	Sunsari Morang Head Works Project
SWOT	Strength, Weakness. Opportunity and Threats
VDC	Village Development Committee
WHO	World Health Organization
WMO	World Meteorological Organization
WUA	Water User Association
WUG	Water User Group
WUS	Water Users' School
WECS	Water and Energy Commission Secretariat

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1. BACKGROUND

On 24 September 2002, the Department of Irrigation[1] (DOI) decided to commemorate its 50 years of establishment (Golden Jubilee). On the same day, a main organizing committee was formed with the chairmanship of the Director General of DOI to celebrate the Golden Jubilee. This committee had 51 members representing the present and past officers of the DOI. Followings were the main objectives of the Golden Jubilee celebration.

- To document the historical evidences of the DOI
- To evaluate the present status of the DOI
- To assert directives for irrigation development in future

On 31 October 2002, the main organizing committee met in DOI and finalized activities to be carried out in celebrating the Golden Jubilee. On the same day, five sub-committees[2] were also formed to implement various activities. Another 13 member committee consisting of the convenors and sub-convenors of these committees chaired by the DG, DOI was to coordinate the overall activities. Of these committees, the seminar management committee had the overall responsibility of managing a one-day seminar, which is the main concern of this proceedings.

On 8 November 2002, the seminar management committee finalized the main theme of the seminar which is entitled as "Fifty Years of Irrigation Development: Achievement and Future Challenges". Followings were the selected sub themes:

Technology	Poverty alleviation
Institution	Gender issues

[1] The Department of Irrigation (DOI) was established on 1952.

[2] These include finance committee, publication committee, seminar management committee, stall management committee, and stage management committee.

Legal aspects of irrigation development
Stakeholders' participation
Irrigation and poverty
Integrated water resources management
Irrigation and environment
Developmemt programs

The seminar management committee announced call for paper on 20 December 2002 through national newspaper. All together 18 papers were received for consideration, of which 10 were selected for presentation. The seminar was held on 8 April 2003.

2. SEMINAR INTRODUCTION

History of agriculture and irrigation dates back to centuries. The old and traditional farmer canals such as Raj Kulos in various districts in hills as well as in terai speak themselves of the unmasked engineering and endeavors carried out in the past.

The modern era of irrigation started with the initiatives from Chandra Shamsher, the Rana Prime Minister, who asked his government to construct what is named as Chandra Canal in Saptari District. Then followed by the Juddha Canal presently known as Manushmara Irrigation System in Sarlahi District, Jagdishpur reservoir presently known as Banganga Irrigation System in Kapilbastu District and so on.

However, the process of planned irrigation development commenced only after the popular revolution of 1951 (2007 B.S.), and more precisely, after the formulation and implementation of periodic development plan in 1957(2013 B.S.). Almost immediately after the advent of democracy, the Department of Irrigation was established as Department of Canal (Nahar Bibhag) in 1952 (2009 BS) with Er. Medini Nath Bhattarai as the first Nepali Chief Engineer in 1957. With establishment of the department, irrigation development in the country started through institutional plan and process.

With the long voyage of fifty years through all the troubled waters on the way, the DOI has gained maturity, has expanded its organization structure and has achieved decisive accomplishments, though there are rooms not to be fully satisfied. The Department, which was just an ill furnished room at Singha Durbar in 1951, now owns a large modern building to umbrella its all staffs. It has its own office buildings in all of its own more than 100 field offices. By manpower, the department of just four persons in the beginning has now the power of 1,545 personnel with some of the most brilliant and highly skilled officials. By service, the country had only 6,228 ha of government irrigated areas of the nation's 1.76 million hectare irrigable land in the beginning, which has now expanded to 820,502[3] ha, an increase more than 100 folds. Water Resource Act, Irrigation Policies, Regulation, and many more changes have been enforced to support the overall irrigation development process.

Over the five decades, DOI has created and maintained its lead role in developing and providing planned irrigation service to the farmers, the target group. However, it is to be realized that there have been success stories and failure stories in its history while nurturing DOI to its present adulthood. And, there is a long way yet to cross before all the potential lands are irrigated and before all the potential water resources are exploited.

It is therefore imperative at this threshold of Golden Jubilee Celebrity to sit together with all concerned and make brainstorming. The history must be respected by commemorating it and by learning lessons from its treasure. At the same time, while we judge our status of the present, we should also open up the spectrum of light to shape up our future direction and express our commitment to take the said direction sincerely and try the best we can to meet the challenges and achieve the institutional goal.

[3] Other than the areas irrigated by the agency managemend irrigation systems, this figure also include areas irrigated by farmer managed irrigation systems modernized under different programs.

The Seminar was expected to offer forum and opportunity to initiate the same in black and white. The theme of the seminar was therefore, "Five Decades of Planned Irrigation Development: Achievement and Future Challenges". It was a one-day seminar which had two technical sessions. A total of ten papers were presented in the seminar. Annex II presents the detailed program of the seminar.

2.1 Objective

Objective of the seminar organization was to review the past experiences of DOI in its total activities of planned irrigation development and recommend guidelines for future direction the Department should take in making the irrigation development more effective, sustainable and result oriented. It was expected that the seminar would address the issues in irrigation development: institutional, policy and program related, the issues of sustainability, poverty alleviation, environment conservation and social transformation while preparing strategical framework for future irrigation development.

2.2 Theme/Sub themes

The following Themes/Sub themes were selected as to be included in the papers that were presented in the seminar:

Theme: Five Decades of planned Irrigation Development: Achievements and Future Challenges. The Sub themes selected to illustrate the main theme were:

- Technology
- Institutional aspect
- Policy
- Legal aspect
- Development Programs
- Farmers Participation
- Poverty alleviation
- Integrated Water Resource Management
- Gender issues
- Irrigation and Environment

3. OPENING CEREMONY

Mr. Bhubanesh Kumar Pradhan chaired the opening ceremony of the seminar program,and Mr. Dipak Gynwali; former Minister of Water Resources was the chief guest. Mr. Shiva Kumar Sharma and Mr. Sagar Raj Gautam were appointed as rapportuer for the first technical session. The program started with a welcome address and presentation of the overview of the program by Dr. Umesh Nath Parajuli. It was followed by a keynote address by the chief guest Mr. Dipak Gynwali. In his keynote address Minister Gynwali emphasized the importance of water for increased agricultural production. He said that it was a very good opportunity to look back with pride and see what had been achieved in the past fifty years while at the same time to come up with self-criticism in order to see what the rooms for improvement are and with that to move forward for the next fifty years. This he said was equally important as the new irrigation policy is in the verge of its finalization. He gave an opinion on declaring the coming year as 'The Year of Management' and to focus on the management aspects of irrigation, completing the ongoing projects while at the same time initiating new plans and programs. Another way he said is to put the irrigation management in a much more sound legal footing which would put on the owners an obligation to deliver the water only when needed and only the quantity needed. Mr. Gyanwali emphasized the need of balancing climatic variations and to make sure diversion structures get sufficient water for which the best options would be storage of surface water optimal use of groundwater. He also raised the issue on intersectoral collaboration on the use of water to remove the confusion on which department would take the initiatives.

The Chairperson, Mr. Bhubanesh Kumar Pradhan, expressed his gratification on being able to take part in the auspious occasion. Having worked in the irrigation sector for 21 years he shared the history of the department and summarized how the department with only 4 projects on hand has now reached in every parts of the country providing irrigation to over 1.1 million hectares of

land. He further said that the efforts made by DOI could only prove to be effective if its services help to increase agricultural production and ultimately aid in promoting the overall national economy

4. SUMMARY OF PAPERS PRESENTED IN THE SEMINAR

4.1 Participation and Governance in Local Water Management

- Puspa Raj Khanal

This paper is about participation in irrigation water management. It questions the ongoing approaches to local water management emphasizing participation and local governance. It argues that such approaches still reveal shortcomings especially on their simplistic views on local organization and participation and calls further shift in current approaches to initiate and sustain local water management. Such a new approach needs to consider wider support and networking from relevant stakeholders and be adoptive with dynamic nature of different water control dimensions, so that complex problems of water management can be locally developed and sustained. Examples are drawn from case studies materials from Nepal.

4.2 Guideline for Estimation of Probable Maximum Precipitation (PMP) for Probable Maximum Flood (PMF)

- Dr. Binod Sakya and Som Nath Poudel,
Silt Consultants (P) Ltd

Probable Maximum Precipitation (PMP) is defined as the greatest depth of precipitation for a given duration meteorologically possible for a given size storm area at a particular location at a particular time of year with no allowance made for long-term climatic trends. Current knowledge of storm mechanisms and their precipitation-producing efficiency is still much to be studied to get precise evaluation of limiting values of extreme precipitation. The guideline for PMP estimates,

therefore, should be carefully approached and must be considered as approximations. The accuracy, or reliability, of an estimate depends basically on the amount and quality of data available for applying various estimating procedures. Procedures for estimating PMP cannot be standardized as they vary with the amount and quality of data available, basin size and location, basin and regional topography, storm types producing extreme precipitation and climate.

Following two methods have been recommended for the estimation of PMP out of which hydro meteorological method looks more convenient as it shows the extreme rainfall distribution with area. Statistical method also can be used for the estimation of PMP.

(a) Hydro Meteorological Method: The three main steps in the hydro meteorological approach in estimating maximum precipitation to transpose storm values, transpose maximum values, maximize storm values, and then envelope the transposed maximum values. The simple and convenient way of storm maximization is moisture maximization and guideline is developed for the same.

(b) Statistical Method: Statistical approach is one of the simplest ways to evaluate concerned PMP. Statistical procedure may be used wherever sufficient precipitation data are available, and are particularly useful for making quick estimates, or where the meteorological data, such as dew point is lacking.

Most of the rain-gauging stations in Nepal are non-recording types, and the published climatological and precipitation records hold mainly daily rainfall and some available hourly data were co-related.

Separate guideline for the estimation of PMP has been developed for following basins to cover entire area of Nepal.

(i) Karnali basin (includes Mahakali basin as well)
(ii) Narayani basin
(iii) Bagmati basin

(iv) Sapta Koshi basin
(v) South-Eastern Basins

For all these basins, as a first step, the maps of 24-hour rainfall intensity have been developed and presented. Then the Depth Area Duration (DAD) curves were constructed based on the GIS numerical methods of map analysis. The relationships between average storm precipitation depth (Y-axis) and area (X-axis) for corresponding rainfall events are shown in graphs.

Finally general instruction for estimation of PMP has been provided and a worked out example for PMP estimation of Kulekhani Watershed at the dam axis site has been computed for ready reference to the guideline users.

4.3 Sunsari Morang Irrigation Project: Development Prospective

-Er. A.K. Pokharel, Er. K.R. Dahal, and Er. S.K. Pokharel

The paper is about Sunsari Morang Irrigation Project (SMIP), which was originally developed some 4 decades ago by the Government of India, and the Government of Nepal is in the process of modernizing part of the project area with the technical and financial assistance of the World Bank. SMIP is the largest irrigation project in Nepal, which receives water from the Kosi River and commands an area of about 68,000 ha. The project still requires huge amount of investment for modernization of its remaining command areas.

This paper analyzes the past, present and the future of the project on the basis of demand and supply theory. The past of the project is divided into two time periods. They can be termed as before hand-over of the system to the Government of Nepal by the Government of India, and after the period of handover. The present situation is the effect of the past actions in the Project. This paper concentrates on the development works of SMIP carried out in the past and analyzes them from the perspective of present demand and future requirements.

The paper views that despite of huge amount of investment since the last four decades the project is still suffering from several obstacles. Some of these obstacles are:

- Many structures are already 40 year old and so have lived up their life
- The main system, as designed some 40 years ago, is unable to fulfill the present demand of multi crops
- The system cannot divert (or acquire) required amount of water from the Kosi River during the dry season, and
- Institutional framework does not match the existing infrastructure

The paper concludes that solving the major obstacles observed in the system at present may not be adequate to meet the fast growing demand of the people. More accurate and efficient system providing irrigation round the year is the demand of the future.

4.4 Effectiveness of river training works

- S.B. Upadhyay

This paper attempts to present an overview of effectiveness of river training works in the devastated areas caused by erosion and sedimentation. The rivers that flow through the Nepalese territory originate not only from different altitudes of the country but also have catchment areas lying in India and Tibetan region of the People's Republic of China, too. All the rivers ultimately join the river Ganges.

The Glacial Lake Outburst Flood (GLOF) and erosion (natural and manmade), of the catchment area are the major processes of the sediment production. The increased bed load that exceeds the carrying capacity of the river is deposited along the river course. In this situation, the original course of the river is blocked by sediment deposition and the river changes to new course devastating the fertile land and the populated area, thus damaging the life and property. So for its protection, river training works have to be done in such a way that river flow may be confined to certain channel. The effectiveness of river

training works cannot be judged immediately; it is only possible after years of experience of floods. A number of river training works were carried out in the past, some of which are functioning well but others are not. Investigation on reasons for such success and failure will certainly offer lessons to be considered in an attempt to develop relevant technology, such as preparation of technical manuals etc. In this connection, to assess the effectiveness of river training works, field survey was made for about 50 sites in the eastern and central regions of Nepal. Among the 50 sites, 38 sites were considered as typical examples and out of which 18 are examples of success and 20 are of failure. Similarly, such events which have already been experienced in other sites should also be analyzed in detail.

4.5 Participatory Learning in Irrigation Management An Experiences from "Nepal: Guideline for Good Governance Project"

-Dhruba Raj Gautam[4]

The livelihood of Nepalese farmers is highly dependant on agriculture so the role of irrigation is very important. There have been many efforts to make irrigation more sustainable but the results have not so appreciative. Irrigation is a complex socio-technical process so only institutionalized institution can manage it. A lot of resources have been invested in the name of capacity building and institution development of institutions through training, workshop and exposure tour, the results are still not so favorable.

So far, in the name of institutional development, most initiatives started with little consultation of stakeholders, and were in response to external pressures. Now there is a growing realization that institutions must be based on the local situation, culture, need of farmers if they are to continue to operate in the

[4] Mr. Gautam is PhD Research Student in Sociology. He is currently associated with Nepal: Guideline for Good Governance Project as Participatory Learning and Action (PLA) Specialist. This project is implemented by DPCS/DoI/Mott MacDonald and funded by DFID (UK).

long run. Local farmers, rather than outsiders should initiate the process. This is essential if farmers are to feel ownership of the system, which is one of the fundamental requirements for institutional reform. Sustainable and equitable distribution of irrigation water is indeed needed to improve the livelihood of rural farmers. So well governed irrigation institutions are crucial.

In order to examine some of theses issues, a Participatory Learning and Action (PLA) Program is being implemented in a few irrigation systems in Nepal with the funding assistance by DFID UK. The major thrust of this program is to use various participatory tools and techniques to involve stakeholders in planning the institutions and institution-building process. Through these detailed diagnostic studies, we have identified many issues that are important for sustainable irrigation management and we have helped the various stakeholders (including landless, poor, women, sharecropper and tenants who are often excluded from WUAs) to develop an action plan suited to their specific needs. These action plans are now being implemented through the medium of Water Users' Schools (WUS), which involve a wide range of stakeholders and help the users to develop their skills and institutions to meet their specific requirements. The programme has been initiated at Sunsari Morang Irrigation Project (a large joint-managed scheme) and Kamala Uttarbahini Irrigation System (an FMIS), with further work due to start shortly at Bijaypur Irrigation System.

This paper summarizes some of the initial experiences of this program, such as the participatory tools and techniques used to involve the stakeholders in collecting socio-economic and socio-technical information on agriculture, institution, water management and infrastructure; the modality of this detail diagnostic study; and the process of preparing action plans. This paper also includes some ideas on the modality of water user schools, selection criteria for WUS participants, how the messages are spread from the school to the wider community

used to strengthen the users' institutions in a cyclic manner. Nepali farmers have wealth of knowledge and skills.

4.6 A Case Study: Environmental Monitoring and Management of an Irrigation Project

-Subarna Bahadur Joshi, Environmental Engineer, GEOCE Consultants (P.) Ltd.

East Rapti Irrigation Project was initiated in 1987 with the assistance of Asian Development Bank, Manila. The Project is located in the periphery of the Royal Chitawan National Park, a World Heritage Site designated by United Nations Educational, Scientific and Cultural Organization in 1982. The Park supports one of the last remaining habitats of the one-horned Asian Rhinoceros, Bengal tiger and various plant species. East Rapti River, the source for irrigation, passes though the Park and it is one of the major sources of water for the habitats of the Park also. Initially the proposed project was to construct a diversion weir across the river and provide the irrigation facilities to about 9500 ha. of land in the Chitwan Valley. Serious environmental concerns were raised by the international and national environmental groups against the implementation of the project due to the possible dewatering at the down stream of the diversion weir, especially in the dry season. The project was reformulated and scale down to 5200 ha. The reformulated project was (i) to increase the efficiency of the water use without increasing the withdrawal of water for irrigation from East Rapti River and (ii) to provide irrigation water by groundwater resources. There were still environmental concerns in the revised project. They were (i) the improved irrigation systems might abstract more water from the river which could affect the dry season flow in the river (ii) the intensive exploitation of the groundwater resources may deplete the ground water resources which might affect the growth of riverine forest in RCNP and (iii) residual traces of pesticides and fertilizers on the surface water of East Rapti River could be dangerous and fatal for the habitats of RCNP. To address the above issues, a comprehensive environmental monitoring of both surface water and

groundwater in terms of water quality and quantity were carried out from September 1994 to July 1998.

The monitoring concluded that there is substantial base flow from groundwater to surface water of East Rapti River during the dry season when the water level in the river is lower than the groundwater level of the surroundings. The minimum discharge during the driest day of the dry season in the East Rapti River at the entry of the RCNP, Sauraha, was more than 6 m^3/s. Hence the environmental impact of the Project on RCNP in terms of water availability for the wild habitats would be insignificant. Even though the sell of fertilizers and pesticides in the Chitawan district is comparatively higher than other districts of Nepal, the residual affect on the surface water and groundwater of the project area were found to be negligible.

East Rapti Irrigation Project is the first project that has been reformulated due to the environmental concern in Nepal in 1989. Since then His Majesty Government Nepal has shown its commitment in the environmental protection while implementing the development projects in Nepal. National EIA Guideline for Water Resources (Draft) was prepared in 1993. HMG/N has enacted Environmental Protection Act in 1996 and followed by Environmental Protect Regulation in 1997. The EPR has been amended in 1999.

4.7 Five decades of planned irrigation development: Achievement and future challenges - *Gambhir Bahadur Hada*

The paper first describes the importance of irrigation in increasing the level of agricultural production and thereby raising the livelihood of local community. The paper then outlines the achievement made in the last five decades in developing country's irrigation systems. Finally, the paper describes the objectives of the ninth five-year development plan, and discusses the future challenges of irrigation development. Some of the future irrigation development challenges as outlined by the paper are:

- Irrigation water treated as social good rather than economic good
- Erratic floods in the river systems
- Lack of appropriate technology for year round irrigation
- Lack of participation in irrigation management
- Poor collection of irrigation service fees

The paper concludes that it is essential to address these obstacles in order to raise the productivity of irrigated agriculture.

4.8 Organization Dynamics for Department of Irrigation (A Discussion Paper)

- Mahendra B. Gurung

Department of Irrigation (DOI) has undergone many changes in many aspects since its establishment in 1952 (2009 B.S.). In 50 years, it has brought about remarkable accomplishments in terms of irrigated area. Also, the manpower within the Department has increased and marveled in terms of number, qualification and experience.

However, the performance of the Department in the later part of its history seems to have come under criticism from inside and outside. The paper has attempted to look into the problems and issues arising in both the sectors, has tried to analyze in rational way and has come up with a set of proposals. The paper proposes models for on-the-job cycle, transfer, academic promotion, planning the program, behavior, annual workshop and environment of political system.

In order to make the organization dynamics work for the Department, it is imperative to address the issues described here in and carry out some corrective measures. The programs are lacking and seems that there may create a vacuum in near future if the organization dynamics is not permitted to work. The investments also seem to decline in recent future. The new programs such as NISP, SISP, IMTP, etc have fallen short of meeting the set targets even though there are claims that the lessons have been learned in the past. This shows that there are some problems or shortcomings which stand to hinder the

process of organization dynamics, the basis for success of an institution. The paper has also touched other aspects while describing evolution process of DOI and focusing mainly the existing issues related with organization dynamics.

4.9 Micro Irrigation- A potential Irrigation Technology for the Future

- Indra Lal Kalu

Irrigation is the hope to alleviate poverty and ensure food security in Nepal. The conventional irrigation system use water less efficiently causing many problems. Less area is irrigated than the target and to cope with these problems micro irrigation technology that permits precise irrigation can be of use.

A low cost dip irrigation kit in use is described here and the various benefits that is possible like water saving and more yield from less water besides less weed infestation etc. are listed. A brief account of the study carried out in the three mid hill districts are also pointed out.

4.10 Canal lining with gabions covered with cement sand plaster

-Basu Pokharel

The paper describes a technology of lining canal by cement sand plaster applied over gabion, also known as Reno Mattresses. The paper claims that such lining facilitates self-cleaning of the canal, prevents the vegetation growth, and allows the use of light mechanical equipments for cleaning the canal. The paper discusses about the characteristics, stages of construction, productivity and costs of such lining. The paper also provides general specification for its construction. The paper claims that this technology is cheaper than a 10 centimeters thick concrete lining, and it is technologically more efficient.

5.1 PARTICIPATION AND GOVERNANCE IN LOCAL WATER MANAGEMENT.

- Puspa Raj Khanal

ABSTRACT

This paper is about participation in irrigation water management. It questions the ongoing approaches to local water management emphasizing participation and governance. It argues that such approaches still reveal several shortcomings especially on their simplistic views on local organization and participation and calls further shift in current approaches to initiate and sustain local water management. Such a new approach needs to consider wider support and networking from relevant stakeholders and be adoptive with dynamic nature of different water control dimensions, so that complex problems of water management can be locally developed and sustained. Examples are drawn from case studies materials from Nepal.

1. INTRODUCTION

The paradigms for rural development pursed and practiced in developing countries have transformed greatly since the 1950s. Failure to achieve intended results through transfer of technology policies caused shift towards a more user-centred approach to development, and 'people first' development model based on popular participation gained popularity in the 1980s and 1990s (Brukley, 1993; Chambers, 1997; Cernea, 1991). Structural adjustment and neo-liberal polices of the 1990s further shifted attention from participation to local governance.

The focus of water resources management has also shifted accordingly, from technology transfer towards decentralized and user-centered approaches emphasizing participation and local organizational development as explained by Clyma (1989), Uphoff (1986), and Korten (1984). This has changed the development problematic in two ways: Firstly, the focus has shifted to the promotion of local water management through

user organizations; secondly, design approaches have also shifted towards participatory design processes to support organizational evolution. More recently, attention has been shifted towards promotion of local governance and transfer of irrigation management to user groups commonly referred to as Water Users Associations (WUAs), has been central in the irrigation reform process (Vermillion, 1999; Meinzen-Dick et al, 2002, Johnson et al., 2002) This shift has been n response to structural adjustment is considered as prerequisite to create effective forms of local organization to govern and manage irrigation water.

This paper traces the evolution of changes from participation to local governance in irrigation water management. It reviews the current participatory approaches to initiate and support organizational evolution to take up water management and their strength and weakness. It argues that governance involves divergence forms of regulation and control, and programs seeking to establish local governance in irrigation water sector has to acknowledge these different water control dimensions and create necessary legal and political support mechanisms without limiting to participatory support process and capacity development of local organization.

After this introductory remark, the paper in section two presents different development context of participation. It then reviews current approaches of organizational development process to govern and manage irrigation water and also explores role of support process in organizational evolution. It then presents case study materials from irrigation management transfer project in Nepal. The paper finally ends with concluding remarks in section 5.

2. THE DIFFERENT DEVELOPMENT CONTEXT OF PARTICIPATION

Participation can be defined in many ways and is often seen as transaction between the farmers and the engineers (or

facilitators)[5]. This paper rather looks at the origins of participatory efforts and the methods used. Participation does not operate in vacuum, it is linked with certain development objectives. It is argued here that there are different development contexts linked to participatory frameworks for intervention, and there are different domains of action in participation (Khanal, 2003, Vincent and Khanal 2002, Vincent 1997). The different development context of participation does have different concepts of innovation and different sets participatory methodologies linked with them.

2.1 Development context 1: Economic development and modernization

In this context, participation is an approach (by agencies) to induce in creases in performance or impact, through providing conditions or incentives that enable farmers to take on new responsibilities and opportunities. Participation here has moved beyond project execution to policy reform and self-governance, and even been considered the way to operationalize decentralization as the motor for democratic transformation (Cornwall, 2001). Innovation then concerns new activities that improve linkages between resource use and production new techniques, artifacts or institutional relations. In irrigation water management, its primary focus is on institutional reform to both local organization and the irrigation bureaucracy, but also heavily focused to system modernization to provide better working conditions for farmers. It lays emphasis on participatory design processes to support evolving organization, and calls for accountability between the irrigation agency and the WUA and between the WUA and the farmers. Thus, participatory approaches that allow local negotiation and evolutionary change rather than blue-print models work best. However, it is vulnerable to blueprint ideas about WUA development and new technologies, and over expectation of

[5] The detailed account of participation is beyond the scope of this paper. For more discussions, see also Khanal (2003), Vuren 1998, Musch, 2001, Cook and Kothari, 2001.

what users can do. Bureaucratic reform is a time-consuming process. and is often outside the framework of funding agencies. This context of participation is the backdrop to the ongoing Irrigation Management Transfer Programs (IMTP) and its policy tools and intervention approaches.

2.2 Development context 2 : Joint planning and problem solving

Here, participation is a process through which stakeholders influence, share control and work together to achieve desired change. Innovation is shown through the changed behaviour of the people involved and the sharing of knowledge and skills. This context focuses on the generation, transfer and exchange of knowledge as a means to beneficial change. It recognizes that technology is not neutral and technological change should reflect local needs and knowledge. Also that people have a right to self-determination over their development. In the field of technology development in this context, Participatory Technology Development (PTD) has got considerable attention as an approach. However, the technical biases of many engineers and their sense of status that makes them unwilling to accept farmers as partners and lengthy bureaucratic process often yields failure to make design process participatory.

2.3 Development context 3: Social inclusion, improved equity and reduced vulnerability

Participation here is organized efforts to increase control over resources and regulative institutions in given situations on the part of groups and movements of those hitherto excluded (a definition from an ILO Program). Innovation is the delivery of different benefits to different people, This context recognizes the tensions and complex politics of negotiating change in many different arenas. but needs highly motivated and conscientized actors to empower change. It is committed to capacity development of the users groups and concentration on the certain marginalized groups. However, the danger may come from its conscientizaion and political action, which may lead to

collapse of existing management arrangements without new forms to replace it.

Water management in recent years is more focused to the development context 1 and the other two are seen as supporting elements to achieve better service provisions.

2.4 Domains of Participation

There are also different domains of actions in participation between users, and other social actors. These different stakeholders can have different interests and sphere of influences in local water management. The different development contexts of participation together with the different domains of interactions constitute a 'Participation Complex' which shapes the outcomes of local water management. In a real-world situation, a program execution can involve all the different development contexts together, requiring understanding of the clashes these can bring between people with different aims and objectives in participation.

3. CURRENT APPROACHES TO LOCAL WATER MANAGEMENT

The current approaches to local water management can be summarized into two key actions:

- Development and empowerment of Water User's Associations (WUAs) as new form of governance to govern and manage irrigation water
- Supporting the new organization through participatory design process to help build up their capacity to manage water and provide better working conditions through more compatible technologies and water management practices.

3.1 WUAs as new form of governance

Work on WUA design and development has generally followed two approaches to institutional design. Researchers like Ostrom (1992) emphasizes governance as a dimension of management

involving the generation of rules for management practice[6]. Another group is more focused in identifying conditions under which the WUA can perform irrigation management tasks (see for example, Vermillion, 1995, Vermillion and Sagardoy, 1999, Groenfeldt, 1999, 1996; Meinzen-Dick et al, 2002). They are more focused on organizational type, size of organization (see for example freeman, et all, 1989), compatibility of structures and clear water rights. Both of these approaches are more concerned over finding appropriate conditions and generating rules to govern and manage irrigation water. However, they fail to understand governance as possible under divergence forms of regulation and control.

These discussions are based on the 'functional model' of the WUA, which describes conditions for the management to work. It is guided by the assumptions that the WUAs are non-partisan, non-political and homogeneous bodies, and perform the irrigation management tasks as designed, These discussion do not show the conditions under which accepted rules and organizations come into being. To understand the dynamics within a WUA and their functioning, their political character has to be recognized.

These discussions also fail to recognize how organization needs external support and networking to govern and manage irrigation water. They are also weak in the way they concern local socio-political dynamics in organizational evolution. Likewise, they also fail to explain how water management is linked to wider control dimensions related to technical and agro-ecological environment which presents different opportunities and challenges to local management[7].

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[6] Governance is seen here as diverse forms of regulation and control used in management conceptualized by a governing institution: a WUA, is only one form of such regulation. Ostrom differentiates between three different layers of rules: the operational rules, collective-choice rules and constitutional-choice rules, which cumulatively shape an irrigation system.

[7] See also Agrawal (2001) and Kloezeon (2002) for further limitations of these approaches.

3.2 Participatory Support Processes and local water management

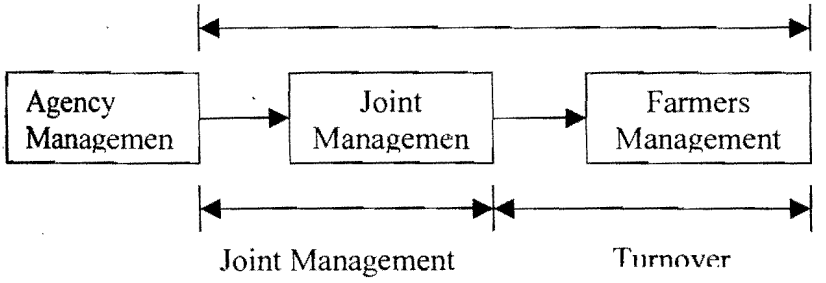
Participatory and process-based intervention emphasizing participation of stakeholders and social learning has been widely called for to support water management. However studies have shown that they fall short in real practice. Though efforts have been made to shift away from blueprint towards the process approaches, in reality, blue-print ideas about project planning and implementation dominates the intervention, and learning and participation are mostly confined at local level of project implementation. Hierarchical organizational structure, lack of organizational learning, shorter time frames, failure to link the project with the broader development objective all pose barriers in maintaining participatory processes. Participatory and process-driven approaches have become a sort of 'good theory, poor practice'. There is a need for fundamental changes in the way projects are designed and implemented to achieve participatory development in real world situation.

Another major constraints in embedding participatory approaches in water management comes from lack of initial learning of the system environment both by the users and outside facilitators. Water resources systems including irrigation systems are sociotechnical systems and technology of the system shapes and are shaped by ecology and society. Designing for participation for water management should thus begin considering both the human and the physical dimension of irrigation systems. The strength of participatory design depends first on what people, both users and designers, know about the system and its opportunities and constraints. Use of participatory approaches without understanding of system environment ultimately leads to its instrumental use without and scope for beneficial change.

4. THE CASE OF IRRIGATION MANAGEMENT TRANSFER IN NEPAL

Since 1999, the government of Nepal began the process of transfer of irrigation management in Agency-Managed Systems to new local organization. The reasons for pursuing this reform in the irrigation sector have been three fold. First there has been increased dependency on the government for system development and management, whereas the performance of the systems has remained relatively poor. Second is the dependency of water resources sector development on donor support, who now favor less government and more private-sector involvement in development activities. Thirdly, it is also inspired by the successful tradition of farmers' managed irrigation systems (FMIS) in the country[8]. The process was formulated around decentralized and user-centred approaches emphasizing participation and local organizational development. "The framework of IMT in Nepal is shown in Figure 1 (Laitos, 1992).

Figure 1 Framework for management transfer process by the DOI Irritation Management Transfer



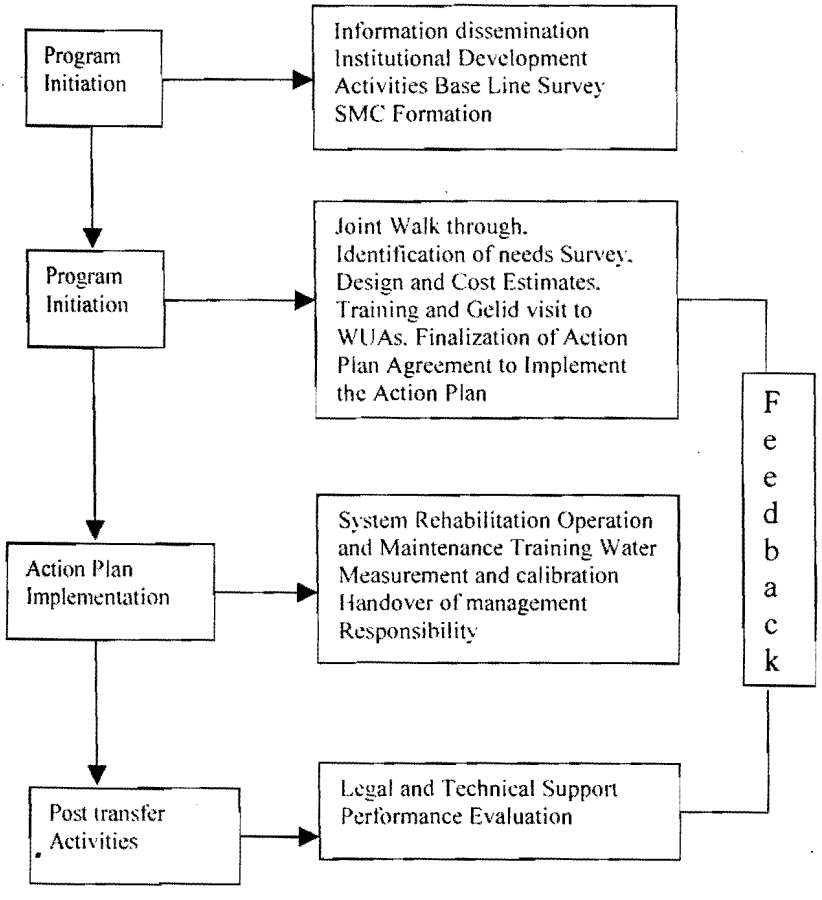
The turnover program aims at the complete transfer of operation and maintenance (O&M) responsibilities of small and medium scale irrigation systems to legally recognized water user groups. 'Turn-over' is said to occur if the whole system is transferred to the WUA. Joint management can follow several forms depending upon the size and technical complexity of the

[8] Irrigation systems in Nepal are classified as Agency managed, Farmers managed, Groundwater systems and private systems.

irrigation system. The most general form for the joint management is that the irrigation agency operates and maintains infrastructure to a certain point of delivery, after which a local organization takes over responsibility of water delivery (Molden 1998). However, joint management domain in Figure 1 may be an intermediate stage to achieve full turnover or a final destination for the management of large-scale irrigation projects.

The project framework for implementing the IMTP as adopted in Nepal is shown in Figure 2. The process has been developed on the basis of experience from previous participatory intervention programs like IMP, ILC and ISP. It consists of four stages: the program initiation an institutional development phase; the action plan preparation phase; the action plan implementation phase; and post-turnover support phase (ADB, 1995). The action plan forms as seen from this framework, the IMT process mainly involves the formation of the WUA which forms the basis of program implementation. It specifies the activities to be carried out during implementation, and the roles and responsibilities of different parties involved in the process. And further support to them through participatory design innovations. It also requires new arrangements between the government and the WUA for the system management. This model of policy implementation for management reform is similar to those widely mentioned in irrigation literature (for example Vermillion and Sagordoy, 1999; Geizer, 1996; and Groenfeldt, 1998). It is influenced by the idea of designing irrigation policy to create conditions under which desired institutions would successfully emerge, for example that would ensure functional infrastructure, debate type and size of organization and allow user involvement at all stages and levels of project implementation.

FIGIRE 2 Project framework for IMTP implementation



The framework shows a top-down approach to designing and implementing policy reform, which Kloezen (2002) refers to as institutional engineering. Farmers were not involved in the design of this frameworks, neither were they informed about the policy reform. The reform itself was not demand-driven, and was induced by the government, as explained earlier. Farmers were told by the DOI that they had to participate in the reform.

Figure 2 clearly shows that the Irrigation Management Transfer (IMT) program in Nepal involves both institutional reform and technical rehabilitation to facilitate decentralization of irrigation

management. However the primary concern is that of a modernization approach to induce institutional innovation.

Initially, the IMT program was implemented in three irrigation systems, namely Khageri Irrigation System (KIS), Panchakanya Irrigation System (PIS) and the Nepal West Gandak Irrigation System (NWGIS). They differ in size, have different social and physical environments and different histories of water management organization. All are gravity irrigation systems supplied by river diversions. Eleven projects were selected to begin the management reform in the country and these three systems were in the first phase of policy implementation. There were different reasons for their selection at the first phase. Khageri and Panchakanya were selected because farmers there were innovative and educated. They also have simple water control structures and a relatively water-scare situation, which is considered to be favorable for inducing collective action. West Gandak was selected because of its potential to provide year-round irrigation to farmers.

The IMT programs in all the three systems were initiated in the mid-nineties. The size and location of the systems are shown in Table 1.

Table 1 Size and locations of the systems

System	*Command Area*	*District*
Panchakanya	600 ha	Chittwan
Khageri	3900 ha	Chittwan
West Gandak	10,300 ha	Nawalparasi

4.1 *The outcomes of the management reform*

However, they have quite different outcomes in terms of their management performance though they were implemented under the same framework by the same implementing agency. In Panchakanya, there has been improvement in water availability, increase in irrigated area and change in cropping pattern. Local people believe in their organization: the WUA is accountable to

its members and is financially capable to take up new management responsibilities. In Khageri, there have been improvements in water delivery schedules, an increase in irrigated area, and change in cropping pattern, but not on the scale seen in Panchakanya. The system falls short in financial viability. However, farmers have strong support to their organization, which has fought battles externally to defend system water supply. Whereas, in West Gandak, the new management arrangement is dysfunctional. The WUA has lost its credibility and acceptability at local level. Attempts to improved system performance through local organization here has been rather disappointing resulting in frustration and demoralization of the local community.

Incidentally, the scale of change in these systems is in parallel with their service area: the Panchakanya is the smallest among the three with 600 ha area and has better outcomes in terms of service delivery whereas the West Gandak, the largest with 8700 ha command area, has experienced in management incompetence. However, these variable outcomes cannot be looked at simply with respect to their area, but also at the challenges of regulation and control of the wider environment (both socio-political and the physical-technical) of system management.

Both Khageri and Panchakanya have relatively simple water control structures and free from threat of inundation and flooding. Farmers are relatively more educed and innovative and knowledgeable in collective action in irrigation development and management. The WUAs were able to craft their institutions as needed, expanded their networks and provide continuity in water management. On the other hand, the West Gandak has much complex biophysical environment and water management is a daunting task for new local organization. Besides, farmers here were less aware of collective action in irrigation development and management. The WUA was seen as platform to check the strength of the political parties and WUA agendas were heavily focused by the party politics. As its command area

covers two parliamentary constituencies, the WUA became a springboard to jump ahead in their political career for aspirant politicians. Farmers on the other hand were salient because of the socio-political dependence on the politician.

5. CONCLUSIONS

Irrigation Water management is a complex dynamic process constructed between various stakeholders. Local management needs actions beyond local level, where local socio-political dynamics, external support and net working, effective accountability mechanisms between different stakeholders might guide the organizational evolution, rather than certain fixed set of design principles. Likewise, participatory support processes needs to be practiced beyond instrumentalist perspectives and focus on social learning rather than on rigid planning procedures. Such processes should be initiated only after adequate learning of the system environment surrounding the water use systems and must be able to translate its opportunities and constraints in practical water management.

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5.2 GUIDELINE FOR ESTIMATION OF PMP FOR PMF

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SUMMARY

Probable Maximum Precipitation (PMP) is defined as the greatest depth of precipitation for a given duration meteorologically possible for a given size storm area at a particular location at a particular time of year with no allowance made for long-term climatic trends. Current knowledge of storm mechanisms and their precipitation- producing efficiency is still much to be studied to get precise evaluation of limiting values of extreme precipitation. The guideline for PMP estimates, therefore, should be carefully approached and must be considered as approximations. The accuracy, or reliability, of an estimate depends basically on the amount and quality of data available for applying a various estimating procedures. Procedures for estimating PMP cannot be standardized as they vary with the amount and quality of data available, basin size and location, basin and regional topography, storm types producing extreme precipitation and climate.

Following two methods have been recommended for the estimation of PMP out of which hydro meteorological method looks more convenient as it shows the extreme rainfall distribution with area. Statistical method also can be used for the estimation of PMP.

- **Hydro meteorological Method:** The three main steps in the hydrometeorological approach in estimating maximum precipitation to transpose storm values, transpose maximum values, maximize storm values, and then envelope the transposed maximum values. The simple and convenient way of storm maximization is moisture maximization and guideline is developed for the same.

- **Statistical Method**: Statistical approach is one of the simplest ways to evaluate concerned PMP. Statistical procedure may be used wherever sufficient precipitation data are available, and are particularly useful for making quick estimates, or where the meteorological data, such as dew point is lacking.

Most of the rain-gauging stations in Nepal are non-recording types, and the published climatological and precipitation records hold mainly daily rainfall. Due to lack of hourly data, the relation between daily rainfall and some available hourly data were co-related.

Separate guidelines for the estimation of PMP has been developed for following basins to cover entire area of Nepal.

- Karnali Basin (includes Mahakali basin as well)
- Narayani basin
- Bagmati basin
- Sapta Koshi Basin
- South-Western Basins
- South-Eastern Basins
- South – Central Basins

For all these basins, as a first step, the maps of 24- hour rainfall intensity have been developed and presented. Then the Depth Area Duration (DAD) curves were constructed based on the GIS numerical methods of map analysis. The relationships between average storm precipitation depth (Y-axis) and area (X-axis) for corresponding rainfall events are shown in graphs.

Finally general instruction for estimation of PMP has been provided and an worked out example for PMP estimation of Kulekhani Watershed at the dam axis site has been computed for ready reference to the guidelines users.

1. INTRODUCTION

Deffination

The significance of precipitation for hydraulic design in Nepal was realized in mid 1930s. The hydro meteorological parameters for design depend on the purposes for which they are required and Probable Maximum Precipitation (PMP) is one of them. The uppermost limit of probable precipitation depth is known as Probable Maximum Precipitation (PMP), which can be defined in various ways. According to American Meteorological Society, 1959; PMP is defined as "the theoretically greatest depth of precipitation for a given duration that is physically possible over a particular drainage area at a certain time of year". Another definition of PMP more operational in concept is "the steps followed by hydro-meteorologists in arriving at the answer supplied to engineers for hydrological design purposes" (WMO, 1973). The recent and more convenient definition is 'theoretically the greatest depth of precipitation for a given duration that is physically possible over a given size storm area at a particular geographical location at a certain time of year" (Hansen et al., 1982) and this definition is appropriate and adopted for the computational procedures.

1.1.1 Storm Rainfall and Depth Area Duration (DAD) Relationship

Point rainfall measurement represents the precipitation at the present point where the gauge is located. Floods, however, result from substantial volume of rain spread outs over a basin or substantial portion thereof. Thus any appraisal of storm rainfall for the purpose of estimating flood magnitudes is concerned with rainfall volumes. These are usually expressed as average depths over specified sizes of area falling in spread intervals of time. These are called depth-area-duration (DAD) values.

The first step in a DAD analysis of a storm is to gather together all the rainfall data. This consists of : a) published climatological

data, which typically shows daily and hourly amounts at standard stations, and (b) original records recorded by other agencies.

For DAD analysis, a storm is assigned with a definite beginning and ending, and with a boundary on the map. The boundaries are usually isohyets. This might be a zero isohyets for an instant local storm. For more general storms the bounding isohyets might be 100mm or more, depending upon the storm duration and intensity; and indeed the purpose of analysis.

1.1.2 Precipitable Water

A final measure of water vapor in the atmosphere to discuss is the precipitable water. This is the statement of the total mass of water vapor in a vertical column of the atmosphere. Precipitable water is in fact a misnomer since no natural process will precipitate all the water vapor of the atmosphere.

1.1.3 Moisture Maximization

The best known and most common storm maximization is maximization for moisture. The assumption is that a given storm could have produced correspondingly more rainfall if the specific humidity of the inflowing tropical air had been higher, and that the maximized combination is representative of a storm that is possible sometime in the future.

1.1.4 Storm Transposition

The extreme rainfall events in a meteorologically homogeneous region surrounding a project basin is a very important part of the historical evidence on which the PMP estimate for the basin is based. The transfer of storms from locations where they occurred together with the areas where they could occur is called storm transposition.

1.2 Literature Review on PMP

All literatures describe hydro meteorological approach with substantial emphasis on extreme precipitation. There are several

corrections suggested depending upon the local rainfall characteristics, topography and distance from the ocean. In US the software HMR 52 are in use for the general estimation of PMP. More practical is hydro meteorological method (DAD analysis) with crosschecking through statistical methods [National Academy Press, US, 1998]. In India for general PMP estimates, hydro meteorological approach has been recommended [WMO No 332, 1986]. For particular specified basin in some cases the time-point PMP were considered reasonable and there are some practices in India [Roorkee-247667, 1998]. In such basins where rain gauges are not available, the point rainfall estimates from nearest station using statistical method are also in use [Mutrejza K.N, 1990].

All the above mentioned methods are using extreme rainfall of the purpose area. Some of the highest world rainfalls are listed in **Table 1.1.**

Table 1.1:World highest point rainfall

Durations	Depths (mm)	Location	Date
1 min	38	Barot, Guadeloupe	26.11.1970
15 min	198	Jamaica	12.5.1916
42 min	305	Holt	22.6.1947
4.5 h	782	Smethport, PA	18.7.1942
9h	1087	Belouve la Reunion	28.2.1964
12h	1340	Belouve la Reunion	28.2.1964
18.5h	1689	Belouve la Reunion	28.2.1964
24h	1825	Foc la Reunion	15-16.3.1952
2 days	2259	Hsin, Taiwan	17-18.10.1967
3 day	2759	Cherrapunji, India	12-14.9.1974
4 days	3721	Cherrapunji, India	12-15.9.1974

1.3 Purpose of Study

There are many publications on procedures and practical applications regarding estimation of PMP. Some guidelines and procedures were described by WMO publications, American USGS publications, etc. There are no definite rules for

estimation of PMP but hydro meteorological method seems to be more reasonable. The statement of WMO sited in its manual is "The practice of hydrometeorology has not been reduced to a handbook. No one can furnish a set of rules, graphs, and procedures whereby one can proceed step by step and necessarily derive an acceptable estimate of probable maximum rainfall. The lectures will discuss only certain principles. Handbooks work best in solving uniform problems from data that are uniform and ample. None of these three conditions is the rule in probable maximum estimates, neither problem nor data are uniform, and the data are certainly not ample."

The purpose of this study is preparation of guideline of PMP for PMF for Nepalese rivers with the help of extreme storm data available and traditional hydro meteorological method and its mathematical modeling. The study also highlights some statistical methods. The procedures for estimating PMP require knowledge of meteorology. No attempt has been made to define or discuss basic meteorological terms or procedures. The report is written in sufficient detail to permit a hydro-meteorologist or an engineer to assess the parameters required for the estimation of PMP with the application of this guideline so as to solve the problems on estimation of PMF.

1.4 Study Area

The study area is limited to whole of Nepal. The extreme rainfall characteristics and topography of Nepal is complex. The studies on climate and topography have been carried out for the regional PMP estimates within the study area. As a result, the study areas were separated as Karnali and Mahakali, Sapta Koshi, Narayani, Bagmati, South Eastern, South-Central and South-Western basins.

1.4.1 General Topography, Climate, River System and Extreme Rainfall

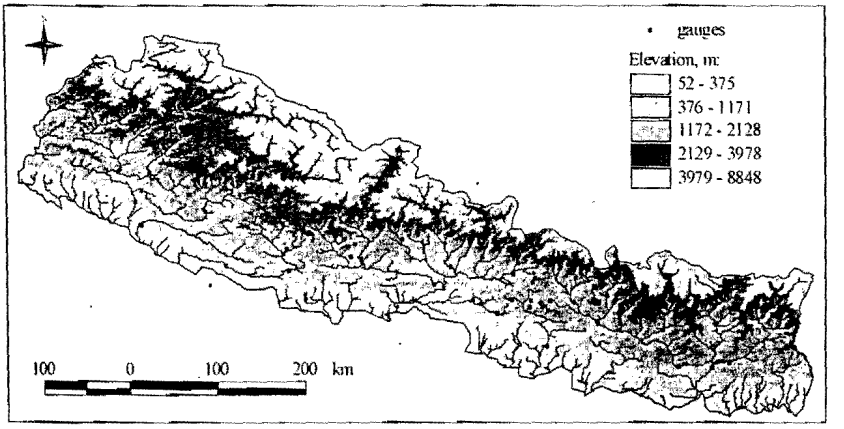
Geometrically the country has roughly a rectangular outline located between latitude 26^0 22' and 30^0 27' and longitude between 80^0 04' and 88^0 12' with average east-west extension of

880 km and north-south extension of 193 km. The total area of the country is 147,181 sq. km with 83% of hills & mountains and 17% of flat terrain in the south.

Geomorphologically Nepal is divisible distinctly into six east-west running belts from south to north.

The topographic map of study area with river systems is presented in **Fig.1.1.**

FIG. 1.1.: TOPOGRAPHY AND RIVER SYSTEMS



❑ Terai Plain (Flatland)

The southern part of the country, the Terai region is an extension of Indo-gangetic plain which is underlain by soil mantle and having an elevation of 100-200 above mean sea level (a.m.s.l.). The width varies between 10 to 30 km and extends from east to west for 880 km.

❑ Churia Hills (Siwaliks)

Adjacent to the Terai in its north, rising abruptly, lies a Churiya range. It rises to 1,300 m a.m.s.l. The topography is rugged & fragile. It is composed of sandstone and shale in alternating layers and contains pebble horizon on the top part. It contributes maximum silt to the rivers originating from Churia. Except in

some places where it is merged with Mahabharat range and where it forms Dun valleys, Churiya hills make a separate east-west extending range. At the base of Churiya foot hills, there lies a zone of about 12 km width called Bhabhar zone and is composed of porous layer of boulder, pebble and cobble of rocks of Churiya hill or Mahabharat range deposited by the existing rivers.

❑ Mahabharat Mountains

North of the Churiya range lies the Mahabharat Mountains, with rugged terrain, deep valleys and incised rivers. It rises to 3,000 m a.m.s.l. and extends from east to west with an average width varying from 30 to 40 km. It has a special importance for the regulation of the flow of the monsoon, being the first high hill ranges facing the Indian plain.

❑ Midlands

North of the Mahabharat range and south of higher Himalayas lies the midland part of Nepal, consisting of low hills, river valleys and tectonic basins. Boundaries of midland belt is ill defined physiographically, however tentatively is can be assumed to lie south of higher Himalayan range and north of Mahabharat mountains. The width is approximately 30 km and it also extends from east to west of Nepal in the form of a strip.

❑ Higher Himalayan Zone

The hills of midland zone slowly rise to the north and make the snow capped peaks of the higher Himalayan range; up to the elevation of 8,848 m a.m.s.l. This zone contains not only the highest peak Mt. Everest but also greatest number of higher peaks of the world. Numerous higher peaks are located in the eastern Nepal in comparison to the western part.

❑ Climate

There is wide range of climate variation due to immense topographical undulations: from the summer tropical heat and humidity of the Terai to the colder dry continental and alpine winter climates across the middle and north mountainous sections. In general, climatic condition of Nepal is highly influenced by elevation, and temperature during both summer and winter months, decreases from south towards north.

Climatically, the country can be classified into the following five regions which match the physiographical zones of Nepal. Since altitude is the guiding factor in the climatic classification of Nepal, five different types of climate have been recognized on the basis of topographic elevation.

- **Tropical climate** of southern Terai, Bhabar, Churiya (Siwaliks) and inner Terai, which has mild and dry winter and hot & wet summer.
- **Warm temperate climate** of Mahabharat region, above the elevation of 2,130 m with warm & wet summer and cool dry winter.
- **Cool temperate climate** of the high Mahabharat region up to the altitude of 3,350 m with mild wet summers and cold winter. Snow falls in the winter months and persists on the high slopes through the winter.
- **Alpine climate** in the higher mountain region with elevation up to 4,590 m having low summer temperature with frosty winter.
- **Tundra climate** in the north Himalayan region with perpetual snow cover and cold desert like condition.

Since Nepal is affected by south-west monsoon it has four major seasons.

❑ Precipitation

Precipitation over Nepal occurs in the form of rainfall and snow. In Nepal, there are two principal sources of rainfall. The dominant source is south-west monsoon bringing moisture

bearing wind through south-east, which along with orographic uplift contributes about 70-80% of annual rainfall amount during the months of June to September. Another source is western disturbances which originate in Mediterranean area and enters Nepal from the west. This is the major moisture source in dry winter months. However, small amount of rainfall is also contributed by pre-monsoon thunder storms and also occasionally affects monsoon depression formed over Bay of Bengal during post monsoon period.

The rainfall distribution in Nepal is highly affected by the topography. The rainfall records show, that annual rainfall varies from 162 mm at Mustang (which lies in rain shadow part on the northern slope of Annapurna range) to 5,224 mm at Lumle in the same region on the southern slope of Annapurna range.

The map shows that, two east-west oriented belts of high rainfall pockets are found in Nepal: one on the southern side along the Churiya hills and the other on the northern hills. The high rainfall pockets of northern belts have higher rainfall values than the southern, and also the elevation affects in the rainfall variation. In addition, the annual rainfall density changes from east to the west. The rainfall gradually increases from east up to central part of the country and then abruptly decreases further to the west. The eastern part receives more rainfall than the western due the fact that as we move westward the distance from sea increases.

❑ Temperature

The temperature of Nepal varies with the altitude. The temperature decreases from south to the north as the elevation increases. For example, Nepalgunj situated at the Terai region (in the south) and Mt. Everest in the north, both lie at the same latitude 28° N but there are contrasts in climate at these two places due to the altitudinal variation. The mean air temperature of Nepalgunj in summer is 39° C and in winter 9° C but in Mt. Everest, air temperatures oscillate between the freezing points

throughout the year. On the other hand in general, the air temperatures, increase from east to west.

The highest mean maximum temperature of 41.3^{0}C in May 1960 was recorded in mid western Nepal (Chisapani Karnali) and lowest mean minimum temperature was -17.8 ^{0}C in 1978 at Mustang station in January.

Similarly, extreme absolute maximum temperature was 46^0 C in May 1966 in mid western Nepal (Chisapani Karnali) and extreme absolute minimum temperature was –26.1^0 C in 1977 at Mustang in the month of January.

❑ Monsoon Rainfall

The period between June to September, characterized by heavy and continuous rainfall is called monsoon season. Monsoon arrives over eastern Nepal around June 10 and within two or three days it covers the whole kingdom. The normal date of retreat of monsoon is September 23rd when the monsoon circulation in fully established the temperature begins to fall. The 70-80% of annual rainfall falls during monsoon period. The eastern part receives more rainfall than the western part. The central part Lumle (Pokhara) receives highest rainfall and decreases both in east-west and south-north direction. The average rainfall during this period varies from less than 200 mm at Mustang to about 4,000 mm in Pokhara. Such a great variation of rainfall within a short distance in the central part of Nepal is due to the rain shadow effect of great Himalayan ranges (with elevation of more than 5,000m). In addition, the rainfall varies sharply from place to place due to topography. Generally the south facing slopes receive more rainfall than the north facing slopes.

❑ River System of Study Area

River systems in Nepal are mainly divided into four major river basins: Sapta Koshi in the east, Narayani in the center, Karnali

in the west and Mahakali in the western most border. Out of four, the three Sapta Koshi, Narayani and Karnali originate from the Tibetan Plateau and enter Nepal crossing Himalayas. Besides these, there are seven medium basins and several smaller sub-basins.

River in Nepal can be classified into three categories in terms of their sources of dry season flow (Ilinger, 1978). In general, the flow of all the rivers follows the rainfall pattern. But, individual response of the rivers is governed by precipitation characteristics and characteristics of the drainage basin. The river system map is shown in **Fig. 1.1.**

The first category of rivers: have their sources in snow and glaciers. Mahakali, Karnali, Narayani and Sapta Koshi are the four river systems of this category. These rivers are from Himalayas.

- **Mahakali:** Mahakali originates from Api Himal (from Milan glacier of India and also from the Lipu lekh of Nepal). It makes western international boundary with India. Its main tributaries are Chaulani and Surnayagad in Nepal. The river basin has total drainage area of about 15,640 km^2 and about 34% of total drainage lies in Nepal.
- **Karnali:** Karnali drains from the mid western region of Nepal. It originates from the southern region of Manasarobar and Rokas Lake in Tibet. Out of total drainage area of 44,000 km^2, 43,227 km^2 lies in Nepal. Its main tributaries are Seti, Humla Karnali, Mugu Karnali and Bheri. With its swift currents, Karnali river valley is steep and confined to narrow gorges.
- **Narayani:** The region in central-north Nepal (north of Kathmandu) is drained by Narayani river system. It starts from Photu pass to Mustang area in Northern Teethes zone. The total drainage area in 34,960 km^2 of which about 90% lies in Nepal. The river is formed by 7 major rivers: Trisuli, Kali Gandaki, Seti, Marsyangdi, Budhi Gandaki, Daraundi and Madi. All these rivers originate from the Himalayan glaciers.

- **Sapta Koshi:** The Sapta Koshi river system drains eastern region of Nepal. It is the biggest river of Nepal. The total drainage area of the river basin is 60,400 km² of which about 47% lies in Nepal. The major tributaries of Sapta Koshi river are Indrawati, Sun Koshi, Arun, Tamur, Likhu, Dudh Koshi and Tama Koshi.

The second group of rivers: originate in the Middle Mountains (Mahabharat Range) They are mostly rainfed and have low dry season flow. Bagmati, West Rapti, Mechi, Kankai, Kamala and Babai are the rivers in the second category. Combined total drainage area of these rivers is 16,251 km^2 and they originate from the mid-hills. The main sources of these rivers are rainfall, springs and groundwater recessions and have very low dry season flow.

The Third Category Rivers: originate from the Churiya or from southern face of the Mahabharat, or from within the Terai. These rivers have small basin area, generally less than 350 km². These rivers have combined total basin area of 22,797 km² in Terai and southern slope of the hills. In dry season the flows of most of these rivers become nominal or generally dry up. Tilawe, Sirsia, Manusmara, Hardinath, Sunsari, Banganga, Mawa, Dhamana, Khado, Keshliya, Jharai, Budhjhora, Singiya, Laxminia, etc. are the rivers in this group.

In Nepal, including both large and small, there are altogether 6,000 rivers, with the total length of about 45,000 km. The drainage density of 0.3 km/km^2 of lateral drainage reflect the closeness of the drainage channels. Approximately 1,000 of these rivers are with more than 10 km length and also include about 100 with the length of more than 160 km.

❑ Causes of Extreme Rainfall : Case Study

Indian sub-continental weather is affected by tropical as well as extra tropical disturbances because of its position in the globe. The extra tropical disturbances, popularly known as "western disturbances," (December to April) travel eastwards originating

somewhere around the Mediterranean Sea. Their track is north of latitude 45^0 N but comes down to as low as 30^0 N during the winter period. These disturbances do not bring heavy precipitation as to cause floods. They generally bring light rain of about 20 to 30 mm in months of December to April over Nepal.

The monsoon is the seasonal wind, actually a southern hemisphere wind moving across the Equator and north wards to the Tropic of Cancer. The south-west monsoon sometimes establishes itself over Malaysia and Thailand by mid May, but generally it does not reach Nepal. The heaviest rainfalls is not the result of the monsoon alone, but triggered by north-west ward movement of depressions that form in the Bay of Bengal.

In Nepal, most floods occur during monsoon season due to heavy spells of rainfall. The heavy spells of rainfall occur in association with the formation and movement of depression or cyclonic storms which originates in the Bay of Bengal and also sometimes in the Arabian Sea. Extreme floods formation during monsoon season is the result of concentrated spells of heavy monsoon rain. Two main synoptic situations causing most heavy rainfall are:

- **"Track of monsoon depression"** when the passage of monsoon depression is over north India and the other favorable condition arises.
- **"Break monsoon"** when the axis of monsoon trough shifts towards Himalayas.

  Besides these phenomena, intense cloudbursts in the basins, especially towards the end of the monsoon in September when the basin is already saturated can create devastating effects.

❑ Extreme Rainfall Within Study Area : Case Study

The central region of Nepal was hit by storm of July 1993. The violent storm was due to "break monsoon". The axis of

monsoon trough was situated over central Nepal on 19th July 1993 and remained so till 21st July. The resulting effect of the storm was heavy precipitation causing devastating floods in and around Bagmati basin, East Rapti basin, Kamala basin and the adjoining basins of Trishuli river tributaries. This particular storm was most violent storm ever hit or recorded in Nepal. The storm disaster claimed the life of about two thousand people, along with large number of animals and loss of property amounting to hundreds of millions of rupees. Heavy damages have been experienced in the Bagmati river barrage at Karmaiya and in the Kulekhani hydropower plant. Also several bridges were washed away along Prithivi Highway. The maximum rainfall recorded was 540 mm a day with night time rainfall at the rate of 65 mm/hour at station Tistung (Inside Bagmati basin). In the meantime, the river discharge was greatest in many rivers of Nepal, even greater than the design discharge of major infrastructures of Nepal. The rainfall received at Tistung, i.e., 540 mm/24 h was highest ever recorded 24 hour rainfall of Nepal.

Table 1.2: 24h Extreme rainfall 19-20 July 1993, (Central Region)

S.N	Station Name	19-20 rainfall(mm)	20-21 rainfall(mm)
1	Markhu	386	43.6
2	Daman	373	240
3	Tistung	540	39
4	Thankot	111.2	69.3
5	Ghantimadhi	482.2	116.3
6	Kulekhani	376.8	52.4
7	Patharkot	38	473
8	Dhunibesi	194	30.2
9	Chisapanigadhi	294	65

1.5 Meteorological Network and Data Availability

There is a network of precipitation stations within the study area. Mostly the data from these stations are collected by the

Department of Hydrology and Meteorology. Besides, few separate stations are available belonging to Department of Irrigation, Nepal Electricity Authority, NGO, INGO, etc.

The most responsible authority for meteorological data is Department of Hydrology and Meteorology. The available station network within study area is presented in Annexes 1, 2 and 3.

There are all together 309 precipitation, 68 climatological, 15 synoptic, and 22 agro-meteorological, and 6 aeronautical stations.

For the study on PMP the required available data from DHM publications and from the records of the Department of Soil Conservation and Watershed Management were used. The storm rainfall analyses have been carried out with the help of data from published books of DHM and previous personal field visit to soil conservation stations. For the study of hourly data, some references of hourly data chart have been analyzed.

2. PROCEDURES FOR ESTIMATION OF PMP

2.1 Methodology

There are two methods for estimation of PMP out of which hydro meteorological method looks more convenient as it shows the extreme rainfall distribution with area. Statistical method is also used for the estimation of PMP.

2.1.1 Hydro meteorological Method

The three main steps in the hydro meteorological approach in estimating maximum precipitation are to transpose storm values, transpose maximum values, maximize storm values, and then envelope the transposed maximum values. Initially, several parameters can be maximized to determine PMP. The simple and convenient way of storm maximization is moisture maximization.

❑ Moisture Maximization

The first step in moisture maximization is to determine the maximum atmospheric moisture that may be expected in the region during storm. A method satisfactory for most localities is to survey a long record of surface dew point or vapor pressure measurement at several stations. Moisture maximization of storms in place is the multiplication of observed storm rainfall by the ratio of maximum precipitable water indicated for the storm reference location to the maximum precipitable water estimated for the storm.

The moisture maximization factor or ratio is:

$$MMF = \frac{R_M}{R_S} \quad \text{_____} 1$$

Where, R_M is maximum perceptible water at storm area

R_S is storm perceptible water

❑ Depth of precipitable

Perceptible water from the 1,000 hPa surface to various altitudes or pressure levels is a function of the 1,000 hPa dew point. In standard atmospheric condition, a column of air of 1 sq. cm. horizontal cross section and with a 1 hPa pressure difference between the top and bottom of column weighs approximately 1.02 grams. In maximizing storm rainfall, only the depth of perceptible water from the ground to some arbitrarily selected level generally from 400 to 200 hPa is used. In an average the 300 hPa level is accepted as the top of the storm. The maximum 24-h dew point over study area is presented in **Fig. 2.1.**

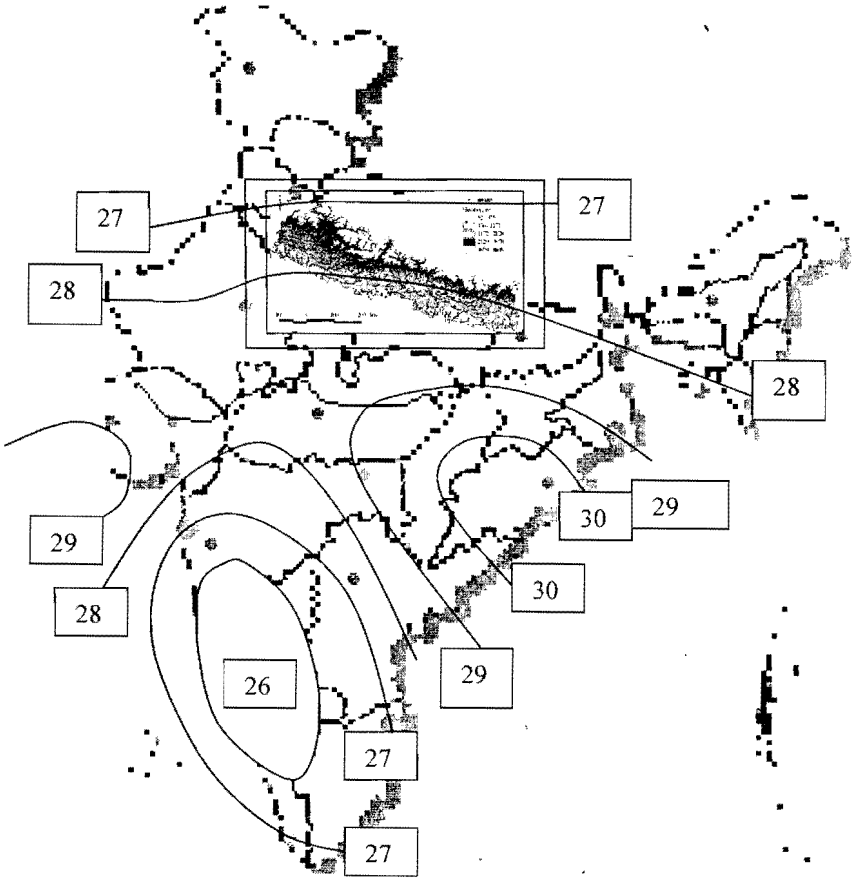


Fig. 2.1:Extreme persisting 24-h dew point temperatures over India and Nepal [Rakhecha and Kennedy, 1985]

The general formula for determining the precipitable water from mixing ratio in a layer is

$$W = \frac{q \Delta P}{g \rho} \qquad \text{_____2}$$

Where, W = precipitable water in cm.

q = mean specific humidity or mixing ratio of layer gm/kg.

P = depth of layer, hPa.

g = acceleration due to gravity, cm/sec

ρ = density of water = 1 gm/cu. cm.

❑ Transposition adjustment

The transposition adjustment for moisture is calculated in a manner similar to moisture maximization. First, the maximum dew point is noted both at the position of the storm and at its transposed location. These maximum dew point values are from maps such as **Fig. 2.1.** The dew points are converted to precipitable water from ground to some great heights. The transposition adjustment is then the ratio of two precipitable water. All storm DAD values are multiplied by the ratio. The transposition adjustment for the moisture may be either greater or less than unity, depending on whether the transposition is towards , or away from, greater moisture.

❑ Combined maximization and transposition adjustment

Once the principles are understood, when a storm is both maximized for the moisture transposed with a moisture adjustment, a single adjustment suffices. Again the moisture maximization ratio is

$$MMF = \frac{R_M}{R_S} \quad \text{_____(1)}$$

Transposition adjustment for moisture is:

$$\text{Transposition. adjustment} = \frac{\text{Maximum precipitable water at new location } (R_N)}{\text{Maximum precipitable water at storm location } (R_M)} \quad \text{—— 3}$$

It is evident that two adjustments can be combined

$$\text{Transposition. adjustment} = \frac{\text{Maximum precipitable water new location}}{\text{Storm precipitable water}} \quad \text{——— 4}$$

Following progress have been achieved to date to prepare guidelines for estimation of PMP for PMF:

- **Adjustment for storm elevation:** If the storm elevation is not at mean sea level, some corrections may be

appropriate for the elevation of the storm If the elevation of storm is less than 300m, it is not necessary to adjust [Hart 1982, Schreiner and Riedal, 1978.] This decision is based on the distance to the moisture source and the storm characteristics and the topography of the region. If storm occurs in some distance from the moisture source on a broadly sloping plain at an elevation "*h*" meter, with no intervening topographic barrier between the rain area and the moisture source then moisture maximization ratio is:

$$MMF = \frac{R_M - \alpha}{R_S - \beta} \qquad \text{_____5}$$

Where, α is precipitable water at elevation "h" at maximum dew point and β is at storm dew point of same height.

- **Adjustment for barrier:**_Assuming that there is an extensive, relatively unbroken range of hills with a mean crest elevation H, the maximization can be determine by:

$$MMF = \frac{R_M - \chi}{R_S - \delta} \qquad \text{_____6}$$

Where, γ is precipitable water at elevation "H" at maximum dew point and δ is at storm dew point of same height.

2.2 Statistical Method

The estimation of point PMP also has great value for the initial assessment of PMF. Statistical approach is one of the simplest ways to evaluate concerned PMP. Statistical procedures for estimating PMP may be used wherever sufficient precipitation data are available, and are particularly useful for making quick estimates, or where the meteorological data, such as dew point is lacking. The following equation is some times used as check on PMP estimates [Hershfield, 1961]

$$X_m = X_n + K_m \sigma_n \qquad \text{_____7}$$

Where X_m is maximum observed rainfall, X_n is mean of the series of n annual maxima, σ_n is standard deviation of the series, K_m is frequency factor for X_m

Using many series of station's data on maximum annual 24-hour rainfall mostly located in United States and some other countries, the greatest value for K_m to obtain X_m was found to be 15. The use of this value is also considered for the computation of statistical PMP.

Where the data are not available, K.N Mutreja recommend Equation 7 as PMP estimates but using K_m as 2 times of 10,000 year return period from Gumbel extreme value type I.
Some modification was recommended by Hershfield in 1965 for the calculation of K_m

$$K_m = \frac{X_1 - X_{n-1}}{\sigma_{n-1}} \qquad \text{8}$$

Where X_1 is the highest value of annual maximum series and X_{n-1} and σ_n are the mean and standard deviation for the series excluding the highest value from the series.

2.3 Guideline for PMP

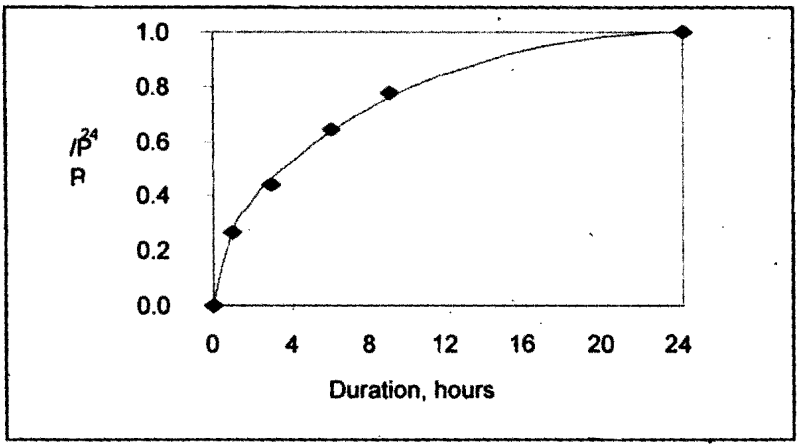
Most of the rain-gauging stations are no recording types, and the published climatological and precipitation records hold mainly daily rainfall. Due to lack of hourly data, the relation between daily rainfall and some available hourly data were co-related.

The best fitted equation between 24 hours and lower duration precipitation depths developed from the available hourly rainfall data of some specified storm period is shown in **Equation 9** and the relationship is presented in **Fig .2.2.**

$$\frac{P_t}{P_{24}} = Sin\left(\frac{\pi \cdot t}{48}\right)^{0.4727}, \qquad \text{9}$$

where t is time in hours.

Fig. 2.2. The relationship between rain intensity and duration



The study area are sub-divided into 7 zones, i.e., Karnali, Narayani, Bagmati and Sapta Koshi Basins and three others: namely southern part of western, central and eastern regions

The basic concept of the hydro-meteorological method is:

PMP for any duration t = Highest average depth of precipitation of the area (Pt) ×MMF

Moisture maximization factor MMF is the function of the dew point

- **Depth area duration (DAD) analysis**: The best fitted depth-area-duration (DAD) curves during the storm are worked out with the help of digital elevation model (DEM) of the Nepal with the cell size equal to 0.0083 degree, which in case of Equal-Area Cylindrical Projection corresponds to 930 m. The capabilities of ArcView® Geographic Information System (GIS) and mapping package Surfer® have been intensively used in this part of work.

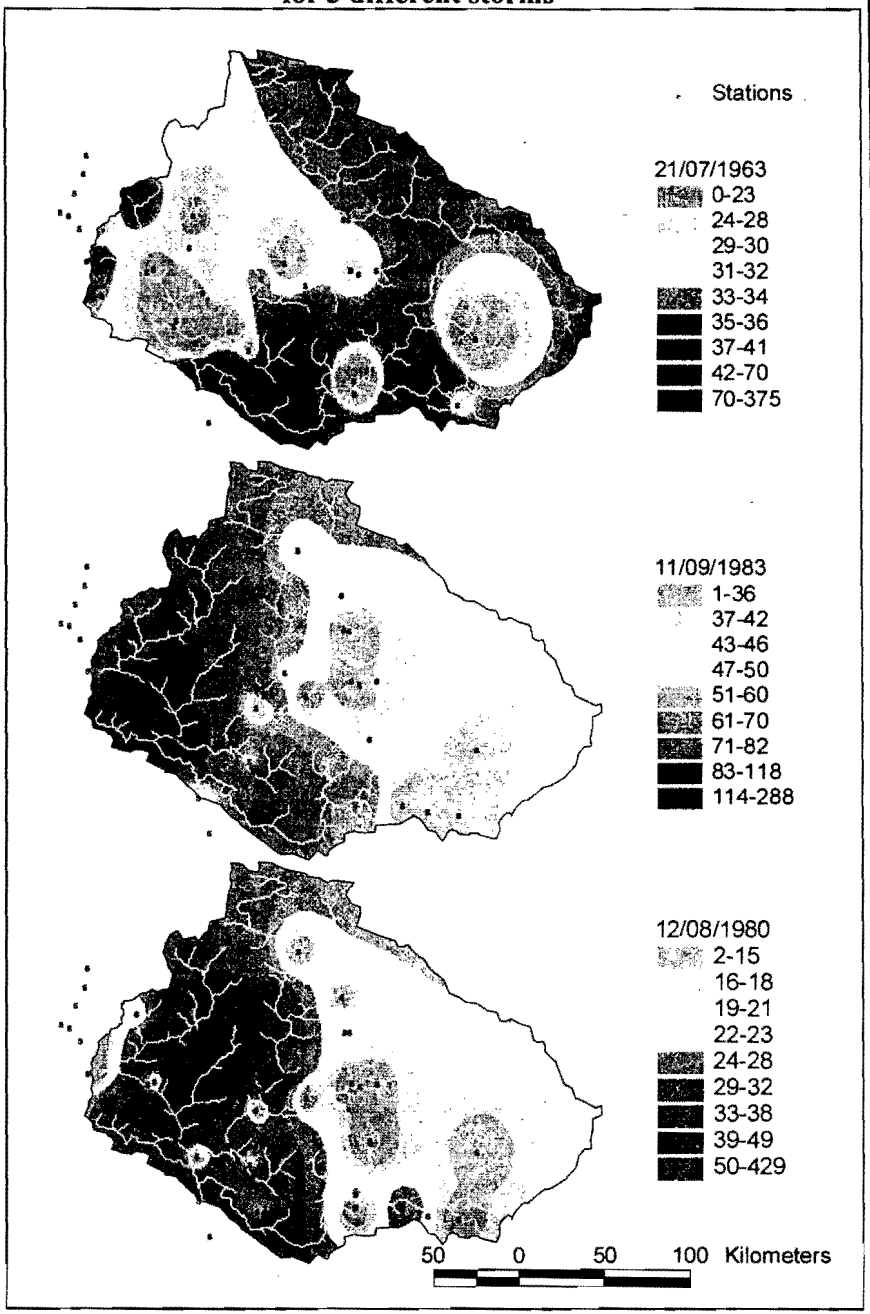
2.4 Guideline for the Estimation of PMP in Karnali Basin

Storm periods in Karnali basin are:

- 21/07/1963
- 12/08/1980
- 11/09/1983

As a first step, the maps of 24h rainfall intensity have been developed and presented in **Fig. 2.3**. The depth-area-duration(DAD) curves are constructed based on the GIS numerical methods of map analysis. The relationships between average storm precipitation depth (Y-axis) and area (X-axis) for corresponding rainfall events are shown on **Fig. 2.4** by blue color circles:

Fig. 2.3. The pattern of 24 hours rainfall over Karnali River basin for 3 different storms



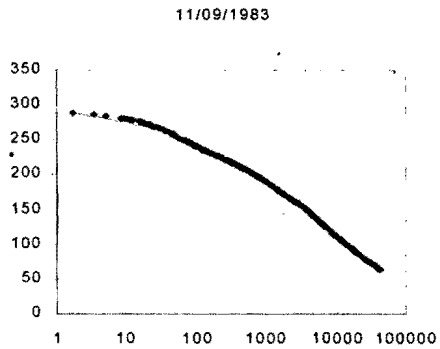
The best curve for DAD has been worked out and the linear equation with hyper- tangent model was found to be the best. The fitted equation has been presented in **Equation 10**. This equation has been applied to fit relationships of average precipitation layer of 24-h (P_{24}) versus area (A, km^2):

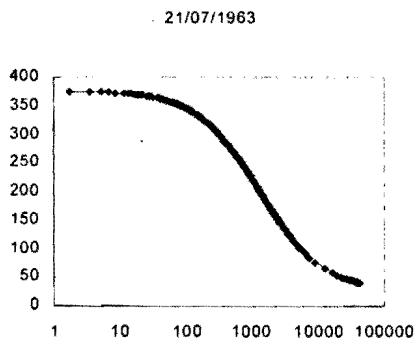
$$P_{24} = a\frac{1+\tanh\left(\frac{\ln(A)-c}{d}\right)}{2}+b, \qquad 10$$

where a,b,c,d are the parameters and tanh is hyperbolic tangent, for any x it can be calculated as follows:

$$\tanh(x) = \frac{e^{x}-e^{-x}}{e^{x}+e^{-x}}$$

The obtained values of parameters are presented in the **Table 2.1.**





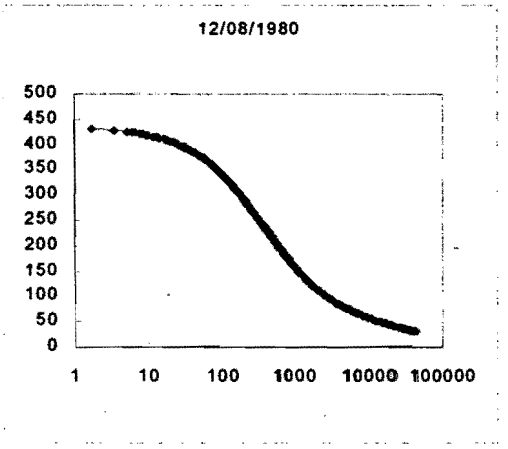


Fig. 2.4. The DAD relationship of 24h storm precipitation (Y-axis) versus area (X-axis, logarithmic) for different rainfall events

2.5 Envelopment of storm DAD

The storm curves with different periods have their own value in describing the extreme storm limits. The curves are superimposed in a single figure (**Fig. 2.5**) and the recommended area with the coefficients are tabulated in **Table 2.1**. The mean standard error of precipitation estimation (S) is given in the 6th column of the said table.

Table 2.1 : The parameters of best fitted curves

Date	a	b	c	d	s, mm	Recommended area limits, km^2
1	2	3	4	5	6	7
12/08/1980	-404.14	432.4	6.0368	2.3130	2.1	< 91
21/07/1963	-349.82	375.8	7.1891	2.1738	0.6	91 - 1950
11/09/1983	-391.13	303.0	9.3816	5.4842	2.1	> 1950

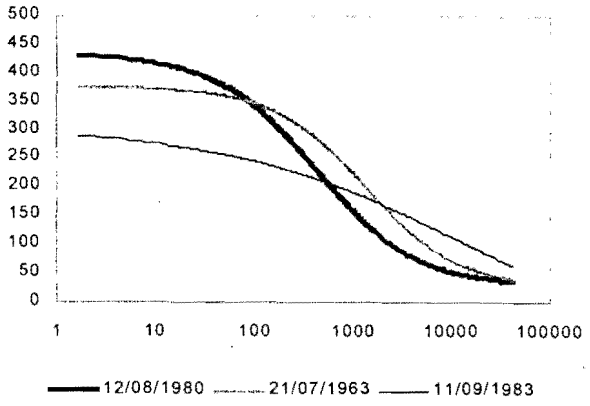


Fig. 2.5. The best fitted curves of relationships between 24h precipitation layer (Y-axis) versus area (X-axis, logarithmic) for different rainfall events

2.6 Guideline for the Estimation of PMP in Narayani Basin

Similar calculation as for Karnali can be done for Narayani Basin as well. The effective storm events in Narayani Basin are :

- 03/06/1974
- 04/08/1974
- 28/09/1981
- 03/08/1974

Similarly as mentioned above, the storm analysis is presented in **Fig. 2.6**. The DAD curves of the events are shown in **Fig. 2.7** and combined envelopment is shown in **Fig.2.8**. The co efficiency with the mean standard errors ,S are presented in **Table 2.2**.

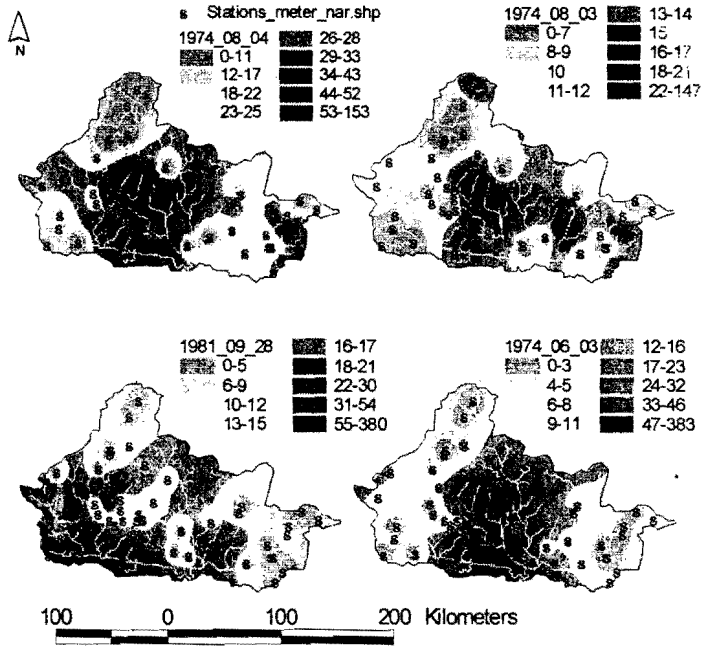
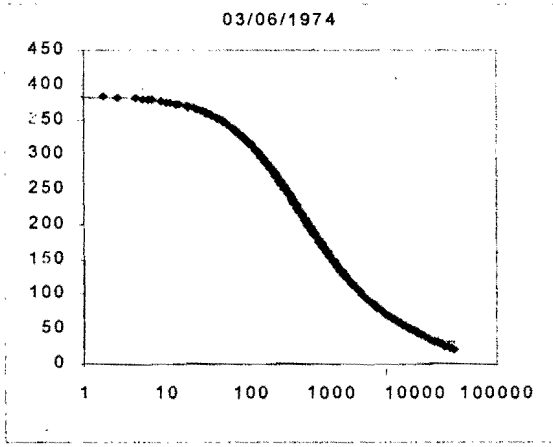
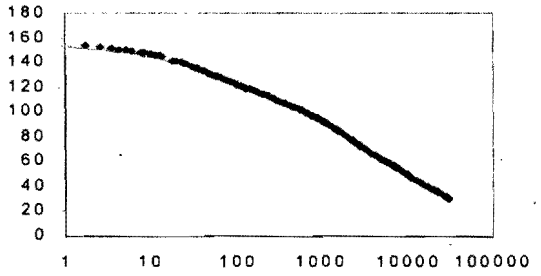


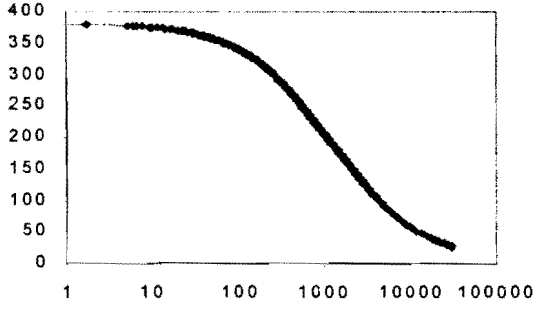
Fig 2.7. The DAD relationship of 24h storm precipitation (Y-axis) versus area (X-axis, logarithmic) for different rainfall events (Narayani Basin)



04/08/1974



28/09/1981



03/08/1974

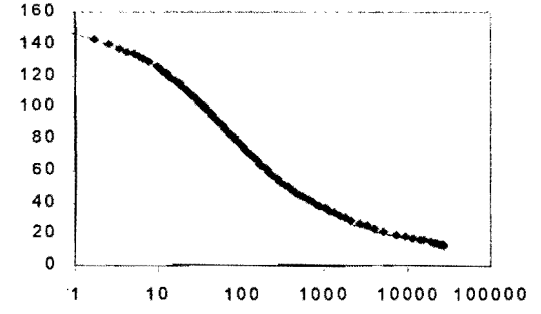
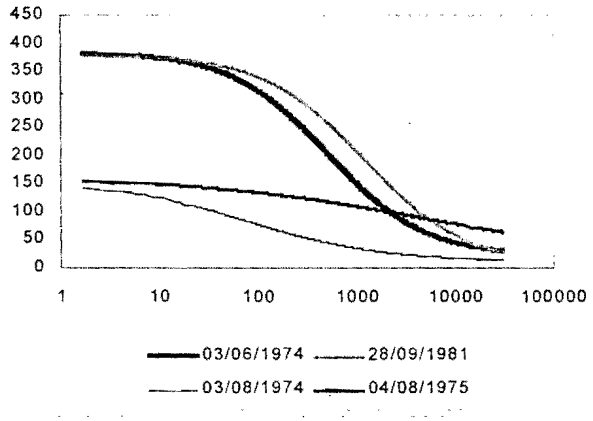


Table 2.2: The parameters of best fitted curves (Narayani Basin)

Date	a	b	c	d	s, mm	Recommended area limits, km^2
1	2	3	4	5	6	7
03/06/1974	-362.43	384.2	6.2300	2.2240	5.9	< 8
28/09/1981	-375.38	380.8	7.0802	2.3477	3.4	8 - 5350
04/08/1975	-193.64	160.5	8.4446	5.1256	1.3	> 5350

Fig. 2.8. The best fitted curves of relationships between 24h precipitation layer (Y-axis) versus area (X-axis, logarithmic) for different rainfall events (Narayani basin)



2.7 Guideline for the Estimation of PMP in Bagmati Basin

Similar calculation can be done for Bagmati Basin. The effective storm event in Bagmati Basin was 19-20 July 1993. It is also highest weather event ever recorded in Nepal.

Similarly as mentioned above, the storm analysis is presented in **Fig. 2.9**. The DAD curve of the events is shown in **Fig. 2.10**. there are no events in this basin which exceed recorded event. The coefficients with the standard error, S are presented in **Table 2.3**.

Fig. 2.9. The pattern of 24 hours rainfall over Bagmati river basin

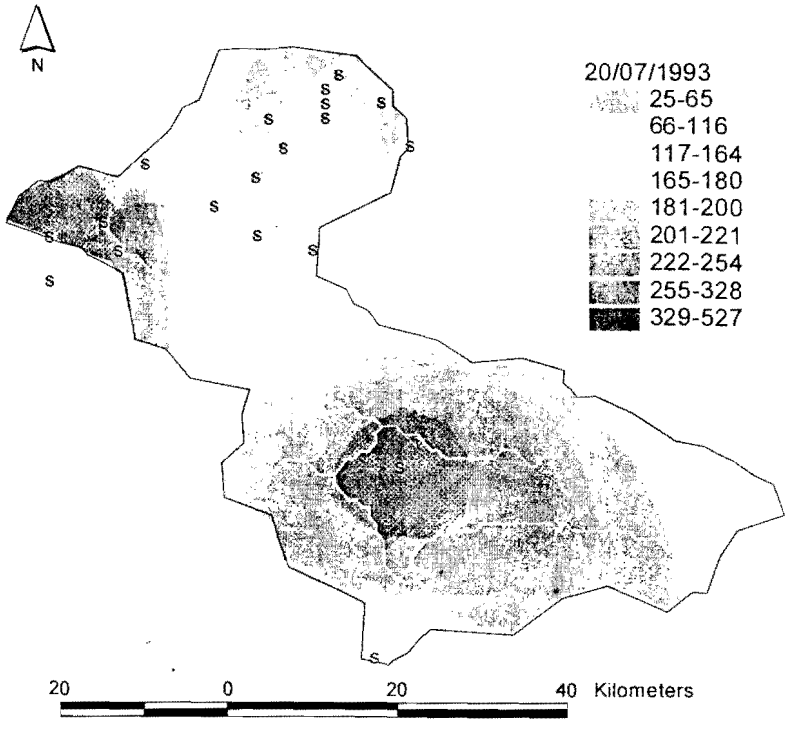


Fig 2.10. The DAD relationship of 24h storm precipitation (Y-axis) versus area (X-axis, logarithmic) for one rainfall event (Bagmati river basin)

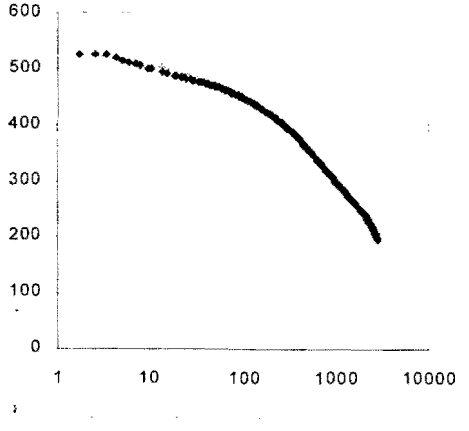


Table 2.3: The parameters of best fitted curves (Bagmati river basin)

Date	a	b	c	d	s, mm	Recommended area limits, km^2
1	2	3	4	5	6	7
20/07/1993	-1020.98	541.0	9.4276	4.2248	3.2	1-2800

2.8 Guideline for the Estimation of PMP in Sapta Koshi Basin

Similar calculation can be done for Sapta Koshi Basin. The effective storm events in Sapta Koshi Basin was 30 Sept., 1981. There are other extreme events within the basin but non of these exceed that storm value. The storm events are listed below:

- 28/071974
- 24/06/1980
- 25/06/1980
- 30/09/1981

Similarly as mentioned above, the storm analysis is presented in **Fig. 2.11**. The DAD curves of the events are shown in **Fig. 2.12**. The coefficients together with standard error, S are presented in **Table 2.4**.

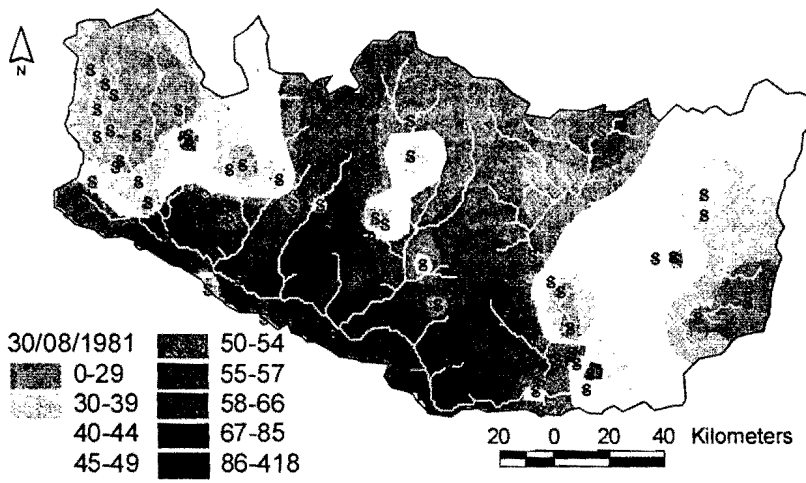


Fig.2.11. The pattern of 24 hours rainfall over Sapta Koshi river basin

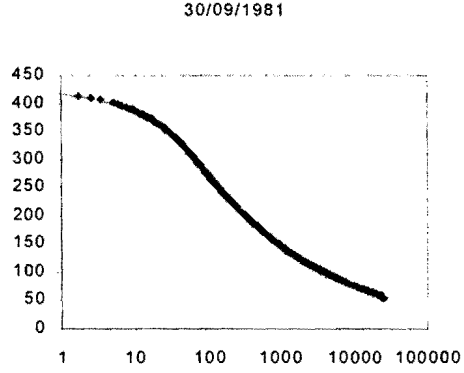


Fig.2.12. The DAD relationship of 24h storm precipitation (Y-axis) versus area (X-axis, logarithmic) for one rainfall event (Sapta Koshi river basin)

Table 2.4: The parameters of best fitted curves (Sapta Koshi river basin)

Date	a	b	c	d	s, mm	Recommended area limits, km^2
1	2	3	4	5	6	7
30/09/1981	-381.62	428.1	5.2622	3.0059	5.5	1-26000

2.9 Guideline for the Estimation of PMP in South Part of Western Basins

Similar calculation was performed at south part of western basins. The effective storm events in south part of western basins are:

- 17/07/1978
- 31/07/1981

Similarly as mentioned above, the storm analysis is presented in **Fig. 2.13**. The DAD curves of the events are shown in **Fig. 2.14** and combined envelopment is shown in **Fig.2.15**. The coefficients together with the standard error, S are presented in **Table 2.5**.

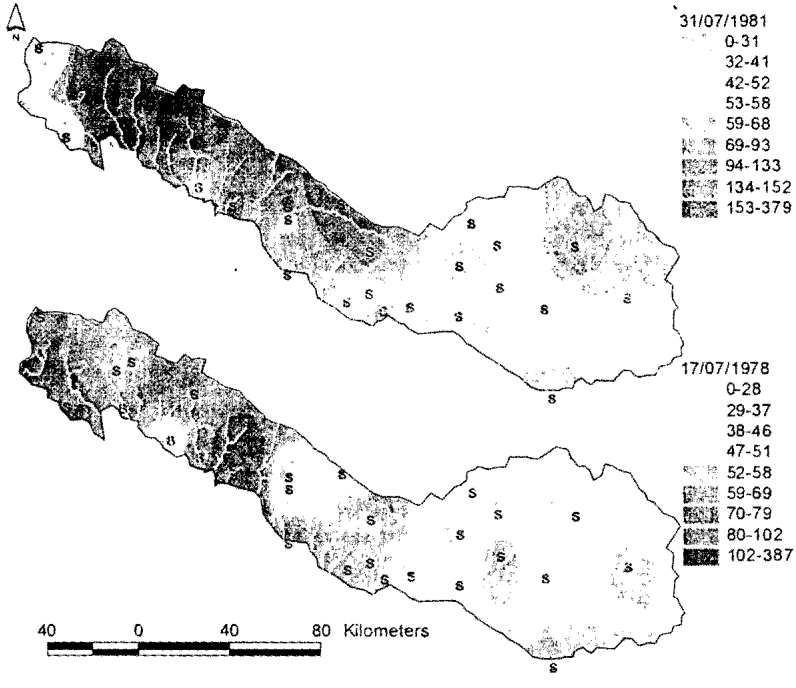
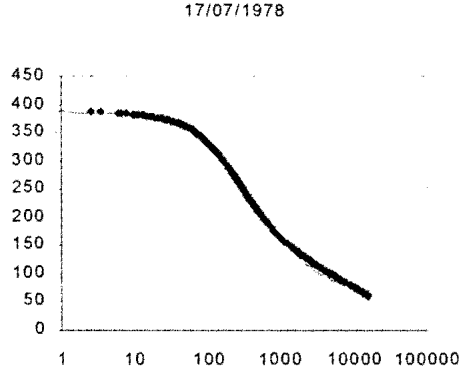


Fig. 2.13. The pattern of 24 hours rainfall over South part of western basins for 2 different storms



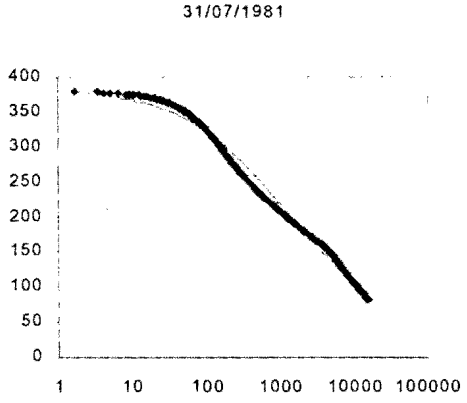


Fig.2.14 The DAD relationship of 24h storm precipitation (Y-axis) versus area (X-axis, logarithmic) for different rainfall events (South part of western basins)

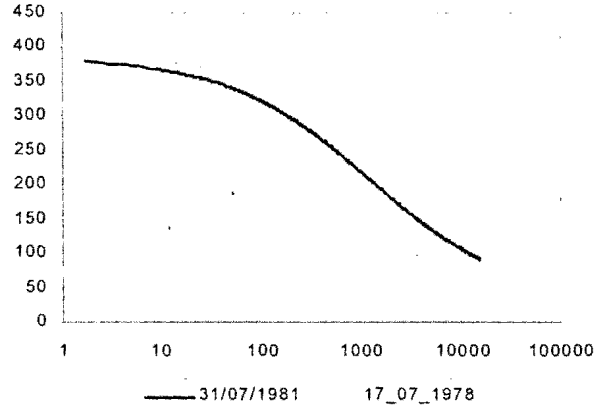


Fig. 2.15 The best fitted curves of relationships between 24h precipitation layer (Y-axis) versus area (X-axis, logarithmic) for different rainfall events (South part of western basins)

Table 2.5: The parameters of best fitted curves (South part of western basins)

Date	a	b	c	d	s, mm	Recommended area limits, km^2
1	2	3	4	5	6	7
17/07/1978	-325.72	387.5	6.1465	1.9660	6.3	<160
31/07/1981	-355.70	385.3	7.1027	3.2698	10.2	>160

2.10 Guideline for the Estimation of PMP in South Part of Eastern Basins

Similar calculation performed at south part of eastern basins. The effective storm event in south part of eastern Basins is

16/09/1984

Similarly as mentioned above, the storm analysis is presented in **Fig. 2.16**. The DAD curve of the events is shown in **Fig. 2.17**. The coefficients together with the standard error, S are presented in **Table 2.6**.

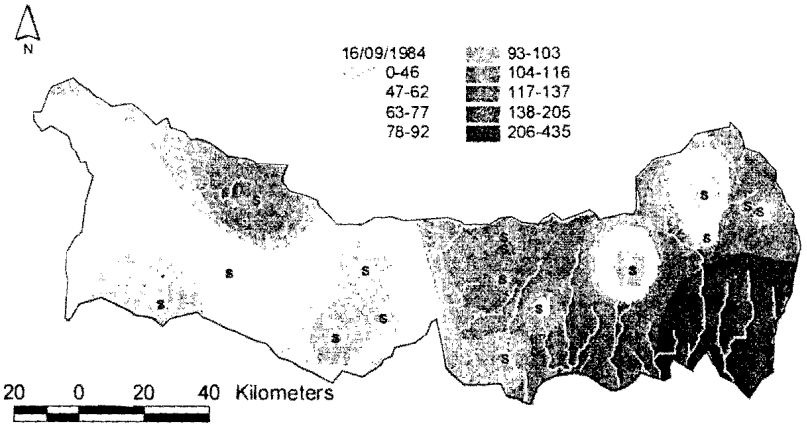


Fig. 2.16. The pattern of 24 hours rainfall over south part of eastern basins

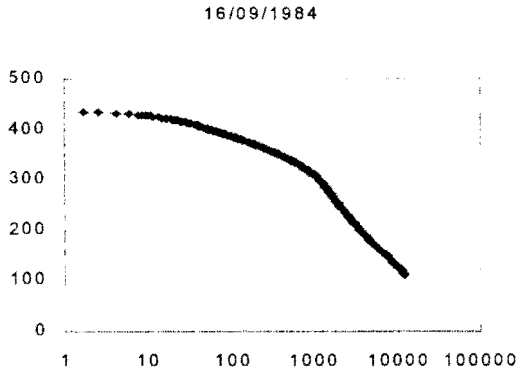


Fig 2.17 The DAD relationship of 24h storm precipitation (Y-axis) versus area (X-axis, logarithmic) for one rainfall event (south part of eastern basins)

Table 2.6: The parameters of best fitted curves (south part of eastern basins)

Date	a	b	c	d	s, mm	Recommended area limits, km^2
1	**2**	**3**	**4**	**5**	**6**	**7**
16/09/1984	-587.20	440.2	8.9658	3.5639	6.3	> 0.1

2.11 Guideline for the Estimation of PMP in south part of central Basins

Similar calculation has been performed at south part of central basins. The effective storm event in south part of central basins is:

- 02/09/1981

In a similar manner as mentioned above, the storm analysis has been carried out and presented in **Fig. 2.18**. The DAD curve of the events is shown in **Fig. 2.19**. The coefficients together with the standard error, S are presented in **Table 2.7**.

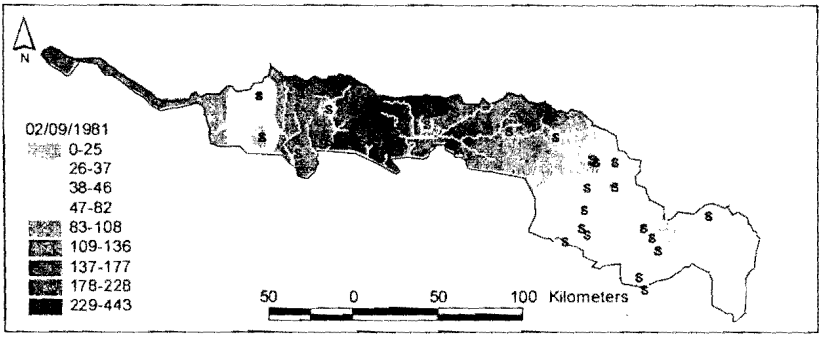


Fig. 2.18. The pattern of 24 hours rainfall over Central flat lands

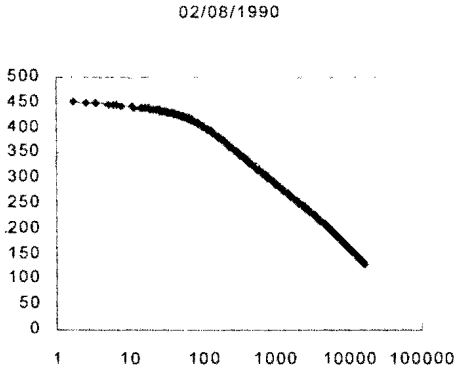


Fig.2.19. The DAD relationship of 24h storm precipitation (Y-axis) versus area (X-axis, logarithmic) for one rainfall event (central flat lands)

Table 2.7: The parameters of best fitted curves (Central flat lands)

Date	a	b	c	d	s, mm	Recommended area limits, km^2
1	2	3	4	5	6	7
02/08/1990	-425.50	457.0	7.7638	3.4048	5.9	>0.1

2.12 Transposition and moisture maximization for study area

The ever highest storm was hovered over central Nepal in 19-20, July,1993. The storm transposition has been made from that event to any new locations within study area in order to estimate PMP. The temperatures during the event is tabulated in **Table 2.8.**

Table 2.8: Temperatures in °C of 1993 storm

Date	Dry Bulb Temp.	Wet Bulb Temp.	Dew point Temp.
19th July	19.8	18.2	20.02
20th July	19.4	18.6	20.4
Average	19.6	18.4	20.21

The maximum dew point temperature of Nepal is shown in **Fig. 2.1.** the maximum dew point lie between 27 to 29°C. The precipitable water up to 300 hPa, for storm and maximum dew point, using **Equation 1** is tabulated in **Table 2.9.**

Table 2.9: Atmospheric precipitable water

Dew point Temp., (°C)	Precipitable water, (mm)
20.21	53.8
27.0	94
27.5	99
28.0	103
28.5	107
29.0	111

At any new location using **Table 2.9** and **Equation 3**, storm can be transposed and maximized. For example within Karnali basin the maximum dew point is 27.5 °C. the combine maximization ratio is 99/53.8.

2.13 Findings

For quick point PMP estimate statistical technique is shown in **equation 1**. At any study area average value of PMP depth will be obtained by combining equations 10, 1 and 4.

$$P_t = [a\frac{1+\tanh\left(\frac{\ln(A)-c}{d}\right)}{2}+b]\times[Sin\left(\frac{\pi\cdot t}{48}\right)^{0.4727}]\times[\frac{R_N}{R_S}]$$

11

For the simple and quick point PMP estimation, the statistical method, **Equation 7** can be used but for the estimation of average PMP at any location from any duration up to 24 hours, **Equation 11** can be used.

2.14 Conclusion

The similar nature of extreme condition was found at Mahakali basin as in Karnali basin. So for the Nepalese part of Mahakali basin the procedure adopted for Karnali will be useful.

3. PMP CALCULATION GUIDANCE

3.1 Steps to be Followed

The quick point PMP can be estimate from statistical methods using historical extreme rainfall data of the meteorological stations. The more reasonable PMP estimate for PMF is hydro meteorological method and the computation procedure using this approach is described in this chapter. The general formula for guidelines of PMP estimation can be obtain by combining **Equation 10, 1 and 4.**

$$P_t = [a\frac{1+\tanh\left(\frac{\ln(A)-c}{d}\right)}{2}+b]\times[Sin\left(\frac{\pi\cdot t}{48}\right)^{0.4727}]\times[MMF]\text{-(11)}$$

X Y Z

To compute from equation 11, following steps have been suggested

Steps for part X

- Identify the location of study area in map of Nepal from **Fig. 2.20**.
- Draw catchment boundary of study area.
- Calculate catchment area in square Kilometer.
- Taking reference of it's location and catchment area, choose coefficients a, b, c and d from one of the **Tables (2.1-2.7)**
- Compute part X of **Equation 11**.

Steps for part Y

- Select required PMP duration (t) in hours.
- Compute part Y for the required duration.

Steps for part Z

- If the study area lies within Terai area, select MMF (R_M/R_S) from **Table 2.8**.
- If the study area lies over mountainous region and has unbroken range of mountains along the path of moisture bearing wind, estimate average elevation of the mountain range and take precipitable water from **Annex 4**.
- After computation of step 9, calculate MMF using **Equation 6**.
- If the study area lies over mountainous region exposed to moisture bearing wind, calculate elevation of the site or catchment outlet elevation and take precipitable water from **Annex 4**.
- After computation of step 11, calculate MMF using **Equation 5**.

3.2 An Worked out Example

3.2.1 Estimation of PMP over Kulekhani Watershed

The study area within Kulekhani Watershed is limited to existing dam site and the total watershed area above dam-site is 126 km^2. The watershed is sub-basin of Bagmati and exposed to moisture bearing wind direction. The elevation of dam site is about 1300 m above mean sea level

For the computation of X, the coefficients a, b, c, d are taken from **Table 2.3**. The station level dew point temperatures are converted to 1000 hPa level with the help of **Fig. 2.21,** and precipitable waters are estimated from **Table 2.8**. Since the catchment is exposed to wind, precipitable water up to elevation 1300 m has been considered for the adjustment of storm elevation. The precipitable water, α and β with reference to its dew point temperatures can be taken from **Annex 4**. The top of the atmosphere has been considered 11 km and using **Equation 5**, MMF has been computed.

The detail estimation of PMP is tabulated in **Table 3.1.**

Table 3.1 Calculation of PMP at Kulekhani Dam site

Catchment Area (A) Sq. Km	a	B	c	d	Ts 1000 hPa	T_M 1000 hPa	α mm At Elv. 1300 m	β mm At Elv. 1300 m	$R_M - \alpha$	RS -β	$MMF = \frac{R_M - \alpha}{R_S - \beta}$
126	-1020.98	541	9.427	4.2248	23.9	28.5	23	29	86	44	1.95
Duration (t) hours	$Y=\text{Sin}\left(\frac{\pi.t}{48}\right)^{0.4727}$			$Z=\frac{R_M-\alpha}{R_S-\beta}$		$X=\alpha\frac{1+\tanh\left(\frac{\ln(A)-c}{d}\right)}{2}+b$				**PMP, mm**	
9	0.702			1.95		436.7				597.8	
12	0.778			1.95		436.7				662.5	
15	0.837			1.95		436.7				712.7	
18	0.882			1.95		436.7				751.1	
24	1.000			1.95		436.7				851.5	

RECOMMENDATIONS

The events of maximum rainfall vary from basin to basin. To cover whole of Nepal, major storms over seven basin groups have been analyzed. After detailed analysis the following recommendations have been suggested:

- In **Fig. 2.1** the maximum dew point temperatures very from 27.0 to 28.5° C. During the study, some meteorological stations show maximum dew point temperature of 28°C, so, the temperatures between 28°C to 28.5°C have been recommended in the guidelines.
- The similar condition of extreme rainfall events were found at the Nepalese part of Mahakali, so, for the tributaries of Mahakali the similar method as for Karnali has been recommended.
- The publications of hourly rainfall data as well as detail meteorological parameters are essential.
- Setting of an additional meteorological station over the northern part of Karnali basin has become urgent.

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5.3 SUNSARI MORANG IRRIGATION PROJECT DEVELOPMENT PROSPECTIVE

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Er. S.K. Pokharel

1. INTRODUCTION

To arrive at the present level, Sunsari Morang Irrigation Project (SMIP) has taken a long course. More than four decades have already passed since the beginning of the Project. It seems it still needs many years to come to a logical end. Many bigger projects have completed in less time. But why it is not so for SMIP? It may be due to financial constraints or the change in demand of society or users. If availability of water in the source is sufficient any changes in the demand can be dealt with. Many modifications are needed to meet the living demand and so require a lot of investment every year. The Project, therefore, has become continuous and can be studied or observed through various fixed ideas, thoughts or concepts. Every paper or discussion means an observation of a moving thing from a fixed point of view. Here in this paper, efforts have been put to analyze the past, the present and the future of the project on the basis of demand and supply theory. The past of the project is divided into two time periods. They can be termed as before hand over and after hand over of the systems. The present is the effect of the past actions in the Project. The existing infrastructure is the out come of the measures taken in the past to meet the existing demand. It is to be investigated whether the existing systems is compatible or not in meeting the present demand. If it is not meeting the demand then what is the problem? Here, it is attempted to identify the present problems of the Project. But solving the present problems may not always cover the future demand of the project. In case of SMIP there is still scope of increasing the supply and so the nature and the size of demand is to be studied. This paper mainly deals with

the development works of SMIP carried out in the past and analyzes them, discusses the present status and future scope of the project. It has also attempted to make recommendations for the future course of the project based on the experience gained so far.

2. THE PAST OF THE PROJECT

The project was initiated in 1964 and is still going on. The period from 1964 to date has been categorized as the past of the project. In this paper, it is further classified into the project before and after hand over for the purpose of study.

2.1 The Project before Hand over

Chatra Canal Project (CCP) is the out come of Koshi Agreement reached between His Majesty Government of Nepal and Government of India (GOI) in 1954 AD. Construction of the project was started in 1964 and was completed in 1970. After a trial run of 5 years, the project was handed over to HMG/N in 1975. The project was composed of a side intake at Chatra, 53 km of Chatra Main Canal (CMC) having a capacity of 45 m3/s, 19 nos. of secondary canals, few nos. of Village Channels (VC) terminated at turnouts serving an area of 200-100 ha without minor canal system below this. It was designed to irrigate about 58,000 ha of area in Sunsari and Morang districts. The designed duty of the project was very low and equaled to 0.66 l/s/ha.

When GOI designed the project, the command area was sparsely populated. There was no road network connecting to the other parts of the country. The project was basically aimed at feeding only the local people there. At that time there were bigger land holdings and so there were no need of many crops in a year. Low irrigation duty and no minor canal systems clearly indicated that the project was designed to supplement the rain for monsoon paddy crop only. The system could meet only the initial demand of the people.

2.2 The Project after Hand over

After hand over HMG/N tried to operate the system. Many big problems were seen in the system. CMC could not carry even the design discharge due to excessive ingress of silt. Its capacity was radically reduced. Koshi River shifted westward and made the problem worse for diverting the water through the intake. The system could not irrigate even one third of the command area. Besides this, the silt carried by the system threatened to desertify the irrigated area. Technically the project became a failure.

Socially also the project became obsolete in fulfilling the growing demand. The living condition in the project area, especially after the construction of the project, improved drastically and the earlier future projection fell far short. Malaria was totally eradicated from the area and so the area started to get densely populated increasing the food demand. Besides this, the area was connected by road network to other parts of the country and became a trade center. Earlier concept of producing food grains for local consumption only proved improper, the people jumped to market oriented crops. The increase in population in the area caused decrease in per capita land holdings. Naturally, people started showing interest in growing other crops also.

Realizing the facts that the system so received could not be run and had become obsolete in meeting the existing demand, HMG/N decided to carry out development work especially focussing on constructing more effective distribution system and minimizing the silt entry in the canals. The World Bank became ready to finance the work. The project was then renamed as Sunsari Morang Irrigation Project (SMIP). Developing the whole command area at a time seemed impossible due to many factors and so the area was divided into Stage I, II and III. Stage III was further divided into Phase I, II and III. The different works carried in these stages are summarized below:

2.2.1 Sunsari Morang Irrigation and Drainage I Project (Stage I)

SMIP, now called Stage I, was initiated in 1978 and completed in 1985. Command Area Development Work of the canals in Jhumka area and Shankarpur distributary was carried out in this stage. The command area covered by effective distribution network was 9,750 ha. An outlet for 10 ha block was provided as an improvement over the existing system. For minimizing the silt in the system Vortex Tubes were constructed which produced certain local effects but proved ineffective in totality. Besides this, river control and flood protection work was done to protect CMC from Koshi River.

2.2.2 Sunsari Morang Irrigation II Project (Stage II)

This stage was started in 1987 and completed in 1995. Major works carried out in this stage were command area development of Sitagunj and Ramgunj distributary covering an area of 16,700 ha and improvement of CMC for increased discharge and better control of the system. Field outlets were provided for 4 ha block and one watercourse for 28 ha which is an action of rectification over Stage I development. No significant work was done in this stage for minimizing the silt ingress in the system.

2.2.3 Sunsari Morang Headworks Project (SMHP)

It became evident that, it would be unwise to carry on the command area development work unless solving the problem of excessive ingress of silt in the system. The command area development work of Stage I and II made the people more interested in growing multiple crops in a year. Every year removal of silt from CMC was to be carried out for maintaining its capacity for the next year after providing irrigation for monsoon paddy. So the system was unable to provide irrigation for other crops thereby adversely affecting the usefulness of the improvement works done in Stage I and II.

In 1991, therefore, HMG/N obtained the advice from an international panel of experts to solve the silt problem. The advice was later implemented which included:

- Moving the intake structure 1300 meter upstream along the Koshi River.
- Constructing a settling basin
- Utilizing dredge for removing silt from the basin, and
- Constructing a micro-hydro unit in the main canal to provide power for dredge.

SMHP was started in 1993 and completed in 1996. The completion of SMHP works and subsequent operation minimized the silt problem and assured the availability of water in the system. The completed components of SMPH were put into full operation since June 1996.

2.2.4 Sunsari Morang Irrigation Project (Stage III)

After the assurance of silt free water in the system, it was decided to resume the command area development work in the remaining area of the project. This stage was further divided into three phases from the implementation point of view. At present, Phase I has just been completed. It was initiated in 1998. Major works carried out in this phase are:

- Command area development work of Biratnagar and Harinagara-Mahadevkol distributary canals covering an area of 11,500 ha.
- Restoration of CMC
- 5.5 km long embankment on the left bank of Koshi River.
- Operation and Maintenance of whole system commanding an area of 68,000 ha.

No special changes were made in the command area development work in this phase. Design is almost same as in Stage II area. The phases to follow in this stage will develop 30,900 ha. The phase II will develop 15,400 ha in Hurhuriya, Bariyati, Nayapatti, Amjhora, and Jhamanpur distributaries in Morang, while phase III will develop 15,500 ha in Sukhsena distributary in Sunsari.

3. THE PRESENT OF THE PROJECT

To arrive at the present state the project has taken more than 40 years. The present of the project is the outcome of the measures taken in the past in meeting the existing demand of the users. At present we have a large network of canal systems covering an area of 68,000 ha. The project now has about 38,000 ha of developed command area and 30,000 ha of area getting irrigation from the same canal systems as constructed by GOI. Intake capacity of the system is 60 m^3/s in monsoon season and 20 to 30 m^3/s in other seasons. At the headwork reach there is an effective sediment removal system with the components like, pre-settling basin, flushing sluice, settling basin and two cutter suction dredge machine. A 3.2 MW hydroelectric station is also located there which is operated by Nepal Electricity Authority. The project has 19 nos. of secondary canals that run north to south and end at the Indian border. The canal network is composed of 53 km of main canal, 200 km of secondary canal, 409 km of tertiary canal and 1580 km of watercourses. About 20 thousands of structures are located at different chainages of the network. Similarly, the length of drainage network is also more than a thousand kilometer.

After completion of the headwork project, users are assured of certain discharge throughout the year. So, they have now started to go for multiple crops, a study shows that the cropping intensity has increased to 216% against the 185% maximum projected for stage III. The major crops grown in the command area are paddy, pulses, sugarcane and vegetables. Alone main paddy covers 97% of the total area. Cultivation of other crops is also intensifying.

The total investment on the project till date is US$ 156.2 million. This does not include the investment made by GOI in CCP.

Major obstacles observed at present while operating the systems are listed below:

- All of the structures in CMC and a few in secondary canals are already 40 year old and so have lived up their life. Rehabilitation/replacement of these structures is inevitable.

- Supply system is to be modified from time to time to meet the demand that changes with time both in size and pattern. The system visualized in 1978 is unable to fulfill the present demand of multi crops in a year. A lot of modification is needed even in the area developed after the implementation of the vision.

- The discharging capacity of CMC is 60 m^3/s. CMC flows full only in monsoon. In other season it is always less than half of the maximum discharge. In monsoon, the discharge of 60 m3/s is sufficient to irrigate the whole command area. In other season, the available water is not sufficient to irrigate the area. But there is ample discharge in the source. It is to be found out whether the discharge of CMC can be increased in dry season just by lowering the present sill level of the intake without constructing a weir or barrage across the river. Another way of increasing the CMC discharge is to tap the perennial sources crossing it in its 53-km long course. Anyway efforts are to be made to use fully the discharging capacity of CMC throughout the year.

- Dredging is found to be more effective in removal of excessive silt collected in the settling basin. Both the dredging machines are in operation for last 8 years. They have so far been able to dispose off 370,000 to 500,000 m^3 of silt deposited in the settling basin per year. They are getting old resulting in the decreased dredging efficiency. Problems of spare parts are mounting and the frequency of break down has gone up. There is an urgent need for third dredge machine and a supplementary gravity flushing system should also be looked at.

- The existing irrigation system of SMIP is the out come of a huge investment done in the last 40 years. The present value of the system is more than US$ 300 million. To operate and maintain the system to design level, a significant amount of budget is to be allocated every year. For the last 5 years no budget allocation was made for the operation and maintenance of the system. The system is near to standstill. Higher authority should consider about this fact.

- Clear-cut demarcation is to be made in the involvement of WUG for operation and maintenance of the systems. Government should operate and maintain the primary and secondary level canals and let WUG do the same in lower level canals.

- All the irrigation systems in Nepal irrespective of small or big are unable to irrigate the whole command area except during monsoon season. This is due to unavailability of required discharge in the source in other seasons. But in the case of SMIP there is ample discharge in the source to command the whole area for any type of crops round the year. So scope is always there to meet the demand of the users for multi crops in a year. Some modifications are to be made in the systems for meeting the requirement and so the project has become a never-ending process.

4. THE FUTURE OF THE PROJECT

Government will not be able to provide employment opportunity in other fields for many in the coming year. Agriculture is and will be a major field for absorbing the most of the people in the country. To raise the standard of living of the people depending on agriculture, it becomes necessary to transform agriculture into industry. Solving the major obstacles observed in the system at present may not be adequate to meet the fast growing demand of the people. More accurate and efficient system providing irrigation round the year is the demand of the future.

5.4 EFFECTIVENESS OF RIVER TRAINING WORKS, (1998)

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ABSTRACT

This paper attempts to present an overview of effectiveness of river training works in the devastated area caused by erosion and sedimentation. The rivers that flow through the Nepalese territory originate not only from different altitudes of the country but also have catchment area lying in Indian and Tibetan region of the People's Republic of China. All the rivers ultimately join the river Ganges.

The Glacial Lake Outburst Flood (GLOF) and erosion, (natural and manmade) of the catchment area are the major processes of sediment production. The increased bed load that exceeds the carrying capacity of the river is deposited along the river course. In this situation, the original course of the river is blocked by sediment deposition and the river changes to new course and devastates the fertile land & populated area, thus damaging the life and property. So far its protection, river training works have to be done in such a way that river flow may be confined to certain channel. The effectiveness of river training works can not be judged immediately; it is possible only after years of experience of floods. A number of rivers training works were carried out in the part, some of which are functioning well but others are not. Investigation on reasons for such success and failure will certainly offer lessons to be considered in an attempt to develop relevant technology, such as preparation of technical manuals etc. In this connection, to assess the effectiveness of river training works, field survey was made for about 50 sites, 38 sites were considered as a typical example and out of which 18 are examples of success & 20 are of failure. Similarly, such events, which have already been experienced in other sites, should also be analyzed in detail.

For the river training works, details of catchment area, drainage pattern, quantity of sediment deposited in the main river, slope, soil texture, climate, high flood level, deepest bed level etc. should be studied. All the sediment brought by the rivers form the mountainous are is finally deposited at the foot hill. Various problems such as aggradation and flooding are created by the river in tarai. The magnitude of loss of property caused by the river has been increasing every year. Such rivers are creating devastation in number of villages and washes out land every year in the downstream of the highway. The protection work is done by constructing embankment with spurs. The construction of embankment restricts the deposition of the sediment in the river bed. As a remedial measure, soil conservation n the catchment can minimize the frequent raising of an embankment.

For control measure such as fixation of waterway, flood height at different return period, estimation of manning's rugosity coefficient, scour depth, silt factor, spacing of spurs etc. should be incorporated in the s dy. Each river structure should be followed by design manuals & cod of practice.

Before execution of any river training structure, the detailed studies on hydrological, geo-technical and engineering aspects should be done. Based on these studies planning, design and execution of major structure can be done. In other words, to execute the river training works for any river, a master plan is to be prepared. For such study the river catchment area should be considered and the design discharge at different reach, assumption about the volume of sedimentation, land utilization, alignment of river training measures etc. are carried out. However, in our context, there is a lack of hydrological data for working out a river twining master plan and therefore, the national rigorous hydrological study is essential.

1. INTRODUCTION

Nepal is a country with a total area of 147,180 sq. km situated between China and India. The country can be divided into three

broad ecological zones, the mountains, the hills and the Terai. The population of the country residing in the mountain located at the northern part, hill at the middle part and Terai at the southern part is 7.3% 46% and 46.7% respectively. Nepal Terai plain part of the Gangatic basin, accounts for 16% of the total areas and 90% of the country. Agriculture provides employment and is the basis for family life in Nepal for 8.5 million out to the 9.5 million economically active population of the country. (Refer [K1])

All the rivers flowing from the north to south in Nepal ultimately joins the river Ganges. Glacial Lake Outburst Flood (GLOF) and erosion, (Natural and Manmade Activity) of the catchment area are the major processes of sediment production.

The perennial high discharge rivers like the Sata Kosi, Gandaki, Karnali and Mahakali originate from the Higher Himalaya while the other large perennial rivers like the west Rapti, Babai, Tinau, Bagmati, Kamala and Kankai originate in the Mahabharat Range. The third type, which are ephemeral and often dry out during dry season, originate from the Siwalik hills.

1.1 Background

This country has numerous rivers, with an estimate of the number of river and rivulets to be about 6000 of which about 1000 are more than 10 km longer and about 100 of them are longer than 160 km in Nepal. The total drainage density covers 0.3 km per square km that expressing the closeness and spacing of channels. Nepal has abundant water resources available. Regarding its character and potential, the surface water resource concentrated on river courses of Nepal have been studied to the extent that it provides a fairly good estimate of this type of water potential for the country. However, for groundwater potential

[K1] Effectiveness Study of river training works examples of success and failure published by JICA & DPTC 1995.

the investigations conducted so far reveal that groundwater potential in southern Terai is also fairly reliable.

Nepal area can be firstly divided into a total of ten basins corresponding to each of the medium and large river flowing from the north to the south. The remaining area in between these basins can be grouped into eight basin which are drained by the small rivers on the southern part of the country which originate from Churiya range to lower part of Mahabharat range. catchment area of river basins from east to west can be made as follows:

Mechi, Kankai,Kosi, Kamala Bagmati, Narayani Gandaki, West Rapti, Babai, Karnali, Mahakali, Southern rivers (Siwalik rivers 8 Divisions).

The long term average annual run-offs of Karnali, Gandaki and Sapta-Kosi are inclusive of the contribution of flows from the catchments located in Tibet. Similarly the run-off of Mahakali is composed of the contribution of flows from the catchment area located in Nepal, India and Tibet.

Regarding the run-off of other rivers, they are totally formed inside the Nepalese territory. Based on these measured data, it is estimated that annual average run-off of rivers formed only inside the Nepalese territory is of the order of 165cubic km, whereas the total run-off inclusive of contribution from the territory in Tibet accounts for 200 cubic km (WECS, 1986)

During the wet season (June-September) the discharge of river is about 80% of the average annual discharge. In the upper reaches, the rivers and streams have steep slope and the flow velocity is higher and they pickup the sediments which are transported to the lower reaches. The transported coarse sediments are mostly deposited just at the foot-hills and become wider channels (Carson, 1985).

1.2 Physical River Behavior

Even the major rivers that origins in the Himalayan region having comparatively more sustained flow character and have the wet-season (June-September) flow in the order of 80% of the annual average whereas this component of flow of other rivers having their origins in the mountains of low elevations exceeds even 85% of the annual average. This kind of sharply uneven distribution of flow in relation to time warrants the need of huge storage facilities for full use of the resources. But in the upper reaches the rivers are such that they flow in narrow valleys with steeper gradients. This situation in the upper reaches limits the potential for creation of storage facilities for regulation of flows. However, the dry season flow in these reaches in comparison with the lower reaches is high due to comparatively higher contribution of flow from snow and glacial zones. (Refer K1)

The rivers have varied characteristic depending upon the altitude and flow of the river. Most of the rivers are active expand and swell during monsoon and the perennial river originate from snow fed area and flow more during dry season. These rivers create a wide spread disaster through out the country by depositing bed load or washing agriculture land, and as well as villages of flood plain area. This phenomena continues along the river. Hence, there is great need to train the river to reduce the disaster in the country.

2. SEDIMENTS SOURCE & DISASTER CAUSED

2.1 Erosion and Sedimentation

In general erosion of watershed, is found to be most intense in the upper reaches and sediment depositions is observed at the lower reaches. The main source of sediment are hill erosion, tributary degradation, gully erosion, flood plain erosion, channel erosion such as river degradation, river bank erosion, landslide, etc. The erosion process is also influenced by the glacier lake outburst floods which caused debris flow, landslide, erosion of

river banks, generally resulting in the huge sediment production. A large amount of sediment are deposited at foothill of Terai plan.

2.2 Shifting of River Course in Terai Area

The increased bed load that exceeds the carrying capacity of a river is deposited along its course. In this situation, the original course of the river is blocked by sediment deposition and the river changes to new course. The phenomenon is repeated and the river oscillates in its flood plain. It is a continuous process, which devastates the cultivated area by drifting river course like a pendulum, swinging to and fro in that area. This is seen, for example, in the Kosi River . The Kosi river has shifted about 120 km from the Rangeli market at the east to the Hanuman Nagar market at the west since 1736 in a period of 267 years.

2.3 Landslides and Sedimentation

Surge form glacier lake outburst, heavy rainfall, wind and earthquake are the main triggering factors for natural landslides. Major quantity of the sediment from landslide are form natural sources. Most of the landslides are caused by:

- the toe erosion during flood
- high pore water pressure
- seismic activity
- damming of rivers, and
- weathered and fractured nature of rocks

In Nepal the process of mass wasting are accelerated by the construction of irrigation canals in unstable hill slopes. After proving irrigation to agriculture land on hill slopes, the soil will have increased pore water pressure, and the angle of repose of soil decreases. So ultimately slope fails producing landslide. Besides this anthropogenic activities such as agriculture on steep slope, construction of road system in geologically fragile area, deforestation etc cause mud flow in catchment area of rivers.

2.4 Glacier Lakes and their Contribution to Sedimentation

The glacier lakes are broadly classified into three categories based upon the damming materials (WECS, 1986).

- Moraine dammed lakes
- Glacier ice-dammed lakes
- Ice-core moraine dammed lake

Glacier lakes dammed by ice have been classified based upon their location. Three distinct lake types are (a) lakes dammed in tributary valleys, (b) lakes dammed by icefall, and (c) lakes occupying super-glacial, and sub-glacial positions

The bursting of glacial lakes owes mainly to the sudden removal of a portion of the dam materials. The erosion of dammed materials is caused due to spilling over the dam adjacent landslide, rock fall, icefall, wind ice calving, etc. also cause the bursting of lake. Piping through the dammed materials, intensive precipitation, etc., are other reasons of bursting of lakes.

The surges from moraine-dammed lakes are more devastative than those resulting form ice-dammed lakes. The peak discharge form ice-dammed bursting take place in a day to weeks but the bursting of moraine dammed lades in sudden; the peak discharge is achieved within minutes and the lake is usually emptied within a few hours. Huge quantity of sediment obtained form glacial lake bursting is deposited in the riverbed. So sudden deposition of sediment increases the river bed level as well as ground level of the valley.

2.5 River Training

In the Terai areas as well as in some valleys of Nepal, river changes its course and thus devastates the good cultivated area. SO far its protection, river training works have to be done in such a way that river flow may be confined to certain channel.

For river training works two type of works are done (a) Structural interventions (b) Non structural interventions.

- For structural measures normally does the protection work against bank erosion and flooding. Such measures are adopted for two purposes (a) flood fighting (temporary one) and (b) River Training. The flood fighting is done for temporary purposes during emergency. However, river training works are conducted to protect land or property for longer period of time with due consideration of hydrological, geo-technical, engineering and financial aspect.

The events which have already been experienced should be analyzed in detail. From these case studies the problems are to be clearly understood and its solution can be identified. In Nepal, geology, topography, density of drainage, climate, slope, soil texture etc. are variable and hence at any time unforeseen problems may come up, which are to be solved in an effective way. To study the problems and identify its solution, proper river training work will have to be needed according to the specialists who are involved for these works.

The problems of mass wasting, erosion and sedimentation are all spread up in the whole country.

For the river training works detail of catchment area like, drainage pattern, gully formation, slopes, soil nature, occurrence of landslides in the drainage system, main river channel flow location, high flood level, deepest bed level etc. are also to be incorporated in its study. For control measures such as fixation of waterway, flood height at different return period, estimation of coefficient of rugosity, manning's"N; scour depth, silt factor, spacing of the spurs etc. should be incorporated in the study.

The construction of embankment, retains the deposition of sediment in the riverbed. If proper soil conservation in the catchment is not property done raising of embankment should have to be done time to time according to the change of high flood level.

- For non structural Intervention
  - Flood Forecasting

Small tributaries originating from southern plan of Nepal area are mostly prone to flood inundation the Siwaliks or Mahabharat Mountain are responsible for extensive damage with flash floods, inundation and high sedimentation. Flood Forecasting section under DHM has been working in developing GIS based data bases on flood zone few southern rivers called East Rapti, Tinau & Bagmati river basins, such studies have to be extensively done in other river basins too.

For developing flood forecasting system voice communication system has also been adopted in Nepal. Thirteen precipitation gonging and twenty three hydrometric stations are recently been equipped with such wireless system covering major river network. It is to be effectively done.

- Bioengineering are found effective in river training works and such measures like plantation of high value trees, different type of grasses etc. are extensively used and root of bioengineering work interlock construction material used to protect erosion.

- Watershed Conservation were concentrated in middle mountains since few years only. Achievement of physical works performed and number of activities are accomplished but its impact is not yet been evaluated in terms of water quality, quantity and reduction in soil erosion. In recent years, population pressure in Terai area has been increased due to immigration from hill side and encroachment of marginal land and the depletion of forest cover over Churiya range were observed. This resulted significant loss of soil cover, landslides and debris flow adding in instability to the river system originating from Churiya range in the category of southern river system mentioned above.

3. CASE STUDY

In order to illustrate the flood related problems and attempts made so far in reducing problems, lesson learned from the efforts, case studies on some of the past experiences are presented in this section.

3.1 West Rapti River System

West Rapti River is one of the river System in Nepal originates from Mahabharat range with total watershed area of about 3904 km^2 and 100 years maximum flood discharge is 2885m^3 at Bhaluwang Bridge of East West highway[K2]. At the upstream of Bhalubang East West highway bridge river. West Rapti is a perennial river Jhimruk. River and Mari River are the two main tributaries of West Rapti River. Out of these two rivers, Jhimruk River originate from Pachase Ko Dhuri at an altitude of 3000 m, flowing due to north side and joins at Mari river at Airawati village in Puthan District.

This river has been depositing enormous quantity of sediment at foothill near to Bhalubang bridge. Consequently, flood events have been inflicting damages to commanded area Praganna Irrigation Project 6684 ha. GCA, Settlement and other property in near vicinity of the river bank. This river is also threatening to Puthan road, Praganna canal system and ultimately East West highway too.

Due to increase in population pressure in hill side upper catchment, large changes have occurred in land cover of its catchment in the form of deforestation, cultivation in slope and conversion of forest land into cultivated land along the rive valley. This has resulted in increase of

[K2] Final Report of Praganna Kulo Irrigation Project 2001

runoff and peak flood magnitudes and subsequently decreases in rate of infiltration.

Further more this river get into 22 numbers of existing farmers canal located at 24 km length of West Rapti and damage fertile land & village area of Praganna Kulo Irrigation Project. For the protection measure an earthen embankment of 10 km length with water face side slope and required launching apron is provided. Construction of this work is in progress still downstream of this reach west Rapti river bank is eroding seriously. So for its protection a master plans is to be prepared soon.

3.2 Bagmati River System

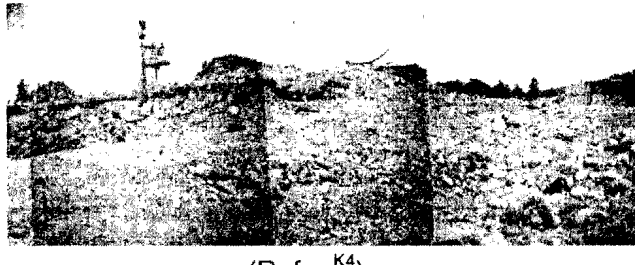
Bagmati is one of the medium river basins that originate from Mahabharat region. This river has total catchment area of 2,720 square kilometers with maximum flood magnitude for 11,000 m3/s (Refer [K1]). However, over the years, the increase of population pressure in Siwalik hills and upper catchment, large changes have occurred in land cover of its catchment in the form o deforestation, cultivation in hill slope, and conversion of forest land into cultivated land along the river valley. This has resulted in crease of runoff and peak flood magnitudes and subsequently decreases in rate of infiltration.

This river has brought huge amount of sediment from the hill area which is mostly deposited at the foothill. This river creates devastation in a number of villages and washed cultivated land every year downstream of the east west highway. For the protection of commanded area of Bagmati Irrigation System embankment with sloping spurs were constructed and some construction work still continued to some extent according to river training master plan.

This master plan was prepared in 1991 for the river stretch covering Karmaiya village in the north to Indo-Nepal border in the south 47.8km. The river training master suggested earthen embankment on either side of river together with 113 numbers of petruding sloping gabion spurs along. The master plan also recommended resettlement of some of the village of 50 years return period flood waterway.[K3]

After preparation of above master plan intensive rainfall had occurred and resulted to huge flood of 1993. This flood had washed out Bagmati Barrage guide bunds canal on either side and village settlement near to Barrage area. After this devastation new guide bunds were constructed. At lower reach of Bagmati river commanded area of Narayani tail portion had been protected by constructing embankment on right bank with number of long spurs (about 260m length) upstream of Gour market as suggested by the above said master plan

(Refer [K3])



(Refer [K4])

[K3] Comprehensive protection of ZNIDP command area including Bagmati Command area project 1991.

[K4] Photo of Construction of Bagmati Barrage Guide funds was taken at site September 2002.

3.3 Kosi River System

Sapta Kosi is the largest river system in Nepal with total watershed area of about 59,400 square kilometers. Some of the tributaries of this river system originate from Tibet in China. The maximum flood discharge observed in this river at Kosi Barrage located at Indo-Nepal border is about 25,780 m^3/s (Refer [K1]). This has been identified as one of the largest sediment-carrying river.

The past research reveals that Kosi river moved its course in between Rangeli Market in the east and to Hanumannagar in the west in Nepal. The largest swing with a total horizontal distance of about 120km from 1736 to 1958 has been observed in Bihar (Chinese Academy, 1982). (**See photo 3a, 3b** shifting of Kosi river over alluvial fan and landsat image of Kosi alluvial fan March 1977, Refer [K5])

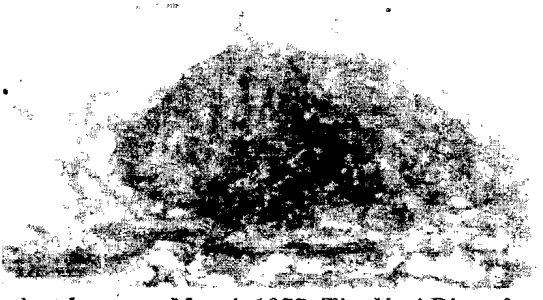


Photo 3a: Landsat Imagery March 1977. The Kosi River from the Himalayan to the Ganges. (Refer [K5])

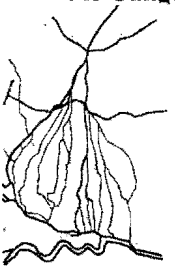


Photo 3b: Shifting channels of the Kosi River over the last 267 years. (Refer [K5])

[K5] Erosion and Sedimentation in Nepal Himalaya, an assessment of river process May 1987 prepared by Water Resources Ministry

In 1964, the Kosi Project with a barrage has been completed with guide bunds and embankments with spurs on both the banks. This has constricted the flow in defined width. However, the bed load of river is normally deposited at the foothills near Chatara village. The deposition of bed load created an island just at the mouth of old chatra canal head regulator and disrupted the hydraulic function of canal system. A detailed study of Kosi River with the help of hydraulic model was prepared in wallingford, U.K. The study revealed that the pressure of flow is mainly on right bank. However, the bank erosion has been observed in left bank in number of locations. To curb this, a number of structural measures covering embankment, spurs, etc, have been provided. (**See photo 3e, 3d**, where series of spurs to protect left bank of Kosi river are visible).

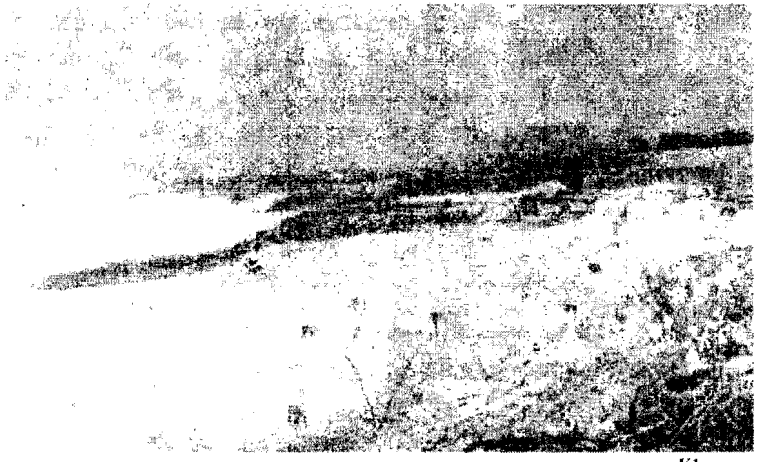


Photo 3c: Sunk sloping spurs in the left bank of Kosi. (Refer [K1])

Although both the banks of Kosi river have been protected with structural measures, the deposition of sediment has been occurring and consequently the river bed is getting raised till today. It is observed that the riverbed in Terai ecological region is in average about two meters higher that the land outside the embankment. This is an alarming situation and this may inflict large damages if proper protection measures are not adopted in time.

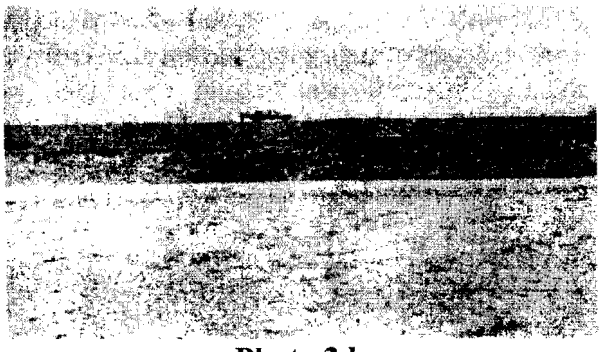


Photo 3d:

Photo 3e:

Ultimate solution to get rid from the flood damages from Kosi will be to reduce the sediment transport. The reduction can only be done with the reduction of soil erosion in this catchment through proper watershed management.

3.4 Manahari River System

Manahari is one of the river system that originates from Mahabharat range and drains into East Rapti River/ The total catchment area of this river is 500 square kilometers. The maximum flood discharge with 50 years return period is estimated at 1,387 M^3/s. The river has been depositing enormous quantity of sediment at downstream of East-West Highway. Consequently, the river course has been

shifting towards the highway since last 20 years. The flood events have been inflicting damages to the cultivated land, settlement and other property in near vicinity of the riverbank and threatening to highway that connects Hetauda and Narayanghat.

Photo 4a: Due to constrained waterway floodwater overtopped the right embankment. Spurs protected the embankment (Refer [K1])

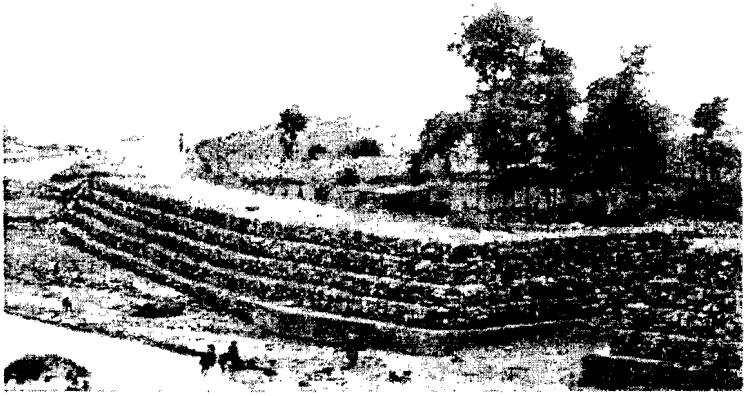


Photo 4b: Newly renovated tight embankment d/s of Manahari Bridge. (Refer[K6])

In 1993, about 3.3 km long dyke with gabion sloping spurs was constructed to solve the problem. However, the floodwater outflanked the embankment (Refer K_1). The reasons identified for the damages include : (i) heavy deposition of bed load in constrained waterway, (ii) expensive rigid structural river training measures such as

dyke and spurs, (iii) subsequent increase of flood height due to deposition of bed load on river bed; and (iv) absence of cut channel that was provisioned in design. (**See photos 4a, 4b**). Eventually, the protection works were renovated with increase of embankment height. Currently this river training work is effectively working (Refer [K6])

[K6] Road Flood Rehabilitation Completion report dated July 7, 1995

5.5 PARTICIPATORY LEARNING IN IRRIGATION MANAGEMENT AN EXPERIENCES FROM "NEPAL: GUIDELINE FOR GOOD GOVERNANCE PROJECT"

- Dhruba Raj Gautam[9]

ABSTRACT

The livelihood of Nepalese farmers is highly dependant on agriculture so the role of irrigation is very important. There have been many efforts to make irrigation more sustainable but the results have not so appreciative. Irrigation is a complex socio-technical process so only institutionalized institution can manage it. A lot of resources have been invested in the name of capacity building and institution development of institutions through training, workshop and exposure tour, the results are still not so favorable.

So far, in the name of institutional development, most initiatives started with little consultation of stakeholders, and were in response to external pressures. Now there is a growing realization that institutions must be based on the local situation, culture, need of farmers if they are to continue to operate in the long run. Local farmers, rather than outsiders should initiate the process. This is essential if farmers are to feel ownership of the system, which is one of the fundamental requirements for institutional reform. Sustainable and equitable distribution of irrigation water is indeed needed to improve the livelihood of rural farmers. So well-governed irrigation institutions are crucial.

The major thrust of this program is to use various participatory tools and techniques to involve stakeholders in planning, the institutions and institution-building process. Through these detailed diagnostic studies, we have identified many issues that

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[9] Mr. Gautam is PhD Research Student in Sociology. He is currently associated with Nepal: Guideline for Good Governance Project as Participatory Learning and Action (PLA) Specialist. This project is implemented by DPCS/DoI/Mott MacDonald and funded by DFID (UK).

are important for sustainable irrigation management and we have helped the various stakeholders (including landless, poor, women, sharecropper and tenants who are often excluded from WUAs) to develop an action plan suited to their specific needs. These action plans are now being implemented through the medium of Water Users' Schools (WUS), which involve a wide range of stakeholders and help the users to develop their skills and institutions to meet their specific requirements. The programme has been initiated at Sunsari Morang Irrigation Project (a large joint-managed scheme) and Kamala Uttarbahini Irrigation System (an FMIS), with further work due to start shortly at Bijaypur.

This paper summarises some of the initial experiences of this program, such as the participatory tools and techniques used to involve the stakeholders in collect to socio-economic and socio-technical information on agriculture, institution, water management and infrastructure; the modality of this detail diagnostic study; and the process of preparing action plans. This paper also includes some ideas on the modality of water user schools, selection criteria for WUS participants, how the messages are spread from the school to the wider community used to strengthen the users' institutions in a cyclic manner. Nepali farmers have wealth of knowledge and skills.

Background

Nepal: Guideline for Good Governance (GGG) is an action research project funded by DFID. It is being implemented in Nepal and China so that ideas and experiences can be shared effectively. It was started in January 2002 and will be completed in March 2004.

Irrigation management transfer from government agencies to water user associations and other user's organizations is widely believed to be important for improving the performance of irrigation systems. This has been adopted as policy in many countries of the world but results have been mixed so far, and

the anticipated benefits have rarely been achieved. This research project aims to identify ways of improving participation in WUAs and strengthening them, with the objectives of enhancing the productivity, sustainability and poverty focus of irrigation schemes.

This research project has four specific outputs. First, review summarizing irrigation system performance on about 20 schemes against standard of governance and second, problem identified and potential solutions developed with stakeholders on about 5 selected systems-this will be key component of the study and will define how the stakeholders envisage the scheme managed. Preparation of guideline that include the means to adopt rules and institutions to suit local requirement and improve the poverty focus of water resource management, third and initial recommendations for policy refinement to facilitate better governance of water management institutions, fourth.

Project Management Set-up

GGG project is funded by DFID and implemented by Mott MacDonald under the close coordination with Department of Irrigation (DoI) and DPCS/User Centre. It has three sub-projects such as Bijayapur irrigation Project, Kamala Uttarbahini Irrigation System and Sunsari Morang Irrigation Project.

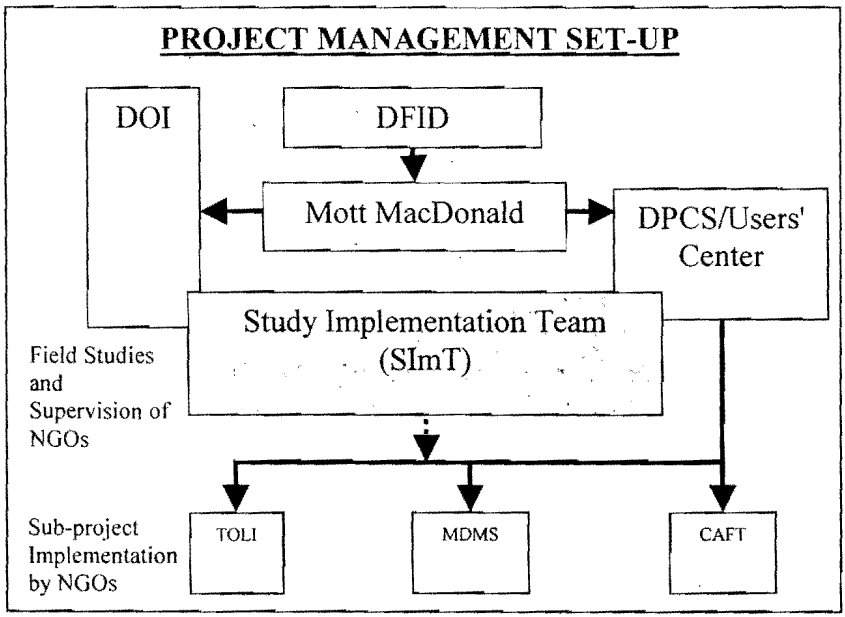
The Bijayapur Irrigation Project (BIP) is located at Lekhnath Municipality of Kaski District in Gandaki Zone, Nepal. This is agency managed irrigation system so it is operated and maintained by District Irrigation Office (DIO). The Water Users Committee (WUC) was registered in the department of irrigation, in April 2002. The total command area of the system is 1280 ha and the study area covers branch 3 and 4 (380 ha).

Kamala Uttarbahini Irrigation System (KUIS) lies in Siraha district of Eastern Nepal. It a farmer managed irrigation system, which covers four wards of Badaharamal VDC. Its command area is about 500 ha and has ten branches. The whole area is included in the study area.

Sunsari Morang Irrigation Project (SMIP) lies in both Sunsari and Morang districts of Eastern Nepal. It is a joint managed irrigation project which covers about 65000 ha of land. The study area consists of about 722 ha. The study is confined in one sub secondary (SS9E) of Sitagunj branch canal.

In the central level, a multi disciplinary team known as Study Implementation Team (SImT) is working for monitoring and supervision of the ongoing sub-projects. In the initial stage, SImT was involved in carrying out DL/AP study in SMIP and KUIS. In SMIP, the team involved directly in tertiary 3 (T3) and in KUIS it was involved in branch 5.

The rest of DL/AP work was carried out by Forum for Rural Women Ardency Development (FORWARD) in association with Multipurpose Development and Management Services (MDMS), Centre for Agro-forestry Technology (CAFT) and Team Organizing Local Initiatives (TOLI), the NGOs in SMIP, KUIS and BIP respectively. These NGOs are involved both in DL/AP and conduction of Water Users School (WUS).



Institutional Development

Software as well as hardware programs are essential for irrigation development but there has been little success in setting up sustainable institutions. The water users Associations (WUAs) are often set up quickly so that many water users are not aware of their purpose, they are not based on detailed local knowledge, they are often dominated by local elites, and they have a focus on rehabilitation on infrastructure.

Objectives and Approaches of GGG

The basic objective of GGG is to involve the stakeholders as much as possible in irrigation management. The other objectives are to understand the local situation and the diversity of interests and problems, enhance the access of poor, landless and women to irrigation management and involve them in management so that they can get benefits from irrigation

GGG builds on previous attempts to improve the situation, for example on IMPT and NISP, and uses an even more participatory approach. This involves two overlapping stages-diagnosis and implementation through water users schools. The diagnostic phases refer to as diagnostic learning and action plan (DL/AP) and methods for strengthening the institutions, through a process of Water Users Schools (WUSs).

This paper ties to explain the relevance of these two approaches (DL/AP and WUS) based on detail field work in three sub-project areas.

Diagnostic Learning and Action Plan (DL/AP)

The objectives of DL/AP is to collect sufficient information on socio-economic, socio-cultural and socio-technical aspects of the system to plan the water users schools, to encourage, sensitise and motivate local people to involve them in the whole process, and to encourage participation of other stakeholders in irrigation management.

For the purpose of DL/AP, four major topics were dealt with such as Irrigation infrastructure, Water management, Institutional development, and Agriculture.

Methods Used in DL/AP

The DL/AP is based on PLA methods such as those outlined in the IIED Participatory Methodology Series, the FAO SEAGA Guidelines and the WB Participation Source Book, followed by institutional development using various approaches which are field tested by (I)/NGOs to assess their suitability and wider applicability. During DL/AP, following tools were used.

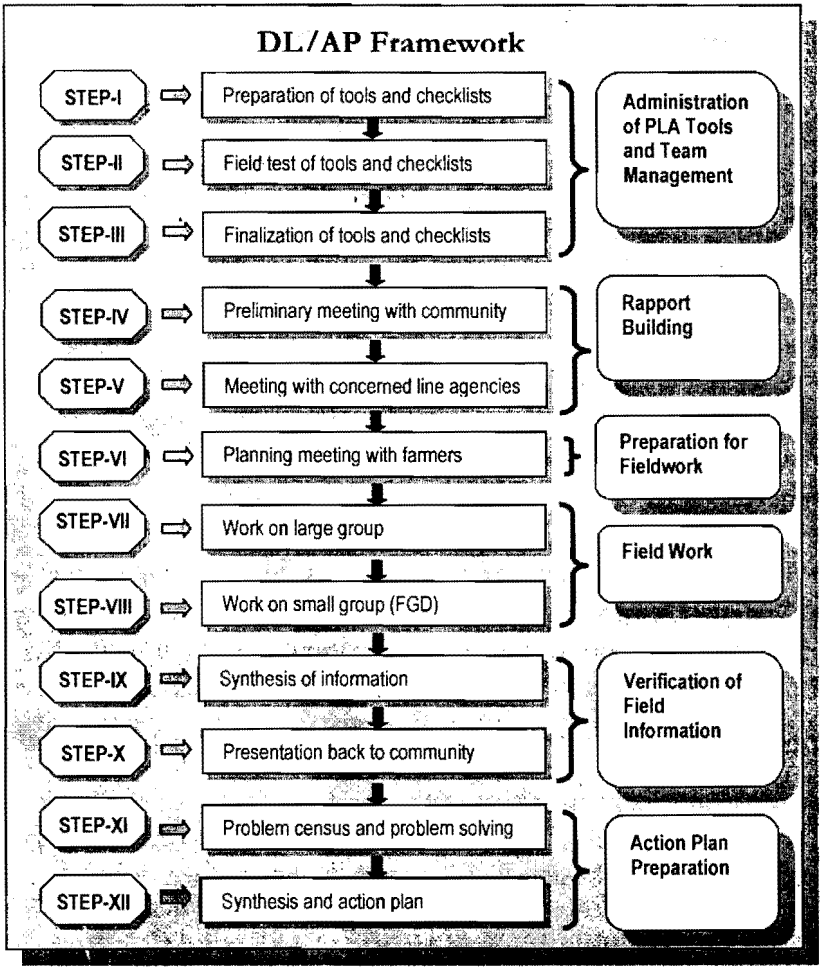
- **Social/Resource Maps**, covering irrigation network, social infrastructures and resources
- **Household Profile** to understand population and access to land
- **Well-being Ranking** fir identifying the strata for small group discussions
- **Transect Walk** to verify the physical condition of canal network and its problems
- **Time Line** to record ethno-history of area
- **Seasonal Calendar** to assess the interrelationship of CBOs (including WUSs)
- **Trend Analysis** to record socio-economic changes
- **Gendered Task Analysis** to assess the work local of men and women
- **Water Use Matrix** to examine multiple users and sources
- **Focus Group Discussion** to identify the perception, beliefs and experiences of farmers related to our study objectives
- **Problem Census and Problem Solving (PCPS)** to present different problems and discussed with the community as a whole
- **Action Plan** to know the specific needs of farmers at different level (Head, Middle and Tail with well-being strata) on the basis of PCPS and synthesis of the findings

Detail Process and Stages of DL/AP Study

A multidisciplinary team of five professionals (Engineer, Senior

Sociologist, Junior Sociologist, Agronomist and PLA Specialist) working with Field Assistants (from sub-project area). All field observations were recorded on large sheets of paper with the water users so that they could be involved in the data collection, see what we were recording and thus learn about their own system. The original sheets were left with the community and transcribed for our records. The team used pictorial techniques wherever possible so that illiterate people could be involved.

The main stages of the process are categorized into three broad heading. They are planning, field work and reporting.



Planning: At first a multidisciplinary team was managed. Based on the nature of work to be carried out, tools and checklists were prepared. Those tools and checklists were tested close to the actual research side in order to familiarise the team with tools. Based on the feedback received from field, some tools and checklist were amended.

The SImT visit to WUA to explain the objectives of GGG and gain their interest in participating in the process. Similarly, the team also visited to other local institutional stakeholders to records their views and feedback and suggestions. Then with farmers, overall planning of DL/AP based on head-middle-tail /size of community. At the end, a general meeting was organized to explain the purpose in detail.

Field work: The field work is categorized in to two groups. Some tools were used in the large group meeting. They were social/resource mapping, household profile, well-being ranking, seasonal calendar, gendered task analysis, and Venn diagram. Similarly, small group activities were conducted through tools like water use matrix, time line, time trend analysis, transect walk, and FGDs (stratified by well-being and gender).

At the end, all the reports were presented back to community. Then all the information were synthesized of collected information and presenting back to community in order to verify the information. Some addition and deletion was carried out on the information. Problem Census and Problem Solving (PCPS) tool was used to identify the problems based on the well being strata. The problems and their solution were tabulated and categorized by ranking based on the level of priority on the farmers. Then the PCPS was synthesized to make an action plan. The action plan is the synthesized form of PCPS summary, findings of DL/AP report and personal observation of study team.

Reporting: Then all information are managed into four main headings of the report such as irrigation infrastructure, water

management, institutions and agriculture. Some secondary information are also used for the study. In each study section, strength, weakness, opportunities and threats (SWOT) exercises are carried out and implication of those in system operation and management is analyzed.

DL/AP might seem a very long drawn out process but it is important to ensure we get a good understanding and develop effective relations with the community.

DL/AP: An Effective Method of Data Collection

All the participatory tools used during DL/AP have created interest among the farmers. These tools are easy to understand and more practical. Hence the data collected through this process is more reliable. This process involved all section of society including gender, caste and ethnicity. It has helped to increase ownership feeling among the farmers.

The attitude of farmers towards DL/AP was found very positive. Most of the people were interested to learn more from the study. Marginalized and medium farmers were more interested and participated equally during study. WUA officials were also supportive. Key persons helped the study, and there is a strong relationship among WUA officials and users. Some well off farmers had much curiosity and few were against the study, because the study was carried out at the time of peak agricultural activity. People symbolized DL/AP work as 'X-ray' of the irrigation system. Some people have some expectations and others thought that the study would be useless because there have been many previous studies carried out but no action was undertaken. But DL/AP has changed the perception of farmers because of its innovative learning process.

The DL/AP brings stakeholders together to discuss their problems and requirements, and helps them understand the issues. This greater awareness can have immediate impact, for example in the new elections to the WUA at Kamala. DL/AP is very fruitful to plan Water User's Schools.

DL/AP : Some Benefits

Through DL/AP, it was easy to get reliable information on socio-economic, socio-political and socio-technical aspects that require knowing any irrigation system as irrigation is a socio-technical process. Farmers were involved in the whole process with whole heartedly. Farmers are now able to demonstrate how women, landless and poor are benefited from irrigation and why it is important to involve them in irrigation management. It has able to raise the awareness level of the farmers about their system and problems. Now, farmers are aware on their roles and responsibilities as a water user. An action plan was made sitting together with farmers based on the findings of DL/AP study. It has helped to identify the performance of institution. The study team found that 'might is right' everywhere in using the water. The provision of *Panibause* (water supervisor) in BIP is one of the interesting examples. The study also found that why female role is important in decision making.

Transparency and building trust is an important phenomenon to run the institution. The study helped to maintain good working relationship among the irrigation officials and farmers. built up among committee members and users. Increased desire of learning for their system. Identification of problems of the system and also found the alternative approaches for resolution. It has helped to identify various stakeholder (both primary and secondary) and create an awareness of multiple uses of water. Awareness of water rights is also enhanced. Now the farmers are realized that water service charge is important. Increased labor mobilization for maintenance and learnt the relationship between water management, institutional development and agriculture for sustainable irrigation management.

Practical Problems Encountered

In irrigation system, social and hydrological boundaries rarely match, so social/resource mapping and well-being ranking related to water users is difficult, but it is essential. People are reluctant to provide accurate data of land holding, but we could

collect sufficient data at this stage and more complete data could be collected later once greater trust has been established with both irrigation officials and farmers. Information sometimes influenced by various group interests, so different tools are used to verify data for its reliability and validity. Well-being ranking is essential but sensitive and creates some misunderstanding among the users unless done very carefully. It requires matured facilitator. Initial suspicion based on dissatisfaction with traditional methods used in earlier programmes could be overcome as people learnt and became interested in the new techniques. The present study also win the confidence of farmers.

Water Users School (WUS)

The basic objective of WUS is to develop skills to enable users to form strong institutions. It is realized that it can be possible by strengthening WUA so that irrigation management is improved over the whole system, increasing involvement of vulnerable stakeholders in irrigation management, encouraging links between water users and other local institutions and agencies and increasing the representation of weaker stakeholder in WUA.

Administrative Management for WUS

Selection of participants: For the establishment of WUS, DL/AP played a vital role. Some tools such as social map and HH profiles and well-being ranking are used to select the various farmers from H/M/T, caste and ethnicity with (highly well-off, well-off, medium, weak and vulnerable). Participants were selected in consultation with respective WUGs and WUC. Several meetings were organized to finalize the list of participants. Efforts were made to meet the criteria of the selection of participants.

The WUS consists of variety of farmers from all section of society (in terms of well-being) and represented from all the section of the canal (head, middle and tail). While selecting the

participants, gender, caste and ethnicity were equally keeping in mind with the help of DL/AP report. Some Dalits and landless were given high preferences in selecting the participants but it is based on the HH profile and in a basis of proportionate - initially reluctant to participate

Selection of site: Site selection for schooling place and demonstration plot was done in consultation with the respective participants. The social and resource mapping also helped to select the appropriate location for school. For the purpose of site selection of WUS and demonstration plot, social and resource mapping, FGD, transect walk were used in order to know the interest of the farmers on the common and agreeable venue for WUS.

Regularity of participants: At least 70% of total participants were found to be regular in attending the school in spring season. Almost all the participants (except few women and landless) are actively taking interest on the school. They are actively participating in each activity (sub-group exercise, discussion, question/answer, field visit) from starting to closing of schooling period (7 AM to 1 PM). Efforts are also being made to create the interest of few women and landless through group dynamics and other activities. Some are irregular, because it is peak farming season. Participants from middle and tail part are more regular in the school. Most participants attend regularly even though no training allowances are given.

During the implementation of WUS, a number of efforts were made to retain the interest of participants in the school. The importance and rationale of WUS was facilitated many times organizing participatory discussions. Regular counseling and door to door visit were also organized through FAs and curriculum was prepared to suit the needs of farmers.

Selection Criteria of the WUS Participants

Participants are selected based on the following criteria.

- Interested and self-motivated, respected, committed to participate in the school for the full duration of the WUS
- Active in farming/agriculture, willing to disseminate what they learn
- WUA official between 6-9 or not more than 33%
- Proportional to number of HH of head, middle and tail
- Aged between 22-60 years and participants between 25-30
- About 50 % women
- Literacy is not mandatory
- Representation proportional to number in each well being category.

Methodology to Run the Schools

Short lecture, games and role play, group discussion, poster show, question and answer, brain storming, field observation and presentation were used in order to use the adult learning methodology.

A simple methodology was set up to organize the discussion more participatory. At the beginning, feedback from minor schools were recaptured then the discussion is entered into special topics. The special topic contain observation of part of system, sub-group exercise, presentation and discussion, synthesis. After this session, a small agricultural topic/activity is discussed. At the end, a tentative plan is made for minor schools and for next session.

Modality of the Schools

There were two types of schools: majors and minors. Major schools are established at tertiary level (SMIP) and branch level (KUIS and BIP). The minor schools are at lower level. Participants in the major schools are the representatives from each watercourse whereas participants in minor schools are the beneficiaries of representative watercourse.

The role of these schools is also different. Role of major schools include: to introduce and explore the special topic for each week through WUS Manager/Subject Matter Specialist (SMS), to stimulate participants to discuss key irrigation management themes and issues, to identify practical measures to promote good irrigation management and to act on their ideas, to share their learning with the wider community and to provide a forum where representatives from all sections of the community, including women, landless, ethnic minorities and feel free to share their ideas and are listened to. Similarly, the role of minor schools is to disseminate their learning to the wider community and to provide feedback to major school in a regular manner. Minor schools are considered as a regular platform for major school participants.

Curriculum for WUS

Curriculum is designed on the basis of DL/AP report. Three themes are considered such as institutional development, water management and agriculture. Among these themes, greater attentions are paid to institutional development, water management. Special topic is identified based on the themes. Adult learning principle is adopted.

Resource persons are selected by NGO from local institutions to promote links between WUA and support institutions. Before that orientation training was organized to provide basic information on the GGG (objectives, goal and DL/AP report) to ensure that they use appropriate teaching methods.

Importance of DL/AP in the planning and Implementation of WUS

DL/AP helped in developing curriculum for the school based on the key issues and problems and it has also helped in the selection of participants. DL/AP provided the information on the categories of farmers who are directly related to irrigation

system (such as land owner, tenant/share cropper, landless, and information on well-being, ethnicity).

DL/AP assisted in selection of participants, which was done in consultation with WUG and WUC, in accordance with criteria to ensure good representation. Site selected in consultation with participants. Most participants active and attend regularly. Curriculum developed on basis of DL/AP. School methodology based on field visits/problem identification, briefing, sub-group exercise and discussion. Major school participants act as facilitators in minor school. DL/AP assisted in selection of participants, which was done in consultation with WUG and WUA in accordance with criteria to ensure good representation. Site selected in the consultation with participants. Curriculum developed based on the action plan developed through DL/AP. School methodology based on the field visit/problem identification, briefing, sub-group exercise and participatory discussion. Major school participants act as facilitators in minor school.

Role of WUS for Networking among Line Agencies

The WUS acts as a catalyst to promote institutional linkage. In the school, line agencies officials are invited in the particular special topic session as Resource Persons. Special session also helped to address issues of cooperation and coordination because higher officers from CBO, NGO, line agencies invited to attend WUS session both as resource person and observer.

Emerging Problems and Constraints

Number of very well-off and landless participants was less than the target. Participation of land owner and tenants/share cropper was more than target. Some women are less active in the discussion and other activities. Participation stabilized at about 70% of the original number after about one month. Some of the chairmen of WUGs were less interested in attending the school.

In order to overcome these problems and constraints, some alternative approaches were administered such as careful selection of participants to ensure that interested people in each category were selected, encouraging more WUG officials to attend, by explaining the purpose of the WUS, pressure from other participants for WUS officials to attend, as they realize that they could only improve the situation if the officials cooperated, and more sub-group activities, using small groups formed according to landownership and gender so women and marginal groups can participate without feeling threatened.

It is obvious that the well being strata of the people is different. Some participants from highly well-off and landless are less participated and landowner and sharecropper more than targeted. Some women are less active in the discussion session. It was found that participation remain stagnant at about 70 % of the original number after one month. Some of the Chairmen of WUGs were less interested in attending the school.

An attention was made for careful selection of participants to insure that interested people in each category were selected. Encourage more WUG officials to attend by explaining the purpose of the WUS. More sub group activities are organized using small groups formation according to landownership and gender so women and marginal groups can participate fully without any hesitation.

Preliminary Impacts of WUS

Significant changes are seen both in attitudes and understanding among the farmers. WUS participants take action on own initiative to improve management. WUS pressurized on WUG to become more active. Awareness on overall system management (joint management, farmer managed and agency managed). Aware on the roles and responsibilities of users. Aware on the need of active irrigation officials. Aware of need to use field channels, and to deliver water in accordance with a schedule. Emerging sense of ownership for irrigation system.

Aware of need for equitable water delivery for the benefit of all farmers (head-middle-tail). Recognized importance of crop planning. Significant changes in attitude and understanding. WUS participants take action on own initiatives to improve management. WUS applies pressures on WUG to become more active. WUGs have already responded positively with action. Aware of overall system management. Aware of need to elect officials themselves. Aware of needs and responsibilities to clean tertiary and water course. Aware on the need to use field channel and to deliver water in accordance with a schedule. Emerging sense of ownership for irrigation system. Aware of need for equitable water delivery for the benefit of all farmers (head, middle and tail). Recognised importance of crop planning

Women's participation in schools is higher than men. The landless/labourers learn skills which give them better employment opportunities. Greater awareness of irrigation management issues by all users leading to better interaction between users. Greater demand to participate in schools after seeing the benefit of the spring season schools. WUA meetings started as users' demand. WUA started record keeping formally. WUA became active in canal related jobs like water distribution, desilting and cleaning. Lower level of WUA reformed. Women have become involved in WUAs

WUS: An Effective Vehicle for Action

WUG meetings are regularized and decisions are implemented. Some tertiary canals are desilted and water courses are cleaned with the collection of *bighauti* (in SMIP and BIP) . Plan to establish tertiary level committees (in SMIP). WUGs are revitalized by filling the vacant postion (in SMIP) and committees are reformed and formation of sub-committee (in BIP). Now, farmers are aware on not to install illegal pipes and they are started for removal of some illegal outlets and pipes (in SMIP).

It provides an environment of participatory discussion, decision making with action involving all strata of the community. Users are benefited from a lot of information about their systems thus an understanding of their system and ways to develop their institutions. Realization of weak irrigation institutions, their reasons and know the alternatives. Users became familiar with their committee members and shared ideas with them. Water users' learnt how to solve these problems themselves. Head users understood the problem of middle and tail users thus build the social harmony among them. ecision to start water fee collection by WUA. Feeling of unity among WU has been created. Committee members became aware of need for sharing institution. Branch committee were reformed and formulated three sub-committees formed (head and middle). Information dissemination about role and responsibility with meeting and committee in HMT. Improve legal and remove illegal *pyans*

Conclusions

These DL/AP techniques can be effective and useful to large scale irrigation also. It is effective for involving all sections of society and maintaining their interest in the project. It is an effective vehicle to starts process of awareness building, provides sufficient information for planning future programs, and requires considerable multidisciplinary human resources in the study team.

5.6 A CASE STUDY: ENVIRONMENTAL MONITORING AND MANAGEMENT OF AN IRRIGATION PROJECT

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ABSTRACT

East Rapti Irrigation Project was initiated in 1987 with the assistance of Asian Development Bank. The Project is located in the periphery of the Royal Chitawan National Park, a World Heritage Site designated by United Nations Educational, Scientific and Cultural Organization in 1982. The Park supports one of the last remaining habitats of the one-horned Asian Rhinoceros, Begal tiger and various plant species. East Rapti River, the source for irrigation, passes though the Park and it is one of the major sources of water for the habitats of the Park also. Initially the proposed project was to construct a diversion weir across the river and provide the irrigation facilities to about 9500 ha. of land in the Chitwan Valley. Serious environmental concerns were raised by the international and national environmental groups against the implementation of the project due to the possible dewatering at the down stream of the diversion weir, especially in the dry season. The project was reformulated and scale down to 5200 ha. The reformulated project was (i) to increase the efficiency of the water use without increasing the withdrawal of water for irrigation from East Rapti River and (ii) to provide irrigation water by groundwater resources. There were still environmental concerns in the revised project. They were (i) the improved irrigation systems might abstract more water from the river which could affect the dry season flow in the river (ii) the intensive exploitation of the groundwater resources may deplete the ground water resources which might affect the growth of riverine forest in RCNP and (iii) residual traces of pesticides and fertilizers on the surface water of East Rapti River could be dangerous and fatal for the

habitats of RCNP. To address the above issues, a comprehensive environmental monitoring of both surface water and groundwater in terms of water quality and quantity were carried out from Sept, 1994 to July 1998.

The monitoring concluded that there is substantial base flow from groundwater to surface water of East Rapti River during the dry season when the water level is the river is lower than the groundwater level of the surroundings. The minimum discharge during the driest day of the dry season in the East Rapti River at the entry of the RCNP, Sauraha, was more than 6 m^3/s. Hence the environmental impact of the Project on RCNP in terms of water availability for the wild habitats would be insignificant. Even though the sell of fertilizers and pesticides in the Chitawan district is comparatively higher than other districts of Nepal, the residual affect on the surface water and groundwater of the project area were found to be negligible.

East Rapti Irrigation Project is the first project that has been reformulated due to the environmental concern in Nepal in 1989. Since then His Majesty Government Nepal has shown its commitment in the environmental protection while implementing the development projects in Nepal. National EIA Guideline for Water Resources (Draft) was prepared in 1993. HMG/N has enacted Environmental Protection Act in 1996 and followed by Environmental Protect Regulation in 1997. The EPR has been amended in 1999.

1. BACKGROUND

East Rapti Irrigation Project was approved by Asian Development Bank for the financing under Loan No. 867-NEP (SF) in November 1987. Its objectives were to increase the agricultural productivity, enhance rural income and accelerate rural development by providing irrigation facilities for 9,500 ha of irrigable land in the Chitawan valley. The project area is located in the in the periphery of Royal Chitawan National Park (RCNP). The park supports one of the most impressive assemblages of large mammals in Asia. It is one of the last

remaining habitats of one-horned Asian rhinoceros, the Bengal tiger and various plant species. The park has been designated as a World Heritage Site in 1982 by the United Nation Educational Scientific and Cultural Organization. The source river for irrigation, East Rapti River passes through the RCNP and it is one of the major sources of water for the habitats of RCNP. The proposed project was designed to construct a diversion wear across the East Rapti River to provide irrigation facilities. A location map of the project area and its vicinity is shown in Figure 1. The project had carried out the EIA study. However the study did not adequately highlighted the possible adverse impact on the RCNP due to the possible dewatering at the down stream of the weir. The possible adverse impacts of the project were high lighted by several international and national environmental groups. A Special Loan Administration Mission was administered in November, 1989 by the Bank and HMG/N to look into the different issues of the project implementation including environmental issues. The mission not only queried the project cost and economic viability of the original appraised design but also raised concerns regarding possible adverse impact that might have on nearby RCNP. Hence the Project was reformulated. The reformulated project excluded the controversial diversion weir and the scope of the irrigation component was limited to the rehabilitation and improvements of 85 existing farmer managed irrigation schemes rather than expanding or constructing new irrigation schemes. The command area was thus scaled down from 9,500 ha to 5,200 ha. The revised project was designed to increase the efficiency of water use without increasing the withdrawal of water for irrigation from East Rapti River. It was also proposed to provide irrigation facilities by groundwater in those areas where there is no access of irrigation water from existing FMISs. The revised project was designed to avoid any incremental reduction in the base flow of East Rapti River and therefore is not expected to have a significant negative impact on the environment.

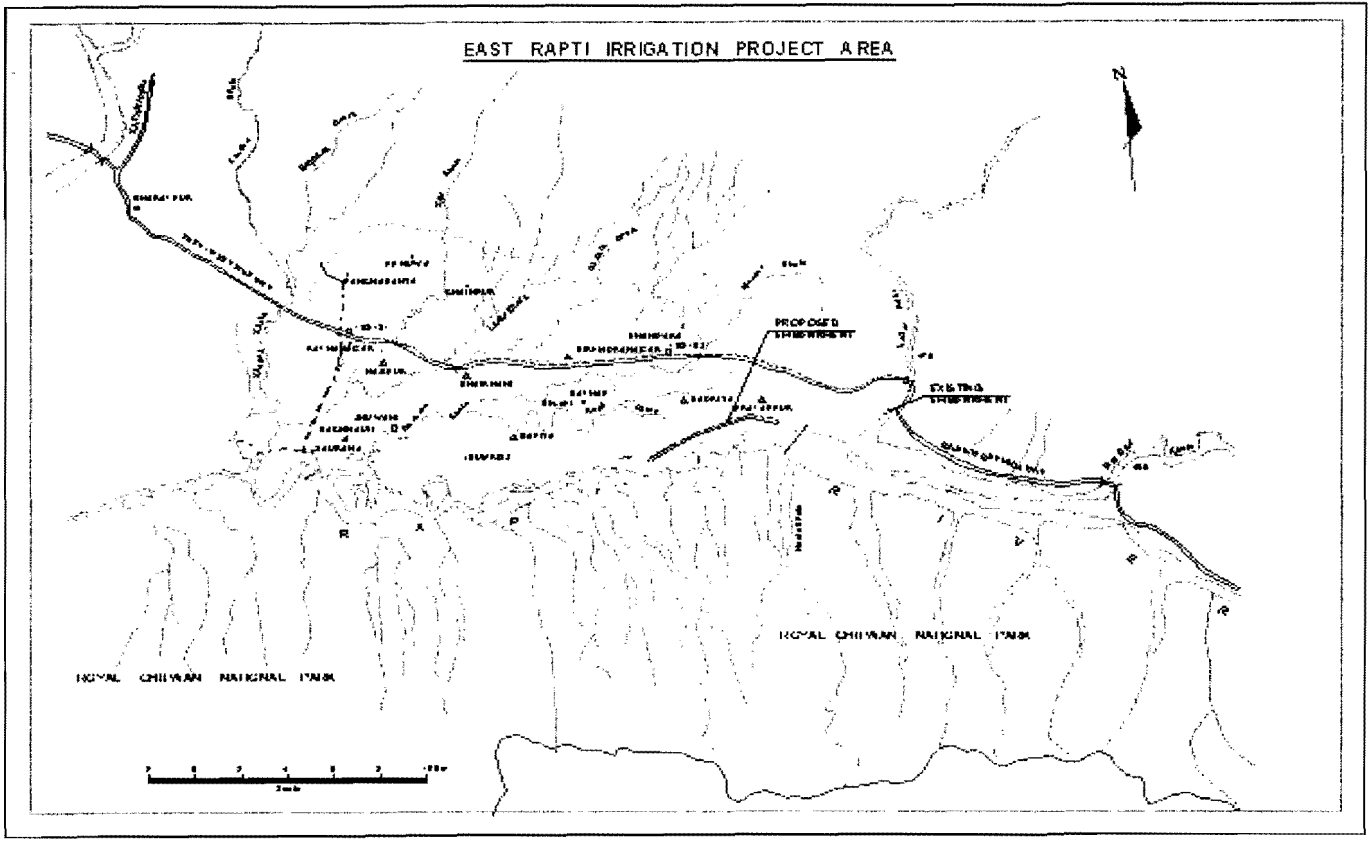
However, there were still environmental concerns in the revised project mainly related to the RCNP due following reasons:

- The improved irrigation systems might abstract more water from the river which would affect the dry season flow in the river.

- The intensive exploitation of groundwater resources by the construction of shallow tube wells might deplete the groundwater table in dry season which might affect the growth of riverine forest in the RCNP

- With the implementation of the irrigation project, there was likely to increase the use of chemical fertilizers and pesticides in the command area which might leave the residual traces in both surface water of the project area including East Rapti River and the groundwater of the project area as well as RCNP. The traces of the pesticides and the fertilizers in these water resources could be harmful to the habitats of the RCNP and the project

In order to address the above concerns, a Technical Assistance was formulated by ADB and DOI for the environmental monitoring and management of above issues. A major component of the project was construction of flood embankment on the right bank of East Rapti River to protect the command area. The plantation along the flood embankments were also proposed as the second line of defense against the flood. This would not only strengthen the embankment but also produce substantial quantity of fuel wood and fodder to the communities in the nearby vicinity which would reduce the stress in RCNP for fuel wood and fodder. Role of TA was to assist DOI in plantation with active participation of the local communities. Towards the end of the TA program, the institutional strengthening and the capacity building of the WUAs were also included in the TA activities.


EAST RAPTI IRRIGATION PROJECT AREA
N
PROPOSED
EXISTING
ROYAL CHITWAN NATIONAL PARK
ROYAL CHITWAN NATIONAL PARK

2. OBJECTIVES OF TECHNICAL ASSISTANCE

The main objectives of the TA was (i) to monitor the dry season flow of East Rapti River as water availability could be affected during the dry season if the water is abstracted from the river (ii) to monitor the groundwater level of the project (iii) to monitor the water quality of both surface water and groundwater of the project area (iv) assist the project in establishing the community forest along the proposed food embankment of East Rapti River (v) to strengthen the institutionalization process of WUAs under ERIP and their capability building in the operation and maintenance of the irrigation systems.

This technical paper will be limited in the water quantity and quality component only

3. ACTIVITIES CARRIED OUT FOR THE MONITORING AND MANAGEMENT

TA service started from September, 1994 to December, 1998. TA service comprised of following components (i) water quality monitoring (ii) water quantity monitoring (iii) suspended load monitoring (iv) institutionalizing environmental monitoring within DOI (v) embankment stabilization and (vi) capacity building of WUAs. For the purpose of this technical paper first two components namely water quantity monitoring and water quality monitoring have been discussed and presented.

4. WATER QUANTITY MONITORING

The main purpose of water quantity monitoring was to assess the water availability in East Rapti River at the Sauraha, the end of the project area and before entering the river into RCNP. For which both surface water and groundwater monitoring were carried out.

4.1 Surface Water Monitoring

For the surface water monitoring, a monitoring plan was prepared considering the water abstraction and addition in the East Rapti River. Number of sites was selected for the regular discharge measurements. The measurement sites are shown in Figure 2. They are as follows

- Two river gauging sites were established in East Rapti River, one at the beginning of the project area at Pratappur and second one at Sauraha at the end of the project area. Daily gauge staff reading and monthly discharge measurement were carried out. Based on these data, rating curves were developed, daily discharge was computed and peak flood discharge was estimated.

- Additional bimonthly discharge measurements were carried out in the seven canals offtking from East Rapti River, in East Rapti River at Icharni and in Dhongre Khola, a major tributary of East Rapti River at the upstream of Sauraha Gauging Station. .Location of these sites is shown in Figure 2. These additional discharge measurements were carried out during the dry season period only to monitor the specific impact of water diversion by the irrigation schemes during the driest period.

- A meteorological station was established within the complex of East Rapti Irrigation Project office at Parsa, Chitawan. The station comprised of an automatic rainguage, an ordinary rainguage, an evaporation pan, and a wooden enclosure with maximum minimum thermometer.

4.2 Groundwater Quantity Monitoring

An inventory of the groundwater wells and the geophysical survey of the project area was carried out. Total 1273 nos. of

well were identified in project area in inventory survey carried out in September-October, 1994. Based on these two survey 69 wells were identified for the monitoring purpose. Bimonthly water level monitoring of these wells was carried.

5. WATER QUALITY MONITORING

A household survey related with the agricultural practice was carried out to identify the type of chemical fertilizers and pesticides that were in use in the project area. The survey was quite useful in identifying the timing of their use. In order to have overall view of water quality of the project area, initially 23 sampling sites were identified. Based on this analysis, the project area was divided into three sections from north to south namely: north of highway, along the highway and south of the highway. This gave three cross sections of water quality of the ground water of the project area.

For surface water quality monitoring, three sites were selected in East Rapti River to get water quality profile of the river and one in Dhongre Khola, a major tributary of East Rapti River within the project area.

The locations of the surface water and groundwater quality monitoring sites are shown in Figure- 3 and the analyzed parameters and methods are presented in Table 1.

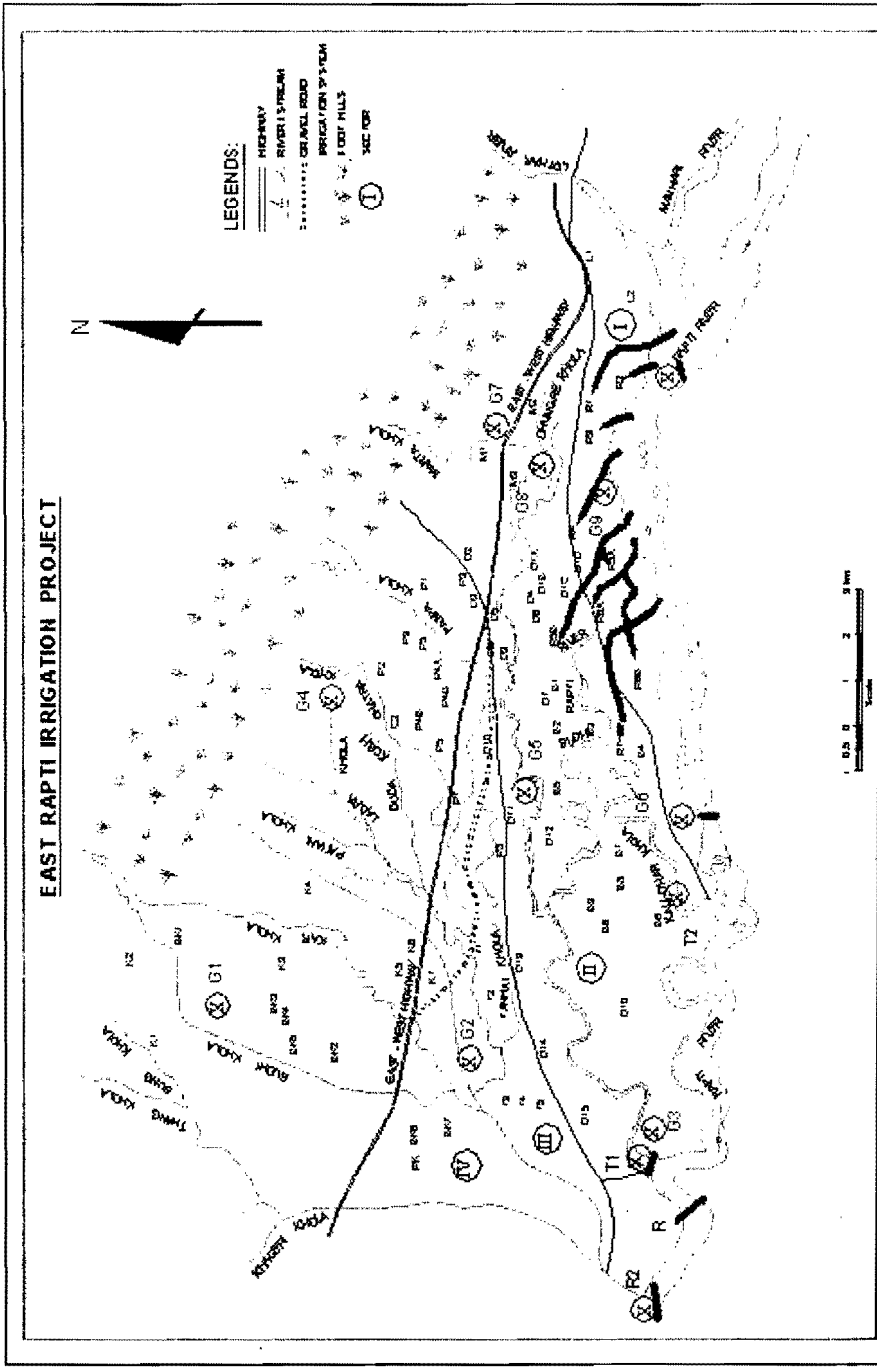

EAST RAPTI IRRIGATION PROJECT
LEGENDS:
N
EAST - WEST HIGHWAY
RAPTI RIVER
KHOLA
G1
G2
G3
G4
G5
G6
G7
G8
G9
T1
T2
R
R2

Table 1 : Water Quality Analysis Parameters

Parameter	Method	Instrument Used
PH	Instrumental	Hach One pH meter
Electric conductivity	Instrumental	Hach Conductivity meter
Dissolved Oxygen	Instrumental	Oxygen meter
Turbidity	Spectrophotometric	Hach Spectrophotometer DREL/2000
Ammonia	Spectrophotometric (Nesslarisation)	Hach Spectrophotometer DREL/2000
Nitrate	Spectrophotometric (Cadmium reduction)	Hach Spectrophotometer DREL/2000
Nitrite	Spectrophotometric (Diazotisation)	Hach Spectrophotometer DREL/2000
Total Iron	Spectrophotometric (Bipiridin)	Hach Spectrophotometer DREL/2000
Total Hardness	Digital Titrimetric (EDTA)	Hach Spectrophotometer DREL/2000
Chloride	Digital Titrimetric (Mercuric Nitrate)	Hach Spectrophotometer DREL/2000
Lindane	Standard	Gas Chromatograph
Malathion	Standard	Gas Chromatograph
Endopsulphan	Standard	Gas Chromatograph

6. INSTITUTIONALIZING WATER QUANTITY AND QUALITY MONITORING WITHIN DOI

As a part institutionalizing the water quality monitoring within DOI, the water quality laboratory of Groundwater Irrigation Division of DOI was strengthened by providing the water quality equipment such as HACH portable laboratory and Gas Chromatograph. The groundwater irrigation staffs were actively involved in the collection of samples and water quality analysis. A groundwater irrigation staff was trained in the operation of Gas Chromatograph in Baroda, India. A week training program

was conducted in hydrometric and hydrological measurement and analysis for 24 technical staffs of the project.

7. RESULTS AND CONCLUSIONS

a) Surface Water

The peak flood discharge of East Rapti River at Sauraha was estimated to be 775 m^3/s in 1996, 227 m^3/s in 1997 and 1160 m^3/s in 1998. These discharges were corresponding to gauge height record of 182.41 m, 181.96 m and 183.05 m respectively.

The main purpose of the water quantity monitoring was to assess the water availability at Sauraha when the irrigation canals were in operation during the dry season. This was checked by three methods (i) derivation of hydrographs based one the daily river gauged staff reading and monthly discharge measurement (ii) water balance study of East Rapti River between Pratappur and Sauraha and (iii) rainfall– runoff simulation.

Derivation of Hydrograph

Based on the surface water monitoring rating curves were developed and daily flows at Pratappur and Sauraha were computed and hydrographs were prepared. The hydrograph of Pratappur and Sauraha are similar in nature but different in magnitude indicating high discharge at Sauraha. The period March to June is the driest time when the flow in the river would be minimum and the farmers try to draw water from the river for plantation of early paddy. There are nine irrigation systems offtaking East Rapti River between Pratappur. This indicated that there is substantial base flow between Pratappur and Sauraha. The minimum discharge estimated at Sauraha was 6.8 m^3/s in 1995, 8.67 m^3/s in 1996, 8.05 m^3/s in 1997 and 11.57 m^3/s in 1998.

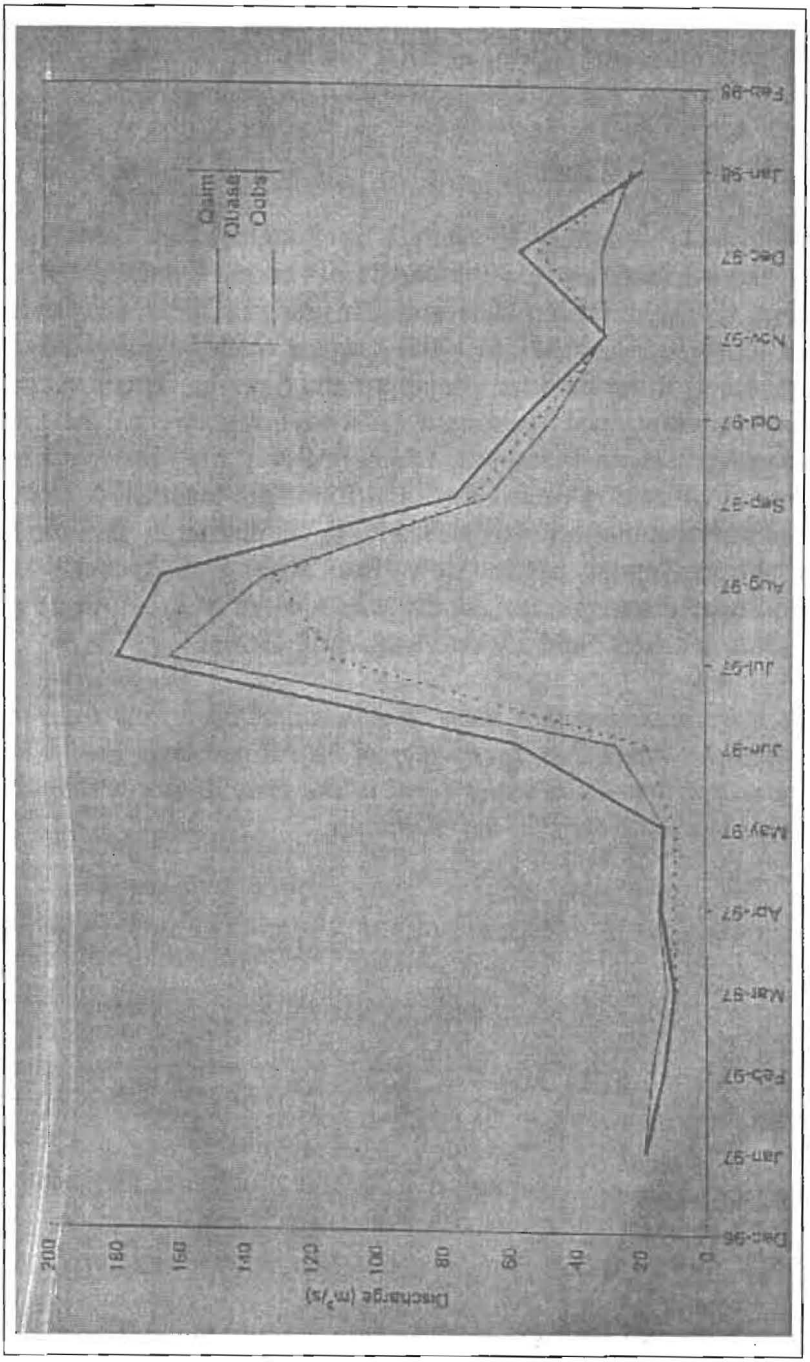
"It was concluded that the discharge in the East Rapti River at the Sauraha would be more than 6.0 m^3/s compare to

Pratapppur even during the driest day of the dry season. Hence, the environmental impact of ERIP on RCNP in terms of water availability for the wild habitats would be insignificant"

Water Balance Study

Additional bimonthly discharges measurement at East Rapti River its tributaries and the canals off taking from East Rapti River also gave the similar result. This measurement was carried out for three years 1996 to 1998. It was a water balance study of East Rapti River between Pratappur and Sauraha. The measured flow (discharge) at Sauraha was always higher that the total measured flow at Pratappur, Dhongre River and nine irrigation systems off taking from East Rapti River put together. It can be assumed that majority of this additional discharge at Sauraha would be mainly base flow from the groundwater. The additional discharge at Sauraha was 5.44 m^3/s in April, 1996, 6.18 m^3/s in 1997 and 5.91 m^3/s in April, 1998.

"It was concluded that there is substantial base flow from the groundwater to the surface water of East Rapti River during the dry season when the water level in the river is lower than the groundwater level of the surroundings".


Qsim
Qbase
Qobs
Discharge (m³/s)
0
20
40
60
80
100
120
140
160
180
200
Dec-96
Jan-97
Feb-97
Mar-97
Apr-97
May-97
Jun-97
Jul-97
Aug-97
Sep-97
Oct-97
Nov-97
Dec-97
Jan-98
Feb-98

Rainfall – Run off Simulation

Rainfall and evaporation are the two major inputs for the discharge at the outlet of the catchments area. Since we have the rainfall and evaporation data for the catchment's area and measured discharge at Sauraha of East Rapti River, an attempt was made to simulate measured data with the hydrological model, SACRAMENTO, developed by Delft Hydraulic Institute of The Netherlands. The hydrograph derived from the daily rainfall and hydrograph derived from simulation matches. It also showed substantial base flow at Sauraha site. The Sacramento model seems to be capable of generating discharge regime of East Rapti River catchment.

"With the help of this model, the discharge of East Rapti River at any point could be estimated or predicted if the rainfall and evaporation is known".

(b) Groundwater

Based on the bimonthly groundwater tables monitoring and geophysical survey of the project area following results and conclusion can be drawn.

There is mainly two type of aquifer in the project area at different depth. A reliable and good aquifer formed by East Rapti River at the greater depth flowing from east to west – north direction and pockets of poor aquifer formed by the tributaries of East Rapti River at the shallow depth. Almost all the existing tube wells were found installed in the poor aquifer in which the water table varies considerably during the dry seasons especially in the northern part of the project area. The fluctuation was found as high as 11.0 m in the well of Jutpani VDC where as it is only 1.0 m in the wells of Kathar VDC.

Based on the monitoring data, hydrograph of the groundwater level of each monitoring well were prepared. They showed that the depletion of water level starts generally from October and continue till middle or end of the May. It then slowly starts

recharging and reaches at its maximum level in month of July/August. The water level remains fairly constant till the end of the September and from October onwards it drops down slowly again. The hydraulic gradient of the groundwater ranged from 1.6 m/km to 4.0 m/km.

It was concluded that, in general the project area has good potential for the groundwater which has been substantiated by the surface flow monitoring also. In the northern part of the highway only deep tube wells would be reliable and feasible where as in the southern part of the highway there is good potential for shallow tube wells. However, due to the availability of reliable surface water irrigation from the ERIP in the southern part of the highway, there is tendency of abandoning the existing wells and switching over to surface irrigation from the groundwater. Hence, groundwater irrigation assistance should be focused in the northern part of the East – West Highway in future.

(c) Water Quality Monitoring

The project area is one of the few sites of Nepal, Where the use of chemical fertilizers and pesticides were comparatively higher that other parts of Nepal due to the intensive agriculture practice. The water quality monitoring of surface water and groundwater indicated that there is traces of chemical fertilizer in the form of Ammonia, Phosphate and Nitrate in the water. The level of their presence slightly increased during the chemical fertilizer application timing in the field. However they were within the guideline set by WHO for drinking water purpose.

Some of the parameters like iron content and hardness in the groundwater samples were found beyond the WHO guideline for drinking purpose. These higher concentrations would be mainly because of minerals content in the soil.

The pesticides related analysis was possible only for three months in 1998. "There seemed to be no influence of pesticides

in the water samples of surface water. However it is recommended that further monitoring would be necessary to draw up the conclusion. The monitoring could be carried out by the Groundwater Irrigation Division. The division has trained manpower as well as the required equipment.

It is strongly recommended that the equipment should be kept in operation. The activities of water quality monitoring of irrigation projects should be continued as the regular program of the division".

"It was concluded that the Project, ERIP, is unlikely to have significant impact on the water quality of the East Rapti River and groundwater of the project area".

INFERENCE

His Majesty Government of Nepal is committed for the protection of the environment. The government has reformulated the major irrigation project and the implementation stage also.

The technical assumptions made in the reformulated project considering environmental issues hold good. Because of the hydro geological condition of the project area, there is substantial recharge in surface water from the groundwater in the dry season.

The residual effect of chemical fertilizers and pesticides on the surface water and groundwater of the project area was not significant. Since the Chitawan district is one of the large consumers of the chemical fertilizers among the other districts of Nepal, the residual effect of the chemical fertilizers may not be a serious in other parts of Nepal as well.

REFERENCE

Final Report, Environmental Monitoring and Management of East Rapti Irrigation Project, (ADB TA: 1969-Nepal), March, 1999.

5.7 नेपालमा योजनाबद्ध सिंचाई विकासका पाँच दशक - उपलब्धी र भोलीका चुनौती

गम्भीर बहादुर हाडा, सहप्राध्यापक, अर्थशास्त्र
भक्तपूर बहुमुखी क्याम्पस

परिचयः

शरिरमा रक्त जस्तै कुनै देशलाई जिवन प्रदान गर्ने त्यस देशको जल प्रणाली हो । नेपालको जल प्रवाह व्यवस्थालाई यहाँको प्राकृतिक स्वरुपले निकै प्रभाव पारेको छ । नेपालमा ६,००० नदीहरु छन् जसमा प्रवाहित जल मध्ये ८० देखि ८५ प्रतिशत वर्षमा बग्दछन् । नेपालमा साना ठुला गरी ६००० भन्दा बढी नदीहरू छन् । पूर्ण लम्बाई ४५००० कि. मी. छ । नेपालमा ११ कि. मी. भन्दा लामा नदी १००० वटा छन् । १६० कि.मि. भन्दा लामा नदिहरु १०० भन्दा बढी नदीहरु छन् । यहाँ २५ देखि ५०० कि.मि. लामा नदीहरु छन् । सम्पूर्ण नदीहरुको अनुमानित लम्बाई ४ देखि ५ हजार कि.मि.बहाव क्षेत्र समेट्दछन् । नेपालका नदिहरुमा वर्षेनी १७० अर्ब क्यूविक मिटर जल प्रवाहित हुन्छ । नेपालको पूरा भूभागलाई १.२ मिटर गहिरो पोखरी बनाउन पुग्दछ । सुख्खा मौसममा नेपाल हिमालय पग्लिएर बगेका पानीले गंगा नदीमा करिब ७५ प्रतिशत जल आपूर्ति हुन्छ । गंगाको जलमा यस क्षेत्रले ५० प्रतिशत अंश आपूर्ति गर्दछ । पर्वत, पाखा र टार तथा बेशीहरुमा पानी प्रवाहित हुन सकेंका छैनन् । हिमालय र पर्वतहरुमा निर्माण गरी बहुमुखी फाईदा हाँसिल हुन सक्छ। तराई क्षेत्रमा नलकूपबाट जलस्रोत उपयोगमा ल्याउन सकिन्छ ।

कृषिका लागि सिंचाईको अति आवश्यक छ । कृषिको विकासले नै किसानहरुको आयमा वृद्धि हुन्छ । र यिनीहरुको जीवनस्तरमा वृद्धि हुन्छ । कृषिको लागि उचित साधन भए तापनी सिंचाई विना कृषि उत्पादन गर्न सकिदैन । त्यसैकारणले एक विद्धानले ठीकै भनेका छन् । "Water is more valuable than land" बोट बिरुवाले पानीको अभावमा माटोमा रहेको खनिज पदार्थलाई ग्रहण गर्न सक्दैन । वर्षाको पानीले मात्र भरपर्दो कृषि हुन सक्दैन । नहर, पैनी,

कुलो, कुवा, पम्पसेट इत्यादि कृत्रिम साधनबाट बाली नालीमा पानी पुऱ्याई पानीको आवश्यकता पूरा गर्ने व्यवस्थालाई सिंचाई (Irrigation) भनिन्छ । प्रकृतिले स्वचालित रुपमा बर्षा गराए तापनी कृषिको निमित्त आवश्यक पानी पूर्ति गर्न सिंचाईको जरुरत पर्दछ । आकाशे बर्षाको भरमा मात्रै कृषि उत्पादन राम्रो नहुनाले बर्षै भरी समान अनुपातले बर्षा नहुनाले उत्पादनको दृष्टिलाई ध्यानमा राख्दै सिंचाईको विभिन्न तरिकाहरुलाई अपनाउनु पर्दछ । बढ्दो जनसंख्याको लागि चाहिने अधिक खाद्यन्न उत्पादन निम्ति पनि सिंचाईको त्यति नै बढी जरुरत गर्दछ ।

नेपालको कूल भूभागको करीव १६ प्रतिशत जमिनमा मात्र आवादी गरिएको छ । आवादी जमिनका करीव २४ प्रतिशतमा मात्र सिंचाई सुविधा उपलब्ध छ । हाम्रो अधिकाँश खेती बर्षामा मात्र निर्भर गर्छ । नेपालको कृषि उत्पादन राम्रो हुने वा नहुने कुरा अन्य तत्वले भन्दा मौसमले नै निणर्य गर्ने गरेको छ । कृषिको लागि भूमिको जति ठुलो महत्व हुन्छ, त्यतिकै सिंचाई सुविधाको पनि उत्तिकै ठुलो महत्व हुन्छ । सिंचाईको सुविधा उपलब्ध हुने हुनाले बाली विविधिकरण गरिन सकिन्छ । देशमा ८१ प्रतिशत मानिस कृषिमा निर्भर छन् र कुल राष्ट्रिय उत्पादनमा कृषि क्षेत्रको योगदान ५० प्रतिशतभनदा बढी छ । कृषि क्षेत्रको विकास नभई अर्थव्यवस्थाको कुनै पनि क्षेत्रको विकास सम्भव छैन र व्यवस्थित रुपमा सिंचाई सुविधा उपलब्ध भएमा कृषिमा आधुनिकिकरण हुन सक्छ र हाम्रो कृषि उत्पादन र उत्पादकत्वमा बृद्धि ल्याउन पनि सिचाँई ले निकै मद्धत पुचाउने गर्दछ ।

सिचाई उपलब्ध हुनसक्ने तराई क्षेत्रमा ठुला-ठुला नदीहरुबाट करीब १४ लाख हेक्टर साना नदीहरु र भूमिगत प्रणालीबाट करीब ७ लाख हेक्टर र पहाडी क्षेत्रमा ५५ लाख हेक्टर गरी कुल २६.५ लाख हेक्टरमा सिंचाई सुविधा उपलब्ध हुन सक्ने देखिन्छ । तर देशमा आवश्यकता र सम्भाव्यता अनुरुप सिंचाई साधनको विकास हुन सकेको छैन । नेपालको सिंचाई कुनै नयाँ कुरा होइन । अति प्राचीन काल देखि नै हाम्रा किसानहरु बालीलाई सिंचाई गर्दै आएका छन् ।

देशका विभिन्न भागका बनावट र भौगोलिक परिस्थितिको विभिन्नताले गर्दा भिन्न-भिन्न देशका विभिन्न भागहरुमा मुख्य रुपले (१) जलासय (२) इनार (३) ट्युववेल (४) गरो (५) पहाडी टार सिंचाई, नहरद्वारा सिंचाईको काम हुन्छ ।

सिंचाईको आवश्यकता र महत्व (Necessity and Importance of Irrigation)

नेपालमा कृषि विकासको लागि सिंचाई (Irrigation) को अति नै आवश्यकता छ भन्ने निम्न शिर्षकहरुबाट थाहा पाउन सकिन्छ ।

१) **कृषि उत्पादन बढाउन**

सिंचाई सुविधाले धेरै प्रकारबाट कृषि उत्पादन बढाउन मद्दत पुऱ्याउँछ । विभिन्न बाली अनुसार ठीक-ठीक समयमा खेतमा चाहिए जति पानी पुऱ्याउने व्यवस्था भएमा बाली राम्रो भई उत्पादन बढ्ने हुन्छ । सिंचाईको राम्रो व्यवस्था नभएसम्म उन्नत बीउ र रासायनिक मलको प्रयोगबाट कृषि उत्पादन बढाउने गुन्जायस निकै सीमित हुन्छ ।

२) **अनिकालबाट बचाउन**

नेपालमा वर्षा पार्ने मौसमी वायु भरपर्दो लायकको छैन,किनभने यसले कहिले अत्यधिक, कहिले अल्प बर्षा गराउँछ । पानी नपुगे बाली पुरा उठ्दैन र देशमा अनिकाल पर्छ । तसर्थ अनिकालबाट बचाउन र बाढी तथा पहिरो नियंत्रण गर्नको लागि पनि सिंचाईको आवश्यकता पर्छ ।

३) **प्राकृतिक सम्पदाको उपयोग**

नेपालको सबभन्दा ठुलो र महत्वपूर्ण प्राकृतिक सम्पदा जल सम्पदा हो । कुनै पनि देशले अर्थिक विकास गर्न प्राकृतिक सम्पदा समुचित उपयोग गर्न सक्नु पर्दछ । देश भित्र सिंचाई सुविधाको विस्तार गरी उपलब्ध भएको जलश्रोतको उपयोग गर्दा नेपालको आर्थिक विकासमा दरिलो टेवा पुग्ने देखिन्छ ।

४) **किसानहरुको आयमा वृद्धि गर्न**

कृषिमा सिंचाई सुविधा उपलब्ध हुन गएको खण्डमा किसानहरुको प्रति हेक्टर उत्पादन बढ्छ । उत्पादन बढे पछि किसानहरुको आयमा वृद्धि हुन्छ र तिनीहरुले आफ्नो धन पूँजीगत साधनहरूमा लगाउन सक्दछन् ।

५) **बहुबाली लगाउन**

पानीको अपर्याप्तताको कारणले नेपालका धेरैजसो भागहरुमा बर्षको एक बाली मात्र लगाउने चलन छ । सिंचाईको सुविधा भएमा एकै जमीनमा समय मिलाए बहुबाली लगाउन सकिन्छ ।

६) **बर्षाको अभाव र त्यसको असमान वितरणबाट कृषिको रक्षा**

नेपालमा बर्षा बाह्रै महिना पर्दैन । यहाँ आषाढदेखि भदौसम्म तीन महिना मात्र मनसुनको रुपमा बर्षा हुन्छ । ९०.४ प्रतिशत पानी यसै तीन महिना भित्र पर्छ र बाँकी ९ महिनामा केबल ९.६ प्रतिशत पानी मात्र पर्ने हुनाले बालीको लागि पानीको अत्यधिक अभाव हुन जान्छ । देशको सबै भागमा बर्षाको मात्रा पनि समान छैन । त्यस कारणले बर्षाको अभावले गर्द कृषिलाई धेरै नोक्सान हुन हुदाँ यस्तो समस्या सिंचाईबाट समाधान हुन सक्छ ।

७) **राजस्वमा वृद्धि गर्न**

सिंचाई सुविधाले कृषि उत्पादनमा वृद्धि गर्दछ । कृषि उत्पादनमा भएको वृद्धिले प्रतिव्याक्ति आम्दानी र राष्ट्रिय आम्दानीमा समेत वृद्धि गर्दछ । अतः सरकारले कृषि उत्पादनमा कर लगाएर देशको राजस्वमा वृद्धि गर्न सक्छ ।

८) **बाँझो भूमिमा खेती**

नेपालमा कतिपय बन्जर भूमि तथा डाँडा- काँडा छन्, जहाँ कृषि उपज राम्रो हुदैन । अतः उब्जा राम्रो नहुने कारणले नै ती भूमि पर्ती तथा बाँझो रहेका छन् । यदि यथोचित सिंचाईको व्यवस्था हुन सकेमा त्यस्ता पाखा तथा बन्जर भूमिलाई आवाद गरी राम्रो बाली लिन सकिन्छ ।

९) **नगदेवाली लगाउनको लागि**

नेपालमा नगदेवालीको विकास गर्नको लागि पानीको अभावले गर्दा राम्रोसँग खेति गर्न सकेको छैन । जुट, सुर्ति, उखु, तेलहन जस्ता महत्वपूर्ण नगदेवाली उब्जाउनको लागि पनि सिंचाईको जरुरत पर्दछ । किनभने यी नगदेवाली नेपालका मत्वपूर्ण कच्चा पदार्थ । किनभने यी निर्यातका सामान हुन् । अतः देशका महत्वपूर्ण उद्योगलाई चाहिने कच्चा पदार्थको उत्पादन गर्न तथा निर्यातवृद्धिको निम्ति पनि सिंचाईको जरुरी छ ।

नेपालमा योजनावद्ध सिंचाई विकासको पाच दशक

सिंचाईको विकास

नेपालमा जलजन्य (Hydroralic) सभ्यताको इतिहाँस निकै पुरानो छ । देशको दक्षिण तराईमा बुद्धको पालादेखि नै सिंचाई विकार र व्यवस्थापनसमेत गरिएको प्रमाण ग्रन्थहरुमा उल्लेख छन् । रोहिणी नदी विवाद मा बुद्धले खेलेको भूमिका लाई लिन सकिन्छ । प्रमाणको लागी पूराना संरचनाहरु भने फेला परेका छैनन् । पाँचौ शताब्दिको उत्तरार्ध तिर लिच्छवी कालमा काठमाडौं उपत्यका मा धावी खोला र टुकुचामा सिंचाईको लागि जल नियन्त्रक संरचना निर्माण भएका प्रमाणहरु अत्यावधिक जिवन्त देखिन्छन् । त्यस पछि आएर शत्रौं शताब्दिको उत्तरार्ध मा मल्लकालीन स्वर्ण दिनहरुमा कयौं राजकुलोहरुको निर्माण गरिए । यि कुलाहरु मध्ये केही अहिले पनि चालु अवस्थामा छन् । यि कुलाहरु उपत्यकाका तिन वटै शहरहरुका राजाहरु बाट आफ्नो सकृयतामा राज्य कोशवाट निर्माण गरिएका हुन् । (स्रोत- "सोमनाथ" पौडेल सिंचाई विभाग को संगठनात्मक विकास "स्मारिका" सिंचाई विभाग : स्वर्ण महात्सव-२०५९ चैत्र २५-२५"२०५९, सिंचाई विभाग, जावलाखेल, ललितपूर" पेज नं-४५)

नेपालमा सिंचाईको लागि अठारौं शताब्दीको मूल्यांकन गर्दा समुदाय र किसानद्वारा निर्मित र सञ्चालित प्रणालीहरुको विकासको स्वर्ण युग भने पनि हुन्छ । कृषक समूदायले शताब्दियौंसम्म स्थानीय साधन र स्रोतमा आधारित साधारण खालका कुला कुलेसाहरू

निर्माणा, विकास, विस्तार र व्यवस्थापन गर्ने कार्यहरु अविरल रुपमा गरिराखेको विभिन्न प्रमाणहरु फेला परेका छन् । केहि हदसम्म राज्य या शासक समुदायवाट जिन्सी वा नगद सहयोग उपलव्ध गराएको प्रमाण पनि देखापरेका छन् । पानी सम्वन्धी विवाद सुल्झाउन र मध्यस्तता गर्न राज्यका प्रमुख भूमिका रहन्थ्यो । यसै प्रसंगमा विभिन्न जातिय तथा क्षेत्रिय समुदायहरुको मौज्दात प्रचलनहरुलाई सुदृढ गर्न र सिंचाइका पुख्यौंली परम्परा कायम गर्ने हिसावले सन् १८६४ मा मुलुकी ऐन जारी गरिएको थियो । मुलुकी ऐनले सिंचाई विकासमा ठुलो यागदान गरेको छ । देशका विभिन्न भागमा भिन्न भिन्न आवश्यकता र जातीय/क्षेत्रिय आधारमा विकार गरिएका परम्परालाई शास्वत रुपमा जगेर्ना गर्ने हिसावले कानूनी आचार वनेकोले गर्दा नेपालले विश्वलाई जनपरिचालीत सिंचाईका अनेकन नमुना प्रदर्शन गर्न सक्षम भएको छ । कृषक समूहवाट परिचालित सिंचाई प्रणालीहरुको विकासको लागि नेपालले विश्वमा नै सफलताको नयाँ आयमहरु थपेर आधुनिक सिंचाई विकासको दिशावोध गराउन मद्दत पुऱ्याएको छ । (स्रोत ऐजन पेज नं ४५)

एक कठिन भू-वनोट भएको देश नेपालमा कृषकहरुले आफ्नो स्रोत सीप र प्रविधिवाट चीरकालदेखि साना र मझौला प्रणालीहरुको निर्माण तथा संचालन गरी सिंचाई कार्य गर्दै आएको भए तापनि सरकारी क्षेत्रवाट विक्रम सम्वत् १९७९ सालदेखि सिंचाईको विकास शुरु हुन गएको हो । विक्रम सम्वत् १९८५ मा निर्मित चन्द्र नहर प्रणालीवाट पानी वितरण हुन गएदेखि नै देशमा नयाँ सिंचाई प्रविधिको प्रादुर्भाव हुन गयो । सम्वत् २००२ सालतिर सर्लाहीस्थित जुद्द नहर निर्माण गरियो । २००७ सालको प्रजातान्त्रिक परिवर्तन पछि संस्थागत रुपमा सिंचाई विकास गर्ने महत्वपूर्ण कदमअनुरुप २००९ सालमा आएर नहर विभागको स्थापना भयो । देशको त्यस ताकाको प्राविधिक जनशक्तिको कमीले गर्दा विदेशी इन्जिनियरहरुले सिंचाई विकासमा प्रमुख भूमिका निभाए । (स्रोत - सिंचाई विकासको प्रयासहरु "स्मारिका" सिंचाई विभाग : स्वर्ण महोत्सव - २०५९ चैत्र २४-२५,२०५९, सिंचाई विभाग, पेज नं -३४) ।

नेपालमा सुनियोजित रुपमा सिंचाई विभागको स्थापना सिंचाई विभागको स्थापना इ.. सं. १९५१ मा भएको थियो । यस पछि नै नेपालमा कृषिले नयाँ क्षितिज पायो । यसै सन्दर्भमा प्रजातन्त्र पश्चात् देशमा सिंचाईको विकासमा विभिन्न कार्यहरु हुन थालेको देखिन्छन् । त्यसपछि विभिन्न विकासका योजनाकालमा सिंचाई विभागको निमित्त रकम छुट्टाई सिंचाईको विकासमा जोड दिन थालियो ।

पहिलो योजना शुरु हुनु भन्दा अगाडि पूर्ण चन्द्र चन्द्रनहर (सप्तरी) जगदीशपुर रिजम्वरा (तौलिहवा) जुद्ध नहर (रौतहट) बाट कुल ६२२५ हेक्टर जग्गामा सिंचाई सुविधा उपलब्ध भयो । यो कुल कृषि योग्य भूमिको ०.२३ प्रतिशत मात्र थियो ।

प्रथम पञ्चवर्षीय योजना (२०१३-२०१८) को अन्त्य सम्ममा कूल ११,४२८ हेक्टर (कूल कृषि योग्य भूमिको ०.४३ प्रतिशत) मा सिंचाई सुविधा उपलब्ध हुन सकेको थियो । दोश्रो त्रि-वर्षीय योजना (२०१८-२०२३) को अन्त्यसम्ममा देशमा कूल १२,४६३ हेक्टर जग्गा (कूल कृषि योग्य भूमिको ०.४६ प्रतिशत जग्गामा सिंचाई सुविधा पुगेको देखिन्छ ।

तेस्रो योजना (२०२२–२०२७)को अन्तसम्ममा कूल ६५,३२३ हेक्टर जग्गा (कूल कृषि योग्य भूमिको २.४६ प्रतिशत) मा सिंचाई सुविधा उपलब्ध भयो । चौथो योजना (२०२७–२०३२) मा नेपालमा कुल १०,३,०५६ हेक्टर जग्गा (कुल कृषि योग्य भूमिको ३.८८ प्रतिशत) मा सिंचाई सुविधा पुगेको देखिन्छ । चौथो योजनाकालसम्म १,०३,०५६ हेक्टर जमीनमा सिचाई सुविधा पुगेको थियो । यसमा तराई तर्फ ९४,८२२ हेक्टर र पहाड तर्फ ८,२३४ हेक्टर पर्दछ ।

पाँचौ योजना (२०३२-२०३७) मा १ लाख ४६ हजार हेक्टर थप जमिनमा सिंचाई सुविधा उपलब्ध गराउने लक्ष रहेकोमा ९५,४२५ हेक्टरमा सिंचाई सुविधा उपलब्ध हुन सक्यो । यसरी नेपालमा प्रथम योनजा सुरु भए देखि पांचौ योजनाको अन्त सम्म (२०१३-२०३७ मा) पुराना आयोजनाहरुको नवीकरण तथा सुधार र नयाँ निर्माण भएका

सिचांई आयोजनाहरु समेत गरी जम्मा १,९८,४८१ हेक्टर जमिनमा सिंचाई सुविधा पुऱ्याइएको अनुमान छ । पाँचौ योजना अवधि (२०३२-२०३७) मा सिंचाई सम्बन्धि हासिल गरेको प्रगति विवरण निम्न बमोजिम छ–

तालिका नं -१

पाचौं योजनाको भौतिक प्रगति

(हेक्टरमा)

कार्यक्रम	लक्ष्य	प्रगति	प्रगति प्रतिशत
१) बृहत सिंचाई आयोजना	१,२४,२६४	७३,८०६	५९.३९
२) साना सिंचाई आयोजना	४,३१६	३,६०४	८३.५०
३) ट्युबवेल सिंचाई आयोजना	१६,४२०	६,२७०	३८.१९
४) कृषकको कूलो सुधार आयोजना	१,०००	११,७४५	११७४.५०
जम्मा	१,४६,०००	९५,४२५	६५.३६
श्रोतः छैठौं योजना २०३७-२०४२), भाग १, श्री ५ को सरकार, राष्ट्रिय योजना आयोग, नेपाल, २०३७, माघ, पेज नं-२९१			

तालिका नं १ बाट थाहां हुन्छ कि ९५,४२५ हेक्टर मध्ये तराईमा ८६,१०४ हेक्टर र पहाडमा ९,३२१ हेक्टर छन् । पाँचौ योजना कालसम्ममा १,९८,४८१ हेक्टर जमीनमा सिंचाई सुविधा पुगेको अनुमान छ । त्यसमा तराई तर्फ १,८०,९२६ र पहाड तर्फ १७,५५५ हेक्टर पर्दछ ।

छैठौं योजना (२०३७ -२०४२) मा सिंचाई सुविधामा दोब्बरभन्दा बढी वृद्धि गरी थप २,३३,४८२ हेक्टरमा सिंचाई सुविधा उपलब्ध गराई योजना अवधिको अन्तिम वर्ष २०४१/०४२ मा कूल सिंचित क्षेत्र ४,३१,९६३ हेक्टर पुऱ्याउने लक्ष्य राखिएको थियो । छैठौं योजना अवधि (२०३७ -२०४२) भरमा कूल १,४०,१९१ हेक्टरमा थप सिंचाई सुविधा पुग्न सकेको अनुमान गरीएको छ । यसबाट छैठौं योजनाको थप सिंचित क्षेत्रको कूल लक्ष्यको ६० प्रतिशत प्रगति हासिल हुने देखिएको छ । यस उपलब्धिबाट छैठौं योजनाको अन्तसम्ममा देशमा कूल ३,३८, ६७२ हेक्टर जमिनमा सिंचाई सुविधा उपलब्ध हुन सकि जम्मा खेति भएको जमिनको १३ प्रतिशतमा सरकारी क्षेत्रबाट सिंचाई

सुविधा पुऱ्याउन सकेको देखिन्छ । श्रोतः (२०३७-२०४२) भाग १, सारांश, असोज २०३७, रा. यो. आयोग, नेपाल पेज नं ५ ।

सातौं योजना (२०४२ - २०४७) मा २,४४,४११, हेक्टर जमिनमा सिंचाई सुविधा थप गर्ने लक्ष्य तोकिएकोमा लक्ष्यको ७३.४ प्रतिशत अर्थात् कूल १ लाख ९० हजार ३३७ हेक्टर जमिनमा थप सिंचाई सुविधा उपलब्ध भयो । यसरी सातौं योजनाको अन्त्य सम्ममा नेपाल अधिराज्यमा कूल ५ लाख ५० हजार ४६७ हेक्टर जमिनमा सिंचाई सुविधा पुग्न गई कूल खेति गरीएको भूमिको करीव २१ प्रतिशत भूमिमा सिंचाई सुविधा उपलब्ध भयो । (श्रोतः -सातौ योजना (२०४२-२०४७) सारांश भाग १, जेठ २०४२ रा.यो. आयोग, नेपाल, पेज नं २० ।

यसरी कृषि विकासका सम्भाव्यताहरु वाट अर्थतन्त्रले अधिकतम् लाभ प्राप्त गर्न नसक्नुमा सिंचाई क्षेत्रको विकास र विस्तारको प्रयासमा शिथिलता रहनु एउटा प्रमुख कारण देखियो ।

तालिका नं. २

सिंचाई सुविधाको विवरण

कार्यक्रम	योजना अवधीमा थप हुने सिंचित क्षेत्र	योजना अवधिमा थप भएको सिंचित क्षेत्र	प्रगति प्रतिशत
१. चालु सतह सिंचाई कार्यक्रम	८२,५४६	२३,१५०	२८.०४
२. चालु पहाडी सिंचाई कार्यक्रम	६,३७७	५,३००	८३.११
३. भूमिगत सिंचाई कार्यक्रम	१६,३५०	१०,०६४	६१.५५
४. एकीकृत ग्रामीण विकास अर्न्तगत सिंचाई कार्यक्रम	१०,७३०	७,३४५	६८.४५
५) सम्भाव्य आयोजनाहरुको कार्यान्वयन (नयाँ आयोजनाहरु)	१९,४९०	१९,४०३	९९.५
६) फार्म सिंचाई र कृषि विकास वैक अर्न्तगत कार्यक्रम	१,००,०००	१,०९,०८२	१०९.८
७) स्थानीय सिंचाई कार्यक्रम	८,९१८	४,८९३	५५.९९
कूल जम्मा	२,४४,४११		७३.३८

(श्रोत- सातौं योजना (२०४२-४७) को प्रगति समीक्षा 'श्री ५ को सरकार रा.यो.आ.को सचिवालय, पौष, २०४९, पेज नं. - २९)

तालीका नं. २ वाट थाहा हुन्छ कि सम्पन्न सिंचाई आयोजनाहरुको यथा समयमा उचित मर्मत र सम्भार उल्लेखनीय रुपमा भएको नदेखिएकोले सिंचाई क्षेत्रको लगानीवाट अर्थतन्त्रले अधिकतम फाइदा उपभोग गर्न सकिएको देखिएन ।

आठौं योजना (२०४९-२०५४) मा सिंचाई विभाग अर्न्तगत संचालित कार्यक्रमहरु मात्र ८५.५ प्रतिशत प्रगति भएको छ । यस मध्ये सतह भूमिगत सिंचाई तर्फ ४५.४ प्रतिशत मात्र प्रगति भएको देखिन्छ । कृषि विकास वैंकवाट संचालित कार्यक्रममा ६३.६ प्रतिशत प्रगति भएको छ । यस मध्ये सतह सिंचाईतर्फ ३२.०० प्रतिशत र भूमिगत सिंचाई तर्फ कूल ७४.९ प्रतिशत प्रगति भएको देखिन्छ । कूल लक्ष्यको आधारमा ७२.९ प्रतिशत प्रगति भएको छ । कृषि विकास वैंक अर्न्तगत संचालित लिफ्ट पम्प कार्यक्रमवाट २२,७२७ हेक्टर भूमिमा सिंचाई भएको देखिन्छ । (नवौं योजना (२०५४–२०५९), रा.यो.आ, आषाढ, २०५४, पेज नं.- १७)

तालिका नं. ३

आठौं योजनाको अन्त्य सम्मको स्थिति

सि.नं.	कार्यक्रम आयोजना	सातौं योजनाको अन्त्यसम्मकोस्थिति	आठौंयोजनाको प्रगति	आठौं योजना सम्मको स्थिति
१	सिंचाई विभाग	३,९५,८७५	१,३८,२४५	५,३४,१०२
	क) सतह सिंचाई	(३,४६,४४४०)	(१,३०,४८४)	(४,७६,९२८०)
	ख) भूमिगत सिंचाई	(४९,४१३)	(७,७६१०)	(५७,१७४)
२	कृषि विकास वैंक	७१,५४५	६८,१५६	१,३९,७०१
	क) सतह सिंचाई	(११,८६०)	(१५,६९४)	(२७,५५४)
	ख) भूमिगत सिंचाई	(५९,६८५)	(५२,४६२)	(१,१२,१४७)
	ग) अन्य विभिन्न कार्यक्रम	१९,२८९	७,९४२	२८,५०४
	घ) लिफ्ट पम्प कार्यक्रम	५,७७७	२२,७२७	२८,५०४
	जम्मा	४,६७,४०२	२,०६,४०१	६,७३,८०३
३	कृषकहरुद्वारा विकसित सिंचाई क्षेत्र	३,८१,८१४		३,८१,८१४
	क) सतह	(३,५७,०९८)		(३,५७,०९८)
	ख) भूमिगत	(२४, ७१६)		(२४, ७१६)
	कूल जम्मा	८,४९, २१६	२,०६,४०१	१०,५५,६१७

श्रोतः - सिंचाई डायरी, २०५६ श्री ५ को सरकार जलश्रोत मन्त्रालय, सिंचाई विभाग, पेज नं. ४६)

तालिका नं. ३ बाट के थाहा हुन्छ कि कृषि विकास बैंकबाट संचालित सिंचाई कार्यक्रमहरु बढी प्रभावकारी देखिन आएको छ ।

नवौं योजना (२०५४- २०५९) मा दीर्घकालीन अवधारणा अनुसार सतह सिंचाई अर्न्तगत नयाँ योजनाहरुबाट थप १७ हजार हे. क्षेत्रमा सिंचाई सुविधा उपलब्ध गराउने उद्देश्य राखिएको छ । कृषक कुलोहरुको नविकरण सुधारवाट थप १ लाख ५५ हजार क्षेत्रमा गरी कुल १ लाख ७२ हजार हे. क्षेत्रमा वर्षभरी थप सिंचाई सुविधा पुऱ्याउने गरी कार्यक्रम संचालन गरिने छ । भूमिगत जल सिंचाईबाट थप ४ लाख ७१ हजार हेक्टर क्षेत्रमा वर्ष भरी नै सिंचाई पुऱ्याउने कार्यक्रम छ । उक्त लक्ष्यअनुसार वाह्रौं योजनाको अन्तसम्ममा थप ६ लाख ४३ हजार हेकटर क्षेत्रमा वर्षभर सिंचाई सुविधा पुऱ्याउने छ ।

नवौं योजनामा सिंचाईको विकासको लागि निम्न उद्देश्यहरू राखिएको छ

१) मौसमी वर्षामा निर्भर रहेको कृषि प्रणालीमा सुधार गर्न बालीको आवश्यकता अनुसार सिंचाई उपलब्ध गराई कृषि उत्पादन वृद्धिमा सघाउ पुऱ्याउने ।

२) सतह र भूमिगत आयोजनाहरुको पानी उपयोग क्षमता (Water utilisation efficiency) मा वृद्धि गर्ने ।

३) सिंचाई आयोजनाहरुको मर्मत, सम्भार, संचालनमा सरकारी दायित्व घटाउन ती कार्यहरुमा उपभोक्ता कृषकहरुको सहभागिता बढाउदै लगी सिंचाई प्रणालीहरुको व्यवस्थापनाको जिम्वेबारी उपभोक्ताहरुको संस्थाहरुलाई हस्तान्तरण गर्ने ।

नवौं योजनाको सिंचाई विकास सम्बन्धी भौतिक लक्ष्यमा निर्माणाधीन आयोजनाहरु तथा नयाँ निर्माणहुने आयोजनाहरु बाट कु २,४९,४०० हेक्टर क्षेत्रमा व्यवस्थित रुपमा सिंचाई पुऱ्याउने छ। यसमध्ये कृषक कुलोहरुको सुदृढीकरण गरी व्यवस्थित रुपमा सिंचाई पुऱ्याउनुका साथै नयाँ आयोजनाहरु निर्माण गरी थप क्षेत्रमा सिंचाई सुविधा उपलब्ध गराउने छ । यसमा सतह सिंचाई, भूमिगत जल सिंचाई तथा कृषक कुलाहरुको सुदृढीकरण गरी व्यवस्थित सिंचाई पुऱ्याउने लक्ष्य रहेको छ । सिंचाई विभागको जिम्मा रहेका विभिन्न ११ सिंचाई

आयोजनाहरूको (६८,००० हेक्टर) व्यवस्थापन कृषक उपभोक्ता संस्थाहरुलाई हस्तान्तरण गरिनेछ भने बाँकी करीव ३,००,००० हेक्टर क्षेत्रमा उपयोग भइरहेका सिंचाई आयोजनाहरुको मर्मत सम्भार, तथा संचालन कार्य गरिने छ।

सिंचाई योजना संचालन गरिदा स्थानीय उपभोक्ताहरुको मागको आधारमा योजना अध्ययन गरी सभाव्यता र लागत- लाभ विश्लेषणको दृष्टिले उपयुक्त देखिएका योजनाहरु संचालन गरिनु पर्छ। यसरी निर्माण गरिने योजनाहरुमा शुरु देखिनै स्थानीय उपभोक्ता समूहहरुलाई संलग्न गराई आयोजना सम्पन्न भई सके पछि पनि मर्मत, सम्भार कार्यमा कृषक उपभोक्ता समूहको सहभागिता बढाउदै लगेमा आयोजना सफल र आत्मनिर्भर हुने देखिन आँउछ।

नवौं योजना अवधिमा सिंचाई क्षेत्रको लागि रु. २५४०.४५ करोड बिनियोजन गर्ने योजना रहेकोमा प्रथम ३ वर्षमा करीव १,०५७.३७ करोड अथवा ४१.६३ प्रतिशत मा विनियोजन गरिएको छ। नवौं योजनाको ३ वर्षको अवधि (२०५४/०५५, २०५५/०५६, २०५६/०५७) मा ४१.६२ प्रतिशत मात्र बजेट विनियोजन भई क्षेत्रगत बाँड फाँडमा व्यवस्था गरिएको रकमको ६९.३६ प्रतिशत मात्र बजेट व्यवस्था भएको पाईन्छ। नवौं योजनाको प्रथम ३ बर्षमा सिंचाई विभागको लागि विनियोजित रकमको ७९.० प्रतिशत मात्र खर्च भएको देखिन्छ। जल उत्पन्न प्रकोप केन्द्र तर्फ विनियोजित रकमको ९०.२१ प्रतिशत खर्च भएको र समग्रमा नवौं योजनामा प्रस्ताव गरिएका आयोजनाहरुका लागि :बतअजष्लन ँगलम आवश्यक मात्रामा उपलब्ध हुन नसकेकोले नवौं योजनाको प्रथम तीन वर्षमा नवौं योजनाको लागि विनियोजन गर्नै भनिएको रकमको ३२.७४ प्रतिशत मात्र खर्च हुन सकेको देखिन्छ।

आर्थिक वर्ष २०५७/०५८ को प्रथम आठ महिनामा सरकारी सिंचाई आयोजना अर्न्तगत १ हजार ५३० हेक्टर र कृषि विकास बैंक अर्न्तगत २०२ हेक्टर गरी जम्मा १ हजार ७३२ हेक्टर थप क्षेत्रफलमा सिंचाई सुविधा उपलब्ध भएको छ। आर्थिक वर्षको २०५६/०५७

सोही अवधिमा जम्मा २ हजार ५९२ हेक्टरमा सिंचाई सुविधा उपलब्ध भएको थियो । आर्थिक वर्ष २०५७/०५८ को अन्त्य सम्ममा सिंचाई विभाग अर्न्तगत ४८ हजार ७८७ हेक्टर र कृषि विकास बैंक अर्न्तगत ८ हजार ६१८ हेक्टर समेत गरी जम्मा ५७ हजार ४०५ हेक्टर भूमिमा सिंचाई सुविधा पुऱ्याउने लक्ष्य रहेको छ ।

आर्थिक वर्ष २०५८/०५९ को प्रथम आठ महिनामा सरकारी स्तरका आयोजनाहरुबाट थप सिंचाई सुविधा उपलब्ध हुन सकेको छैन भने कृषि विकास बैंकबाट संचालित आयोजनाहरुबाट ३ हजार १७ हेक्टर भूमिमा थप सिंचाई सुविधा उपलब्ध भएको छ । यस आ. व. को अन्त्य सम्ममा सरकारी स्तरबाट ३९ हजार ५३९ हेक्टर तथा कृषि विकास बैंकबाट संचालित आयोजनाहरु बाट ४ हजार ४८३ हेक्टर गरी जम्मा ४४ हजार २२ हेक्टर क्षेत्रफलमा थप सिंचाई सुविधा पुऱ्याउने लक्ष्य रहेको छ ।

कुल कृषि योग्य जमिन २६ लाख ४२ हजार हेक्टर मध्ये १७ लाख ६६ हजार जमिनमा मात्र सिंचाई सुविधा पुऱ्याउन सकिने सम्भावनना रहेकोमा हालसम्म सिंचाई सुविधा पुऱ्याउन सकिने जमिनको करीव ४२ प्रतिशतले हुने क्षेत्रफल ११ लाख ४ हजार हेक्टरमा सिंचाई सुविधा पुऱ्याउन सकिएको देखिएको छ । त्यसमा पनि वर्षभरी नै सिंचाई सुविधा पुगेको क्षेत्रफल भने ४ लाख ५२ हजार हेक्टर रहेको अनुमान छ ।

तालिका नं -४

नवौ योजनाको भौतिक लक्ष्य तथा प्रगति

सि.नं.	निकाय	नयाँ क्षेत्र			कृषक प्रणाली सुधार		
	सिंचाई विभाग	लक्ष्य	प्रगति	प्र.श.मा	लक्ष्यमा		
(१)	सतह सिंचाई	५२४००	२९५८६	५६	८१५००		१००००
	भुमिगत सिंचाई	३००००	२३६१३	७९	५००		
	क) डिप ट्यूववेल	११६५०	९९६९	८६	१००		८२०००
	ख) स्यालो ट्यूववेल	१८३५०	१३६४४	७४	५००		८१३७९
	जम्मा	८२४००	५३१९९	६५	१००		९९
(२)	कृषि विकास बैंक				०		
	क) सतह सिंचाई	६००००	१२१२५	२०	१००००		
	ख) भुमिगत सिंचाई	१४२४००	६५३२५	४६	८२०००		
(३)	गैर सरकारी क्षेत्र जम्मा				९९		

(श्रोतः दशौं योजना (२०५९-२०४६), श्री ५ को सरकार राष्ट्रिय योजना आयोग, नेपाल, २०५९ फागुन, पेज नं २६५)

तालिका नं ४ बाँट थाहा हुन्छ कि नवौं योजनामा नयाँ क्षेत्रमा डिप ट्यूववेलमा सबभन्दा बढि सिंचाई भएको देखिएको छ भने कृषक प्रणाली सुधारमा सबभन्दा बढी भुमिगत सिंचाई र डीप ट्यूववेलमा बढी भएको देखिन्छ ।

नवौं योजना अवधिमा नयाँ सिचाई आयोजनाबाट ६५,३२४ हेक्टर र कृषक कुलो सुधारबाट ८१,३७९ गरी जम्मा १,४६,७०३ हेक्टर सिंचाईको पूर्वाधार विकास भएको अनुमान छ । आंठौ योजनाको अन्त सम्ममा सिंचाई तर्फ ५,०४,४८२ हेक्टरमा सिंचाई सुविधा पुगेकोमा नवौ योजनामा १,१०,४६५ हेक्टरमा सतह सिंचाई पुगेको भुमिगत सिंचाई तर्फ १,६९,३२१ हेक्टर सिचित रहेकोमा योजना अवधिमा ३६,२३८ हेक्टर थप भई २,०५,५५९ हेक्टर पुगेको छ ।

दशौं योजना (२०५९-२०६४)

दशौं याजनामा सिंचाई सम्बन्धी उद्देश्य यस प्रकार राखिएको छ–

१) देशमा उपलब्ध जलश्रोतको उपयोग गरी सिंचाई योग्य जमीनमा वर्षै भरि सिंचाई सुविधा उपलब्ध गराउन विद्यमान सिंचाई प्रणालीको व्यवस्थापन सुदृढ गर्नुका साथै थप पूवाधारका विकास गर्न आवश्यक पूर्वाधारहरुको विकास गर्ने ।

२) कृषक सहभागितामूलक अवधारणा अनुरुप विकसित सिंचाई प्रणालीहरुको दिगो व्यवस्थापन गर्न कृषक उपभोक्तहरुको संस्थागत विकास गर्ने ।

दशौं योजना (२०५९/६०–२०६३/६४) मा उल्लेख गरिएअनुसार गरिए यस योजनामा सिंचाईको विकास गर्न निम्न नीतिहरु राखिएका छन् ।

१) दीर्घकालीन कृषि योजनाको अवधारणा अनुरुप वर्षै भरी सिंचाई सुविधा उपलब्ध गराउन सक्ने सिंचाई प्रणालीहरुको पहिचान र विकासलाई आर्थिक र प्रविधिक उपयुक्ताको आधारमा बिषेश जोड दिइने छ ।

२) पहाड तथा तराई क्षेत्रका सीमान्त कृषकहरुको समस्या समाधान गर्ने हेतुले वर्षात्को पानी संकलन तथा पानीको स्थानिय श्रोतलाई उपभोग गरी साना सिंचाई कार्यक्रमलाई प्रबर्धन गरिने नीति राखिएकोछ ।

३) सिंचाइतर्फ सिंचाई सुविधाको सम्भार तथा पुनरुद्धार कार्यक्रम मा स्थानिय लागत सहभागिता र पानि पोत तिर्ने प्रतिबद्धता भएका क्षेत्रमा प्राथमिकता दिईनेछ ।

४) कृषकहरुद्वारा व्यवस्थित हुदै आएका सिंचाई प्रणालिहरुलाई सहभागी गराई भौतिक तथा संस्थागत सुधार गर्ने कार्यक्रमलाई निरन्तरता दिइनेछ ।

आर्थिक वर्ष २०५९/६० को आय/व्ययको सार्वजनिक जानकारी वक्तब्यमा उल्लेख गरिए अनुसार यस आर्थिक वर्षमा बागमति सिंचाई, सुनसरी-मोरङ्ग सिचाई, दोस्रो सिंचाई सेक्टर आयोजना लगाएतका विभिन्न सिंचाई आयोजनाहरुको निर्माण हस्तान्तरण, निर्मित सिंचाई आयोजनाहरुको मर्मत, सम्भार भुमिगत जल सिंचाई, नदि नियन्त्रण, जलउत्पन्न प्रकोप नियन्त्रण लगाएतका कार्यक्रमहरु संचालन गर्ने गरि सिंचाई क्षेत्रमा रु.२ अर्ब ९७ करोड ९७ लाख विनियोजन गरिएको छ ।

समस्या तथा बाधाहरू:

नेपालमा सिंचाईको विकासमा हालसम्म देखा परेका वाधा तथा समस्याहरु निम्न प्रकारका छन् ।

१) आयोजनाहरु कार्यान्वयन गर्न नभई साधनहरु जस्तै प्राविधिक जनशक्ति र निर्माण सामाग्रीहरुको उपलब्धि समयमा हुन सकेको देखिदैन ।

२) योजना कार्यान्वयन गर्ने सिलसिलामा कुनै कुनै आयोजनाहरुको विस्तृत सर्भेक्षण पुनः गराउनु पर्ने कुनैको संभाव्यता नै नदेखिनु र कुनैको डिजाइन तथा बाँध निर्माण स्थलहरुमा हेरफेर गरि रहनु पर्ने देखिन आउँछ ।

३) पहाडी आयेजनाहरुमा शुरुमा भौगर्भिक सर्भेक्षण हुन नसकेको कारण निर्माणकालमा आएर भौगर्भिक विषमताले गर्दा

आयोजनाको कार्य बीचमा रोकिनु वा समयावधि बढ्न गएकोले निकै समस्या भएको पाइन्छ ।

४) बाह्य आर्थिक श्रोतको व्यवस्था नभएको कारणले गर्दा आफ्नो श्रोतबाछ निर्माण शुरु गरिएको केही आयोजनामा सिमित बजेटबाट मात्र काम गर्नु परेकोले निर्माणमा समय बढी लाग्नाले समस्या हुन गएको छ ।

५) सिंचाई आयोजना कार्यान्वयनमा गैर सरकारी र निजी क्षेत्रको संलग्नता पर्याप्त मात्रामा नभएको र कार्यान्वयन गर्ने सरकारी निकायको जनता प्रति प्रत्यक्ष उत्तरदायित्व नभएकोले आयोजनाबाट कषकहरुले अपेक्षित लाभ प्राप्त गर्न सकेको देखिँदैन ।

६) सरकारी निकायले कार्यक्रम कार्यान्वयन गर्दा संस्थागत पक्ष प्रति आवश्यक ध्यान नपुऱ्याउदा सिंचाई आयोजनाहरुमा दिगोपन आउन सकेको छैन ।

७) सिंचाई आयोजनाहरुको निर्माण, मर्मत संभारमा अपेक्षकृत रुपमा जन सहभागिता जुट्न सकेको छैन र निर्मित सिंचाई आयोजनाहरुमा मर्मत संभार सञ्चालन र व्यवस्थापन कार्यमा कमी कमजोरीको कारणले सिंचाई सेवा भरपर्दो हुन सकेको देखिदैन ।

८) नदीको जलाधार क्षेत्र र भुमिगत जलश्रोतको पुनरजलीय क्षेत्रमा वन जंगल विनाशको कारणले गर्दा सिंचाई आयोजनाहरुको मुहानमा र भुमिगत जलश्रोतको भण्डारमा प्रतिकुल प्रभाव पर्न गएको छ ।

९) तराईमा सतह सिंचाईको विकाससंग भुमिगत जलश्रोतको प्रणाली आवद्ध गरी जलको संयुक्त उपयोग विकास हुन सकेको छैन । पहाडमा वर्षायामको पानी पोखरीमा जम्मा गरी पानी कम भएको बेलामा प्रयोग गर्ने सिंचाई प्रणालीको विस्तार हुन सकेको छैन् ।

१०) कृषिसँग सम्बन्धित निकायहरुबीच समन्वयको कमीले सिंचाई सुविधा भएको सबै ठाउँमा कृषि प्याकेज कार्यक्रमले नसमेटनाले उत्पादनकत्वमा अपेक्षित वृद्धि हुन सकेको देखिँदैन ।

सुझावहरुः

नेपालमा सिंचाईको विकासमा देखा परेका बाधा तथा समस्याहरुलाई हटाउन निम्न सुझावहरु प्रस्तुत गर्न सकिन्छ -

१) आयोजनाहरु कार्यान्वयन गर्ने प्रकृयामा निर्माण सामाग्रीको अभाव हुन नदिन तत्सम्बन्धी व्यवस्था आयोजना स्थलबाट गर्दै आएकोमा अब केन्द्रीय स्तरबाट गरि दिएमा अझ राम्रो हुनेछ ।

२) प्राविधिक जनशक्तिको संभावित अभावलाई ध्यानमा राखी सिंचाई विभागले आफ्ना विभाग र अर्न्तगतका क्षेत्रीय र जिल्लास्तरीय कार्यालयहरुमा खासगरी प्रशासनिक कार्यहरुमा अलमलीरहेका प्राविधिकहरुलाई वढी से वढी परिचालन गर्न नीति अवलम्वन गरिनु आवश्यक छ ।

३) आर्थिक श्रोतको व्यवस्था भई सकेको आयोजनाहरुको मात्र निर्माण गर्ने लक्ष्य राखिनु साथै सवै निकायहरुलाई लागु हुने गरी निर्माण कार्यको दर विश्लेषणमा तयार गरी लागु गरिनु पर्दछ ।

४) सिंचाई आयोजनाहरुको अध्ययन र संभाव्यता निर्धारणको लागि आधार तयार गरि लागु गरिनु पर्ने आवश्यक भई सकेको छ ।

५) सिंचाईको विकास गरी कृषि उत्पादन वृद्धि गर्ने लक्षित उद्देश्य प्राप्त गर्नका लागि विभिन्न निकायवीच समन्वयको व्यवस्थालाई सुदृढ गर्न आवश्यक छ ।

६) सिंचाई क्षेत्रको विकासका लागि उपयुक्त सूचना प्रणाली विकास गर्ने कार्य प्राथमिकताको आधारमा गरी निरन्तर रुपमा अनुगमन कार्य गर्न आवश्यक छ । ट्युववेल सिंचाई विकासमा भएका प्रभावबारे समेत मूल्यांकन तथा अनुगमन गर्न आवश्यक छ ।

७) कृषि विभागको कृषि विकास कार्यक्रम र सिंचाई विभागको सिंचाई विकास कार्यक्रमलाई समन्वयात्मक ढंगले तयार गरी सो क्षेत्रहरुमा कृषि सडक र ग्रामीण विध्युतीकरण कार्यक्रमहरु पनि समन्वयात्मक रुपमा संचालन गर्नु आवश्यक छ । विभिन्न निकायहरुको कार्यक्रम तयारीमा समन्वय गर्ने कार्य केन्द्रीय स्तरमा गर्नु आवश्यक छ ।

८) सिंचाई प्रणालीहरुमा मर्मत सुधार तथा मुल नहरमा जम्मा

भएको थिग्रेनी निकाल्ने कार्य मर्मत सम्भारको लागि वार्षिक विनियोजन गरिएको रकम पर्याप्त नहुने, प्रशासनिक कार्यमा नै बढी खर्च हुने आदि कारणले गर्दा आवश्यकता अनुसार मर्मत सम्भारका कार्यहरु हुन सकिरहेको देखिदैन । यस्तो समस्यालाई पनि समयमा नै ध्यान पुऱ्याउनु पर्दछ ।

भोलिका चुनौति

नेपालमा सिंचाई विस्तारमा मन्दता हुनु , भएका सुविधालाई सामाजिक बस्तुको रुपमा लिईने परम्पराले गर्दा सिचाई प्रणालिहरुको उचित मर्मत संभारमा कृषकको सहभागिता नहुनु अप्रत्यासित रुपमा आउने बाढि पहिरो ले सिचाई संरचना तथा सिंचित क्षेत्रमा क्षति पुग्ने जस्तो कारण हरुले कृषि क्षेत्रको मौसम माथिको निर्भरता विद्धयमान रहेकोछ । कृषि क्षेत्रको मौसम माथिको निर्भरता विद्धमान रहेकोले कृषिबालिको उत्पादन तथा उत्पादकत्व बढ्न सकेको छैन भने सिंचित क्षेत्रमा समेत सघन 'कार्यक्रमहरु पर्याप्त रुपमा लानसकिएको छैन । हालसम्म विकसित पुर्बाधारहरुले कुल विकास भएको सिंचित क्षेत्रको ३७ प्रतिशत क्षेत्रमा मात्र बर्षै भरि सिंचाई सुविधा पुचाउन सक्षम भएको कुराले यसालई पुष्टि गरेको पाईन्छ । बढ्दो जनसंख्याको चाप तथा वालि विविधि करणका लागि हाल देखा परेको कृषकहरुको चाखलाई समेत दृष्टिगत गर्दा बर्षै भरि सिंचाई सुविधा पुचाउन सक्ने खालको प्रबिधिको क्रमिक रुपमा बिकास गर्दै लग्न र उपलब्ध संरचना हरुको अधिकतम उपयोग गर्ने तर्फ जोडदिन आवश्यक भएको छ । सिंचाई आयोजना हरुको निर्माण संचालन तथा मर्मत संभारमा अपेक्षाकृत रुपमा जनसहभागिता जुट्न सकेको छैन । निर्मित सिंचाई योजनाहरुमा मर्मत संभार संचालन र व्यबस्थापन कार्यमा कमिकमजोरिको कारणले सिंचाई सेवा भरपर्दो हुन सकेको छैन । जनउपयोग क्षमता अपेक्षाकृत कम भएको ले सतह र भुमिगत जल सिंचाई आयोजनाहरुबाट लक्षित कमाण्ड क्षेत्रमा सिंचाई सेवा पुग्न सकेको छैन । यसको साथसाथै नदिको जलधार क्षेत्र र भुमिगत जलस्रोतको पुनरजलिय क्षेत्रमा जंगल विनाशको कारणले सिंचाई आयोजनाहरुको मुहानमा र भुमिगत जलस्रोतको भण्डारमा प्रतिकुल प्रभाव पर्ने गरेको पाईन्छ । बर्ष भरिनै पानिको श्रोत उपलब्ध हुन सक्ने र नसक्ने सिंचाई प्रणालिहरु

पहिचान गरि सो अनुरुप कृषी कार्यक्रम संचालन गर्न सकको छैन। सिंचाइ प्रणालिहरुको उचित मर्मत संभार नहुनु स्यालो टयूबेलको अपेक्षित विकास नहुनु अप्रत्यासित रुपमाआउने बाढि पहिरोले सिंचाई संरचना तथा सिंचित क्षेत्रमा क्षति पुग्नु कृषि र सिंचाई विच समन्वयको कमिले सिचाई सुविधा बाट उत्पादकत्वमा अपेक्षित बृद्धि हुन सक्नु यसक्षेत्रका प्रमुख चुनौतिहरु हुन् । सिंचाइ सेवा शुल्क असुलिको समस्या समाधानमा सुधार आएको छैन । सिंचाई सेवा शुल्क नतिरेपनि सिंचाई सेवा काट्न नसक्ने भएकोले पनि शुल्क तिर्ने तर्फ प्रोत्साहन नभएको हुँदा सिंचाई सेवा शुल्क नतिर्ने कृषकलाई श्री५ को सरकारबाट प्रदान गरिने अनुदान सुविधाबाट बन्चित गराउन वा जगा वेचविखनमा रोक लगाउने कानुनि व्यबस्था गरि सिंचाई शुल्क तिर्ने तर्फ प्रोत्साहित गर्ने व्यबस्था गर्नु पर्दछ । भुमिगतज जलश्रोत प्रयोग गर्ने सम्भावना नभएका पहाडि तथा हिमालि क्षेत्रमा बर्षै भरि सिंचाइ सुविधा उपलब्ध गरि कृषी उत्पादन बृद्धि गर्न बर्षातको पानि संकलन गर्ने व्यबस्था मिलाई सुखासमयमा सिंचाई को व्यवस्था मिलाउन आवश्यकछ । सिंचाईको विकास गरि कृषि उत्पादन बृद्धि गर्ने लक्षित उद्धेश्य प्राप्त गर्नको लागि विभिन्न निकाय विच समन्वयको व्यबस्थालाई सुद्धृढ गर्न आवश्यकछ । सरकारि स्तरमा निर्माण कार्य पुरा भएका ठूला आयोजना हरु पुर्ण क्षमता अनुसार संचालन भई रहेका छैनन् । सरकारि स्तरमा निर्माण भएका आयोजना हरु को प्रति हेक्टर लागत बढि भएको छैन । सिंचाई विकास कार्यक्रम संग कृषि विकास कार्यक्रमको समन्वय हुनु आबश्यक हुन्छ । एक्लै सिंचाई विकास द्धारा मात्र कृषिविकास सम्भब छैन । सिंचाई सुविधा उपलब्ध हुने ठाँउहरुमा पानि जमेको पनि ठूलो समस्या देखा पर्दछ । यो समस्या खासगरि नहर बनाउनका निमित्त नदिमा बाध बाध्ने ठाँउहरुमा देखिन्छ । अतः यी सबै समस्याहरुको समाधान गर्न सकेमा मात्र सिंचाईको राम्रो विकास हुन सक्छ र कृषि उत्पादनको बृद्धिमा मद्धत पुग्न जान्छ ।

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5.8 ORGANIZATION DYNAMICS

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ABSTRACT

Department of Irrigation (DOI) has undergone many changes in many aspects since its establishment in 1953 (2009 BS). Its organization has expanded in many folds. Its institutional development has taken many shapes through the decades. In 50 years, it has brought about remarkable accomplishments in terms of irrigated area. Also, the manpower within the Department has increased and marveled in terms of number, qualification and experience.

However, the performance of the Department in the later part of its history seems to have come under criticism from inside and outside. The paper has attempted to look into the problems and issues arising in both the sectors, has tried to analyze in rational way and has come up with a set of proposals. The paper proposes models for on-the-job cycle, transfer, academic promotion, planning the program, behavior, annual workshop and environment of political system.

In order to make the organization dynamics work for the Department, it is imperative to address the issues described here in and carry out some corrective measures. The programs are lacking and it seems that there may create a vacuum in near future if the organization dynamics is not permitted to work. The investments also seem to decline in recent future. The new programs such as NISP, SISP, IMTP, etc have fallen short of meeting the set targets even though there are claims that the lessons have been learned in the past. This shows that there are some problems or shortcomings which stand to hinder the process of organization dynamics, the basis for success of an institution. The paper has also touched other aspects while describing evolution process of DOI and focusing mainly the existing issues related with organization dynamics.

Background

Department of Irrigation was initiated as Canal Department after the advent of democracy in Nepal, 1951. However, it took some time to formalize as an institution primarily because there was a dearth of technical manpower and lack of experience in the country. Mr. Kartar Singh Garcha, an engineer from Indian Government was in-charge of all irrigation activities in Nepal. That was the period, when the then Canal Department had only four personnel as staff and just a room in the old Sigha Durbar complex as office space. It was in 2009 BS, when the Department started to take shape with increased staff and a separate office space but still headed by the foreigner chief. The Department received Er. Medini Nath Bhattarai as its first Nepali chief in 2013 BS. This was also the year of promulgation of the country's first Five Year Plan.

Since then the Department of Irrigation (DOI) has undergone numerous changes by its name, organization and associations. It has seen and experienced many odds and evens in its due course. Many modifications in its policy of irrigation planning and implementation have taken place. With the passage of time it has expanded its organizational structure throughout the country and acquired great strength in terms of high-level manpower, their maturity and financial absorptive capacity. Yet it is not far from public criticism and questions on meeting the targets set forth for project implementation, irrigation service and management.

Objective

The principal objective of the organization (DOI) is to provide irrigation to farmlands. However, with the planning point of view the DOI has set different mode of irrigation targets at different time, as follows.

Year round irrigation
Supplemental irrigation
Sustainable irrigation
Construction

Management (Turnover)
Participatory Approach

Poverty Alleviation
Storage and Diversion (VISION)

Initiatives of 50's:

This decade in Nepal is characterized by the political transformation from autocratic Rana Regime to Democracy. With advent of democracy in 1950 (2007BS), the Department was established as Department of Canal in 1952. In April 1954, the Government signed a treaty with India to use Koshi River water. Similarly, in December1959, another treaty was signed to use Gandak River water. Small irrigation schemes were taken up to provide irrigation service. First periodic Five Year Plan was implemented in 1957 (2013 BS).

Efforts of 60's:

Panchayat political system was promulgated in 1960 (2017 BS). Second (three year) and third (five year) Periodic Plans were implemented. Department of Canal gradually transformed itself in to that of Irrigation but was associated with various other faculties such as electricity, agriculture, drinking water, meteorology etc. Various small and medium scale irrigation projects were designed and implemented. Large projects were planned and prepared for implementation. Organizationally, division- and sub-division offices were established in various regions to supervise irrigation development works. Small Irrigation Department was opened in during this period (in 1966) to focus into small- scale irrigation works. It was later again amalgamated to DOI. International donor agencies started to show their interest for investment.

Development of 70's:

This decade saw transformation of rule to King Birendra from King Mahendra after his passing away. Fourth and Fifth Five Year Plans were implemented. The period is characterized by massive change in administrative structures in the country and a

surge in construction of irrigation infrastructures. The Kingdom was divided into four and later into five development regions. Accordingly the organization structure of the DOI was also expanded to all five regions by establishing regional directorates. Irrigation component in various local development integrated programs (Integrated Approach) and Irrigation as separate program were implemented in the country. The DOI was brought under Ministry of Water Resources. Various large and medium projects were selected and implemented.

Development of 80's:

The decade of 80's saw further push in development oriented changes in national administrative structures, the concept of development and in mode of implementation. Seventh and Eighth Plans were implemented. The Basic Need Program was announced as a national campaign that shook all the Government machineries and the institutions outside Government from their conventional thought and models to work for the people requiring basic need to be fulfilled. In irrigation sector also, a conceptual change from traditional, one party involvement of the agency- alone to people participation in the form of farmers' participation came up as a prominent issue. The focus started to shift from construction alone to management. Command Area Development Project, Irrigation Management Project and sectoral programs for irrigation development were new programs and mode for irrigation development in the country. The first ever Irrigation Development Working Policy was formulated and brought in force. During this period, the organization structure of the DOI was further expanded to reach out to all districts in the form of district irrigation offices (DIO). Large opportunities of jobs were created with the expansion of organization structure. In the same time, political dissatisfaction brewed in the country, which started magnifying to reach to a level of popular upsurge.

Modifications of 90's:

This is the decade of yet another political transformation, which reinstated multi party democratic system. Many new initiatives

were taken up in the water resources sector as well regarding its development and the procedure. For example, new Water Resource Act- 2049 was passed in the House and Irrigation Policy and Regulations were revised in great scale to give an impression of the changed context. The out side world, on the other hand, was generous enough to nurture the newly reborn democracy. Lots of foreign financial assistance poured in. But the continuous tug of war within and among the political parties, unsurpassed politicization in employee transfers and highly garnered corruption overshadowed the reforms and continued to create a situation of confusion culminating toward Maoist insurgency and uncertain future. Thus, this period is characterized as the decade of politicization, mismanagement and turmoil. The existing environment did affect irrigation sector very badly. The result was that there were multiplication of problems and very few thoughts to resolve them.

Major Issues:

Major issues may be listed as follow:

1. Changing organizational structure
2. Observed prejudice in fulfillment of high-level posts
3. Stalemate in opportunities for new jobs and for promotion
4. Cases of Transfer
5. Lessons learned. Not applied (Programs)
6. Dwindling ethical values
7. Declining enthusiasm

Proposed Model

1. On-the-Job Life cycle

Each person has certain extent of inherent enthusiasm toward a certain job assigned. The enthusiasm virtue seems to have an unknown relationship with physical and mental or psychological state of the person. Without a degree of enthusiasm, one cannot expect the assigned job to be completed in a desired manner in terms of time, cost, quality and effectiveness. A fresher engineer

upon completion of his engineering degree gives first priority to the Government job with high expectation of the recognition of the sacred service he is prepared to deliver, the expected economic upliftment, the job security and dignity. With passage of time most of these selected crème personalities meet with the fate that happens to be declining and frustrating. Psychologically, a person in the same post for a prolonged period without promotion will develop fatigue-ness and will loose motivation toward the job.

The normal life span of a civil service including one in the DOI is around 30 years. The maximum level a civil servant from an entry point of engineer (Gazetted Officer Class III) can reach is that of a Secretary for the most and Chief Secretary for a very few. Therefore it may be rational to plan the whole job cycle to the total life span of the service in such a way that the service life becomes upclimbing and encouraging. This sort of planning and the subsequent implementation will be helpful to materialize the spirit of the principle of what is known as Development Administration.

A Model has been proposed for discussion. (THE MODEL)

Fresher Engineer

		Orientation at DOI
Assistant to Seniors(Low Profile)	Division Office, Hills	4 Years
Assistant to Seniors(High Profile)	Division Office, Terai	4 Years
ChiefSub- Division		4 Years
Total		**12 Years**

PROMOTION TO CLASS II OFFICER

Assistant to Project Chief	Large Project	4Years
Chief	Division/ Project	4 Years
Total		**8 Years**

PROMOTION TO CLASS I OFFICER

Chief	Large Project, RID	4 Years
DDG/ DG	Central DOI	2 Years
Total		**6 Years**

PROMOTION TO SPECIAL CLASS

Secretary	Ministry	4 Years
Grand Total		**30 Years**

The underlying concept behind the proposed model is that more duration has been given for the base level officer so as to enable to gather sufficient experience and seasoning which will enable him/ her to be naturally eligible and competent for the next higher post and, at the same time, considerate towards his lower levels and the field problems. The proposed service duration is progressively lower for higher posts.

This model is workable only if the Government opens opportunities equally to all and without any prejudices. If the promotion within the specified deadline is guaranteed, the enthusiasm toward work prevails. It may be noted that the hierarchical system in the civil service follows the structure of pyramid, meaning the screening out will be more as one goes up. Generation of new opportunities on one hand will add up to motivation and removal of the stalemate in administration as seen at present in fulfilling the existing Class I posts in the DOI will help maintain the self momentum of the General- as well as Development Administration. [The three Class I posts have been filled up only on 2060 Bhadra 4 (21 Aug 2003)- Author]. .

No model is free from exceptional cases, nor is this. There may be some brilliant officers who will get promotion earlier than normal and there may also be some who will have to wait quite longer. Some hard working sincere staff will/ should earn reward where as those paying little or incorrect interest toward the job will/ should face punishment. These situations will and should have influence while bringing the model into implementation. Therefore, this Model also assumes that the decision makers follow the rationale while he evaluates the juniors for promotion and/ or motivation. All these will exert positive influence on system scenario and the institutional performance will enhance.

2. Transfer

Transfer or placement of staff is very important aspect of the job's life cycle. It plays a decisive symbolic role both for employer and the employee. It is a great administrative tool that can motivate or de-motivate the concerned employee because it has the automatic psychological impact depending on where (s)he has been placed or transferred.

The current trend, especially since the reinstatement of the Multi-party political System in 2047 BS, has been found to go against the spirit of norms and values of the DOI's institutional development. Nepotism on the basis of political linkage was awfully widespread in a scale that escalated to create chaos and frustration among sincere employees. The relationship developed through illicit (under-table) behavior became another deciding factor to disturb the employees. The result was that, those who did not accept the two 'specified norms' remained always under-rated no matter how sincere and dedicated (s)he was. The existing political atmosphere during the 12 years of democracy never attempted to look back, in stead, continued to nurture it, directly or indirectly, by the leaders or the advisers or the local workers. In other words, directly or indirectly, employees were forced to take the newly invented route for his betterment. Plenty of cases reveal that the DOI employees were badly influenced by this environment.

The DOI should be given full authority, with the empowered Director General, to transfer up to Class III Officers anywhere in the Kingdom. The Regional Director should be given authority to transfer up to Class I Non-gazetted officers (*Na.Su.* rank) anywhere within his region. However, their decisions need to be checked by the Ministry and Department respectively on the basis of program-based rationale and the performance at the end of the year. It is not advisable for minister- level figure to get entangled with the transfer cases of field level Class III- and lower officers when he has to perform lot of policy level jobs of the national significance. Basic reason

is that the information from the 'vote bank worker' about a professional may be biased and misguiding.

The placement of employees should be planned and implemented in such a way that the person and the environment around get the message of placement decision in accordance with the intention to fulfill institutional objectives.

3. Academic Promotion (Studies and Training):

Academic promotion and enrichment is another aspect, which requires continuous attention from authority in order to maintain the manpower updated with the technological advancements taking place in the world and upkeep their sense of devotion towards profession and the parent organization. Availing the opportunities for higher studies and training may provide academic enrichment to the employees. The opportunities may be provided as follows.

3.1	Higher Studies	Opportunities to all by role
3.2	Training/ Workshop	Opportunities to all by program
3.3	Abroad Training/ Seminar	Opportunities to all by program
3.4	Training for Trainers	Opportunities to selected ones
3.5	DOI representation	Opportunities to selected ones

4. Planning the Program:

The DOI should no more stay as a conventional administrative organization, where the staff works only when a person with the file and 'smile' stands in front of the table. In the modern era and with a wider responsibility on shoulder, it should be prepared to be more dynamic than ever before. The manpower should have this realization.

The first thing perhaps is to adopt the program approach rather than to work on adhoc basis. The personnel in the implementation level should stay more in the fields. More importantly, the habit of doing design, drawings and cost

estimate with engineering details and certain standard should again be revived among engineers and overseers.

The regional directorates should be sufficiently equipped with manpower and budget. The directorate should allocate about 30 to 40 percent, i.e., 3.5 to 5 month time in a year for supervising the field level activities. The central office (the concerned Branch) of DOI should allocate about 20 percent, i.e., about 2.5 to 3 month time in a year for supervising the five regions. Regulatory actions to ensure the non-frictional movement of files towards its destination should be strictly taken. If these activities are done on program basis, many of the apparent problems will be solved and issues resolved on time.

Lesson Learning

The other aspect is about 'lesson learning'. DOI has organized and almost all responsible officers have participated in numerous workshops and have prepared every time a long list of lessons learned. This starts, to cite an example, from Irrigation Line of Credit Pilot Project (ILC) to the present Nepal Irrigation Sector Project (NISP). Another example may be cited of the lessons from Irrigation Sector Project (ISP) to the present Second Irrigation Sector Project (SISP). Some other examples may be cited from Hill Irrigation Projects and others, which started even before ILC and ISP.

However, the question is still alive,: 'Have we, the Department, really learned the lessons?' This may perhaps be answered by yet another question: **' Are we, the Department, satisfied with the performance such as credit effectiveness, procurement process, reimbursement status, donor's excessive intervention etc in the existing irrigation credit programs?' If the answer is 'no', then it is perhaps high time that the Department should really learn lessons.** This holds equally good for the Ministry as well because it is the supreme authority to make decision as to who and what kind of person should be assigned to the key posts.

While the Government is preparing to appraise another loan with the donor agencies, the Ministry and the Department should make sure that the mistakes are not repeated. The mistakes and the lessons are already enough. It is high time that proper selections be made. Some tips:

1. Project Coordinator	Should be dynamic, forward-looking, prompt decision maker and should have coordinating ability. He should be exemplary to the regions and districts.
2. Senior Accountant	Should have sound experience of relevant accounting and reimbursement procedure. Comptroller General should take DOI's consultation prior to the assignment and transfer.
3. Implementation Plan	The team of Project Coordinator should prepare themselves to educate others at the regions and the districts, now Divisions and Sub- Divisions. A workshop should be planned for the concerned regions not only to inform the launching of the Project but also to give them orientation about the Project. The salient feature of the Project, the implementation procedure and the specific conditions should be laid out to the implementing agencies. Every unit of the DOI should prepare implementation plan in congruence with the annual program and carryout activities.

5. Behavior

Normally in bureaucratic approach, the behavior of an officer or an employee is not so important. All that matters is whether the

work has been done or not. Also, prolonged experience in the conventional bureaucratic approach may have made the employee behavior lethargic and apathetic to the aspirations of the target group. Since whole of our system has been democratized and farmers participatory approach has been introduced, the time has come for us to review the traditional departmental behavior or the way we behave among ourselves and with our clients. Let us ask questions to ourselves as to whether we are self-centered, whether we enjoy helping each other and whether we have professionally harmonious relationship with our clients such as water users, consultants and contractors.

If we feel that there are some uncomfortable situation among the same professionals, then that certainly means that there are problems, which needs corrections through our behavior. In modern time non-bureaucratic or professionally harmonious behavior is perhaps the most appropriate way to deal with the people, the target group, and with the clients.

6. Annual Workshop:

Annual workshops should be planned and organized for two purposes, the first for preparing annual programs and the second for reviewing the annual progress. Preparation of plans and programs through workshops will impart the figures of target to the minds of field level staff as well as to those of supervision levels. Limitations of budgets and prioritization of projects can be rationally formulated in presence of everybody's knowledge.

The progress review workshop has wider impact. Progress status (%) of the program, physical and financial, is readily recorded. Problems and issues are presented and discussed. During the discussion, an assessment as to how much has the program been effective to cause social transformation may also be made, which will be a part of evaluation of the program as a whole.

The forum of workshop may also be aligned with nomination of 'best performance' of the Year to be felicitated on the Irrigation Day celebration

7. Political environment:

The universal truth is that all the general and developmental activities are to be carried out under the existing political environment, no matter what and how it is. In a multi-party political system, all the government institutions must work under the ruling party's broad polity and the policies formulated under it.

The experience has given us some bitter lessons. Too much politicization of the plan, implementation process and organizational structure in the past twelve years has left the government machinery at peril and has backfired the political system as a whole. It is therefore important for the political parties to sincerely and honestly acknowledge the past errors and remain committed to help the correction process. It is to be noted that without the patronizing help from these parties, especially from the one in ruling seat, nothing will succeed no matter how ideal and genuine the Departmental thought may be.

Concluding Remarks

After fifty years of continued and expanded service of irrigation development in the country, the general realization is that the DOI's performance has been not satisfactory; rather has come under question. The separation of river training division from and the restructuring of the DOI organization in recent time should be taken seriously regarding its future course. Now the opportunities for promotion will be pretty limited. Also, the DOI's close distance with the farmers has widened with the new decision. However, the concern alone will not be sufficient to save it from any sort of unpleasant accident if it is going to happen. Also, the expression of utter annoyance or frustration

from us will only add to its continued declination toward unwanted destination.

The first thing to do therefore is to have self- realization of the problems and issues. The habit of avoiding the problems and fingering out to others should be reviewed. We should be prepared to take responsibilities of what we have done, good or bad. Initiation of this habit will help develop a professional culture of 'thinking good and doing good' for the institution. There are failure stories and success stories, both are no doubt the creation of ours'. Therefore, we should not expect anybody from out side to come and solve the problems for us. It is we who should do it.

In order to make the DOI a smart and dynamic institution, the Government should formulate a broad and just policy as to how the vast treasure of highly qualified 'technical manpower could be utilized for planned and sustainable irrigation development in the country. But more responsibility is on the shoulders of the DOI employees themselves. Planning of programs and their implementation are carried out non other than the engineers, hydrologists and overseers employed in DOI. Their performance will therefore determine the strength and dynamism of the Department. All this in collective manner will in turn determine the future course of the Department, ascending or descending.

5.9 MICRO IRRIGATION-A POTENTIAL IRRIGATION TECHNOLOGY FOR THE FUTURE

- Indra Lal Kalu
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ABSTRACT

Fresh water is one valuable natural resource, which promise to lift Nepal's economy. As most people are farmers, irrigation is much relied on to alleviate poverty and ensure food security in Nepal. The conventional irrigation system use water less efficiently causing many problems. Less area is irrigated than the target and to cope with these problems. Almost 10 times more water is applied than required for crop use. Micro irrigation technology that permits precise irrigation can be used to improve irrigation efficiency.

A low cost drip irrigation kit promoted by IDE consists of a tank and small soft PVC pipes with small holes. These have been promoted in few mid hill districts of Nepal. Here the benefits accrued to farmers and various effects that is possible like water saving and more yield from less water besides less weed infestation etc are listed. Farmers are able to recover the cost of drip kits about US $ 13 for small kit in one year. SWOT analysis of adopting drip kit is presented. And recommendation to promote micro irrigation is provided expressing potential of irrigating in estimated not irrigable by the described method.

Introduction

Agriculture being the mainstay of Nepal's economy with over 80 % farmers and adequate fresh water resources being available in Nepal, development of irrigation has been emphasized since the past and is still the potential hope to transform Nepal's society by alleviating poverty and ensuring food security for the growing population. This is reflected in all recently published strategy documents: Agricultural Perspective Plan (APP, 1997),

Water Resources strategy (2002) Tenth Plan (2002), I-PRSP (2001). APP straightforwardly has attributed one fourth of the agriculture production increase to irrigation. Irrigation development cannot only increases agricultural production but also alleviates poverty through employment generation, ensure food sufficiency and empower rural women. Therefore in this prevailing food deficiency situation, emphasis to utilize local resources water, human as well as land and environment for meeting national needs is quite natural.

Irrigation Situation

Out of 2.46 million Ha cultivated land, 1.76 mill ha is considered irrigable leaving 0.77 mill ha non irrigable by conventional means. Out of that so far through the efforts of farmers and the government agencies, irrigation infrastructure has been developed to irrigate 1.1 million Ha. And some 70% of that is actually irrigated in summer and only about 30 % is supplied water in the winter. Year round irrigation is much less in an order of 10 %. The poor performance of agency managed irrigation systems (AMIS) developed has raised skeptics to invest further in the harnessing of water for irrigation. And at the same time it is compared with farmer managed irrigation system (FMIS) for their good governance and self-reliance among others. In fact FMIS in Nepal is exemplary for good their organization. And these systems pose fewer problems to the agency. But "no complain in FMIS" is not adequate to be complacent. Analysis of situation should be made objectively. AMIS are designed assuming water duty of about 1 – 1.5 liters per second per ha whereas in practice actual water usage is very high due to high percolation loss and seepage amounting water requirement in some system to almost 6 liters per second per ha or even more. It is the case in farmer managed irrigation systems e.g. in Rajapur, some branches water use about 10 liters per second per ha.

But excess water application is detrimental for loss of water and nutrients besides accumulation of silt. Nutrients leached may

even pollute groundwater. Further due to increasing demand of water for drinking water and other purposes, there is more pressure on the water for agriculture. Now there is need to analyze ways to expand irrigation to larger area with the same amount of water. Micro irrigation technology shows promise of growing more crops per drops of water. Micro irrigation technology is a frequent application of small quantity of measured water on or below the soil surface near the root zone of plants as discrete drops, continuous drops, or fine spray. This has been developed to increase water application efficiency in an order of 75 % or more compared 20 – 50 % in conventional surface irrigation. Micro irrigation system encompasses a number of concepts or methods such as inline drip, on line drip, micro jet, mini/micro sprinkler, sprinkler, misters etc depending on the emitting device.

Many potential irrigation schemes operation especially lift irrigation schemes and groundwater irrigation systems, where energy is used to lift, are underutilized for wastage of water making operation costly for farmers to bear the cost. Farmers of BLWGP use water only for critical irrigation in contrast to for what usage the systems were developed. Actual water requirement for crop is about 0.6 l/s/ha (5 mm/day). But as the water application method is inefficient we are applying almost 10 times more in some systems than what crop use. Due to such excessive water duty, many potential irrigation projects have become unfeasible and few systems have even been abandoned or underused due to poor return from crop production to meet O & M costs, after O&M responsibility is handed over to the users. Paying high cost for the water lost for which they have to pay has to be reduced. Increasing water use efficiency is a most and is of global concern now especially in dry basins. This raises a need to promote efficient irrigation method that shall reduce water requirement and increase net benefit from irrigated agriculture. For that the technology that matches the demand should be developed and promoted.

Description

Agricultural Development Bank and International Development Enterprise are promoting the mini/micro sprinkler irrigation and drip irrigation method in small scale in Nepal an INGO.

A standard drip irrigation system used consists of pumping, standard filtration system and piped water application systems besides fertigation arrangements. In the hills with and terai where artesian flow is there, the gravity head of water may be used instead of pumping reducing the cost of operation. Several types of drip kits using tanks ranging from bucket to oil drums are used at different parts of the world to economize the cost. The small holders use these systems across the world (Postel, et al, 2001). IDE/Nepal promoted the simplified drip kit (Figure 1) which consists of a) Head unit (Tank and Filters) and b) Pipe system. Head unit comprises a 50-liter plastic water tank integrated with filtration system: fitted with two filters: a disk filter at lid and a Jerry can with nylon net fabric at outlet. Recommended head is one to two meters. Pipe system consists of main pipelines of 13-mm diameter soft PVC material and a drip pipe (lateral) is of 8 mm punched small holes of 0.75 mm at 60-cm spacing. Baffles cover holes to drip water as drops. Discharge from one hole is 1.to 3 liters/hr.

Features:

- Shift able drip lines (one drip line to be used for several rows by shifting)
- Changed in to a low pressure system (1 to 2 meters)
- Simple low cost filtration system
- Simple and inexpensive pipefitting.

Therefore where water supply is less and conventional gravity canal irrigation is not feasible, use of pipes can be done to convey water for micro irrigation. In this way if water-harvesting technique is adopted in conjunction, even the identified non-irrigable area may be irrigated. Drip irrigation has been adopted

Use of Micro irrigation

Of the micro irrigation technology, the drip irrigation is best suited for high value wide spaced vegetable, flowers and fruits whereas mini/micro sprinkler can be used for close spaced vegetables and other crops. These methods are more appropriate for water scarce, marginal, undulating land and pervious soil where other flow irrigation methods cannot work properly. These methods offer several benefits over surface irrigation method. These are good for the wide spaced fruits and vegetable. Various studies (INCID, 1994). done have shown that crop yield increases almost 10 to 50 % along with water saving of 30 to 80 %. Irrigation efficiency is in order of 80 – 90 % and also fertilizer application can be done through it. Micro/mini sprinkler can also be used for close growing crops and vegetables. But the irrigation efficiency sprinkler is slightly low about 75 %.

IDE/Nepal has promoted low cost drip kits in the mid hills of Nepal to serve small holders. The assessment studies (Kalu, 2002) showed that there is appreciable saving of water as less water can be applied as lifesaving deficit irrigation where water is scarce. In the first month, plant is small and crop foliage diameter is about or less than 30 cm and then afterwards crop will grow and its foliage diameter is expected to be about 45 cm (1.5 ft) diameter. Considering these the amount and frequency is recommended assuming irrigation efficiency of 90 %, farmers are instructed to apply water as shown below.

Plant phase	Winter (Oct. – Jan.)	Spring(Feb – May)
First One month	50 lt./ 200 plants	50 lt/ 200 plants
After one month	50 lt/ 150 plants	50 lt/ 50 plants

Source IDE (2000)

It produces several benefits such as only a part of the soil is wet, hence soil remains loose and consequently reduction in weed growth.

CROPS

The farmers changed cropping practice in drip plot. They are cultivating cauliflower, cabbage in place of *rayo*, radish in winter and cucumber, zucchini in spring season. The vegetable area and yield has also increased after introduction of micro irrigation.

Crops and Cropping Pattern

Land Type	**Monsoon**	**Winter**	**Spring**
Khet	Paddy	Wheat/Potato/pulse	Paddy
Bari	Maize/paddy	Wheat/mustard/millet /potato	

Drip Plot

Before Drip	Maize/legume	Leafy vegetable	
After Drip	Maize	Cauliflower/cabbage	Cucumber/gourd

Farmers have now fresh vegetable for table purpose as well as for sale thereby increasing income. The cost of small drip kit for 80 holes for 125 sq. m area (if the pipes are shifted) is about Rs.916, which can be recovered from one season's harvest. In the study area (Kalu, 2002), one farmer in Bhimad, Tanahun reported to have earned more per month than what he earned in Middle east.

Most fill water carried in bucket from water sources like tap, spouts, canal and streams, this add workload for the family member mostly women, yet women find privileged to have a drip kit and be an earning member in the family. Drip kit has elated importance of women and they are engaged in vegetable production and sale. In many villages women groups were found to be actively involved. Thus there is enthusiasm among the villagers to grow vegetables using drip kit. One VDC of Palpa, Darlamdanda has realized the potential of the kit in dry hill and started to provide 33 % subsidy for drip adopters of that VDC.

High value vegetable growing techniques should be provided to sustain its adoption and make it economic. Most farmers install

drip kit in the *karesa bari* near the home, bringing marginal *bari* land (which is in not irrigable) to be irrigated. Hence in this way, the conventionally non irrigable land could also irrigated after water is carried there. Assistance should be given to bring piped water supply to some common point. As water has to be carried manually most farmers are adopting drip in small area thus giving equitable benefit to poor and rich alike. It provided rural employment for the small landholders in growing crops and irrigating, while landless got vegetable selling and labor works. Also food sufficiency in the form of fresh vegetable is ensured in dry months enriching nutrition and improving health. Women are elated most for getting attractive job to sell vegetable.

SWOT Analysis

Analysis of strength weakness, opportunity and threat in using drip kits is summarized below:

STRENGTH

- High value(HV)Vegetable production and income increased.
- Limited water helped to irrigate HV vegetable.
- Leisure time is utilized in vegetable garden, keep people active; create employment
- Need less investment.
- Waste/barren land utilized for vegetable.
- Soil becomes loose
- Fertilizer can be applied with water effectively
- Improve Family nutrition,
- Women empowerment,
- Development of market
- Improves social harmony due to interaction between users.

WEAKNESS

- Increase use of pesticides may endanger health.
- Shortage of water to fill tank made farmers subject to more workload.

- Water filter system in the kit not so effective
- Rats cut the pipe and fittings
- Poor farmers cannot afford the cost.

OPPORTUNITY

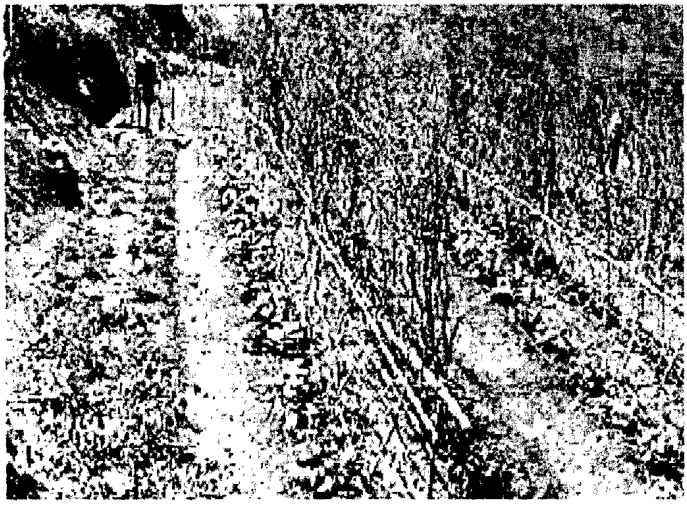
- Potential for increase in production of off season vegetable.
- Drip kit technology is simple and can be spread wider
- Can be applied for cash crops (coffee etc.)
- Can be promoted in dry areas with rainwater harvesting and/ or wastewater recycling Opportunities to substitute vegetable imports
- Women and socially disadvantaged people can be supported.

THREAT

- *Some conflict may arise in the use of water between users and non-users.*
- *There is fair competition to fetch water either from the tap stand/well as the number of users increases.*
- *If vegetable production is increased more than the demand, then market problem may arise.*
- *Increased use of pesticide may endanger health.*
- *Low quality seed supply may discourage users*

Recommendation

Looking at the promise of the drip kit in use, the department should shift its preference and promote micro irrigation technology. The investment for micro irrigation is less expensive than the norm set for surface irrigation system. Water filtration and development works should be promoted. The proposed irrigation subsidy for poor (I-PRSP, 2001) should be spent in such technique that directly benefits smallholder. Poor farmers mostly own non-irrigable land.



A photo of Drip kit in use

Conclusion

Micro irrigation technology is a precise water application requiring less water to be applied frequently. The low cost drip irrigation technology is spreading in the mid hills. It has provided fresh vegetable for consumption and sale thereby increasing the income. It has fostered women to be active and empowered. As it permits full control of water supply, it is highly efficient water application methods even facilitating fertilizer application effectively. Hence it should be promoted to alleviate rural poverty and ensure fresh vegetable foods to eat even in dry months.

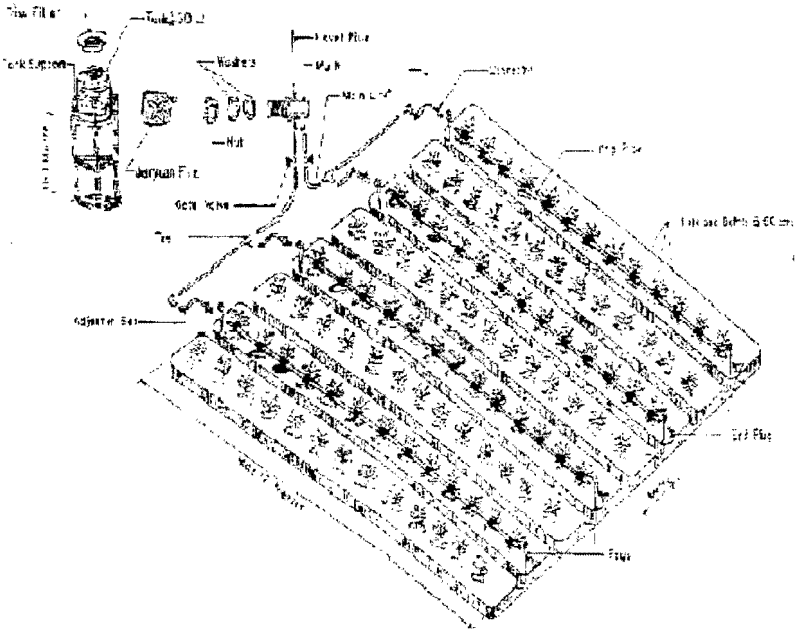


Figure 1. Schematic Diagram of Drip Irrigation kit

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5.10 CANAL LINING WITH GABIONS COVERED WITH CEMENT SAND PLASTER

- Bashu Dev Pokharel

1. PURPOSE

The main objective of the work is getting an appropriate basic sanitation and an improvement in the flow rate, using a coating of reduced roughness and a protection of the channel against possible erosion. In irrigation channels the coating is still to avoid loss of water for infiltration.

The gabions (Reno mattresses) have been used broadly for canal lining works and protection of margins and they have been showing a series of advantages in relation to other solutions.

In places where, for space limitation, the flow has to be led through a channel of reduced section, it has been adopting with great success the coating with gabions covered in the surface for a layer of cement plaster of quite slender thickness (3cm). That solution also guarantees, an almost impermeable lining for irrigation channels.

The cement sand plaster lining also facilitates the self-cleaning of the channel and it prevents the vegetation growth. It also makes possible, when necessary, the removal of all deposited material, in this case could be used light mechanical equipments for the cleaning operations.

2. CHARACTERISTICS OF THE CEMENT SAND PLASTER LINING

In soils of low bearing capacity the lining with gabions with cement sand plaster forms a semi-flexible structure that can absorb accommodations of the soil without losing the main function of protection.

The own mesh of the mattress serves as reinforcement for the cement sand plaster. Due to the hexagonal format of the opening of the mesh, that reinforcement type offers larger durability. Due this fact, in equality of area of iron per square meter the hexagonal mesh, we obtain a better absorption of the efforts when compared to a square or rectangular mesh.

During the plastering process, the wood ribbons are left spaced along the length of the channel positioned in the bottom and in the margins. Those wood ribbons are removed before the consolidation of the mortar.

In that way a continuous drain is obtained which solves the problems of dilation of the mortar, along all longitudinal section of the channel. That eliminates pore pressures and it turns the structure a semi-flexible structure able to absorb movements of the mattress due to accommodations to the base soil.

In case of irrigation channels, to guarantee the impermeable behavior, as much the traverse as longitudinal joints should be filled out with asphalt.

Another great advantage of this solution is that it allows the creation of a mattress below the coating in mortar, with all the advantages of the gabions, in other words, permeability, drainage of the waters, relief of the pore pressures and a monolithic behavior of the material contained by the mesh of the gabions.

The simple construction and the low cost do of the mattress covered with mortar a very economical structure when compared the other types.

3. STAGES OF CONSTRUCTION

The phases of execution of that coating are quite simple and fast, sparing foundations and soil change, usually expensive and slow, necessary in the rigid structures.

The inclination of the margins recommended it is 1:1.5 (maximum) and the thickness of the gabions (Reno mattress) of at least 0,17m. In places where the water or the soils are aggressive, heavy galvanized and PVC coated gabions shall be used to guarantee the integrity of the work.

After excavation and regularization of the bottom and margins the gabions are placed, laced all the joints, filling, placement of the covers and closing.

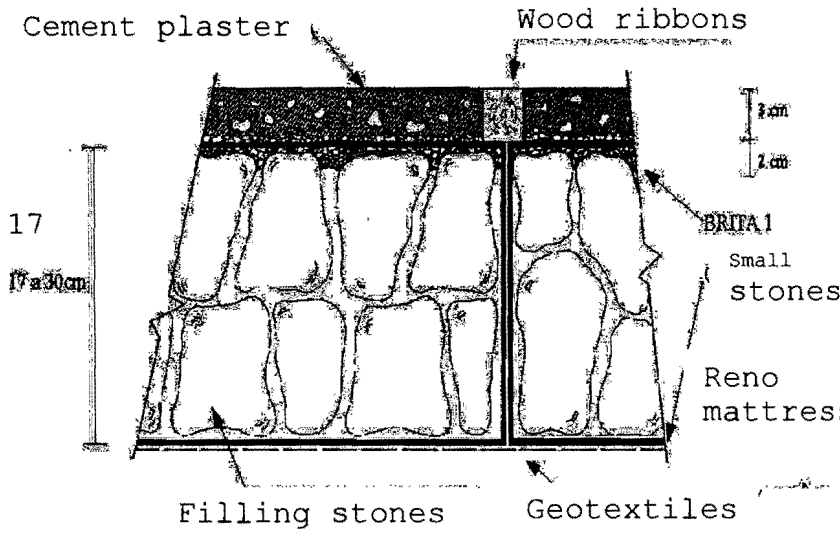
The filling can be made manually or with mechanical equipments aid that will increase the productivity.

If the base soil doesn't have good support capacity or it goes of small granular range, it is recommended between the soil and the gabions the application of a layer of gravel of approximate thickness of 30 cm.

Placement of a geotextile is necessary to avoid escape of the base soil for the interior of the gabions.

After the application of the gabions wood ribbons with cross section of 3x3cm, shall be placed, which serve as guide for the final thickness of the cement sand plaster (3 cm).

The wood ribbons can be fastened to the mesh of the gabions with joints in points, done with lacing wire sent with the mattresses.



Stones or aggregates of smaller sizes shall be placed in the voids of filled gabions in order to not to waste cement sand mortar limiting the penetration of the mortar to a thickness of 2,0cm (maximum), enough to guarantee a good adherence.

The mortar should be made with a relation sand/cement of 5:1 (non structural) and it can be prepared in conventional concrete mixer. The mortar coating can be thrown manually and dispersed and regularized with the aid of a manual equipment, a thickness of 5cm, 2cm of the which penetrated among the stones of stuffing of the Reno mattresses.

Before the consolidation of the mortar the wood ribbons are removed and they can be used again in the construction of other joints.

4. PRODUCTIVITY

The productivity for assembly, placement in the work, seams among adjacent elements, stuffing and closing of the mattresses has been analyzed in following examples / photographs.

5. COST ANALYSIS

Cost of canal lining with gabions / Reno mattresses covered with cement sand mortar	**Nrs. 560.00/m2**
Cost of canal lining, (concrete lining, 10 cm thickness)	**Nrs. 610.00/m2**

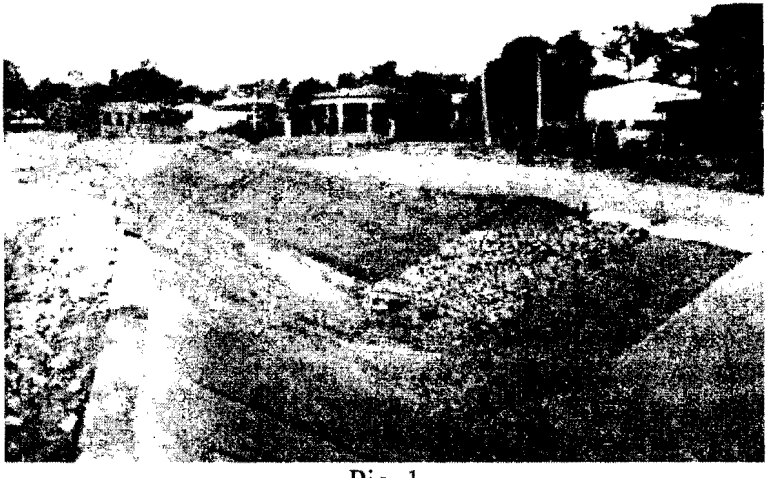
Details of cost estimation has been attached in the following pages.

6. CONCLUSION

This solution can be used with technical and economical advantages in the previously described way in the almost totality of the channels.

6.1 Examples

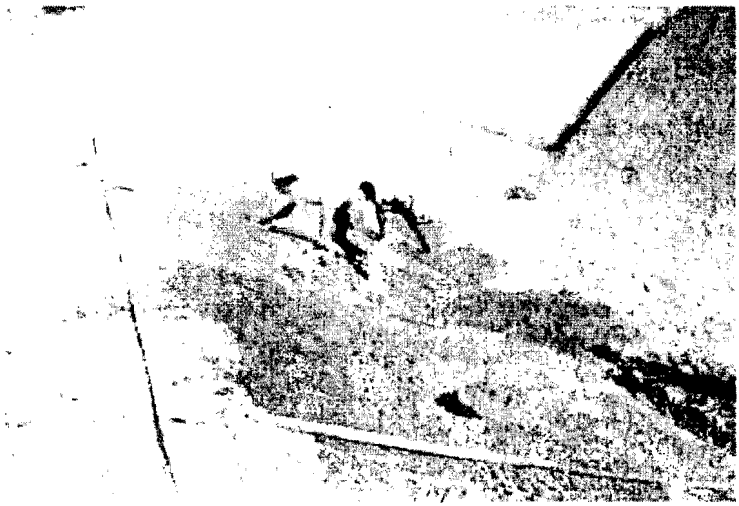
Sequence of canalization with Reno mattress



Pic. 1

In the picture 1 we can observe four different stages during the construction of a canal lining with gabions (Reno mattresses) covered with cement sand plaster. The first stage shows the mattresses placed over the geotextile and properly tied to each other. The second stage shows the full mattresses or partially filled out with stones. In the third stage, the application of a

layer of small stones to minimize the mortar consumption. And finally in a fourth stage the layer of cement sand plaster.



Pic. 2

In picture 2 details of the regularization of the mortar are shown. Observe the strafes that facilitate the control of the thickness and the finishing of the surface.

6. CLOSING CEREMONY

Hon'be Dr. Shankar Sharma, Vice Chairman of the National Planning Commission, chaired the closing ceremony.

At the closing ceremony Mr. Sharadha Prasad Sharma, Chairman of the Golden Jubilee Celebration Committee, first gave a brief overview of the whole program. While expressing his views, Mr. Sharma proposed to form an association of irrigation engineers for the overall development of the country. He further mentioned that formation of such an association could be an excellent outcome of this Golden Jubilee.

Participants of the closing ceremony supported Mr. Sharma's idea of forming a society of irrigation engineers through marvelous claps. In order to initiate the formation of "Sociaty of Irrigation Engineers, Nepal (SIREN)" Mr. Sharma then proposed to form an ad hoc executive committee with the leadership of Mr. Bhubanesh Kumar Pradhan

The next speaker, Mr. Komal Prashad Timilsina, Deputy Director General, Planning Division of DOI, presented the irrigation development vision. The vison, as presented by Mr. Timilsina, consisted of sustainable management of existing irrigastion systems, completion of ongoing projects, and development of new multipurpose projects. Some of these multipurpose projects include SunKosi – Kamala diversion, SaptaKosi – Marine diversion, KaliGandaki – Tinau diversion, and so on. Annex III presents the draft DOI vision.

Several participants raised issues and concerns about the irrigation development vision presented by the DDG, DOI. Some of the participants mentioned that the vision is too ambitious. They noted that the vision should give adequate focus to the commertialization of agriculture, diversification of crops, conjunctive management of surface and ground waters, and O&M costs of irrigation systems.

Based on the discussions in the floor, the participants suggested to form a technical committee in order to give final shape to the draft irrigation development vision.

Finally, Dr. Shankar Sharma, Vice Chairman of The National Planning Commission, stated that the vision document developed in the two-day discussion is a good beginning and everybody's commitment to it is very important. He congratulated DOI on playing a vital role for the increased agricultural production over 50 years and told that many problems, which have still remained unresolved, should now be tackled quickly and effectively.

The closing ceremony ended with the following decleration:

A It was decleared to have formed "Sociaty of Irrigation Engineers, Nepal (SIREN)" with the leadership of Mr. Bhubanesh Kumar Pradhan. For this following ad hoc executive committee was formed.

President:	Mr. Bhubanesh Kumar Pradhan
Vice-President:	Mr. Sharada Sharma
General Secretary:	Dr. Umesh Nath Parajuli
Secretary:	Mr. Madhav Belbase
Treasurer:	Mr. Basistha Adhikari
Members:	Mr. Durga Shankar Sharma
	Mr. Rishi Ram Sharma Neupane
	Mr. Ram C. Mahato
	Mr. Damodar Bhattarai
	Mr. Navin Mangal Joshi
	Mr. Basudev Raj Pokherel

B It was decleared that every year 25 of Chaitra[10] will be celebrated as Irrigation Day

C It was decleared that the ad hoc executive committee of the Society of Irrigation Engineers would review, finalize, and adopt the proposed Irrigation Development Vision

[10] This is as per Nepali calander.

ANNEXES

सिंचाइ विभागः स्वर्ण महोत्सव - २०५९

२०५९ चैत्र २४-२५)

SEMINAR THEME:

FIVE DECADES OF PLANNED IRRIGATION DEVELOPMENT: ACHIEVEMENTS AND FUTURE CHALLENGES

SEMINAR PROGRAM

Date: **8 April 2003 (Chaitra 25, 2059)**

Venue: **Birendra International Convention Center / Nuptse Hall, Baneshwor**

Seminar Coordinator: **Dr. Khem Raj Sharma / Dr. Umesh Nath Parajuli**

Time	Activities			Organization
9:30-10:00	Registration and Tea			
10: 00-10:30	**Opening Session**			
	Chair Person		Bhubanesh Kumar Pradhan	
	Chief Guest		Minister of Water Resources	
	Rapportuer		Damodar Bhattarai / Shiva Kumar Sharma	
10:30-10:40	Welcome address and overview of Seminar		Dr. Umesh Nath Parajuli	
10:40-11:00	Key notes address- by Chief guest			
11:00-11:15	Paper 1	Pushpa Raj Khanal	From Participation to Governance in Local Water Management	DOI
11:15-11:30	Paper 2	Som Nath Poudel	Guideline for Estimation of PMP for PMF	Silt Consultants
11:30-11:45	Paper 3	Anil Kumar Pokharel, Khom Raj Dahal, Sanat Kumar Pokharel	Sunsari-Morang Irrigation Project: A Development Perspective	SMIP, Biratnaga

11:45-12:00	Paper 4	Surya Bhakta Upadhyay	Effectiveness of River Training Works	Multi Consultants
12:00-12:40	Discussion on the Paper			
12:40-13:00	Chairperson's Remarks			
13:00-14:00	Lunch Break			
14:00-16:00	**Second Session**			
	Chair Person		Chitra Dev Bhatta	
	Rapportuer		Dr. Dibya Ratna Kansakar / Keshav Dhoj Adhikari	
14:00-14:15	Paper 5	Dhruba Raj Gautam	Participatory Processes in Irrigation management Research: Guidelines for Good Governance	Mott McDonald/DPCS
14:15-14:30	Paper 6	Subarna Bahadur Joshi	Environmental Monitoring and Management of an Irrigation Project: An experience of East Rapti Irrigation Project	GEOCE Consultant
14:30-14:45	Paper 7	Gambhir Bahadur Hada	Five Decades of Planned Irrigation Development (Nepali)	Bhaktapur Campus, TU
14:45-15:00	Paper 8	Mahendra Bahadur Gurung	Organization Dynamics for Department of Irrigation	DOI, Division Kanchanpur
15:00-15:15	Paper 9	Dr. Indra Lal Kalu	Micro Irrigation	Riti Consultants
15:15-15:45	Paper 10	Mr. B. Pokharel	Canal lining with gabions covered with cement sand plaster	
	Discussion on the paper			
	Chairperson's Remarks			

सिंचाइ विकासको गुरु दृष्टि

- कोमल प्रसाद तिमिल्सिना

हामीहरु सिंचाइ विकासको ५० वर्ष पूरा भएको उपलक्ष्यमा समारोह मनाई रहेका छौं । विगत ५० वर्ष अवधिमा ११ लाख २१ हजार हेक्टर कृषियोग्य जमिनमा सिंचाइ सुविधा पुऱ्याउने संरचनाहरुको निर्माण भएका छन् । जसमध्ये ४० प्रतिशत क्षेत्रमा वर्षैभरी सिंचाइ सुविधा पुऱ्याइएको अनुमान गरिएको छ । दशौं पञ्चवर्षिय योजनाले सम्पूर्ण सिंचाइ योग्य जमिनमा वर्षैभरी सिंचाइ पुऱ्याउने लक्ष्यको शुरुवात गरेको छ । यसका लागि निम्न दृष्टिकोणलाई अगाडि सारिएको छ ।

- ठूला नदीहरुमा बहुउद्देश्यिय आयोजनाहरुको कार्यान्वयन गरी सिंचाइ क्षेत्रको विस्तार गर्ने,
- सिंचाइ दक्षतामा वृद्धि गरी कृषि सघनतामा उल्लेखनिय वृद्धि ल्याउने,
- वर्षैभरि सिंचाइ गर्न सक्ने क्षमतामा बृद्धि ल्याउन भूमिगत जलस्रोत र सतह जलस्रोतको संयोजनात्मक उपयोग गर्ने गरी योजना कार्यान्वयन गर्ने,
- सिंचाइ प्रणालीहरुको दिगो व्यवस्थापनमा जनसहभागिताको प्रभावकारी परिचालन गरी जलाधार क्षेत्रको आधारमा सिंचाइ विकास गर्ने ।

उपरोक्त कार्यको लागि निम्न आयोजनाहरुको कार्यान्वयन गर्न दीर्घकालिन आयोजना सूचिभित्र समायोजन गरिएको छ । यी आयोजना कार्यान्वयन गर्दा प्राप्त हुन सक्ने प्रतिफललाई विचार गरी सिंचाइ आयोजना र विद्युत आयोजनाको स्पष्ट वर्गिकरण गरी निम्न वहुउद्देश्यिय आयोजनाहरुको क्रमिकरुपमा कार्यान्वयन गरिने छ ।

१) कन्काई वहुउद्देश्यिय आयोजना,
२) पश्चिम कोशी सिंचाइ आयोजना,
३) सुनकोशी - कमला डाईभर्सन,
४) सुनकोशी - मरिन डाईभर्सन,

५) सप्त गण्डकी बहुउद्देश्यिय आयोजना,
६) काली गण्डकी - तिनाउ डाईभर्सन,
७) पश्चिम राप्ती बहुउद्देश्यिय आयोजना,
८) भेरी - ववई डाईभर्सन,
९) कर्णाली बहुउद्देश्यिय आयोजना,
१०) पञ्चेश्वर बहुउद्देश्यिय आयोजना

माथि उल्लेख गरिएका आयोजनाहरुको निर्माण कार्य पूरा भएपछि तराईका १३ लाख ६६ हजार हेक्टर जमिनमा सिंचाइ सुविधा पुग्ने छ। यस अतिरिक्त परम्परागत सिंचाइ योजनाको सुदृढीकरण गर्दै हाल सञ्चालनमा रहेका सिंचाइ विकास प्रक्रियालाई निरन्तरता दिईने छ। यसमा निम्न उपलव्धीको प्रक्षेपण गरिएको छ।

- सिंचाइको उपयोगको लागि उपभोक्ताहरुलाई कानुनतः सुदृढ गरी सिंचाइ सेवा शुल्कको संकलनमा पूर्णता ल्याईने छ।
- पहाडमा ५०० हेक्टर तराईमा २,००० हेक्टर भन्दा कम सिंचाइ हुने सिंचाइ प्रणालीहरु उपभोक्ता समूहबाटै व्यवस्थित रुपमा संचालन हुने व्यवस्था गरिने छ।
- औसत वाली सघनता २५० प्रतिशत भन्दा बढी हुनेछ।
- सिंचाइ पानीको उपयोग दक्षता ७५ प्रतिशत भन्दा बढी हुनेछ।
- सिंचाइ क्षेत्रको उपयोगको दक्षता ८० प्रतिशतको हाराहारीमा पुग्नेछ।

भौतिक विकासका लागि प्रक्षेपण गरिएका यी लक्ष्य हासिल गर्नलाई सबै सहकर्मी (Stakeholders) हरुको सहभागिता हुनेछ। त्यसैलाई दृष्टिगत गरी निकट भविष्यमा लागु हुन गई रहेको सिंचाइ नीतिले निम्न अवधारणालाई अगाडि सारेको छ।

- एकिकृत जलउपयोग व्यवस्थापनको अवधारणालाई स्थापित गर्ने।
- बहुउद्देश्यिय आयोजना कार्यान्वयन गर्दा सिंचाइ लाभलाई उचित प्राथमिकता दिने।

- पहाडी क्षेत्रमा पोखरी सिंचाइ, फोहरा सिंचाइ, थोपा सिंचाइ जस्ता नयाँ प्रविधिहरुको विकास गरी सिमान्त कृषकहरुलाई बढी मूल्यका बाली उत्पादनमा उत्प्रेरित गर्ने ।
- उपभोक्ता समूहलाई तालिम, संस्थागत विकास र प्रविधि हस्तान्तरणको माध्यमबाट बढी दक्ष, संगठित र स्वरोजगारमुखी बनाउने ।
- कृषकहरुको आयमा अभिबृद्धि ल्याई लागत उठौति प्रक्रियालाई सरलीकरण गर्ने ।
- देशमा रहेका प्राविधिक शिक्षण संस्थाहरुमा पाठ्यक्रम विकास गरी आवश्यक प्राविधिक जनशक्ति बढाउने ।

यी सम्पूर्ण लक्ष्य हासिल गर्न योजनाबद्ध कार्य पद्दतीलाई कार्य क्षेत्रमा ल्याउन हामी सबैको प्रतिवद्धताको आवश्यकता छ ।