Proceedings of National Irrigation Seminar

Micro to Mega: Irrigation for prosperous Nepal

29-30th Ashar, 2068 (13-14 July, 2011)

Department of Irrigation, INPIM/Nepal and IWMI/Nepal

Foreword

Department of Irrigation has been constantly working in irrigation development and management in Nepal since 2009 B.S for increasing agricultural production and productivity by providing irrigation facilities. In these six decades, expansion of irrigation facilities has been highly responsible in protecting Nepal from food crisis and has made substantial improvement in the available irrigation infrastructures, human resources and institutional built up in the public and private sectors. Still lot more efforts is needed in irrigation sector to address the flat and fertile land of terai to marginal land in mountains to eliminate the vicious cycle of poverty. This calls for coordinated and concrete efforts of all the stakeholders in the process of planning and implementation in forthcoming years.

To review the achievements and explore future opportunities and challenges in irrigation development and management, Department of Irrigation has been organizing a national level irrigation workshop/seminar every fiscal year since last five years. In continuation to it, National Irrigation Seminar themed “Micro to Mega: Irrigation for Prosperous Nepal” held on 29-30th Ashar,2068 (13-14 July, 2011) was organized to bring national level stakeholders from government and non government sectors in one forum to discuss the various issues and aspects of irrigation. This proceeding report is a collection of above findings and it is hoped that it will be more helpful in fulfilling the future need for planning of irrigation development and management.

On behalf of Department of Irrigation, I would like to thank INPIM/Nepal and IWMI/Nepal for being the co-organizer in hosting the seminar. My special thanks goes to Hon. Minister Raghubir Mahaseth, Ministry of Irrigation for his support and guidance for overall irrigation development and management. I am especially thankful to Hon. State Minister Dal Bahadur Sunar, Ministry of irrigation and Mr. Tana Gautam, Secretary, Ministry of Irrigation for their constant encouragement and support in conducting the seminar. Paper presenters are well acknowledged for their valuable technical papers and presentation. I am equally thankful to the participants for the active participation and lively discussions.

I would like to thank Er. Uttam Raj Timilsina, DDG, DoI and all others members of the seminar organizing team for their laborious work in organizing the successful seminar. Lastly, I would like to extend my appreciation to all who were directly or indirectly involved to make this seminar successful.

Anil Kumar Pokharel
Director General
Department of Irrigation

Contents

ACRONYMS

APP	Agriculture Perspective Plan
CIAA	Commission for Investigation of Abuse of Authority
CMIASP	Community Managed Irrigated Agriculture Sector Project
DDG	Deputy Director General
DG	Director General
DHM	Department of Hydrology and Meteorology
DoED	Department of Electricity Development
DoI	Department of Irrigation
DOLIDAR	Department of Local Infrastructure Development and Aglicultural Roads
DWIDP	Department of Water induced Disaster Prevention
FMIS	Farmer Managed Irrigation System
IBWTP	Inter Basin Water Transfer Project
IDE	International Development Enterprises
IMT	Irrigation Management Transfer
INGO	International Non-Government Organization
INPIM	International Network for Participatory Irrigation Management
IWMI	International Water Management Institute
IWRMP	Irrigation and Water Resources Management Project
KIS	Kankai Irrigation System
MoE	Ministry of Energy
MoI	Ministry of Irrigation
MTWTP	Melamchi Inter Basin Water Transfer Plan
MUS	Multiple Use System
NITP	Non-conventional Irrigation Technology Project
NWP	National Water Plan
R&D	Research and Development
SDE	Senior Divisional Engineer
SE	Superintending Engineer
SEMP	System and Environmental Management Plan
SMTP	System Management and Training Program
SWAT	Soil and Water Assessment Tool
SWOT	Strength, Weakness, Opportunity and Threat
VDC	Village Development Committee
WUA	Water Users' Association

1. Introduction

1.1 Background

Department of Irrigation (DoI) has been organizing National irrigation seminar every year since 2064 B.S. The aim of the workshop is to review the achievements and explore future opportunities and challenges for the development and management of irrigation sector. Senior level officials from Ministry of Irrigation and the line agencies participate in the workshop. Fifth edition of the national seminar was held on 29-30 Ashad, 2068(13-14 July, 2011) at Hotel Country Villa, Nagarkot. It was jointly organized by Department of Irrigation (DoI), International Network for Participatory Irrigation Management/Nepal (INPIM/Nepal) and International Water Management Institute/Nepal (IWMI/Nepal). Eleven technical papers were presented in four different sub-themes. The workshop was attended by more than ninety experts and intellectuals from Ministry of Irrigation, line agencies and water related institutions.

1.2 Rationale of Workshop

Nepal is endowed with abundant water resource. There are more than 6,000 rivers flowing from the Himalayan Mountains to the hills and plains. The majority of Nepal's present population depends on agriculture for their subsistence but still only 32 % of the total irrigated land is facilitated with year round irrigation (Irrigation Year Book, 2067). The winter crops depends mostly on rainfall for irrigation and uncertainty of precipitation in amount and time often creates difficulties in cultivating these crops and could result in probable food scarcity for the population. Thus, concept of the interbasin water transfer was proposed as an alternative to balance the varied temporal and spatial distribution of water resources and water demands year round. Likewise, where conventional surface Irrigation schemes are not feasible, DoI is promoting for micro irrigation.

While irrigation plays an important role in enhancing livelihood, trends in its development is often facing challenges like ambiguity in policy and strategies, land acquisition, labour shortage, water management, environment and climate change, human resource management. So far efficiency of the irrigation systems is assessed to be below 35 %, thus rehabilitation and modernization of irrigation system is felt necessary. Similarly, sustainability of the irrigation system depends on ability of Water User's Associations (WUAs) to take over the responsibility of the system thus efforts on capacity building through human resources development (training, education and extension) for WUA should be enhanced.

The gradual environmental changes due to climate changes and global warming have been affecting agricultural production for the last couple of years. Hence further assessment and exploration is needed to find out the adaptive to mitigate climate change problems in agricultural sector. This national seminar has been designed in such a way that is encompasses all the major challenges of Micro to Mega irrigation schemes and draw the future road map of DoI activities.

1.3 Seminar Objectives

The overall objective of the seminar was to review the achievements and assess the opportunities and challenges in irrigation development from micro to mega scale. The following are the specific objectives of the seminar:

- Review the policy and strategic issues for the irrigation development and management
- Assessment of the modernization of the irrigation system
- Impact analysis of climate change on irrigation, exploration of mitigation measures and adoption alternatives to minimize its adverse effect.
- Explore the challenges and opportunities of transbasin water transfer
- Assessment of scope of micro irrigation in enhancing water productivity

1.4 Content of the Seminar

The theme of the Workshop was "Micro to Mega: Irrigation for prosperous Nepal". However it was divided into four sub theme to incorporate present challenges of irrigation sector. To address the objectives mentioned above, four technical sessions given below were carried out based on the main theme.

1. Strategy and Policy Issues
2. Modernization of Existing Irrigation Systems
3. Climate change impact on Water Resources and Challenges and Opportunities in Trans Basin Water Transfer
4. Enhancing water productivity with micro irrigation

Following eleven technical papers that focused in the above mentioned sub themes were presented in the seminar.

S.No	Paper Title	Author(s)
1	Institutional Reform under Ministry of Irrigation	Baburam Adhikari
2	Research Priority of Irrigation Management in Nepal	Prachanda Pradhan
3	Good Governance in an Irrigation Agency	Prakash Paudel
4	Revitalization of Irrigation system through irrigation management transfer " A case study of Kankai irrigation system"	Basu Dev Lohanee
5	Availability Assessment of Groundwater for effective irrigation	Sagar Kumar Rai
6	Seepage Analysis Underneath the headworks of Chanda Mohana Irrigation Schmes, Sunsari	Santosh Kaini
7	Inter basin water transfer project: Opportunity and Challenges	Ashish Bhadra Khanal and Krishna Belbase
8	Impact of global changes on water resources and agricultural practices in Indrawati Basin	Dinesh Bhatta and et al.
9	Downstream Hydrological Impacts of the Melamchi inter-basin Water Transfer Plan (MIWTP)	Pabitra Man Gurung, Luna Bharati
10	Enhancing water productivity with Micro Irrigation	Kailash Sharma, Luke A. Colavito
11	Micro Irrigation Mega Impact : A small step towards Social integration and Economic uplifting of the poor, disadvantaged and women	Kishore Kumar Bhattarai

Agenda of the program is attached in Annex 1.

1.5 Participants

Irrigation experts and intellectuals from different organizations participated in the seminar. They were selected on the basis of the following categories:

- Paper contributers
- Special invitees
- Official representation from Ministry of Irrigation (MoI)
- Official representation from Water and Energy Commission Secretariat (WECS)

- Official representation from Department of Irrigation
- Official representation from Department of Water Induced Disaster and Prevention (DWIDP)
- Official representation from IWMI/Nepal
- Official representation from INPIM/Nepal
- Consultants of DoI
- Seminar Management Committee

List of Participant is attached in Annex 2.

2. Proceedings

2.1 Registration and Opening Session

The seminar was inaugurated by Chief guest Mr. Dal Bahadur Sunar, Honorable State Minister, Ministry of Irrigation (MoI) on 13th July, 2011 at Hotel Country Villa, Nagarkot, Bhaktapur .In the opening session Mr. Tana Gautam, Secretary, MoI, Er. Shital Babu Regmee, Secretary, WECS and Er. Uma Kanta Jha, Secretary, Information Commission were the special guests. Er. Anil Kumar Pokherel, Director General, DOI chaired the opening session and Er. Devaraj Niraula, SDE of DOI was the Master of Ceremony.

Er. Niwas Chandra Shrestha, Chief, SMTP, DoI welcomed the participants and highlighted the needs of this seminar in the present context. He said that Nepal has high potential of water resources and every source can be tapped for micro and mega irrigation purpose however it is only feasible if there is concrete commitment of Government and line agencies from policy making to implementation. He took the opportunity to thank IWMI/Nepal and INPIM/Nepal for co-organizing and added that organizing the seminar together is the step forward to achieve the common goal and objectives.

Er. Ashish Bhadra Khanal highlighted the history of National Irrigation Seminar and contents of this seminar. He gave the overview of the 5 technical sessions and 11 papers to be presented.

Er. Shital Babu Regmee, Secretary, WECS, expressed that the theme of seminar (Micro to Mega: Irrigation for Prosperous Nepal) includes everything for irrigation development. He added, to achieve the dream of prosperous Nepal, every responsible organization should work together. Concept of mega irrigation started in Nepal with construction of Bagmati Irrigation System and now Sikta and Bheri Babai are emerging as pride of country. He added that equal priority should be given to micro irrigation to irrigate the marginal lands. He stressed in rural employment by facilitating with year round irrigation.

Mr. Tana Gautam, Secretary, MoI said that this seminar gives opportunity to gather intellectuals in irrigation sector and brainstorming in the sessions will definitely guide the future of irrigation development in country. He said that our concern should be on making water available from our structure to farmer field for increasing production and productivity. He stressed on the challenges on effective operation and management of the irrigation system and for that, WUAs should be capable and self sustainable. He also highlighted on the specific job description of different professional staffs and on human resource development of organization. Finally he felicitated success of seminar, thanked paper contributors and wished participants for active participation in discussion and fruitful outcomes.

Hon. State Minister, Dal Bahadur Sunar, MoI stressed on projects to be demand driven rather and based on potentiality and strength of the organization and its employees. He said that projects constructed with huge investment should be sustainable and should provide irrigation facilities even after decades of its construction otherwise; we should be accountable for it. He gave stress on development of micro irrigation to address the marginal land and generation of rural employment. He concluded with the best wishes for the success of the seminar.

The opening session was closed by the Chairperson, Er. Anil Kumar Pokharel, DG, DOI. He said the encouragement and direction has been provided by the chief guest and special guests of the seminar and added that the discussion and brainstorming will lead to right track towards generation the future roadmap of DOI. He highlighted that the need of mega irrigation system in Nepal is for year round irrigation facilities. Similarly, he emphasized on giving high priority to the micro irrigation to address marginal land and generation of rural employment for marginalized population.

2.2. Session I: Strategy and Policy Issues

Session I was concentrated on Strategy and policy issues which was chaired by Er. Sarada Prasad Sharma, Ex-DG, DOI and rapporteur for the session was Mr. Udhab Prasad Bhattarai, Senior Legal Officer, DOI. Three papers were presented in this session namely as Institutional Reform under Ministry of Irrigation by Mr. Babu Ram Adhikari, Chief Administrative Officer, DOI, Research Priority for Irrigation Management in Nepal by Mr. Prachanda Pradhan, Consultant and Good Governance in an Irrigation Agency by Er. Prakash Poudel, SE, DOI.

The objective of this session was to highlight the ongoing strategic and policy issues that are limiting the development of irrigation sector. Through this session, it was expected to seek the recommendations for the improvement of the irrigation sector through institutional reform, capacity building of the human resources, prioritizing R&D for sustainable management of existing system and assessment of the new system to increase production and productivity through irrigation and good governance of effective management of the irrigation systems.

The first Presentation of this session concentrated on the need of institutional reform in Ministry of Irrigation, Department of Irrigation, Department of Water Induced Disaster Prevention, Ground water Development Board and Sunsari Morang Irrigation development Board. He highlighting on the initiation for improvement and recommendation for future development of organization structure. Similarly, second and third presentation highlighted on the importance of R & D and the need of good governance for the effective management of the irrigation systems.

2.2.1 Institutional Reform under Ministry of Irrigation

Mr. Babu Ram Adhikari, Chief Administrative Officer, DoI presented first paper of session on institutional Reform under MoI.

Department of Irrigation, Department of Water Induced Disaster Prevention, Ground Water Development Board, Sunsari Morang Irrigation Development Board works under the direct supervision of Ministry of Irrigation. Ministry of Water Resources was divided into Ministry of Irrigation and Ministry of Energy not for the need of the institutional reformation but simply for the political interest. Such splits of ministries limits MOI in Irrigation and MOE in Electricity and Energy thus a question arises who is the ultimately responsible for the entire water resources management. Likewise, organizational restructuring done on 2058 B.S shrinks 75 Irrigation District Offices into 46 Division and Sub-divisions, 8 Management Divisions and 3 Mechanical Divisions. In doing so, unequal division of responsibility and resources has been experienced in field offices. Like Palpa alone which is comparatively easily accessible district is under Western Division No -3 while division offices in rural part of Nepal like Rukum, Bhojpur, Okhaldunga covers 2 districts each. This restructuring has created lots of issues like misuse of government assets, human resources and employing temporary staffs to avoid Public Service Commission's selection procedures. Bhaktapur Division office of DWIDP alone covers 11 districts which challenges the efficient public service. Likewise, legal validity of Ground Water Development board and Sunsari Morang Irrigation Development Board is again another question.

To add more, promotion of government staffs under clause, **24 (Gha)1** has created additional conflicts regarding the role and responsibilities of the staffs. Issues of unequal division of responsibility and opportunities for self development among Hydro- geologist, Agricultural Engineers and Civil Engineers is also persistent. In addition to that, engineer's migration for the better opportunities in other organization and abroad and bulks of staffs are in retirement phase in near future is going to create voids in organization and consequently lead to scarcity of efficient human resources.

Thus to overcome all these issues of organizational setup and role and responsibilities of organization and human resources, assessment on the institutional reformation is on top priority. On the basis of the separate respective reports on institutional reformation by board, advisory committees, CMIASP and consultants, few recommendations were assessed. To address management and development of water resource in holistic approach the need of Ministry of Water Resources was recommended, addition of few more divisions in Department of Irrigation, establishment of separate directorate for monitoring and evaluation of Surface and Groundwater Divisions and appointment of Division chiefs according to the work nature, since function of division and sub division is same, thus sub divisions should be replaced by division office, open more division offices of DWIDP and institutional restructuring accordingly, reformation of Ground Water Development Board into Ground water Development Authority. Similarly, recommendations were noted for deduction of unnecessary placement, adjustment of **24 (घ)** promoted staffs and effective program for human resources development.

2.2.2. Research Priority for Irrigation Management in Nepal

Mr. Prachanda Pradhan, Consultant presented paper on research priorities for irrigation management and development. He said, irrigation sector is responsible to ensure food security for increasing population by contributing in domestic production and rural employment, thus it is important to pay attention for better management and improvement of the existing irrigation system. Mr. Pradhan highlighted the need of investment on Research and Development (R & D) in irrigation field.

He stressed on collaborative research with consultation of other organizations and promotion of documentation in DoI by strengthening the existing library. He gave overview of research area in irrigation performance assessment and issue relating to economic issues, technology issues, institutional framework for management, environmental and sociological issues.

2.2.3 Good Governance in an Irrigation agency

Er. Prakash Paudel, SE, DoI presented paper in good governance in irrigation agency. The long term vision of the Government of Nepal on good governance is to make public, judicial and development administration more competitive, participatory, transparent, service-oriented, result-oriented, accountable, inclusive, disable friendly and gender equity oriented. That would also support sustainable economic and social development works by ensuring good governance to the people while making the public, judicial and development administration sector accountable and sensitive towards peoples' needs and to promote access to service delivery through public participation, transparency, accountability and create a corruption free situation by strengthening the state mechanism according to the values and tradition of the rule of law. For doing so, various institutional (CIAA, PPMO, NVC, and OAG) arrangements are formally introduced and practiced in Nepal and are already functioning for watching and act for the enforcement of good governance any way, Working procedures of different 49 departments of government of Nepal are already prepared and being used, The Corruption Prevention Act 2002 is in practice, Anti-money-laundering Bill has been passed by the legislative parliament and many others.

By introducing national scenario on good governance implementation, Er Poudel focused on DoI activities and its results. He highlighted the issues of project document qualities, its approval and adequacy, transparency, competiveness of procurement procedure, record keeping, budget allocation, documentation of project reports, and personal management in DoI.

He stressed on updating design manuals like Project Development and Strengthening Programme (PDSP), training manuals, budget imbalance in irrigation development thus budget allocation is to be justified to the poor farmers of the remote area, deputation of the employees as per their ability and qualification , establishment and administered in the central level of the organization and effective monitoring and Evaluation .

Discussion Session

After presentations, Chairperson Mr. Sarada Prasad Sharma opened floor for comments. Participants raised the questions on legal existence of Sunsari Morang Irrigation Development Board. Similarly, relevance of employee training, Research and development and inclusive distribution of opportunities were also discussed.

2.3. Session II: Modernization of existing irrigation system

This session was chaired by Er. Uma Kanta Jha, Secretary of National Information Commission and rapporteur was Er. Ashish Bhadra Khanal, SDE DoI. Three papers were presented viz Revitalization of Irrigation Management Transfer "A case study of Kankai Irrigation System," Availability Assessment of Groundwater for Effective Irrigation and Seepage analysis of Chanda Mohana Headworks.

2.3.1 Revitalization of Irrigation Mangement Transfer "A case study of Kankai Irrigation System"

Er. Basu Dev Lohanee, SDE, DoI was the presenter of this paper. In the beginning he discussed the background of irrigation management transfer that occurred in the past and linked it with the management transfer of Kankai Irrigation System under IWRMP. He briefly highlighted the modality of management transfer under IWRMP and explained about essential structural improvement. He then elaborated other activities of management transfer such as completion of parcellary map, completion of Social and Environment Management Plan (SEMP) and improvement of field level structure taking place in KIS. Then he briefly explained about the resource mobilization of Water User Association and reported that they have aimed to collect Rs. 9.1 million and so far collected Rs 0.8 million. Finally he reported that after the implementation of management transfer program crop production has increased in KIS.

2.3.2. Availability Assessment of Groundwater Irrigation

Following the first paper Mr. Sagar Kumar Rai, Chief Hydrogeologist, DoI presented the paper on the Availability Assessment of Groundwater Irrigation. Initially he focused on annual potentiality of groundwater in Nepal, its present abstraction, abstraction according to APP and NWP, abstraction GDC area and its revision etc. Then he highlighted the major issues on it. He further said that because of high demand of irrigation during winter and deficit surface water flow during that period ground water has high scope. While computing the groundwater in terai, he said that Bhabar zone is the recharge area for groundwater for Terai and based on the data the potential is very high for irrigation from groundwater.

At the end he discussed the major issues of groundwater development in which he mentioned the issues of institution, legal aspect, policy and technical part regarding activities in groundwater.

2.3.3. Seepage Analysis underneath the headworks of Chanda Mohana Irrigation Schemes

Er. Santosh Kaini presented the last paper of this session about the Seepage analysis of Chanda Mohana headworks. Chanda Mohana headworks constructed in 2000 has problem of sand boiling. He did research on the cause of sand boiling using Mseep model where he used Khosla's as well as Lane theory. His paper was based on his research where he checked the soil of headworks, analyzed the design and the measures to mitigate the sand boiling by using sheet piles.

Discussion Session

In the end of the presentations of this session, group discussion was held. Many queries were raised from audience. Queries raised by Er. Bhubanesh Kumar Pradhan and Er. Sheetal Babu Regmi was answered by presenters. Many queries were focused on research on Chanda Mohana headworks.

2.4. Session III: Climate change impact on Water Resources and Challenges and Opportunities in Trans basin water Transfer

This session was chaired by DDG. Shiva Kumar Sharma and reported by SDE Surendra Prasad Joshi. In this session four presenters, namely SDE Ashish Bhadra Khanal and SDE Krishna Belbase, Er. Dinesh Bhatta and Er. Pabitra Man Gurung has presented their papers on the Inter basin water transfer project: opportunities and challenges, Impact of global changes on water resources and agricultural practices in Indrawati basin. Downstream hydrological impact of the Melamchi Inter-basin water transfer plan (MIWTP) respectively.

2.4.1. Inter basin water transfer project (IBWTP): opportunities and challenges

This presentation was jointly presented by SDE Ashish Bhadra Khanal and SDE Krishna Belbase. Mr. Khanal had highlighted present scenario of irrigation development in Nepal, its role in overall agricultural production of the nation and available irrigation facilities in various seasons of a year. He had pointed out that the intensity of irrigation from surface irrigation systems are 91%, 61% and 16% in summer, winter and spring season respectively. At the same time, he has also informed that only 32% of the irrigation potential area and 46% of the total irrigated area is getting round the year irrigation facility. So, he had emphasized the need of the development of multipurpose, inter basin diversion projects to provide year round irrigation facilities to the farmers.

Mr. Belbase had presented the objectives of inter basin water transfer projects and Government's efforts for development of such projects. He had focused that the main objective of the development of such projects are equitable distribution of available water resources in the nation and increment of the economic efficiency. In this context, he had informed that the Department of Irrigation is presently studying seven inter basin water diversion projects, namely Bheri- Babai, Kaligandaki-Tinau, Kaligandaki- Nawalparasi, Trishuli- Chitwan, Madi- Dang, Sunkoshi- Marin and Sunkoshi- Kamala diversion projects. From the preliminary study it shows that these projects can irrigate 516,000 ha. land and produce 462 MW hydro power. Mr. Belbase had made the tentative cost benefit analysis of such projects and found that it will cost in total 247 billion rupees to complete these seven projects and will get 791 billion rupees benefit in 25 years life span. He had added that the nation will get yearly 24.4 billion rupees benefit from such projects.

Mr. Belbase had also presented the SWOT analysis result on inter basin water transfer projects and noted that the high political commitment, Government's commitment for funding and availability of skilled manpower in DoI for projects are major strengths of such projects. Besides that he has also pointed out the major weakness of such projects, like fragile geology, lack of organizational experience in tunnel technology, lack of policy and existing policy on land compensation. He explained that there are lots of opportunities from such projects like reliable and round the year irrigation, promotion of economical development, regional balance, poverty alleviation etc. At the same time, he had also warn about the possibilities of arising lower riparian issues, back track of Government's commitment from financing and unpredictable sub surface condition of Siwalik area. So, Mr. Belbase had suggested for changing the mandate of Department of Irrigation and strengthening WECS, development of human resources in the department, revision of land acquisition act and strengthening of political commitment for the smooth implementation of such projects.

2.4.2. Impact of global changes on water resources and agricultural practices in Indrawati Basin

Er. Dinesh Bhatta of DoI has presented on the above topic based on the preliminary finding of AGLOCAP project, a joint initiative project of UNESCO-IHE Netherlands, AIT Thailand and DoI Nepal. He had highlighted the overview and objective of the project, trends in precipitation and temperature indices and influence of farm management, socio-economic and climatic factors on agricultural production in Indrawati basin. The main objective of the project is to identify the impact of global changes in agricultural practices and develop the adaptation measures to mitigate the negative impacts.

The study area of the project is Koshi basin and field area is Indrawati basin. He had noted that the study is based upon measurement data of 13 precipitation stations and 2 climatological stations of DHM. He had analyzed available data (from 1978 to 2008) of these stations and found that there is no significant change in mean precipitation, however, there is an increasing trend of dry days in winter season. Similarly, he had also observed that the mean maximum temperatures of winter and autumn season are also in increasing trend. Likewise, during the questionnaire survey with the local community it has been informed that the birds, which usually found below 800m in the past is now appearing in elevation range of 1900m in Indrawati basin. This evidence also indicates towards effects of the rise of temperature in this region.

Mr. Bhatta had compared the impacts of climate change in agricultural practices in mid hill and foot hills of Indrawati basin and found that 85% lands of foot hills are getting irrigation facility, while only 20% lands of mid hills are getting such facility. The people of foot hills are trying to adopt to hybrid seeds, while people of mid hills are still following traditional farming. The people of mid hills are poorer than that in foot hills and at the same time they are more dependent on rainfall and hence more vulnerable to climate change.

In the conclusion, Mr. Bhatta had pointed out that the agricultural systems in Indrawati basin are influenced by both climatic as well as non climatic variables with pronounced impact on marginal people. So, certain adaptation measures are necessary to develop to cope with the changes in environment, although foothill farmers are already adapting some coping measures.

2.4.3. Down Stream Hydrological Impacts of the Melamchi Inter basin water transfer plan (MIWTP)

Er. Pabitra Man Gurung, a research Officer of IWMI, has presented paper in this topic based on his Master’s Degree, which was jointly supported by British Columbia and WECS Nepal. He had informed that Melamchi project is planning to develop in three stages; in the first stage 170 MLD water will be diverted from the Melamchi River, in the second stage 85 MLD water will be added from the Yangri River, while in the third stage additional 85 MLD water will be diverted from the Larke River. The downstream impact of this project would be carried out in 11 of the 79 sub basins of the Koshi basin. Calibration and validation of the research were carried out from the data of 15 stream flow stations of the basin. The flow data available from 1996 to 2000 period were used for calibration purpose, while the data available from 2001 to 2005 period were used for the validation of the research.

Mr. Gurung had used Soil Water Assessment Tool (SWAT hydrological Model), developed by Department of Agriculture, USA to simulate water quantity, water quality and sedimentation. He found that the impact of the project is higher in the Melamchi River in compare to the Yangri and Larke Rivers. At the same time, the reduction of flow due to the project reaches almost 36% in winter season, while in the wet season it is only 6%. The study has confirmed that the project will have considerable impact in immediate downstream sub basins of the diversion point, while there is no considerable impact in the further downstream sub basins toward the Koshi basin outlet Chatara.

Discussion Session

The discussion session was very lively and participants have actively participated in this session. Secretary Regmi raised issue whether the implementation of Inter basin Multipurpose project is the mandate of DoI or not? DoI is the most capable organization for such works, so DoI can implement such projects and doing such projects. However, he has emphasized to review the policy for such projects. At the same time, he has also informed that some exercises are going on to convert the Ministry of Irrigation to Ministry of Water Resources.Mr. Bhubanesh Kumar Pradhan mentioned that if we highlight only our weakness about lack of our experience on tunneling, it does not give good message to politicians about our capacity to implement inter basin projects. So, we have to say that there are lots of international organizations, who have got good knowledge on tunneling and we can hire them and use their expertise. At the same time, he has also raised the concern about lack of knowledge about our Nepalese river systems on our young engineers, so he has suggested making them more knowledgeable. S. D. E. Prem Shribastav raise the issue about the coordination of DOED and DoI, as DoED is planning to built reservoir type Hydro power projects and in the same river DoI is also planning to build inter basin projects. Mr. Nivas Chandra Shrestha made query whether it is so important to correlate between the education level of the farmers and the agricultural production in Indrawati basin? Mr. Sagar Kumar Rai made a query, how can 7 inter basin projects will make regional balance? Whether we have calculated required water for providing round the year irrigation to 516000 ha land?

In response to the queries raised Mr. Krishna Belbase said that it took about six months to get the permission to implement Bheri Babai Diversion Project by DoI, so it is very important to clarify in the policy about the responsibility of DoI to conduct multipurpose inter basin projects. He has informed that a study of 300 MW hydropower project in Naxal gunj is being conducted, however he has added that such reservoir projects in the upstream side will help to get regulated flow in the down stream side. Similarly, Er. Dinesh Bhatta emphasized that the overall objective of his project is to find out the adaptation measures for coping the impact of climate change on agriculture and regarding the study of impact of education level in agricultural production, he has clarified that when a villager is educated he has more chances of getting better jobs and diverts from agriculture to a prestigious job as agriculture is still not a respectable profession in the country.

2.5. Session IV: Enhancing water productivity with micro irrigation

Session IV was chaired by Mr. Prachanda Pradhan, Consultant and the rapporteur was Er. Prabin Raj Maskey, SDE, MoI. Two technical papers on Non conventional micro irrigation were presented in the session. First paper was focused on Enhancing water productivity with Micro Irrigation by Mr. Kailash Sharma, IDE and second paper was on Micro Irrigation in Nepal: An effective tool to fight against poverty by Dr. Kishor K Bhattarai, SDE, DOI.

2.5.1 Enhancing water productivity with micro irrigation

Mr. Kailash Sharma presented the paper on behalf of the team. He started with the introduction of International Development Enterprises (IDE). He highlighted that IDE is an INGO that focuses on creating income opportunity to poor people to escape poverty and become commercial producers thru the PRISM value-chain approach. He added IDE has worked in Nepal since 1992 and developed locally based micro irrigation supply chains and small scale water resource management. He then explained in details the technologies developed by IDE for micro irrigation like Treadle Pump, Simple Drip Irrigation System, Micro Sprinkler System, Modified Thai Jar and Ferro-cement Lined Tank.

He said, to get maximum benefit of micro irrigation technologies there is need of an associated effort to link farmers to agricultural markets and appropriate inputs including water supply system which allows for efficient use of water. IDE has developed the supply chain for drip irrigation and micro sprinklers in many hill districts of Nepal. IDE works with private sector partners building their capacity to manufacture and market low cost micro irrigation systems. He added, MUS are also ideal for the use of low cost sprinklers that operate under low pressure.

2.5.2. Micro Irrigation: Mega Impact A small step towards Social integration and Economic upliftment of the poor, disadvantaged and women

Dr. Kishor Bhattarai started with the Irrigation Master plan 1996 which says of the total 2.64 M ha cultivated land in Nepal, only 1.76 M ha is potentially irrigable, leaving almost 0.88 M ha as rain fed land. These non-irrigable areas lie in the hills and mountains, are in the water scarce regions, and are inhibitant by the poor small landholders farming on the marginal sloping terraces, scattered patches thus to address those areas with irrigation, micro irrigation is the only option. Only such schemes in reality encourage target communities i.e. poor, women, *Dalits* and *Janjatis* to take initiatives to improve their livelihoods by providing opportunities to produce commercial vegetables. He then explained the advantages of adoption of micro irrigation where being small in size, every voice is listened and contribution and participation of individual in every phase of project implementation and its direct impact on women empowerment and their access to resources.

Discussion Session

After presentations, the chairperson opened floor for discussion and comments. Lively discussion on constraints to promotion of NITP by Government and overlapping roles for small scale irrigation projects undertaken by DoI and DOLIDAR were done. Er. Shiv Kumar Sharma raised the issues of promoting NITP as important technologies by policy makers to address poor and marginalized people. Here, Er. Dev Raj Niraula said, the total irrigated area defined by DOI is different from DOA thus assessment is required to know the exact irrigated area in country so that areas that cannot not be irrigated by conventional method is identified where

NITP can contribute effectively. In same issues, Mr. Sagar Kumar Rai added that DOI should be more focused on promoting NITP and micro irrigation rather than surface irrigation to address hills and mountain of country.

Similarly, overlapping of the responsibility of small scale irrigation project between DOI and DOLIDAR was also discussed where Mr. D.B. Singh highlighted that Community irrigation program (CIP) in 12 districts is implemented by ADB through DOLIDAR and Donors are more focused on benefit sharing on social and environmental insurances. Mr. Nabin Mangal Joshi added that CIP is under DOLIDAR but NITP is run by DOI in policy making which is creating confusion for district level activities.

2.6. Closing Session

The seminar was concluded on the 14th July 2011. Er. Shiva Kumar Sharma, DDG, DOI was the chairperson of the session. Er. Bhubanesh Kumar Pradhan, former secretary, then Ministry of Water resources, was the chief guest of the session. Er. Suman Sijapati and Er. Pabitra Man Gurung from INPIM/Nepal and IWMI/Nepal were the special guest for the session.

Dr. Kishore Kumar Bhattarai summarized the seminar activities highlighting the key points raised in discussion during the technical sessions. He said that equal opportunities and priorities were given to micro and mega irrigation system development in the session and stressed on need for giving more priority in policy making and planning. He added that seminar was fruitful, lively and successful in achieving its objectives.

Er. Pabitra Man Gurung, IWMI/Nepal representative said that technical papers were well knowledgeable. He added that lots of work is being done in irrigation sector thus documentation is necessary for future references. He thanked DoI for giving opportunity of collaborating with IWMI/Nepal for seminar and committed that IWMI/Nepal will always be positive for any such works in future.

Er. Suman Sijapati, INPIM/Nepal said that this workshop has brought the intellectuals of irrigation sector in common forum for discussion on irrigation development issues and critical review of the works. However, irrigation is closely linked with agriculture, so he recommended including the agriculture sector intellectuals to be part of it. He also stressed on including private sector in this forum making it a national program rather than of DoI alone. He thanked DoI for collaboration and making INPIM/Nepal part of the seminar and assured for future collaboration as well.

Chief Guest, Er. Bhuwanesh Kumar Pradhan said the development of micro level irrigation is the landmark as well as the development of mega irrigation. Thus micro and mega level irrigation development should be equally prioritized rather than emphasizing on any one. He congratulated the workshop committee for successful organization of seminar and thanked all participants for experience sharing in lively discussion.

Chairperson Er. Shiva Kumar Sharma thanked participants for the active participation. He said that technical sessions were relevant, brain storming and exciting. He added, Department of irrigation has forseen Groundwater development as immediate solution and diversion and storage projects as long term solution for year round irrigation . However, both complement each other in every level and in all these NITP deserves priority in DoI planning to address marginal land. He said that this workshop was successful in generating the key issues related to policy, organization setup, human resources development and irrigation system development and modernization. He added that the outcomes of the seminar will be incorporated in future planning of project and activities of DoI. Finally thanking participants, paper presenters and seminar management committee he announced the closing of the session and end of the seminar.

3. Conclusion and Recommendation

The highlights of the sessions and the recommendations generated from the seminar are enumerated as follows:

3.1 Highlights of the technical sessions

Brief highlights of the different papers presented in technical sessions are enumerated as key points in following section.

Technical Session I: Strategy and Policy Issues

- Issues of division of Ministry of water Resources into Ministry of Irrigation and Ministry of Energy without enough homework and need of the institutional reformation but according to political interest was question in the session. This division of Ministries confined MoI in Irrigation and MoE in Electricity and Energy sector thus generating question of linking overall responsibility towards development of water resources sector is underestimated.
- Organizational restructuring done by DoI on 2058 B.S changing 75 irrigation district offices into 46 Division and Sub- divisions, 8 Management Divisions and 3 Mechanical Divisions also seemed irrational in some ways: Western region irrigation Division No -3; Palpa is responsible for one district only while sub-division offices in remote areas like Rukum, Bhojpur, Okhaldunga looks after 2 districts and more. Likewise, Bhaktapur Division of DWIDP looks after 11 districts. In addition to that, government asset and resources in remaining district where district offices no longer exists has been misused and defunct.
- Legal status of Ground Water Development Board and Sunsari Morang Development Board is also a question to policy makers.
- Promotion of government staffs under clause, **24 (Gha) 1** creating issues of role and responsibilities among staffs was raised.
- Issues of unequal division of role and responsibility and opportunities for self development among Hydro geologist, Agricultural Engineers and Civil Engineers was also raised in the session.
- Stress was given on Research and Development by collaborating research with linkages with other organizations and promotion of documentation in DOI by strengthening the existing library of DOI.

- Research areas were identified as in irrigation performance assessment, economic issues, technologies issues, institutional framework for management, environmental issues and sociological issues.

- Good Governance is felt important by GoN to make public, judicial and development administration more competitive, participatory, transparent, service-oriented, result-oriented, accountable, inclusive, disable friendly and gender equity oriented.

- Different arrangements are formally introduced and practiced in Nepal like oversight Offices (e.g. CIAA, PPMO, NVC, and OAG) are already functioning watch and act for the enforcement of good governance in government organization and service.

- DOI is also practicing good governance by improving on transparency, competiveness of procurement procedure, record keeping, budget allocation, documentation of project reports, and personal management in DOI.

Technical Session II: Modernization of Existing Irrigation Systems

- Irrigation management transfer empowers WUA through promotion of sense of ownership and responsibility sharing.

- IMT provides opportunity of assessment of need and constraints of irrigation system as WUA is responsible for the sustainability of the system.

- Kankai Irrigation System transfer under IWMRP has shown positive result in crop production and water management and distribution.

- Ground water has high scope for irrigation during winter as surface water flow is deficit in that season.

- Bhabar zone is the recharge area for groundwater for Terai and its potential is very high for groundwater. According to hydrogeological studies, the annual potential storage in the unconfined aquifers of main Terai is about 8951 million cubic meters (mcm). The annual groundwater recharge in the confined aquifer is 2762 mcm. Therefore, the total annual storage of groundwater in the Terai is upto 11713 mcm.

- According to the target, marked by the Agriculture Perspective Plan 1995 (APP), about 1, 75,000 STWs and about 1250 DTWs would be made at the end of APP (2015). Thus the total irrigated land from DTWs and STWs will be about 4, 87500 ha.

- In groundwater development process lots of issues are persistent like institutional issues, technical, legal and policy level.

- Seepage is one of the major causes of failure of irrigation headworks constructed on permeable foundation in Chanda Mohana irrigation system constructed in 2000 A.D.

- MSeep model (2-Dimensional) was used for seepage analysis. Due to continuous seepage flow, the horizontal and vertical hydraulic conductivities in 2009 might have been increased to 2.5 times and 1.3 times respectively than the values in 2000.

- The research finding in Chanda Mohana irrigation project suggests that the ongoing maintenance work from 2010 is safe only if the pressure grouting recovers the soil parameters to the stage during construction in 2000, which is generally not achievable.

- Considering the hydraulic conductivity and porosity of the soil as the average values of 2000 and 2009, extension of the downstream floor with additional sheet piles is proposed as an alternative measure for achieving the safety of the structure.

Technical Session III: Impact of Climate change on Water Resources and Challenges and Opportunities in Trans basin water Transfer

- Area receiving Year round irrigation in Surface Schemes is 271,000 ha and through groundwater is 300,000 ha thus year round irrigation is only available in 32% of total irrigation potential area. In this context, it is time to develop multipurpose diversion projects and storage projects for economic and social development of country.

- Department of Irrigation is presently studying 7 inter basin water diversion projects, namely Bheri- Babai, Kaligandaki- Tinau, Kaligandaki- Nawalparasi, Trishuli- Chitwan, Madi- Dang, Sunkoshi- Marine and Sunkoshi- Kamala diversion projects.From the preliminary study it shows that these projects can irrigate 516,000 ha. land and produce 462 MW hydro power.

- Major weakness of such projects are like fragile geology, lack of organizational experience in tunnel technology, lack of policy and existing policy on land compensation. He explained that there are lots of opportunities in such projects like reliable and year round irrigation, promotion of economical development, regional balance, poverty alleviation etc.

- Possibilities of arising conflicts from lower riparian issues, back track of government's commitment from financing and unpredictable sub surface condition of Siwalik area are threats of the project.

- Possible impact of climate change on water resources and agricultural practices in Indrawati Basin is assessed.

- The agricultural systems in Indrawati basin are influenced by both climatic as well as non climatic variables with pronounced impact on marginal people. So, certain adaptation measures are necessary to develop to cope with the changes in environment.

- Melamchi Inter Basin Water Transfer Plan (MIWTP) planning to develop in three stages; in the first stage 170 MLD water will be diverted from the Melamchi River, in the second stage 85 MLD water will be added from the Yangri River, while in the third stage additional 85 MLD water will be diverted from the Larke River.

- According to Soil Water Assessment Tool (SWAT hydrological Model), to simulate water quantity, water quality and sedimentation it was found that the impact of the project will be higher in the Melamchi River as compared to the Yangri and Larke Rivers.

- At the same time, the reduction of flow due to the project will be almost 36% in winter season, while in the wet season will be only 6%.

Technical Session IV: Enhancing water productivity with micro irrigation

- Of the total estimated 2.64 M ha cultivated land, only 1.76 M ha is potentially irrigable, leaving almost 0.88 M ha as rain fed land (*Irrigation Master Plan,* *1996")*. These non-irrigable areas lie in the hills and mountains, are in the water scarce regions, and are inhibited by the poor small landholders farming on the marginal sloping terraces, scattered patches. Micro irrigation technology is the best solution to provide irrigation services in the area.

- IDE has worked in Nepal since 1992 and developed locally based micro irrigation supply chains and small scale water resource management.
- It has been shown that Micro Irrigation Technology (MIT) has yielded cost effective benefits for smallholder farmers' commercial farmers and should be promoted. Newly introduced MIT cover larger areas and enable commercial scale production.
- It is critical that MIT programs have a complementing agricultural value-chain program to yield the full benefits.
- MIT has shown significant impact to empower women through increased income and control over income, improved status within community.
- MIT promotion should include development of the supply chain to ensure that spare parts and product are available and impacts are sustainable.
- Programs should also promote MIT for their environmental and climate change benefits of utilizing water efficiently and increasing productivity through adoption of appropriately improved technology.

3.2 Recommendations

Recommendations made by specific papers and plenary discussions at the end of each session have been enumerated as follows:

- To overcome issues of organizational setup and allocation of appropriate role and responsibilities of human resources, assessment on the institutional reformation should be on top priority.
- Responsibility of small irrigation program should be under DoI not under DOLIDAR as DoI is sole organization for irrigation development and sustainable management.
- For monitoring and supervision accountability and responsibility to eight management Dvision offices, separate Irrigation management Directoriate is required.

- Likewise to supervise and monitor the Ground Water Development Divisions, separate Directorate is required.
- Chief of Irrigation management division offices should be Agricultural Engineers and Groundwater development division offices should be Hydrogeologist.
- Working area and role and responsibility of Division and Sub-divisions offices need to be revised.
- Unproductive staffs should be deducted and personal management should be based according to dividsion of work and responsibility.
- Establish additional adequate Division and Sub-division offices in DWIDP.
- Assessment of human resources requirement in DWIDP.
- Resolve legal issue of GWDB by converting it into Authority.
- DoI should invest adequately in R & D for future irrigation service extension and sustainability of the irrigation development and management likewise development of technologies and approaches for irrigation development.
- Research priority should be given to Irrigation performance assessment, economic issues, technology issues, and institutional framework for management, environmental issues, and sociological issues.
- Department of Irrigation should address national campaign for Governance Reforms and set priority (like transparency, accountability, participation and management reform).
- During the winter (dry) season, most of the surface water sources dry up and the groundwater is only a main reliable resource to overcome the deficit thus appropriate Groundwater act and law are needed for judicial of GW without its exploitation.
- Identification and zonation of DTWs and STWs area should be done.
- Update of GDC map in 1:2500 should be continued district wise to get the maximum benefits.

- For the sustainable and functional irrigation system enforcement of governance of WUA is necessary.

- Reorganization of Department of Irrigation and Ministry Water Resources incorporating having mandate to implement multipurpose project.

- All legal issues should be addressed appropriately to develop inter basin transfer and multipurpose project including revision of Land acquisition act 2034 and revision of water resources act and should mainly focus on infrastructure development.

- Capacity building of the human resources to facilitate multipurpose projects.

- Micro irrigation development is successful in implanting sense of economic independence among the poor and underprivileged community especially women. Thus NITP and micro irrigation should be more prioritize for allocation of adequate budgets.

3.3 Identified themes for the next workshop/seminar

- Human resources development and management

- Rehabilitation/Modernization of Irrigation systems

- Adoption of water saving Irrigation technologies and Micro Irrigation technologies.

- Irrigation Management transfer concept and practices.

Annex -1
Program Schedule

National Irrigation Seminar, 2068

"Micro to Mega: Irrigation for Prosperous Nepal"

Program Schedule

Venue: Hotel Country Villa, Nagarkot, Bhaktapur

Date: 2068.03.29-30 (2 days) Master of Ceremony: Er. Devaraj Niraula

DAY 1 (Ashad 29, 2068 Wednesday)		
10:30-11.00	Registration of Participants	
Inaugural Ceremony		
Chairperson: Er. Anil Kumar Pokharel, DG, DOI Chief Guest: Hon. State Minister Dal Bahadur Sunar, MOI Special Guest: Mr. Tana Gautam, Secretary, MOI Special Guest: : Er. Uma Kant Jha,Secretary, Information Commission Special Guest Er. Shital Babu Regmee ,Secretary,WECS Special Guest: Mr. Ram Prasad Meheta ,Chairman, NFIWUAN		
Time	**Activities**	**Resource Persons**
11:00-11:05	Welcome Address	Er. Niwas Chandra Shrestha, Chief, SMTP
11:05-11:15	Introduction to the seminar design and content	Er. Ashish Bhadra Khanal, SDE, DOI
11:15-11:20	Few words from Special guest	Mr. Ram Prasad Meheta, Chairman, NFIWUAN
11:20-11:25	Few words from Special guest	Er. Shital Babu Regmee, Secretary,WECS
11:25-11:30	Few words from Special guest	Er. Uma Kant Jha,Secretary, Information Commission
11:30-11:35	Few words from Special guest	Mr. Tana Gautam, Secretary, MOI
11:35-11:40	Few words from Chief guest	Hon. State Minister Dal Bahadur Sunar, MOI
11:40-11:45	Few words from Chairperson	Er. Anil Kumar Pokharel, DG, DOI
11:45-13:30 Lunch Break		
Technical Session I (Strategy and Policy Issues)		
Chairperson: Er. Sarada Prasad Sharma, Ex-DG		
Rapporteur: Mr. Uddav Bhattarai, Legal Officer, DOI		
13:30- 13:50	Institutional Reform under Ministry of Irrigation	Baburam Adhikari
13:50- 14:10	Research Priority of Irrigation Management in Nepal	Prachanda Pradhan
14:10-14:30	Good Governance in an Irrigation Agency	Prakash Paudel
14:30-15:00	Discussion session	
15:00-15:30 Break		
Technical Session II (Modernization of Existing Irrigation Systems)		
Chairperson: Er. Uma Kant Jha,Secretary, Information Commission		
Rapporteur: Er. Ashish Bhadra Khanal,SDE,DOI		
15:30- 15:50	Revitalization of Irrigation system through Irrigation Management Transfer "A case study of Kankai Irrigation System"	Basu Dev Lohanee

15:50- 16:10	Availability Assessment of Groundwater for effective irrigation	Sagar Kumar Rai
16:10-16:30	Seepage Analysis Underneath the headworks of Chanda Mohana Irrigation Schemes, Sunsari	Santosh Kaini
16:30-17:00	Discussion Session	
18:30 Onwards Reception Dinner		
DAY 2 (Ashad 30, 2068 Thursday)		
7:30-09:00 Breakfast		
09:00-9:15 Review of Day 1		
Technical Session III (Climate change impact on Water Resources and Challenges and Opportunities in Trans basin water Transfer)		
Chairperson: Er. Shiv Kumar Sharma, DDG, DOI		
Rapporteur: Dr. Surendra Prasad Joshi, SDE, DOI		
09:15- 09:35	Inter basin Water transfer project: opportunity and challenges	Ashish Bhadra Khanal and Krishna Belbase
09:35- 09:55	Impact of global changes on water resources and agricultural practices in Indrawati basin	Dinesh Bhatta
09:55- 10:15	Downstream Hydrological Impacts of the Melamchi Inter-basin Water Transfer Plan (MIWTP)	Pabitra Man Gurung
10:15-10:45	Discussion Session	
Tea Break 10:45-11:15		
Technical Session IV (Enhancing water productivity with micro irrigation)		
Chairperson: Mr. Prachanda Pradhan, Consultant		
Rapporteur: Er. Prabin Maskey, SDE, DOI		
11:15-11:35	Enhancing water productivity with Micro Irrigation	Kailash Sharma
11:35-11:55	Micro Irrigation Mega Impact : A small step towards Social integration and Economic uplifting of the poor, disadvantaged and women	Kishore Bhattarai
11:55-12:25	Discussion Session	
Lunch Break 12:25-14:00		
Group Discussion and Wrap up		
14:00- 14:30	Group 1 - Strategy and Policy Issues	Respective Chairperson and Rapporteur
	Group 2 - Modernization of Existing Irrigation Systems	"
	Group-3 – Climate change impact on water resources and Challenges and Opportunities in Trans basin water Transfer	"
	Group-3 – Climate change impact on water resources and Challenges and Opportunities in Trans basin water Transfer	"
	Group -4 – Enhancing water productivity with micro irrigation	"

14:30-15:00	Group Presentation/ Wrap up Discussion	
15:00-15:30 Tea Break		
Closing Session		
Chairperson: Er. Shiva Kumar Sharma , DDG, DOI		
Chief Guest : Er. Bhuwanesh Kumar Pradhan, Ex- Secretary		
Special Guest : Er. Pabitra Gurung , IWMI/Nepal Representative		
Special Guest : Er. Suman Sijapati, INPIM/Nepal President		
Time	**Activities**	**Resource Persons**
15:30-15:40	Conclusion remarks of the seminar	Dr. Kishore Kumar Bhattarai , SDE,DOI
15:40-15:45	Few words from special guest	Er. Suman Sijapati, INPIM/Nepal President
15:45-15:50	Few words from special guest	Er. Pabitra Gurung , IWMI/Nepal Representative
15:50-15:55	Few words from Chief guest	Er. Bhuwanesh Kumar Pradhan, Ex- Secretary
15:55-16:00	Seminar closing from Chairperson	Er. Shiva Kumar Sharma , DDG, DOI

Annex - 2
List of Participants

List of Participants

S.N.	Name	Designation	Organization	Address	Email	Telephone		
						Office	Mobile	Resident
1	Abadhesh Chandra Jha	SDE	Ministry of Irrigation	Kupandole, lalitpur	acjha1@gmail.com		9745050995	
2	Ajit Kumar Chaudhary	SDE	Department of Irrigation	Jawalakhel	-		9841296085	5539809
3	Amod Kumar Thapa	MD	PRECAR	Mid-Baneshwar, Devkota Sadak	amodthapa@hotmail.com	4465084	9841202763	4478365
4	Amrit Shrestha	SDE	Ministry of Irrigation	Singha Durbar, Kathmandu	amrit_sh@hotmail.com	4211515	9841336658	
5	Anil Kumar Pokharel	D G	Department of Irrigation	New Baneshwor, Kath-mandu	-	5537136		
6	Ashish Bhadra Khanal	SDE	Department of Irrigation	Basundhara, Kathmandu	ashishkhanal@hotmail.com	5537306	9841425211	
7	Bishnu Bahadaur Pradhan	SDE	Department of Irrigation	Jawalakhel	-	5537302		4352082
8	Bashu Dev Lohanee	SDE	Department of Irrigation	Naxal-1, Bhagwatibahal, Kath, Nepal	lohanibasu@yahoo.com	5528585	9841277760	4443306
9	Bhuwanesh Kumar Pradhan	Ex-Secretary	MOWR	Baluwater, KTM	Bhubaneshpradhari@yahoo.com	4414099	9841251052	5536328
10	Binaya Regmi	SDE	Ministry of Irrigation	Singha Durbar, Kathmandu	regmi_binaya@live.com.sg	4211515	9841269968	4473474
11	Bishnu Datt Awasthi (Dr)	Deputy Director General (Tecnology Transfers Coordinator)	Department of Agriculture	Harihar Bhawan, Lalitpur	awasthibd@gmail.com	5521356	9841526412	4370422
12	Bishnu Prasad Gyawali	Account Officer	SMTP	Department of Irrigation, Jawalkhel, Lalitpur	bishnuddc@yahoo.com		9841361238	
13	Budda Ratna Tuladhar	Senior Devisional Engineer	WECS	Maharajgunj, Kathmandu	brtuladhar@into.com.np	4211508	9841293696	427700
14	Chet Man Budthapa	Exective Member	INPIM Nepal	Jawalakhel	kamalakarki2005@yahoo.com		9841578667	4363601
15	Dal Bahadur Sunar	State Minister	Ministry of Irrigation	Singha Durbar, Kathmandu	-			
16	Devaraj Niraula	Coordinator, ICWMP	Department of Irrigation	Mid Baneshwor, Kathmandu	devu2002dec@yahoo.com	5548113	9851034433	4469992

17	Dhirendra Napit	SDE	Department of Irrigation	Sankhamul, Kathmandu	dhiren.napit@gmail.com	4783059	9841429339	
18	Dhurba Kumar Pokharel	Project Chief	IDS, DOI	Mid Baneshwor, Kathmandu	dkpokhareal@hotmail.com	5548112	9851036900	4109782
19	Dinakar Khanal	Senior Divisional Engineer	WECS	Singha Durbar, Kathmandu	dinakarkhanal@gmail.com		9841801919	4265623
20	Dinesh Bhatt	Engineer	Department of Irrigation	Jawalakhel	dinesh_bhatta@yahoo.com		9841682402	
21	Dipendra Laudari	SDHG	CRID	Bhanimandal, Lalitpur	dipu61@gmail.com	5535003	9841385972	4281442
22	Echhya K. Shrestha	SDHG	GWRDB	Babarmahal, KTM	ichha@hotmail.com	4262953		
23	Ezee G.C	Engineer	Department of Irrigation	Dhobighat, Lalitpur	gcezee@yahoo.com		9841490579	5014315
24	Gauri Lal Upadhyay	Sociologist	SMTP	Sankhamul, Kathmandu	upadhyay_gl@hotmail.com	5527151	9841304501	
25	Gauri Shankar Bassi	Deputy DG	DWIDP	Pulchok, Lalitpur	bassigauri@yahoo.com	5543285	9841241379	
26	Kailash Sharma	Director,Engineering Program	IDE Nepal	Bakhundole, Lalitpur	kailash2025@yahoo.com	5520943	9841228968	4720942
27	Kamal Prasad Regmi	D G	DWIDP	Pulchok, Lalitpur	regmikpd@yahoo.com	5549004	9841386425	5550799
28	Kedar Kumar Shrestha	SDE	CRID	Kathmandu-29	Kedarshrestha38@gmail.com		9841391637	4357821
29	Kishor Kumar Bhattarai	Coordinator, NITP	Department of Irrigation	New Baneshwor, Kath-mandu	kisho_bh@hotmail.com	5545345	9841405742	4784996
30	Krishna Belbase	SDE	Department of Irrigation	Kathmandu	belbasekrishna@yahoo.com		9851055355	4287490
31	Krishna Chandra Prasad (Sah)	Senior Lecturer	UNESCO-IHE	Netherlands	K.prasad@unesco-ihe.org			
32	Laxman Prasad Singh	SDE	Department of Irrigation	Jadibuti, Kathmandu	-	5527151	9741167223	6632948
33	Lekindra Bhattarai	Engineer	Department of Irrigation	Anamnagar, Kathmandu	l.bhattarai@yahoo.com	5527151	9841461399	4265049
34	Naveen Mangal Joshi	Project Director, CMIASP	Department of Irrigation	Jawalakhel	cmiasp@wlink.com.np	5546425	9841328083	5537930
35	Niwash Chandra Shrestha	Chief, SMTP	Department of Irrigation	Jawalakhel	nibasshrestha2007@gmail.com			
36	Pabitra Gugung	Research Officer	IWMI/Nepal	DoI, Jawalakhel Lalitpur	p.gurung@CGIAR.ORG	5542306	9841304145	5592816

37	Prachanda Pradhan	Consultant, WB	World Bank	St May Road Adarsha Tole, House No 9, Lalitpur Nepal	pradhanpp@hotmail.com.np		9851027593	5524104
38	Pradeep Kumar Manand-har	SDE	Department of Irrigation	Mid Baneshwor	manandharpk@hotmail.com	5537306	9841235920	4471685
39	Pradeep Thapa	SDE	Department of Irrigation	Jawalakhel	erpradth@yahoo.com		9851003309	
40	Pradip Raj Pande	Regional Director	CRID	Baluwatar	Pradiprajpandey@gmail.com	5535003	9841420547	4438747
41	Prakash Paudel	SE	Department of Irrigation	Jawalakhel	mailppaudel@yahoo.com		9851118822	4375622
42	Pramod Kumar Shrestha	SDE	Ministry of Irrigation	Jadibuti, Kathmandu	pramod_052@hotmail.com	4211515	9841328789	6632245
43	Pramoda Pradhan	SD Chemist	Department of Irrigation	Jawalakhel	-	5535382	9841391073	4021558
44	Pratibha Sapkota	Consultant	IWMI/Nepal	Jawalakhel	pratibhasapkota@gmail.com	5542306		
45	Pravin Raj Maskey	SDE	Ministry of Irrigation	Singha Durbar, Kathmandu	prmaskey@gmail.com	4211515	9841284409	4256109
46	Prem Kumar Srivastava	SDE	Department of Irrigation	Jawalakhel	pksrivastava383@gmail.com		9851107625	4782831
47	Prem Lasiwa	Engineer	Department of Irrigation	Byasi-10, Bhaktpur	Prem-lasiwa@gmail.com		9841495063	6617421
48	Raj Narayan Shah	SDE	Department of Irrigation	165,Basuki Marg	rajns100@yahoo.com	5521082	9841315490	
49	Rabinath Babu Shrestha	SDE	Department of Irrigation	Jawalakhel	rab41@rediffnail.com	5537306	9840051517	4494663
50	Rajendra Bir Joshi	SDE	Department of Irrigation	Nagbahal, Lalitpur	rajendrabir-joshi@hotmail.com		9851095211	5250095
51	Rajeshwor Gyawali	Under Secretary	Ministry of Irrigation	Singha Durbar, Kathmandu	Gyawalime@hotmail.com	4200027	9841203674	
52	Ram Babu Regmi	Co-ordinaor, MIP	Department of Irrigation	Jawalakhel	regmirambabu@yahoo.com		9841518609	
53	Ram Krishna Ghorasaini	SDE	CRID	Subidhanagar, Kathmandu	er_ghorasaine@yahoo.com	5535003	9751008447	4469822
54	Rama Nand Rasad Yadav	SE	DWIDP	Pulchok, Lalitpur	yadav_ramanand@hotmail.com		9849102230	5550700
55	Ramesh Bandhu Aryal	Division Chief	CIDD No.7, Kavre	Dhulikhel. Kavre	rbaryal@gmail.com	011-490461	9851144666	4352762
56	Sanat K.C.	Chief Account Coutroller	Department of Irrigation	Jawalakhel	kc_sanat@yahoo.com	5537307	9841553808	4781906
57	Santosh Kaini	Engineer	Department of Irrigation	Jawalakhel	santoshkaini@yahoo.com		9846069953	

58	Santosh Kokh Shrestha	Senior Agri.Economist	Department of Irrigation	Jawalakhel	skokh190@hotmail.com	5527151	9841558179	4252186
59	Sanu Maiya Shrestha	Sr. Agri, Economist	Department of Irrigation	Jawalakhel	-	5537313	9841666444	5526535
60	Sarita Dawadi	SDE	Department of Irrigation	Pulchok, Lalitpur	luckysasu@hotmail.com		9841355557	
61	Saroj Pandit	SDE	CRID	Samakhusi, KTM	sarojcp@yahoo.com		9851090307	4352430
62	Sharada Pasad Sharma	President	SIREN	72/9,Muralidhar Marg	spsharma_21@yahoo.com	5542476	9851089029	4470464
63	Shishir Koirala	SDE	WECS	kathmandu	ccrkoirala@hotmail.com	4211415	9841446340	4443064
64	Shital Babu Regmee	Secretary	WECS	Kalikasthan, KTM	regmeesb@yahoo.com	4211423	9841523500	4436713
65	Shiv Kumar Sharma	DDG	Department of Irrigation	Jawalakhel	shiv1301@gmail.com	5537311	9851091724	4423310
66	Siddhi Pratap Khan	DDG	Department of Irrigation	Jawalakhel	Khansiddhi@gmail.com	5537312	9841326458	5006145
67	Sudhir Man Baisyat	DDG	Department of Irrigation	Jawalakhel	smbaisyat@hotmail.com	5537313	9841333219	4370956
68	Suman Sijapati	President	INPIM/Nepal	3/237 Dhobighat, Lalitpur	suman@sijapati,wlink.com.np	5553918	9841388100	5532800
69	Sunil Khanal	Under Secretary	Ministry of Irrigation	Singha Durbar, Kathmandu	sunil-khanal@yahoo.com	4211511	9841260122	
70	Surendra Man Shakya	SDHG	GWRDB	Babarmahal, KTM	shakyasm72@gmail.com	4262953	9841235024	
71	Surendra Meher Shrestha	Division Chief	CIDD-6 , Kathmandu	Basundhara, KTM	surendra53@ntc.net.np	4354722	9851092401	4273729
72	Surendra Prasad Joshi	SDE	Department of Irrigation	Kupandole, lalitpur	spjoshi2006@gmail.com		9841200600	5539339
73	Suresh Adhikari	Accountant	Department of Irrigation	Jawalakhel			9841554444	
74	Tribhuban Paudel	Joint Secretary	INPIM Nepal	Kathmandu	paudel.tribhuban@gmail.com		9851061290	4332757
75	Udhab Prasad Bhattarai	Senior Legal Officer	Department of Irrigation	Lokanthali, Bhaktapur	udhab38@yahoo.com	5537309	9841469198	6634640
76	Upendra Ratna Sthapit	SDHG	Department of Irrigation	Makhangalli, word no. 25, KTM	apendrasthapit@yahoo.com	5537312	9841268626	4363883

Annex – 3
Full papers

सिंचाइ मन्त्रालय अन्तर्गत संस्थागत सुधार

बाबुराम अधिकारी

मुख्य प्रशासकीय अधिकृत, सिंचाइ विभाग

१. विषय प्रवेश

नेपाल एक कृषि प्रधान देश हो । देशको एक तृतीयांश आय हाल पनि कृषिबाट प्राप्त भइनै रहेको छ भने दुई तिहाइ मानिसको पूर्ण वा आंशिक भए पनि रोजगारीको माध्यम कृषि नै रही आएको छ । त्यसैले यस क्षेत्रको विकासले देशको अर्थतन्त्रलाई मात्रै नभै यस पेशामा लागेका मानिसहरुलाई सकारात्मक प्रभाव पार्ने गर्दछ ।

कृषिको लागि अपरिहार्य कुरा सिंचाइ हो । देशमा करिव २६,४१,००० हेक्टर कृषि योग्य जमिन छ भने १७,६६,००० हेक्टर सिंचाइ योग्य जमिन रहेको छ ।

हाल सम्मको आकंडा हेर्दा हालसम्म १२,५२,४७६ हेक्टर जमिनमा सिंचाइ सुविधा पुगेको देखिन्छ। तर यो सबै जमिनमा बाह्रै महिना सिंचाइ सुविधा पुगेको भने होइन। हालसम्म सजिला र कम खर्च लाग्ने खालका सिंचाइ प्रणालीहरुको विकास भैसकेको छ। तर बाह्रै महिना र भरपर्दो सिंचाइका लागि हिमालमा मूल भएका ठूला नदीमा संरचना बनाई सिंचाइ प्रणालीको विकास जरुरी देखिन्छ। जे होस सिंचाइ विकासको क्षेत्रमा हामीले अझै पनि धेरै गर्न बाँकी नै छ ।

कुनै पनि क्षेत्रको विकास तथा व्यवस्थापनमा श्रोतसाधनको अतिरिक्त उपयुक्त प्रकारको संगठन संरचना पनि आवश्यक पर्छ त्यसैले संगठनात्मक तथा संस्थागत पक्षलाई निरन्तर अध्ययन मूल्यांङ्कन एवं सुधार गरिरहनु पर्दछ। यस प्रसंगमा सिंचाइ विकासको मुख्य जिम्मेवारी रहेको सिंचाइ विभागका बर्तमान संगठनात्मक एवं संस्थागत पक्षको पूनरावलोकन गर्नुको साथै यसको पक्षमा भएका प्रयासको सिंहावलोकन गर्नु यस लेखको उद्धेश्य रहेको छ।

२. बर्तमान संगठनात्मक संरचना

हाल सिंचाइ विकासको कार्य गर्ने मुख्य सरकारी संरचनाहरु देहाय बमोजिम रहेका छनः

क) सिंचाइ मन्त्रालय

ख) सिंचाइ विभाग

ग) जल उत्पन्न प्रकोप नियन्त्रण विभाग

घ) भूमिगत जलश्रोत विकास समिति

ङ) सुनसरी मोरङ सिंचाइ विकास समिति

क) सिंचाइ मन्त्रालयः

सिंचाइ मन्त्रालय साविकको जलश्रोत मन्त्रालय विघटन भै उर्जा मन्त्रालयसँगै स्थापना भएको हो । यो मन्त्रालय नयाँ मन्त्रालय हो । यो मन्त्रालयको स्थापनासँगै नाम तथा कार्यक्षेत्रको विषयमा असन्तुष्टीहरु रहेको पाईएको छ । अन्य मूलुकको अनुभव हेर्दा सिंचाइ मन्त्रालय कमै मूलुकमा रहेको देखिन्छ भने जलश्रोत मन्त्रालय विघटन भै सिंचाइ र उर्जा मन्त्रालय जन्मिएपछि समग्र जलश्रोतको व्यवस्थापन गर्ने Ministry of Water Resources को समेत अभाव भएको वा अथवा समग्र जल सम्पदाको व्यवस्थापन गर्ने र समन्वय गर्ने निकायको अभाव खड्किएको महशुस भएको छ । यसको संगठन संरचना तथा कार्य विवरण समेत अध्ययनमा आधारित नभै मन्त्रालय फुटिसकेपछि हतारमा बनाईएको संगठन चार्ट र दरबन्दीमा सीमित रहेको छ । हालै मन्त्रालयको नामै पनि उपयुक्त नभएकाले संशोधनको लागि मन्त्रिपरिषद्मा प्रस्ताव पठाईएको तर सो प्रस्ताव उपर निर्णय भैनसकेको अवस्था छ ।

ख) सिंचाइ विभागः

देशमा सिंचाइ विकासको समग्र जिम्मेवारी रहेको यो विभाग सरकारका पुराना विभागहरु मध्ये एक रहेको छ । विगतमा ७५ वटै जिल्लामा जिल्ला सिंचाइ कार्यालय रहेकोमा २०५८ सालमा यस विभागको पून संरचना भै सिंचाइ विकास डिभिजन तथा सव डिभिजन गरी ४६ जिल्लामा कार्यालयहरु सीमित गरी यिनै कार्यालयहरुबाट ७५ वटै जिल्लाको सिंचाइ विकास सम्बन्धी कार्य गर्ने व्यवस्था मिलाईएको छ । हाल सिंचाइ विभाग अन्तर्गत देहाय बमोजिमका कार्यालय र दर बन्दी रहेको देखिन्छ :

कार्यालयहरु	दरबन्दी
विभाग १	महानिर्देशक १
क्षेत्रीय निर्देशनालय ५	रा.प.प्रथम १४
डिभिजन कार्यालयहरु २६	रा.प.द्धितीय १०१
सब डिभिजन कार्यालयहरु २०	रा.प.तृतीय ३३५
व्यवस्थापन डिभिजनहरु ८	रा.प.अनं प्रथम १४१
यान्त्रिक व्यवस्थापन डिभिजनहरु ३	श्रेणी विहिन ४८४
स्थायी संरचना जम्मा ६३	जम्मा १८६९
केन्द्रीय आयोजनाहरु २१	

ग) जल उत्पन्न प्रकोप नियन्त्रण विभाग

साविकमा सिंचाइ विभागको नदी नियन्त्रण महाशाखा र जल उत्पन्न प्रकोप नियन्त्रण प्राविधिक केन्द्रलाई मिलाई स्थापना भएको यो विभागले जल उत्पन्न प्रकोपहरुको व्यवस्थापन गर्ने कार्यहरु गर्दै आएको छ । यस विभाग र मातहतको संगठन, संरचना र दरबन्दी देहाय बमोजिम रहेको छ :

कार्यालय	**दरबन्दी**
विभाग १	महानिर्देशक १
डिभिजन कार्यालय ७	रा.प.प्रथम १
सव डिभिजन ५	रा.प. द्धितीय १४
जनताको तटवन्ध संयोजकको कार्यालय १	रा.प.तृतीय ५१
फिल्ड कार्यालय ७	रा.प.अनं. प्रथम ९७
केही योजना आयोजनाहरु (छुट्टै कार्यालय नभएको)	रा.प.अनं. द्धितीय र तृतीय २१
	श्रेणी विहिन ४५
	जम्मा २५१

घ) भूमिगत जलश्रोत विकास समिति

भूमिगत जल सम्पदाको अध्ययन अन्वेषण नियमन तथा अनुगमन गर्ने उद्देश्यले विकास समिति ऐन २०१३ अन्तर्गत गठन आदेशको माध्यमबाट स्थापना भएको यस समितिले हाल भूमिगत सिंचाइ विकास सम्बन्धी कार्यहरु गरी आएको पाइन्छ। यस अन्तर्गत देहाय बमोजिमका निकायहरु रहेको देखिन्छ :

समितिको कार्यालय	१
APP	१
CGISP	१
शाखा कार्यालयहरु	९

ङ) सुनसरी मोरङ्ग सिंचाइ विकास समिति :

भूमिगत जलश्रोत विकास समिति जस्तै गठन आदेशको माध्यमद्वारा स्थापना भएको यो समिति सुनसरी मोरङ्ग सिंचाइ आयोजना कै रुपमा परिचित छ । सीमित कार्यक्षेत्र र मातहतमा अन्य निकायहरु नभएकोले यसले आफ्नो अस्तित्व र आवश्यकता एवं पहिचान कायम गर्न सकेको देखिदैन ।

३. बर्तमान संगठनात्मक समस्याहरु :

सिंचाइ मन्त्रालय र मातहतका निकायहरुको संगठनात्मक सुधारको पक्षमा भएका अध्ययनहरु त्यहाँ कार्यरत कर्मचारीहरुको अनुभव एवं यस सम्बन्धमा भएका गोष्ठी, अन्तर्क्रिया, छलफल समेतका आधारमा देखिएका समस्याहरुलाई निकायगत हिसावले बुँदागत रुपमा देहाय बमोजिम उल्लेख गर्न सकिन्छ :

३.१ सिंचाइ मन्त्रालय

- जलश्रोत मन्त्रालयबाट विभाजन भै गठन भएको
- अध्ययनले पुष्टी गरेको नभै तत्कालिन राजनैतिक आवश्यकता पुरा गर्न स्थापना भएको
- नाम र कार्य क्षेत्रमै समस्या
    - विभागको जस्तै (समान) नाम
    - कार्य क्षेत्रको संकूचन
    - जलश्रोत कसको जिम्मेवारी (उर्जाको विजुली, सिंचाइको सिंचाइ)
    - समग्र रुपमा जलश्रोतको व्यवस्थापन गर्ने जिम्मेवार निकायको अभाव
    - नयाँ मन्त्रालय भएकोले Recognition मा समस्या

३.२ सिंचाइ विभाग

- साविकमा ७५ वटै जिल्लामा कार्यालय रहेकोमा २०५८ सालमा डिभिजन र सव-डिभिजनको रुपमा ४६ जिल्लामा सीमित
    - कृषक तथा उपभोक्तामा सिंचाइ सेवाको पहुँचमा कमी
    - सरकारी सम्पति (भवन, जग्गा) को दुरुपयोग
- डिभिजन कार्यालय वा सव-डिभिजन कार्यालय बनाउँदा कुनै निश्चित आधार वा अध्ययन नभएको र फेला नपरेको
- निश्चित मापदण्ड नभएको (कार्य क्षेत्र, सिंचाइ सम्भाव्य क्षेत्र)
- कुनै डिभिजनले पनि एक जिल्ला हेर्ने (पाल्पा) कुनै सव-डिभिजनले पनि दुई जिल्ला हेर्ने (रुकुम, भोजपुर, ओखलढुङ्गा)

- दरवन्दीमा एकरुपता नभएको कार्यालय पिच्छे संगठन संरचना र फरक फरक दरवन्दी
- एकै जिल्लामा थुप्रै सिंचाइ सम्बन्धी कार्यालय, कुनै जिल्लामा एक पनि कार्यालय नभएको
- विविध प्रकारका र अनावश्यक दरवन्दी (दरवन्दी भएपछि माग पठाउनु पर्ने बाध्यता, अनावश्यक जनशक्तिको नियुक्ति) । यस पूर्वको दरवन्दी बनाउदा फाजिलमा नपार्ने कुरालाई ध्यान दिइएको देखिन्छ
- सेवा समूह वीच कार्य विभाजन र वृत्ति विकासको अवसरको बाडफाँड वीचमा असन्तुष्टी (इरिगेशन उपसमूह, एग्री इरिगेशन समूह, हा.जि. समूह)
- दक्ष जनशक्तिको अभाव :- अधिकांश जनशक्ति जागीरको उत्तरार्धमा रहेको, वृद्ध विरामी, परिश्रमी काम गर्न असमर्थ
- धेरै जनशक्ति एकै चोटी अवकाश हुने सम्भावना
- जनशक्तिको Generation Gap :- वीचमा लामो अवधि इन्जिनियर, सव-इन्जिनियरको पदपूर्ति नभएको
- जनशक्ति पलायन :- अफगानिस्तान
- २४(घ) १ वमोजिम बढूवा भएका कर्मचारीको व्यवस्थापनमा समस्या
- सरुवा पदस्थापनमा कठिनाइ
- ज्येष्ठ-कनिष्ठको समस्या
- उत्प्रेरणा
- कतिपय कर्मचारी जिम्मेवारीविहिन
- काम लगाउनेले पनि विर्सेको वा उपयूक्त काम दिन नसकिएको
- काम गर्नेले पनि कार्यालयमा जिम्मेवारी खोज्नुको सट्टा अन्यत्र छुट्टै आय आर्जनतर्फ उन्मुख भएको पाइएको
- सवै कर्मचारीलाई उचित जिम्मेवारी दिन वजेट तथा कार्यक्रमको कमी भएको पाइएको
- मान्छेमा गरेको लगानीले दिर्घकालीन प्रतिफल दिन्छ भन्ने कुरा व्यवहारमा आउन वाँकी नै रहेको
- सार्वजनिक खरिद व्यवस्थापनमा दक्षताको अभाव रहेको पाइएको ।

३.३ जल उत्पन्न प्रकोप नियन्त्रण विभाग

- सिंचाइको नदी नियन्त्रण महाशाखा र DPTC को समायोजनबाट स्थापित नयाँ विभाग
- कार्य क्षेत्र देशभर नदी नियन्त्रणको काम धेरै, माग बढी तर संगठनात्मक क्षमता, श्रोत साधनको न्यूनता
- एक सव-डिभिजनको एघार जिल्लासम्म कार्य क्षेत्र रहेको । जनशक्ति- एक इन्जिनियर र दुई सव-इन्जिनियर (वर्ष भरिमा कार्य क्षेत्रका सवै जिल्ला भ्रमण गर्न पनि कठिन)

  आ.का.स. मा दरवन्दी न्यून (१०) । काज खटाउनु पर्ने आयोजना बढ्दो । अस्थायी दरवन्दी - १६४

३.४ भूमिगत जल विकास समिति

- विकास समिति ऐन, २०१३ अन्तर्गत गठन आदेशबाट स्थापितः - कानूनी आधार कमजोर
- कार्य क्षेत्रमा अस्पष्टताः- गठन आदेश (नियमन) र कार्यान्वयन पक्ष (विकास)
- संगठनमा आवश्यक भन्दा अनावश्यक दरवन्दी (एकै कार्यालयमा १० जना सम्म सवारी चालक वा कार्यालय सहयोगी)
- जनशक्तिको आधार कमजोर (हा.जि. वा इन्जिनियर जस्ता प्राविधिक कर्मचारी समितिसंग छैन)
- भैरहेको सीमित जनशक्तिको पनि वृत्ति विकासको अभाव

  सिंचाइ विभागको वजेट र जनशक्ति लिएर सिंचाइ विभाग कै कार्य गरेको तर आफ्नो जिम्मेवारी विर्सेको अवस्था

३.५ सुनसरी मोरङ्ग सिंचाइ विकास समिति

- विकास समिति ऐन, २०१३ अन्तर्गत गठन आदेशबाट स्थापितः - कानूनी आधार कमजोर
- सीमित कार्य क्षेत्र (सुनसरी मोरङ्ग सिंचाइ आयोजना मात्र)
- समितिको आफ्नो उद्देश्य तथा कार्यक्रम नभएको
- समितिको आफ्नै श्रोत, साधन कुनै नभएको
- समिति राखिराख्नुको औचित्य पुष्टी गर्न कठिन
- समितिको कार्य क्षेत्रमा रहेको सु.मो.सिं.यो.को अवस्था नाजुकः- ठूलो कार्य क्षेत्र, सीमित श्रोत, साधन, अनावश्यक दैनिक ज्यालादारीका कर्मचारी, दक्ष जनशक्तिको अभाव

४. सुधारको पक्षमा भएका प्रयासहरु

सिंचाइ मन्त्रालय तथा मातहतको संगठनात्मक तथा संस्थागत सुधारको पक्षमा थुप्रै कामहरु तथा प्रयासहरु भएका छन् । यी सुधारका प्रयास तथा मुख्य सुझावहरु देहाय बमोजिम रहेको पाइन्छ :

(क) मन्त्रालय र अन्तर्गतका रा.प.प्रथम श्रेणीको कर्मचारी समुहद्धारा सो पदमा बढुवा भई पदस्थापन हुन बाँकी रहेको मन्त्रालयमा हाजिर गरिरहेका कर्मचारीहरुको टोली बनाई मन्त्रालयले सिंचाइ मन्त्रालय र मातहतको संगठनात्मक एवं संस्थागत सुधारको पक्षमा अध्ययन गराएको थियो । यस टोलीले आफ्नो अनुभव एवं केही छलफल र अर्न्तक्रिया समेत गरी सुझाव सहितको प्रतिवेदन दिएको छ । विस्तृत रुपमा कार्यबोझ विश्लेषण गरी कस्तो संगठन संरचना वा कति दरबन्दी हुनुपर्ने विस्तृत रुपमा यसले काम गर्न नसकेको भएपनि नीतिगत रुपमा के कस्तो सुधार गर्ने भन्ने विषयलाई समेटेर यसले प्रतिवेदन दिएको पाईएको छ । यस टोलीले खास गरी कार्यविभाजन नियमावलीमै संशोधन गरी मन्त्रालयको नाम जलश्रोत व्यवस्थापन मन्त्रालय हुनुपर्ने, कार्यक्षेत्र फराकिलो हुनुपर्ने जस्ता सिफारिस/सुझावहरु दिएको पाइन्छ ।

(ख) मन्त्रालय र मातहतका सवै निकायहरुको संगठन तथा व्यवस्थापन सर्भेक्षण कार्य अघि बढाइएको छ । यी मध्ये सिंचाइ विभाग, भूमिगत जलश्रोत विकास समितिको संगठन तथा व्यवस्थापन सर्भेक्षेणको कार्य सम्पन्न भई प्रतिवेदनहरु प्राप्त भईसकेका छन् भने जल उत्पन्न प्रकोप नियन्त्रण विभागको प्रतिवेदन प्राप्त हुने क्रममा रहेको छ । सुनसरी मोरङ्ग सिंचाइ विकास समिति र सो आयोजनाको पनि यस प्रकारको अध्ययन गराउनुपर्ने आवश्यकता महसुस भएको भएपनि सो कार्य हालसम्म अघि बढन सकेको छैन ।

(ग) हालै मात्र विघटन भएको प्रशासन पून: संरचना आयोगले हरेक मन्त्रालयमा प्राविधिक समिति गठन गरी संगठन र दरबन्दीको विषयमा र खासगरी मुलुकमा संघीय संरचना लागू भएपछि हालको संगठन र दरवन्दी एवं जनशक्तिलाई के कसरी रुपान्तरणमा वा मिलान गर्ने हो सो सम्बन्धी पूर्व तयारीका कार्यहरु गर्न निर्देशन दिए बमोजिम सिंचाइ मन्त्रालयमा समेत प्राविधिक समिति गठन भएको थियो । यो समितिले प्रत्येक बिकास क्षेत्रमा सिंचाइ मन्त्रालय मातहतका सवै निकायलाई संलग्न गराई गराएको अर्न्तक्रियाहरुलाई समेत समेटी मन्त्रालयको तर्फबाट प्रशासन पून संरचना आयोगमा पठाउने प्रतिवेदन तयार गर्न उप समिति समेत गठन भएको थियो । उप समितिले कार्य गर्दागर्दै आयोग नै विघटन भएको छ । जे होस यस कार्यले पनि संस्थागत सुधारको पक्षमा केही कार्यहरु गरेको छ ।

(घ) करिब एक डेढ बर्षअघि रा.प. द्वितीय श्रेणीको पदमा बढुवा भई पदस्थापन हुन बाँकी रहेका कर्मचारीहरुलाई समेत संस्थागत सुधारको पक्षमा अध्ययन गरी प्रतिवेदन दिन लगाईएको थियो । यो टोलीले समेत केही सुझावहरु सहित प्रस्तावित संगठन तथा दरबन्दीहरु उल्लेख गरी प्रतिवेदन दिएको छ ।

(ङ) सिंचाइ विभाग अन्तर्गत एशियाली विकास बैंकको ऋण सहयोगमा संचालित समूदायमा आधारित (CMIASP) कार्यक्रमले समेत Institutional Reform Component अन्तर्गत परामर्शदाताद्धारा अध्ययन गराएकाे छ ।यसरी परामर्शदाताको सहयोग गराईएको यस अध्ययनले समेत छुट्टै प्रतिवेदन पेश गरी सकेको छ ।

५. मुख्य मुख्य सुझावहरु

माथि उल्लेखित सवै अध्ययन प्रतिवेदनहरुले विविध प्रकारका सुझाबहरु दिएको देखिन्छ र अधिकांश सुझाव तथा सिफारिसहरुमा समानता रहेको देखिएको छ ।यसैले हालको अवस्थामा सिंचाइ मन्त्रालय र मातहतका निकायहरुको संगठनात्मक समस्याहरुको राम्रो विश्लेषण भएको पाइएको छ । मुख्य मुख्य सुझाबलाई बुँदागत रुपमा देहाय बमोजिम उल्लेख गर्न सकिन्छ :

(क) कार्य विभाजन नियमावलीमा संशोधन गराई सिंचाइ मन्त्रालयको नाम संशोधन गरी जलश्रोत मन्त्रालय वा जलश्रोत व्यवस्थापन मन्त्रालय नामाकरण गर्नुको साथै यसको कार्यक्षेत्र विस्तार गरी समग्र जलश्रोत व्यवस्थापनको जिम्मेवारी निकाय बनाउनु पर्ने ।

(ख) सिंचाइ विभागको हकमा देहाय बमोजिम गर्ने

- सिंचाइ विभागमा महाशाखा थप गर्नु पर्ने
- आ.का.स.मा दरवन्दी थप गर्नु पर्ने
- सिंचाइ व्यवस्थापन डिभिजनहरुको सुपरिवेक्षण एवं अनुगमनको लागि छुट्टै सिंचाइ व्यवस्थापन निर्देशनालय स्थापना गर्ने
- भूमिगत जलश्रोत विकासको कार्यको निमित्त तराईका जिल्लामा भूमिगत जलश्रोत विकास डिभिजन कार्यालय खोल्ने र भूमिगत जलश्रोत विकासको कार्य सोही डिभिजन मार्फत गराउने
- भूमिगत सिंचाइ विकास डिभिजनहरुको सुपरिवेक्षण एवं अनुगमनको लागि छुट्टै भूमिगत सिंचाइ निर्देशनालय स्थापना गर्ने

- संगठनको उद्देश्यको आधारमा सेवा, समूहगत दरवन्दी राख्ने
- सवै व्यवस्थापन डिभिजनको प्रमुख एग्री इरिगेशन समूहको गर्ने
- सवै भूमिगत सिंचाइ व्यवस्थापन डिभिजनको प्रमुख हा.जि. समूहको गर्ने
- हालको सिंचाइ विकास डिभिजन, सव-डिभिजनहरुलाई कार्य क्षेत्रको आधारमा वर्गीकरण गर्ने, सव-डिभिजनको नामाकरण परिवर्तन गरी डिभिजन कायम गर्ने
- अनावश्यक दरवन्दी कटौती गर्ने
- कार्य सम्पादनमा आधारित जनशक्ति व्यवस्थापन गर्ने

ग) जल उत्पन्न प्रकोप नियन्त्रण विभागको हकमा देहाय बमोजिम गर्ने

- जल उत्पन्न प्रकोप नियन्त्रण विभाग अन्तर्गत डिभिजन तथा सव-डिभिजन कार्यालय थप गर्नु पर्ने
- विकास आयोजनाको जनशक्तिको निमित्त आ.का.स.मा दरवन्दी थप गर्नु पर्ने
- संगठन तथा व्यवस्थापन सर्वेक्षण गर्ने
- कार्य क्षेत्रको विस्तार गर्ने :- जल उत्पन्न प्रकोपको कारण समेत यस विभागको कार्य क्षेत्र हुनु पर्ने
- जलाधारमा आधारित कार्य प्रणाली र सोही वमोजिमको संगठन संरचना एवं दरवन्दी हुनु पर्ने ।

घ) भूमिगत तर्फको हकमा देहाय बमोजिम गर्ने

- भूमिगत जलश्रोत विकास समितिलाई प्राधिकरणमा रुपान्तरण गर्ने
- भूमिगत जलश्रोत विकास ऐन वा जलश्रोत ऐनमा संशोधन गर्ने
- भूमिगत जलश्रोत विकास समितिलाई प्राधिकरणमा रुपान्तरण गर्ने कार्य सम्पन्न नभएसम्म :-
    - समिति र शाखा कार्यालयको संगठन संरचना र दरवन्दीमा सुधार गर्ने
    - नयाँ संगठन संरचना र दरवन्दी वमोजिम पदपूर्ति गर्ने
    - बढी हुने कर्मचारी कटौती गर्न स्वेच्छिक अवकाश योजना लागू गर्ने

६. निश्कर्ष

सिंचाइ मन्त्रालयको स्थापनासँगै यसको नाम तथा कार्यक्षेत्रको विषयमा विभिन्न प्रकारका असन्तुष्टिहरु देखा परेका छन् । साथै मातहत निकायहरुको संगठन संरचना दरबन्दीहरु लगायत संगठनात्मक सुधारको पक्षमा थुप्रै कामहरु गर्नुपर्ने देखिएको छ । जुन विषयलाई कार्यरत कर्मचारीहरुको अनुभव, विभिन्न छलफल, अन्तर्क्रिया र अध्ययनहरुले पुष्टि गरेको अवस्था छ । बर्तमान अवस्थामा कार्यबोझ तथा संगठन संरचना र दरबन्दी बीच तालमेल देखिएको छैन । कतै कार्यबोझ बढी छ भने थुप्रै कर्मचारीहरु बर्षौदेखि जिम्मेवारी बिहिन अवस्थामा रहेका छन् । विभिन्न समूह, उप समूहबीच कार्यक्षेत्र, काम गर्ने अवसर देखि बृत्ति बिकासको पक्षमा असन्तुष्टिहरु रहेको पाईएको छ । खासगरी एउटा कार्यालयले एकभन्दा बढी जिल्ला हेर्ने गरी संगठन संरचना खुम्च्याउने कार्यले सिंचाइ तथा जलउत्पन्न प्रकोपसँग सम्बन्धित सेवा सुविधामा कृषक तथा उपभोक्ताको पहुँचको कमी देखिएको छ । कार्यालय नभएको जिल्लामा कार्यालय खोलिदिन पऱ्यो भन्ने आग्रह त्यस्ता जिल्लाका उपभोक्ता र जनप्रतिनिधिहरुबाट आइरहेको छ । केही जिल्लामा अस्थायी रुपमा खोलिएका इकाई कार्यालयहरु पनि व्यवस्थित हुन सकिरहेका छैनन । निजामती सेवा ऐन २०४९ को दफा २४(घ) १ बमोजिम बढुवा भएका कर्मचारीहरुलाई समायोजन गर्ने गरी संगठन संरचना र दरबन्दी मिलान गर्ने आवश्यकता समेत देखिएको छ ।

यस सन्दर्भमा हालसम्म भए गरेका अध्ययन विश्लेषणहरुलाई समेत आधार बनाई सिंचाइ मन्त्रालयबाट प्रदान गरिने सेवा सुविधामा सम्बन्धित कृषक तथा उपभोक्ताको सहज पहुँच हुने विषयलाई केन्द्र विन्दुमा राखेर कार्यरत सबै कर्मचारीको बृत्ति विकासको समान अवसर समेत प्रदान गर्ने गरी संगठन, संरचना र संस्थागत सुधारको कार्य अघि बढाउनु ढिला गर्न नहुने देखिएको छ ।

Research Priority of Irrigation Management in Nepal

Prachanda Pradhan

Abstract

Irrigation Sector in Nepal now occupies very strategic importance in the national development. It occupies substantial share of annual investment in the national budget. World Bank and Asian Development Bank have substantial share of investment in irrigation sector of Nepal. This is an important driver to promote irrigated agriculture which occupies important place in domestic production as well as rural employment in Nepal. Hence, it is strategically important sector in Nepal because it does not only help produce the food required for increasing population but also ensures food security , maintenance of law, order and peace in the country. It is , therefore, important to pay attention to the better management and improvement of the irrigation sector.

There are several agencies involved in the irrigation sector. These include the policy making agencies like the National Planning Commission and Ministry of Irrigation and implementing agencies like Department of Irrigation, Department of Agriculture, Ministry of Local Development through DOLIDAR, Ground Water Development Board , community , private sector and training and research institutions like the agriculture and engineering colleges and National Agriculture Research Council (NARC). These agencies have to sit together to identify the problems affecting the irrigation sector. With mutual understanding and respect, they are also the group to solve the identified problems so that the irrigation system could perform better.

This paper aims at presenting:

- *A) features of irrigation sector in Nepal*
- *B) problems and issues identified in the sector and*
- *C) criteria for setting research priority for improving irrigation management in Nepal*

Introduction

Irrigation Sector in Nepal now occupies very strategic importance in the national development. It occupies substantial share of annual investment in the national budget. World Bank and Asian Development Bank and other donors have substantial share of investment in irrigation sector of Nepal. This is an important driver to promote irrigated agriculture which occupies important place in domestic production as well as rural employment in Nepal. Hence, it is strategically important sector in Nepal because it does not only help produce the food required for increasing population but also ensures food security , maintenance of law, order and peace in the country. It is, therefore, important to pay attention to the better management and improvement of the irrigation sector in Nepal

There are different agencies which influence on the irrigation sector of Nepal. The National Planning Commission (NPC), the Ministry of Irrigation (MOI) and Water and Energy Commission Secretariat (WECs) are responsible for initiating appropriate policy on irrigation development in Nepal. Recently, Government of Nepal (GON) has shifted towards mega-irrigation projects and inter-basin water transfer projects as well. However, the micro-irrigation like non-conventional irrigation systems, small and medium irrigation systems also have important roles to play in making agriculture more productive as well. These policy making bodies are to decide on the investment, choice of appropriate technology, water right issue on different water sectors, allocation of water resources to different sectors keeping in view of integrated water resources management program, direction towards management methods and governance modes, etc. Hence, these agencies also need to have inputs from research findings to decide on that irrigation related issues.

Irrigation development and management is undertaken by different agencies of the government and private sector in Nepal. The actor institutions are: a) Department of Irrigation , b) Department of Agriculture, c) Ministry of Local Development through DOLIDAR, d) Ground Water Development Board, e) farmers' community and private sector like NGOs for example International Development Enterprizes (IDE), SAPPROS etc. Similarly, the educational and research institutes like agriculture and engineering colleges and National Agriculture Research Council (NARC) are also to contribute for the better performance of irrigation systems. Among these different agencies involved in irrigation sector development, Department of Irrigation (DOI) has major share in promoting and managing the irrigation systems in Nepal. DOI is involved in multi-facet aspects of irrigation development. Prominent among them are surface irrigation system of all sizes above 25 ha (small, medium and large), ground water development by STW and DTW, lift Irrigation like Koshi Pump Irrigation, Marchwar and Chitwan Pump Irrigation. etc and non-conventional irrigation systems like drip and sprinkles. Pioneering pump irrigation systems like Battar Pump Irrigation systems became defunct due to wear and tear as well as change in the water availability of water at Trisuli after Devighat Hydro-power construction. By management type, 30% of irrigations systems in Nepal are managed by DOI. They are called Agency Managed Irrigation Systems (AMIS). Similarly, DOI provides assistance to Farmer Managed Irrigation Systems (FMIS). With the bigger responsibility of DOI, it also contributes on equity, poverty alleviation, inclusive benefit sharing, participatory irrigation management and food security in the country (Khanal, 2010).

There are other agencies like Department of Agriculture (DOA) and Department of Local infrastructure and Agriculture Roads Development (DOLIDAR).

In order for an organization to be dynamic and make felt its existence, Research and Development (R&D) has to be an on-going activity of an organization. Research and Development (R&D) is an investment in an organization's future. An organization which does not allocate fund in R&D is considered as "eating the seed corn". In business term, the present product lines become outdated and there will not be viable successors in the pipelines. Similarly, DOI has also to be updated with the market scenario and with the new technology keeping in view of the changing scenario of the water availability for agriculture.

The question is: how much is reasonable to spend on research and development (R&D)? This is dependent on the type of technology and trend in the market. It is considered that the investment on R&D between 2-15 percent of the total budget of an organization would be appropriate depending on the competition in the market and environment.

Role of DOI in R&D

Looking at the organization chart of DOI, research and development (R&D) activities can be identified at Planning, Design, Monitoring and Evaluation Division under the Deputy Director General. Within this division, one unit called Design, Research, Human Resources and Technology Development is established. Within this unit there is program called **Irrigation Feasibility Study and Research Program**. In DoI, this is the only one unit which looks after research activities. Resource is allocated for the research activity in this program. As the initiation of the research program on behalf of DOI, certain amount of budget allocation is made to carry out research program. In this fiscal year, this division took initiative to support M.Sc Engineering thesis and Institute of Engineering has signed MOU for MSc theses support which will concentrate mainly on Irrigation issues and relevant topics. In the next fiscal year, it is proposed to expand research activities and undertake more collaborative activities. [1]

Similarly, Irrigation Management Division (IMD) used to have a unit called Research and Technology Development. Several books on irrigation management are published from this unit. At present, this unit at IMD does not exist.

Looking at the activities undertaken by the Planning and Design Division of DOI, one would find more on feasibility study regarding inter-basin water transfer, data collection through the use of GSI and establishment of the Quality Control laboratory (DoI Handbook, 2068). What should be the role of DOI in promoting research on important agenda of irrigation development of Nepal? Can DOI be undertaking research activity? Within last 25 years, many Nepali and foreign scholars have written Ph.D thesis by conducting field research of Nepali irrigation systems on Irrigation Management Issues. Many of those theses were on Farmer Managed Irrigation Systems. However, a few studies were made on AMIS. Master theses were written at AIT, Bangkok and Tribhuban University, Nepal (Pradhan, 2007).

There are now many professional organizations which are engaged in the study of Irrigation Management. They are engineering colleges, FMIST, IWMI, INPIM, JVs and others. It is necessary that DOI has to take the advantage of research findings in order to be updated in technology, changing environment caused by climate change, investment return, etc.

The role of DOI should be to decide the agenda of research but these research activities are to be commissioned to the research centers outside DOI. The financial and personnel flexibility required for research activities are not present at DOI. Hence, DOI has to identify appropriate institutes, collaborate with them and get the research undertaken. The role of DOI has to be facilitator, collaborator and supporter of research activities. If Hydraulic Simulation is to be done, it will be useful to collaborate with HydroLab of Nepal. Similarly DOI has to take initiative for collaboration on research issues with other institutes outside of DOI.

One of the infrastructures require for research is the proper documentation and library facility. DOI has to strengthen its Departmental library and make it mandatory

1 Based on the communication with Mr. Ashish Khanal, Divisional Engineer, DOI

that all documents , feasibility, reports and books be compulsorily deposited in the library and make this library as the depository of irrigation information resources.

What could be Research Priority of Nepal?

Following items are the indicative research agenda to be considered by DOI. They are grouped into six categories.

1. Irrigation Performance Assessment
2. Economic Issues
3. Technology issues
4. Institutional Framework for Irrigation Management
5. Environmental Issues
6. Sociological issues

These items are only examples keeping in view that irrigation management is concerned with socio-institutional and technological factors..

Six major areas are suggested for consideration to undertake research.

1. **Irrigation Performance Assessment**;

    a. Develop usable indicators and methodology to assess various types of irrigation system (large , medium and small)
    b. Development of the mechanism for, and undertake regular monitoring and evaluation
    c. Study the irrigation efficiency and water use efficiency of the systems
    d. Collect relevant data of the system and analyze them. (Crop area survey, ground water level, surface and ground water quality, salinity, canal water loss, soil fertility, climate change , hydrological and hydro-geological information)
    e. Study the inter-relationship between the design, operation and management of irrigation systems
    f. Capacity utilization of the existing irrigation systems
    g. Productivity of water and labor in irrigation systems

h. Investigate the procedure for rehabilitation and modernization of irrigation system

i. Water accounting and Water balance study of strategic places of Nepal before major investment.

2 **Economic Issues:**

a. Comparative cost advantage of small scale vs. large scale

b. Investigate the problems of cost recovery

c. Procedures for water charge collection

d. Cost effectiveness of various irrigation systems

e. How to increase productivity of investment?

f. Shrinking of irrigated area by urbanization and commercial housing programs like (Phewa, Bijaypur, and Seti of Kaski district, Chhatis Mauja and Lumbini- Bhairwa Ground Water Project of Pupendehi and Kodkudha of Lalitpur.) Need to investigate on appropriate legal instruments to protect the irrigated paddy fields in Nepal

3 **Technological issues:**

a. Identify appropriate and sustainable irrigation technologies for Nepal

b. Study on the use of local materials for use in irrigation systems (keeping in view the geographical diversity in Nepal)

c. Identify appropriate water lifting devices for tar irrigation systems

d. Identification of alternative energy sources for pumping irrigation systems.

e. Water conservation methods

f. Development of user friendly drip and sprinkle systems

g. Control of water loss in the canals

h. Scheduling of management of maintenance in participatory manner

i. Relation between catchment conservation and water sources for irrigation, role of the users

j. Methods of ground water recharge

4. **Institutional Framework for Irrigation Management**

a. .Institutional framework and legal framework for farmers participation in irrigation development and management
b. Process and Procedures for the WUA establishment
c. Private sector participation in irrigation development and management
d. River Basin approach in irrigation development

Environmental Issues

e. development of appropriate environment assessment and its application
f. study of impact of irrigation systems on health
g. down stream and upstream relationship
h. protection of wildlife
i. Groundwater quality study and water depletion study

6 **Sociological issues**;

a. Socio-cultural attitudes of the beneficiaries towards irrigation system
b. Gender issues in irrigation
c. Conflict management in the irrigation systems
d. Equality in contribution for maintenance
e. Monetization of maintenance activities
f. Type training programs to make the farmers from labor intensive work to cash intensive work.

References

Khanal A.B (2010) “Retrospective of the Irrigation Related Policies in Nepal: Post 1990 Era in Proceedings of the National Irrigation Seminar on Challenges in Irrigation Development and Management, Kathmandu: Department of Irrigation

DOI.2068. Irrigation Handbook. (in Nepali), Lalitpur, Department of Irrigation. pp.21-22.

Pradhan P (2007) “Twenty Five Years of FMIS Study in Nepal” in Prachanda Pradhan and et.al.(eds.).Irrigation in Transition: Interacting with Internal and External Factors, Proceedings of the Fourth International Seminar, Kathmandu: Farmer Managed Irrigation System Promotion Trust.

Good Governance in an Irrigation Agency

Er. Prakash Paudel

SE, DoI

Abstract

For recent years, 'governance' and 'good governance' are taking important place in public service delivery, development administration and international assistance program. The condition contrary to good governance is literally spelled as 'bad governance" though in Nepal we do not prefer to say so. Governance deals with processes and systems by which an agency operates. The 'good governance' is a condition of 'ideal governance' and should bear eight characteristics namely: participatory, consensus based, accountable, transparent, responsive, efficient, equitable (and inclusive), and the rule of law. In Nepal there are numerous private agencies having attained higher level of competency or competitively good governance. The Government of Nepal initiated its effort to attain good governance in public service delivery and development agencies through governance reform during the beginning of the twenty-first century. Presently 'good-governance' is considered as important pillar of periodically planned projects in Nepal. Many people may have misunderstood good-governance as activities of general administrative units only of the Government not knowing the fact that the good-governance program and anti-corruption strategy launched by the government is also applicable to development agencies like the Ministry/Department of Irrigation. Good governance in an irrigation organization may give change results in mainly three aspects, namely, fulfillment of commitments to the beneficiary farmers, development of sustainable irrigation systems and earned value for a Rupee spent in a project. Department of Irrigation has some of its own documents guiding for the delivery of its services efficiently. However, much more can be done to comply with the beneficiaries' needs as well as the mandatory government provisions. The working procedure, monitoring mechanism and evaluation standards can be introduced or reviewed and effectively implemented in this context. The reform in administrative practices, strengthening of institutional capacity and compliance of requirements in any Irrigation project throughout its life cycle are observed as the hard but necessary works to be done in the present time. The evaluation here means, to some extent, the performance measurement independently. As majority of irrigation engineers do not come up against 'good-governance', it is the appropriate time for the higher authority to act for assured commitments and effective implementation of the same.

1. Introduction

Governance is the functioning of national government, local government, international institution and public or commercial organization. Governance is the process of decision-making and the process by which decisions are implemented. The poor performance or functioning of an organization is 'bad governance', while the efficient and effective performance of the same is nearer to 'good governance'. The term is used with great flexibility; is sometimes very difficult at operational level.

In Nepal too, about a decade has passed since the concept of 'good governance' has been introduced in periodic national development planning as well as regular service delivery to the public.

In this paper, we are going to discuss the issues pertinent to 'good governance' with special reference to the performance of the government institution having authority to implement irrigation projects, mainly the Department of Irrigation.

2. Characteristics of Good Governance

The United Nations has defined eight characteristics of Good Governance, summarized as follows:

Participation: Participation by both men and women is a key cornerstone of good governance. Participation could be either direct or through legitimate intermediate institutions or representatives. Participation means freedom of association and expression, but decision making is possible by the organization.

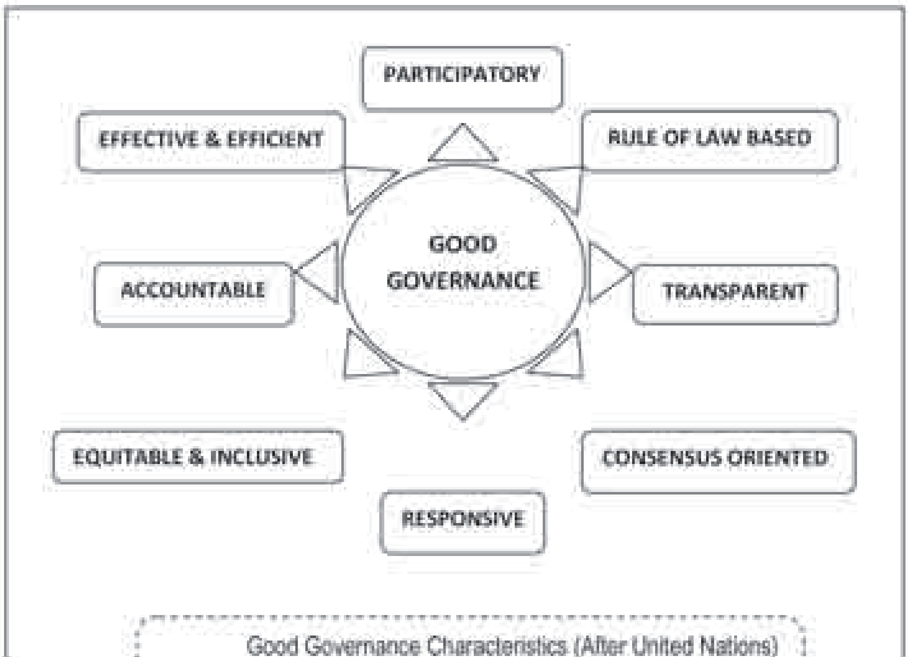
Rule of law: Good governance requires fair legal frameworks that are enforced impartially. Impartial enforcement of laws requires an independent judiciary and an impartial and incorruptible police force.

Transparency: Transparency means that any decision and its enforcement are as per rules and regulations. Also, information is freely available and directly accessible to those who will be affected by such decisions and their enforcement.

Consensus oriented: Good governance needs reach a broad consensus in organization for sustainable development.

Responsiveness: Good governance requires that institutions and processes should serve to and work for all stakeholders.

Equity and inclusiveness: Good Governance requires all related groups, including the most vulnerable, do have opportunities to improve and maintain the condition.



Good Governance Characteristics (After United Nations)

Illustration by : Er. Prakash Paudel

Accountability: The key requirement of good governance is that the governmental institutions and the private sector and civil society organizations must be accountable to the public society.

Effectiveness and efficiency: Good governance means that processes and institutions produce results that meet the preset objectives and other requirements.

3. Governance reform program in Nepal

3.1 Vision and Objectives

Long Term Vision:

The long term vision is to make public, judicial and development administration more competitive, participatory, transparent, service-oriented, result-oriented, accountable, inclusive, disable friendly and gender equity oriented.

Objectives:

- To support sustainable economic and social development works by ensuring good governance to the people while making the public, judicial and development administration sector accountable and sensitive towards peoples' needs.
- To promote access to service delivery through public participation, transparency, accountability and to create a corruption free situation by strengthening the state mechanism according to the values and tradition of the rule of law.

3.2 Institutional Arrangement

Following arrangements are formally introduced and practiced in Nepal.

- Oversight Offices (e.g. CIAA, PPMO, NVC, and OAG) are already functioning watch and act for the enforcement of good governance any way.
- Working procedure of different 49 departments of government of Nepal are already prepared and being used.
- The Corruption Prevention Act 2002 is in practice.
- Anti-money-laundering Bill has been passed by the legislative parliament.
- Law relating to Right to Information has been already made functional.
- Good Governance Act, 2064 and Directives is implemented by the Government and is in operation in all government bodies
- National Vigilance Centre Regulation implemented
- Anti-corruption Strategy of the government of Nepal is frequently updated.
- Management audit has been introduced in government bodies.

3.3. Development Project

Public Works Directives (PWD) 2002, Public Procurement Act 2006 (& Regulation) help the project run with systematic, transparent, effective and sustained manner while the authority becomes more managed, accountable and responsive. Technical Auditing, to be conducted by the National Vigilance Centre of the Government of Nepal, as per NVC Regulations, is now a legal provision of Nepal to improve the performance and governance of the infrastructure projects. The technical specifications, norms and directives are issued by line ministries/departments and implemented by respective public entities.

4. Good Governance in Irrigation

Department of Irrigation is the utmost responsible agency to implement the irrigation activities and is playing the leading role in implementing good governance in irrigation sector.

4.1. Important issues

Following are the issues to be dealt with:

- Project documents with required adequacy and quality
- Transparency, Competitiveness and Equal opportunity in procurement of works and consultancy services
- Adequate quality documents for contract agreement
- The quality assurance plan (QAP) and quality control (QC) mechanisms
- Enough record/minutes and letter of exchange between construction partners
- Material testing (and recording) to satisfy the quality requirement
- Effective monitoring mechanism to attain quality and timely progress
- Enough feedback from the stake holders while addressing the grievances and complaints from the end users
- Sustainable and functional development with user friendly technology
- Participation from user farmers at every stage of project development
- Assured financial plan for works and activities
- Strict follow up of contract conditions, design and drawings, social and environmental norms, technical specifications and legal provisions

- Periodic evaluation of progress by construction partners (earn-value curve etc.) and

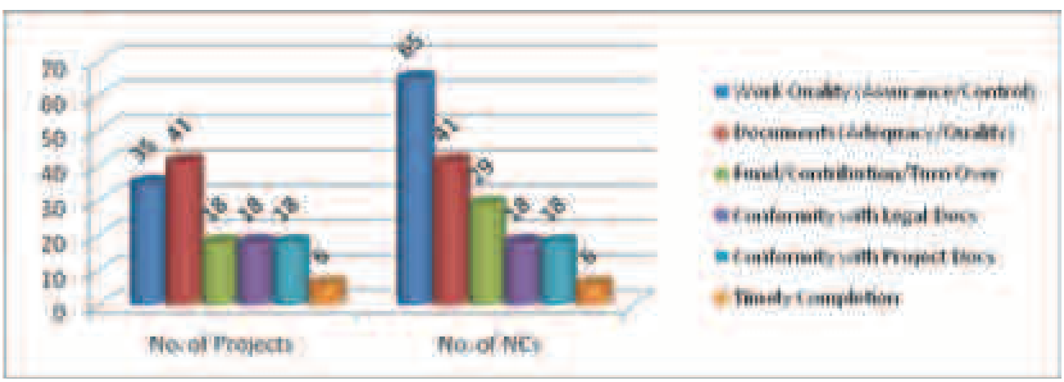
- Work completion reports with as-built drawings, operation maintenance manual, training to users and regular funding assurance for regular operation of the system

- There seems no problem to fully comply with the conditions expected except the fund assurance. Hence the commitment for new project or programme can however be limited on the basis of available or assured fund.

4.2. Irrigation project performance

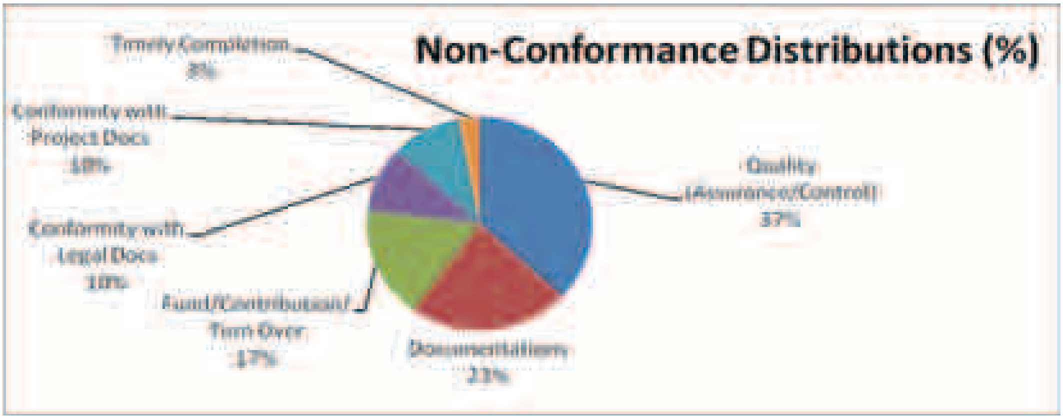
The project performance as evaluated by the Technical auditors in the form of non-conformances as negative indicators. The non-conformances found during actual technical auditing by National Vigilance Centre (NVC) through the qualified Technical auditors are analyzed in categorizes as follows.

Data per 100 (projected) Projects



(Data Courtesy: Tech Audit Div (NVC); Projected By: Er. Prakash Paudel)

Percentage distribution of total non-conformances in the irrigation projects/systems audited is again represented in the chart below.



(Data Courtesy: Technical Audit Division/NVC; Projected by: Er. Prakash Paudel)

Some of the findings, in many irrigation projects, with respect to good governance are as follows:

- The project documents are not signed properly during approval or agreement
- Procurement master plan are not approved or implemented
- Procurement packages are not approved before or during cost approval
- Agreement documents for procurement with Water Users Associations (WUA) are not suitable or sufficient to be implemented
- Material testing facilities are not established at site and test certificates are missing
- The regional level laboratories under DoI are nonfunctional (as good as non-existing except that in Pokhara) due to lacking of sufficient budget, trained manpower, permanent post (*darvandi*) and mandatory guidelines
- Additional cost estimation are prepared and approved against the Procurement Act
- Work scope and specifications are changed without approval
- Field log book and records/minutes are missing
- Budget allocation is not sufficient to meet payment against planned procurement
- Project works are delayed, with or without reasons, breaching commitments to people

- Farmer participation in decision making and cost sharing is lacking in larger (central) projects
- Contractor are found fairly strong in their proposal documents but perform practically very poor in respect to technical, financial and managerial aspects and
- Project completion reports are missing
- Thus ultimately the performance and sustainability of irrigation projects is frequently questioned.

4.3 Institutional Performance

Department of Irrigation is utmost responsible organization for institutional arrangement and policy formation regarding irrigation development in Nepal. Some observations regarding institutional performance of the department are presented below.

The department has had prepared many documents relating to project performance in the past. The most common and extensive document is a set of more than two dozen manuals prepared under project development and strengthening programme (PDSP). However updating of the documents and norms is yet to be initiated. The *norms* for engineering surveying are urgently needed as the old one is obsolete and nonfunctional.

Irrigation development divisions and subdivisions are established to serve the people in the country. However the focus of the selection criteria, annual programmes, and budget allocation is not yet justified to the poor farmers of the remote areas.

The deputation of the employees as per their ability and qualifications is expected for good governance. The personnel management in the department need to be departed from traditional way (personal decision) to the scientific method (pre-set criteria based decision).

One of the major pillars of good governance known as 'rule of law' is yet to be established and administered in the central level of the organization.

Co-ordination mechanism between the Department of Irrigation and other agencies, especially the Department of Agriculture, is to be functionally strengthened for effective outcome of the irrigation programmes.

Monitoring is one of the key functions of central department. The criteria and guidelines for baseline survey and progress measurement are to be established along with the functional mechanism for the same.

The training to the personnel involved in irrigation development is necessary for update technological knowhow to them and effective experience sharing between them. Training to a few selected individuals may not be enough. The department hence should pay the attention to the fact that transparent, thorough and regular training programmes for all the needy people will solve the problem.

4.4. Problems

Administrative Legacy: Some people in the decision making level choose autocracy to consensus and seldom bother to collect feedback from end users. This stops in the very beginning the process of good or progressive governance.

Budget Inadequacy: The budget to fulfill the requirement of the public service activities is not sufficiently, suitably and timely allocated and released by the Ministry of Finance and the National Planning commission. Hence the work is difficult to complete as committed in quantity, quality and time.

Ineffective Monitoring/Auditing System: At present the mechanism for monitoring, quality control and technical auditing (including institutional arrangement, budget, tools and manpower) as already explained is either absent or not implemented for effective output of the good governance programmes.

Knowledge/Information Sharing Problem: The national campaign on good governance has very little effect on irrigation agencies till date. The knowledge, skill and information owned by the personnel in irrigation agencies are insufficient to implement the good governance programme.

4.5. Challenges

To make the agency activities accountable to the beneficiary farmers and participatory

To comply the agency activities with legal mandate, technical guidelines and project requirements

4.6. Opportunities

The elements of good governance have been realized.

Legal documents, guidelines and strategic programme of the government have been prepared and implemented.

5. Step forward

The irrigation agencies are made active and the good governance requirements in Irrigation are fulfilled to optimum level with following specific aspects as per the above defined characteristics.

Participation: Participation of the beneficiary farmers in decision making process at all stages of Irrigation projects/systems shall be made compulsory in all (including large ones) projects. Also the administrative and organizational decisions shall be made by management team with appropriate feedback from subordinates.

Rule of Law: Rules, guidelines and working procedure in the organization shall be prepared with clarity, uniformity and simplicity so as to be implemented effectively and impartially. Actions will be taken on legal grounds only.

Responsibility and Accountability: The overlapping or gap of responsibility shall be eliminated. The organization and the individual personnel working in the organization shall be made accountable for the job given.

Inclusiveness and Impartiality: The remote, neglected and backward area and people shall be given special consideration for inclusion. Similarly the inclusiveness and impartiality shall be implied in every type of opportunity, authority and responsibility for all the staffs in the organization.

Personnel Management: The internal criteria for relocation and deputation of the employee to any specified responsible post shall be prepared, approved and implemented.

Organizational Reforms: A separate division in the department shall be responsible for enforcement of the good governance, quality monitoring and technical auditing in the organization.

6. Conclusion and Recommendation

Good Governance is the optimum level of users' satisfaction for the assured service and of organizational achievement for sustained development works. Good Governance being also an anti-corruption mechanism is important to improve the image of the organization.

Department of Irrigation, an utmost agency for irrigation development, has yet to do much for actively joining the national campaign for governance reforms. It is important for the department to set priority (like transparency, accountability, participation and personnel management) and act accordingly.

The formulation and implementation of the procedural guidelines and standards based on elements of good governance and on legal ground are urgent. The commitment from the higher authority in the organization and strong mechanism to monitor the performance will enable the staffs in the organization (including that in project or scheme level) work efficiently for effective results.

References:

United Nations / UNDP: "Corruption and Good Governance", *(Paper 3),* July 1997

United Nations / UNESCO: "What is Good Governance", UN-paper (Web-page)

Law Book Management Board: "Good Governance Act, 2007", Govt. of Nepal

National Planning Commission: "Good Governance", Policy Doc. (Ch. 36), Feb. 2008

Prakash Paudel (Er.): "Technical Auditing" Workshop Proceeding, DoI etc., April 2008

Revitalization of Irrigation system through Irrigation Management Transfer "A case study of Kankai Irrigation System"

Bashu Dev Lohanee
SDE, DOI

Abstract

Agency managed Irrigation Systems in Nepal are performing poor in account of resources poured in its development. In addition to other major policy level issues and constraints, reasons like poor system management, insufficient operation and management due to lack of user participation are also responsible for it. To improve the efficiencies water user's participation in system management is very important. Irrigation Management Transfer (IMT) to the respective Water User's Associations (WUA) below certain level of canal system may be the one of the effective way for the improvement. Kankai Irrigation System (KIS) of Jhapa district is one of the candidate systems for IMT under Irrigation and Water Resources Management Project (IWRMP).

This paper deals with the change in Technical (O&M and Agriculture), Institutional and financial capacity of WUA of KIS. The methodology adopted for this study is the data obtained from the WUA and sub project office of KIS and observation. Management transfer agreement was held on September 2010. After the MTA, the operation and maintenance (O&M) has been started with the participation of water users. Contribution from users in construction works has been made as per requirement. WUA office has been well established with their own building. Collection of Irrigation Service Fee (ISF) has been increased than previous years. Women's group in irrigation has been formed and active in agricultural cooperative activities. Improved agricultural activities implemented through Integrated Crop and Water Management Program (ICWMP).

Thus, IMT ease WUA to enhance the irrigation system improvement through the active participation. Hence improving the technical, institutional and financial capacities of water users and helping in sustainability of institution and irrigation system.

1. Background

Nepal's policy and institutional experience on participatory irrigation management has been internationally recognized. One of the most remarkable features of Nepal's irrigation administration is that more than 70% of the irrigated area is operated and administrated by water user associations. These FMIS have been clearly more efficient than the systems administrated by the Department of Irrigation. Based on this, GoN launched a large program for transferring the operation and management of public schemes to users associations. The results of these efforts have been mixed and new strategies for completing and consolidating the process of transferring has been analyzed. There has been insufficient interest, and inadequate capacity in the line agencies for involving farmers in the operation and management of the systems.

The country's new irrigation policy and irrigation regulations have targeted year-round irrigation recognizing the importance of service-oriented management as a means for providing more efficient, reliable and flexible water service to farmers. This represents a major conceptual shift in policy from a supply orientation ensuring equitable water supply for all users to a service oriented management characterized by response to demand emanating from the farmers themselves.

Increasing food production and enhancing rural employment and income must come through more intensive use of land and diversification of production to more valuable crops. This requires an adequate planning for meeting the seasonal demands for water and for year-round supply with conjunctive use of groundwater and the improvement of irrigation services in existing command areas, a problem that could be addressed through a combination of both infrastructural and managerial solutions.

2. IMT under IWRMP

The overall objective of the Irrigation Management Transfer is to improve service performance and service delivery of selected public irrigation schemes in Terai where management transfer to WUAs will be completed and consolidated. The IMT is designed to address the problem of below-capacity performance, poor O&M, negligible cost recovery (below 5% on average) and inadequate maintenance funds in large public irrigation schemes.

The approach of the concept is to improve performance and service of the selective schemes through improved governance mechanisms and financing arrangements as well as capacity building of WUAs and DOI, in addition to Essential Structural Improvement (ESI).

Governance: The governance arrangements will have the following four aspects: (a) respective roles and responsibilities of WUA and DOI defined through a IMT Agreement; (b) Scheme Coordination Committee (SCC) to agree and coordinate plans and actions, especially regarding water charges for each irrigation scheme; and (c) enhanced transparency and accountability through establishment of a benchmarking system, periodic rapid evaluations of scheme performance and user satisfaction, and the installation of water measuring devices to monitoring water delivery relative to the entitlements of different user groups.

3. Study area in brief

Kankai Irrigation System is located in Jhapa district of eastern region of Nepal. The construction of the system has been done in different phases. First phase of construction began in 1973 and completed in 1981 with the command area of 5000 ha. Second phase construction began in 1980 and completed in 1991 which brought another 2000 ha under irrigation but command area development work left over during the phase. The total length of main canal is 34 km which has 22 branch canals. The totals of seven VDCs are covered by the system which comprises Satashidham, Shivgunj, Panchgachhi, Mahabhara, Topgachhi, Dharampur and Baigundhara.

4. Irrigation Management Transfer Agreement

The Management Transfer Agreement signing ceremony held on September 2010. After the MTA, the operation and maintenance (O&M) has been started with the participation of water users. Contribution from users in construction works has been made as per requirement.

Irrigation System Improvement: Essential Structural Improvement (ESI) cost estimate has been prepared which includes repair and maintenance of Headwork, Main Canal, Secondary canals and building works is NRs. 313156000.00 out of which 10% has to be contributed by the users. Construction and improvement of aqueduct, cross drainage, culvert, division box, road crossing, Drain crossing, village road bridge structures etc. The minor works consists of reshaping of canal and bank filling, repair and maintenance of gate and service road etc.

Organizational structure of WUA: Water Users' Association (WUA) exists and has a constitution and is registered according to the Water Resources Act (1992). There are three tiered committees i.e. Prashakha (tertiary canal -109)/Upsakha (sub branch canal -36) samiti, Sakha samiti (branch canal -17) and Main committee (main canal). Newly constructed branch canals committee has yet to be included in the existing committee.

Institutional Strengthening of WUA: Handover of one excavator machines, office equipment (Computer, printer, fax, photocopy etc) and motorcycle and bicycles to WUA. Unconditional grant is given to WUA for office establishment. Different Trainings and Educational tour has been conducted to enhance the capacity of WUA at all level. To support the WUA contribution part, payable contract has been provided to water user association.

Physical progress:

IWRMP part

Contractor part : 60%

WUA Payable part : 75%

WUA Contribution part : 70 %

Government part progress is only 17% due to non availability of budget.

Institutional Development Progress:

Trainings: 49 training completed in different topics to enhance the capacity of WUAs of different levels. Total of 1605 participants benefited from the training.

Observation tour: Total of 90 participants among users group participated through the 3 observation tours.

ICWMP: Implemented in 9 pilot sites and 3 demonstration plots of SRI in rice, beans and brinjal.

Financial progress: WUAs have prepared the enthusiastic plan for collecting resources to meet the user contribution part as given in Table 1. Table 2 shows the status on the resources collected in FY 2067/68.

Table 1: WUA Plan to collect Resources:

S.N.	Description	Collection Plan	Expected collection for this year (NRs.)	Remarks
1	Irrigation Service Fee	300/ ha	1183200	Anually
2	Operation & Maintenance	600/ ha	2366400	Anually
3	Share Membership Fee	300/ ha	1740000	Once
4	Membership Renewal Fee	(Nrs.10/HH)	79520	Once
5	Peoples Participation	6.75 Labour/ha	3066205	Once
6	Income from Machine		830000	Anually
7	Grant		50000	Once
8	Last Year Balance		425783	
		Total	9741108	

Table 2: Status of ISF, O &M and Membership fee collected (till 8th June, 2011)

Branch	ISF	0 & M fee	Membership Fee	Remarks
S0	19,219.20		740.00	
S1	33,242.80		2,040.00	
S2	44,463.78	61,930.50	3,340.00	
S3	54,961.26	18,717.00	4,100.00	
S4	62,439.00	48,000.00	4,280.00	
S5	91,814.92	1,99,000.00	2,760.00	
S6	15,063.05		1,920.00	
S7	11,891.00	32,019.00	1,730.00	
S8			2,240.00	
S9	43,020.84	38,749.00	1,940.00	
S10	22,846.03		2,080.00	
S11		43,429.00	460.00	
S12			2,020.00	
S13	26,105.66			
S14	20,505.54	83,690.00	5,280.00	
S15			3,860.00	
S16			5,660.00	
S17			5,000.00	
Total	**445,573.08**	**326,534.50**	**49,450.00**	
Grand Total				**821,557.58**

Agricultural progress: The trend of agricultural production shows the increment in yield in last three years and it will be increased more in days to come (Table 3). Increment in yield is not only the factor of yield increment but also the change in agricultural technology seen in the command area.

Table 3: Crop Production Data of Kankai Irrigation System

Major Crops	2065/66 (t/ha)	2066/67 (t/ha)	2067/68 (t/ha)	Remarks
Monsoon Paddy	3.5	3.7	3.9	
Spring paddy	4.0	4.2	4.8	
Maize	3.0	3.2	4	
Wheat	2.2	2.5	2.5	

Source: Crop cut Survey

5. Conclusions

In conclusion Irrigation Management Transfer (IMT) enhances the irrigation system towards technically sustainable through essential structural improvement, institutionally sustainable via training delivery and conducting observation tour etc. Also productive through integrated crop and participatory irrigation water management. Thus revitalizes the system as a whole.

Availability Assessment of Groundwater Resources for Effective Irrigation

Sagar Kumar Rai

Chief Hydrogeologist, DoI

Abstract

*We have not able to been utilizing the groundwater resources as properly though the country is highly potential of this resources. In the absence of round year irrigation the agriculture land of the country is left barren for half the year. Thus most of the people involving in the agriculture sector are under miserable condition. In this situation, the socio-economic status of the farmers can be improved very soon by utilizing the groundwater resource because the groundwater resources provides round year irrigation in simple way without investment of large cost for heavy and time consuming infra-structures. The utilization of the groundwater is cost effective, easy available, quick result oriented, reliable; self control, cheap, handy, low risk, manageable and environment friendly. Besides, it can be available during the dry (winter and summer) season when the most of the surface water are dry up. Of course, it might be the unique and important feature of groundwater resources for Nepal. However, a lot of improvements are needed to be done for sustainable development and management of this resource, especially in the legal, institutional, and technical sectors. Therefore, it can be said that the groundwater resources is a "**Gift of the Nature** " for Nepal if the planner, decision maker and leaders could understand it seriously.*

1. Background

The Terai Plain of Nepal is highly potential for groundwater resources because it is a part of the biggest groundwater basin in the world known as **Indo-Gangetic Basin**. The unconsolidated porous material of the basin has high capacity to store or release the groundwater resources. Presently, about 1.4 million people are living in the Terai and all of them are utilizing the groundwater resources for drinking, domestic, irrigation, industries, and for cattle purposes so it can be concluded that approximately half of the entire population of Nepal has been depending on the groundwater resources directly. Among of various uses, high amount of the groundwater resources is utilizing in the sector of irrigation. Now, about 300,000 ha land of Terai is irrigated from this resource which is about 24 % of the total irrigated land of the country. During the winter (dry) season, most of the surface drainages are dry up and the groundwater is only a main resource for overcome the burning situation. Therefore, the trend of groundwater utilization for irrigation is rapidly increasing in the country.

2. Literature review

Various studies have been carried out in the field of estimation of groundwater balance of Nepal. However all of them have dissimilar type of result. **D. Duba (1982)** has considered recharge to the Bhabar zone and to the shallow aquifer i.e. south of Bhabar zone. According to him, the total area of Bhabar zones is 4014 sq km and means annual recharge is 685 mm (33.5%) of annual rainfall. The direct average annual rainfall recharge to the shallow aquifer (south of Bhabar) is 429 mm. **Jenkins 1983** study has based on some C14 isotopes in the region between the Siwaliks, Butwal and the boarder, and has suggested some boundary recharge from subsurface Siwalik sediments in to the Terai alluvium like BLGP. ***Electrowat (1984) e***stimated of potential recharge to Bhabar zone, generally based only on rainfall recharge (ignoring the river bed infiltration and upward leakage) is about 465 mm. **Kenting 1984** ***e***stimated of direct rainfall recharge to the shallow aquifers south of the Bhabar zone is 124 to 370 mm. **Groundwater Development Consultant GDC (1994)** ***e***stimated of potential recharge is 450 mm after reducing safety factor and for conservative value for planning purpose. **Tahal 1992** Israel, modeling works (BLGWP/ Tahal 1992) present a groundwater balance for the Bhabar zone which allows that 42 % rainfall (1100 mm) reach the aquifer, this study also considered recharge inputs from stream which across the Bhabar Zone. **Groundwater Resources Development Board/UNDP (1992)** has presents that the annual recharge of Terai is 5800 MCM.

3. Potential recharge of groundwater in Terai

Let us consider that the entire Terai plain is a huge groundwater basin where groundwater inflows and outflows naturally and makes groundwater system. In the system the differences between the total inflows and outflows are equal to any change in groundwater storage. In this condition the non equilibrium balance is set up in the system. This is denoted by,

$$\boxed{\mathbf{I - O = S_{bal.}}}$$

Where, I is total rate of groundwater inflow, O is total rate of groundwater outflow and S_{bal} is volumetric rate of groundwater stored or released. The unit is MCM/yr. The inflow and outflow of groundwater have different parameters which are as given as below.

Groundwater inflow	Groundwater outflow
• *Precipitation* (Q_{pre}) • *Inflows from surface water* (Q_{surf}) • *Lateral subsurface inflow* (Q_{lsi}) • *Upward leakage* (Q_{up})	• *Discharge at springs* (Q_{Spring}) • *Discharge to surface water* ($Q_{surfout}$) • *Abstraction* (Q_{well}) • *Lateral subsurface outflow* (Q_{lso}) • *Downward leakage* (Q_{dwn}) • *Evapotranspiration* (Q_{evapo})

On the basis of available data related to the groundwater of Terai, the specific yield is about 0.2. In the same way, the annual fluctuation of groundwater level for unconfined aquifer is about 1.5 m and the surface area of main Terai is about 29838 sqkm. Then the annual potential storage in the unconfined aquifers of main Terai is about **8951 million cubic meters** (**mcm).** The estimation is based on **hydro geological** method.

$$\boxed{\mathbf{S_{gws} = BS_y \, \Delta\varphi/\Delta t.}}$$

Where, $S_{gws\ is}$ rate of groundwater stored or released mcm; B is surface area of the aquifer -29838 Km^2; Sy is specific yield (dimension less) - 0.2; Δφ is difference in water table - 1.5 m (ave); and Δt is length of time (year) - 1 year. In the case of deep confined aquifer, the Bhabar zone of Nepal is 4014 sqkm and means annual infiltration is 685 mm. Thus the annual groundwater recharge from the Bhabar zone is **2762 mcm** which is considered as recharge of confined aquifer through horizontal flow. Therefore, the total annual storage of groundwater in the Terai is **11713 mcm.**

If the groundwater recharge on the **hydro-metrological** methods is computed then the result will bit be similar to the mentioned result from hydro geological method. For this let's see the D. Duba/HMG 1982 estimation. According to him the area of Bhabar zone is 4014 sqkm and means annual infiltration is 685 mm. Thus the annual groundwater recharge from the Bhabar zone is 2762 million cubic meters. In the same way, the area covered by the main Terai is 29838 sqkm and the mean annual vertical infiltration is 294 mm. Thus the potential recharge in unconfined aquifer is 8837 mcm. Thus the total annual potential recharge of the Terai is **11599** mcm. Both of methods have indicated

4. Present (2010) outflows of groundwater resources

There are various parameters of outflows of groundwater system mentioned as above. However the abstraction by for irrigation, industries, domestic, and cattle purpose are taken in account since of huge volume. As per the data available from different institutions involving in this field (Ministry of Irrigation, Industry, Physical Planning) the abstraction of groundwater in 2010 is about **3001** mcm. And it is about 26% of the total annual recharge. Out of this, outflows from irrigation (DTWs and STWs) are 2246 mcm (19%), from industries (DTWs) is 197 mcm (1.7%), from domestic use is 166 mcm (1.4%) and cattle use is 4 mcm (0.03%). In addition, the lateral subsurface flow is also a main factor for groundwater outflows. From this, 388 mcm/y groundwater is outflows annually through the lateral subsurface.

$$\mathbf{Q_{lso} = - KHWs\ (\Delta\varphi/\Delta s)\ or\quad Q_{lso} = TWs\ (\Delta\varphi/\Delta s)}$$

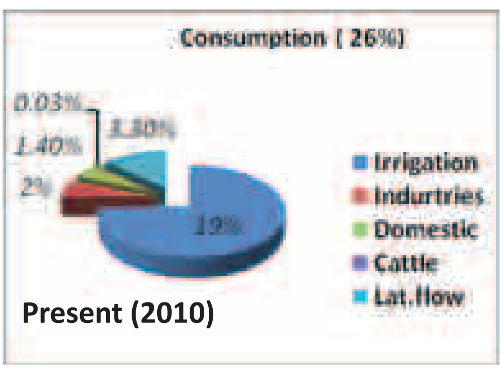
Where, Ql_{so} is flow rate through the stream tube (m3/day);T is transmissivity (m2/day) -1500 m2/day; Ws is width of the stream tube (m) - 885 km; Δφ is discrete difference in hydraulic head (m)- 1; Δs is discrete difference between contour line m-1250 and Δφ/ Δs (hydraulic gradient) is 0.0008 (1/1250 m). The abstraction rate is considered as 10 l/s for STWs, 40 l/s for DTWs (irrigation) and 30 l/s for DTWs (industries). The operation hours of DTWs and STWs are considered as 600 hrs per year for irrigation. Similarly, it considered as 2190 and 2920 hrs per year for industries and domestic purpose. The irrigated area from each DTW is taken as 40 ha and from STW is 2.5 ha. The population by 2010 is estimated as 13997684.

$$\mathbf{P_n = P_o\ (1+r)^{\ n}}$$

Where, P_n is population in n^{th} year; P_o is present population (11205288 in 2001); R is population growth rate (2.25) and n is number of years (10 years). It is considered that about 10 million people use groundwater from shallow aquifer at the rate of 10 lt per day/ person. In the same way, about 2 million cattle consume groundwater at the rate of 5 lt per day water is about 5 lt. per day /number.

5. Irrigated areas and Tube wells by the end of APP (2015)

According to the target, set by Agriculture Perspective Plan 1995 (APP), about 175000 STWs and about 1250 DTWs would be made at the end of APP (2015). The irrigated land from STWs will be about 437500 ha and from DTWs will be 50,000 ha. The total irrigated land from DTWs and STWs will be about **4, 87500 ha.** The consumption of groundwater by the end of APP are about 3924 mcm (33.5%) is in irrigation (DTWs and STWs); abut 217 mcm (2%) in industries (DTWs); about 184 mcm (1.6%) in domestic use and 5 mcm (0.04%) in cattle use (Figure 1). The lateral subsurface flow remained as same in previous case. The operation hours of DTWs and STWs are considered as 800 hrs per year for irrigation while others will be same i.e. 2190 and 2920 hrs /year for industries and domestic purpose. The population by 2015 is estimated as 15300635. The P_n is population in n^{th} year; P_o is present population (11205288 in 2001); R is population growth rate (2.25) and n is number of years (15 years). It is considered that about **1.7** million people use groundwater from shallow aquifer at the rate of 10 lt per day/ person. In the same way, about 2.5 million cattle consume groundwater at the rate of 5 lt per day water is about 5 lt. Per day /number.



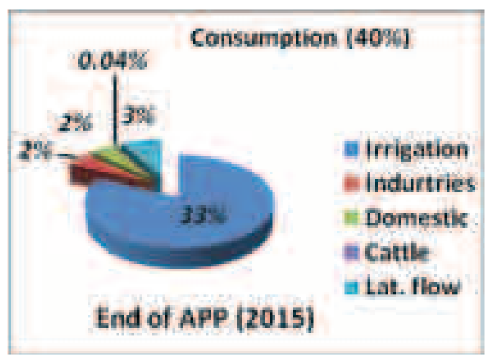


Figure 1: Present status and APP target on GW consumption

6. Optimum number of tube wells and water consumption in irrigation (National Water Plan-2005)

According to the National Water Plan 2005, groundwater potential for irrigation is about 612000 ha. To provide the irrigation facilities on the mentioned land about 200000 STWs and about 2800 DTWs should be made. Let's considered the operation hours of STWs and DTWs will be 800 hrs per year. Then the annual groundwater abstraction will be about **6080 mcm** (Figure 2). It will be about 52% of total annual recharge i.e. 11700 mcm.

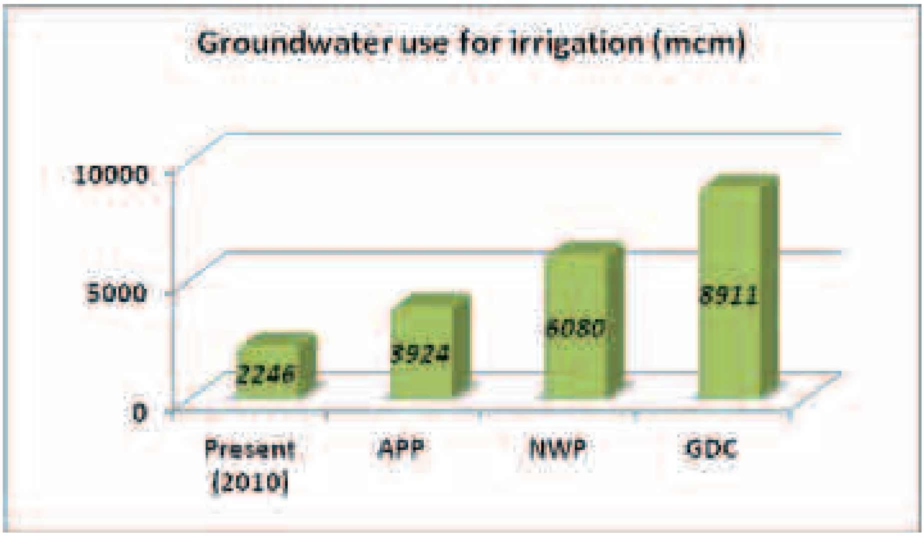


Figure 2: Groundwater use in irrigation

7. Tube wells and water consumption in potential area proposed by GDC

According to the Reassessment of the Groundwater Development Strategy for Irrigation in the Terai , 1994, GDC/ UK the potential area is about **916000 ha.** In which DTW potential is 190000 ha and STW is 726000 ha. If we are ready to meet the proposed target, it is needed to make about 4750 DTWs and about 290400 STWs. If all STWs operate smoothly for 800 hrs per year in the rate of 10 l/s then the total abstraction of groundwater will be about 8364 mcm. Similarly, in the same condition mentioned as above except abstraction rate i.e. 40 l/s then the consumption of all DTWs will be about 547 mcm. Thus the total from both DTWs and STWs will be about **8911 mcm** which is about **76 %** of total recharge.

The case is quite controversy if the consumption of STWs is taken only. The consumption from STWs itself will be the 99 % (8364 mcm) of total annual recharge i.e. 8951 mcm of unconfined shallow aquifer. Therefore, the use of 99 % groundwater is not suitable for optimum utilization of groundwater i.e. 50% to 80% (Figure 3).

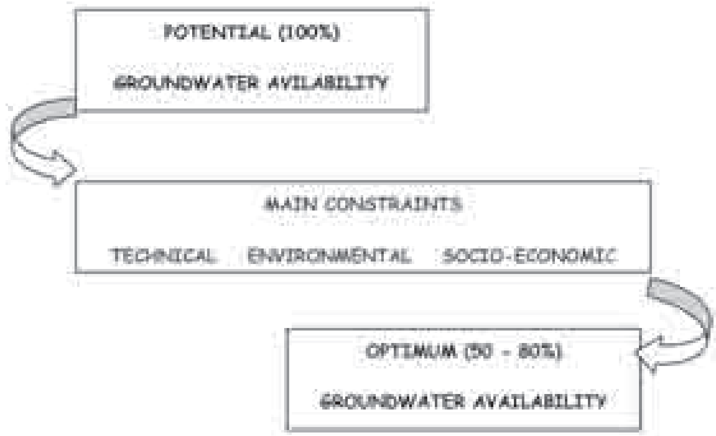


Figure 3: GW consumption

8. New scenario in groundwater utilization

If groundwater availability in confined aquifers is taken 50 % (1381 mcm) only, it is possible to make about 12000 DTWs instead of 4750 of GDC (Figure 4). About **480000** ha land can be irrigated from these DTWs if the abstraction rate and running hrs per year is considered as same as mentioned above . In this case, the potential area of DTWs will be 670000 ha instead of 190000 of GDC. In the same way, if the 70 % (6266 mcm) of potential recharge of STWs will be taken in consideration, then the number of STWs will be about 217500 and the irrigated land will be about **543700 ha.** In this new situation, about **7647 mcm** groundwater will be consumed to provide irrigation facility to **1023700 ha** land of Terai (Figure 5). For this only **65 %** groundwater will be consumed.

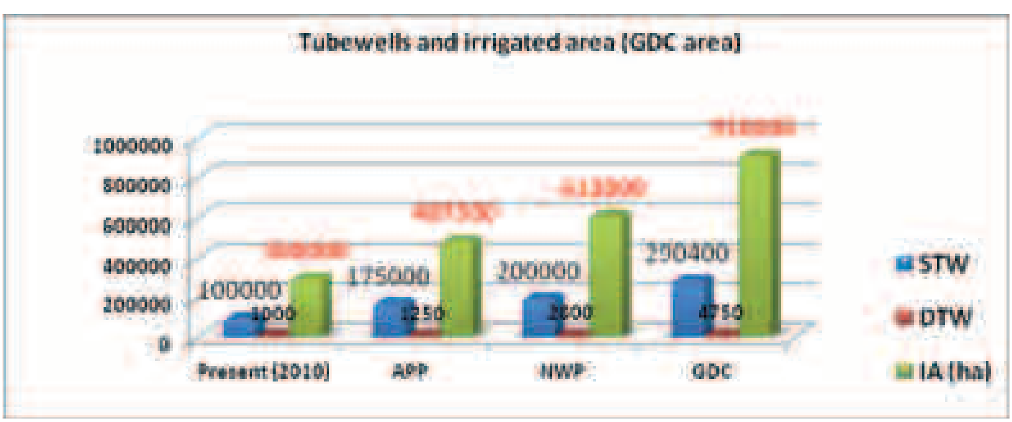


Figure 4: Tubewells and irrigated area

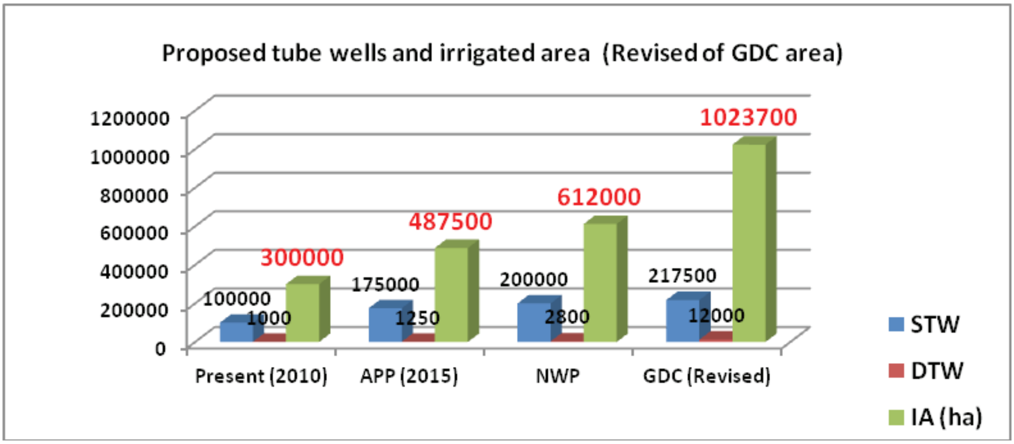


Figure 5: Proposed tubewells and irrigated area (Revised of GDC area)

9. Emphasized districts for groundwater irrigation

Jhapa, Siraha, Saptari, Dhanusha, Mahottary, Chitwan, Rupandehi, Dang, Bardiya, and Kailali districts are more emphasized for groundwater irrigation because these districts have least surface drainages in comparison to the other districts.

10. Main issues on groundwater development and management in Nepal

Institutional aspect: should be established a proper organizational set up either under the department of irrigation or separate independent organization (Department of Groundwater Resources).

Legal aspect: should be made groundwater act and law for better management and conservation of groundwater resources (quality and quantity).

Policy aspect: Groundwater policy for sustainable utilization focusing to socio-economic and environmental approach.

Technical:

- Clear identification zoning of DTWs and STWs area in each district.
- Clear identification and zoning of Thokuwa and Dhikuli area for STWs in each district.
- Clear identification of present status of DTWs and STWs, and real irrigated areas in each district.

- Implementation of inventory scheme of TWs (DTWs, STWs, hand Tube wells, dug wells) belongs to all government and non government agencies.
- Update of GDC map in 1:25000, district wise.
- Implementation of pipe line projects i.e. 32000 ha of Terai Groundwater Project and 8000 ha of Birganj Groundwater Irrigation Project.
- Conjunctive use of groundwater in large surface irrigation projects (60,000 ha) as per APP.

Bibliography

Agriculture Perspective Plan, Final Report, Jun 1995, National Planning Commission and ADB, Kathmandu

Annual Report F.Y. 2066/06, Nepal water Supply Corporation, Tripureswor Kathmandu

Figures updated upon F.Y. 2066/67, Groundwater Resources Development Board, Babarmahal, Kathmandu

Groundwater resources of Nepal, Dr. Chandra Kanta Sharma, 1974, Kathmandu,

Introduction to Groundwater Resources, J.A.M. Vander Gun UNESCO-IHE Delft, 2003, the Netherland

Introduction to Hydrogeology, Johannes C. Nonner UNESCO-IHE Delft, 2002, the Netherland

Irrigation and Water Control, 1995, Dr C. K. Sharma and Som Nath Poudyal, Katmandu

Master Plan for Irrigation Development in Nepal, Working Paper – Sixth Issue CIWEC/East Consult, Kathmandu

National Data of Beneficiary People, 2066, Department of Drinking Water Supply and Sanitation, Kathmandu

National Water Plan, 2005, Water and Energy Commission Secretariat, Kathmandu

Reassessment of the Groundwater Development Strategy for Irrigation in the Terai, Vol.3, GDC/UK& East Consult, Kathmandu

Regional Hydro geological System Analysis, J.W.A Foppen, UNESCO-IHE, Delft, 2003, The Netherland

Shallow (Phreatic) Aquifer of Nepal, 1995, Dr. C. K. Sharma, Kathmandu

Sichai Hand Book, 2068, Department of Irrigation, Jawlakhel

Statistical Year Book of Nepal 2003, Central Bureau of Statistic, Kathmandu

Water Resources Strategy Formulation Phase II Study, 2000, National Planning Commission, Kathmandu

Seepage analysis underneath the headwork of Chanda Mohana Irrigation Scheme, Sunsari, Nepal

Santosh Kaini, MSc[2],
L.G.Hayde, PhD[3],
Bart Schultz, PhD[4],
Miroslav Marence, PhD[5]

Abstract

Seepage is one of the major causes of failure of irrigation headworks constructed on permeable foundation in the Terai (plain) Region of Nepal. There is an urgent need to upgrade these schemes in order to meet the increasing food demand. A seepage problem was seen at the headwork of Chanda Mohana Irrigation Scheme, Sunsari situated at the confluence of Budhi and Katle Streams from the very beginning of the commissioning in 2000. The headwork consists of a weir (65 m span) with under-sluice (7 m opening). This research was focused in the seepage analysis underneath the headwork.

MSeep model (2-Dimensional) was used for seepage analysis. Different scenarios were developed to represent the different works carried out in 2000, 2009 and 2010. The results indicate that the exit gradient was within the range of permissible safe exit gradient without considering the lateral flow. In contrast, the exit gradient was increased above the maximum permissible limit considering lateral flow. Due to continuous seepage flow, the horizontal and vertical hydraulic conductivities in 2009 might have been increased to 2.5 times and 1.3 times respectively than the values in 2000. This has reduced the rate of head-loss and hence increased the exit gradient. Therefore, this is one of the major causes for the failure of the structure in 2010 regardless of the maintenance carried out in 2009.

The research finding suggests that the ongoing maintenance work from 2010 is safe only if the pressure grouting recovers the soil parameters to the stage during construction in 2000, which is generally not achievable. So, considering the hydraulic conductivity and porosity of the soil as the average values of 2000 and 2009, extension of the downstream floor with additional sheet piles is proposed as an alternative measure for achieving the safety of the structure.

Keywords: Seepage analysis, Piping, MSeep model, Chanda Mohana Irrigation Project

2 Engineer (Irrigation), Department of Irrigation, Nepal. Email:santoshkaini@yahoo.com
3 Senior Lecturer, UNESCO-IHE, Delft, the Netherlands
4 Professor, UNESCO-IHE, Delft, the Netherlands
5 Associate Professor, UNESCO-IHE, Delft, the Netherlands

Introduction

Importance of water resources has been recognized by Nepalese farmers and hence they have been constructing irrigation systems at their own initiative since long ago (Pradhan, 1988). Agricultural sector plays a crucial role in the Nepalese national economy providing employment opportunities to 66 percent of the total population and contributing about 39 percent in the GDP (http://www.doanepal.gov.np, 2010). Although the Nepalese economy mainly depends on agriculture, the optimal production is not being achieved because of failure of irrigation structures, mainly headwork. These schemes should be upgraded to meet the increasing food demand. 80 - 90% of the required increase in food production will have to be realized on existing cultivated land in coming decades (Schultz *et al.*, 2009). The Terai (plain) Region is suitable for agricultural production. Seepage is one of the major causes of failure of irrigation headworks constructed on permeable foundation in the Terai (plain) Region of Nepal.

Failures of dams by piping action have occurred since the earliest dams were constructed around 2900 BC. Out of all dam failures in US, 20% are due to the problem of piping (http://www.damsafety.org/news/?p=412f29c8-3fd8-4529-b5c9-8d47364c1f3e, 2010). 46% of all large embankment dam failures up to 1986, excluding dams constructed in Japan pre 1930 and in China are related with piping failure (Foster *et al.*, 2000). According to the research done by Richards *et al.*, (2007), the recent data from National Performance of Dams Program together with Jones (1981) and Lane (1934) shows that about 267 dams have failed due to piping failure. Cracks and fissures, weakening of the shell material due to burrowing animals, root growth penetration from vegetation and internal erosion or seepage are some causes of piping failure (Moayedi *et al.*, 2011).

The CMIS[6], located in Sunsari district within the Koshi zone of Eastern Development Region of Nepal had seepage even at the very beginning of commissioning of the headwork in 2000 (CMIP, 2001). It was constructed in 2000 to irrigate 1800 hectares of command area. The headwork of CMIS lies at the confluence of Budhi and Katle Stream. Initially, the confluence point of Budhi, Katle and Jala Stream

6 Chanda Mohana Irrigation Scheme, Sunsari, Nepal

was at the same location where the present east (left) head regulator exists. From the construction of headwork, the Jala Stream is being diverted towards the East which meets two streams at the downstream of the headworks. Just after the operation of canal in October 2000, soil subsidence was seen near the Eastern head regulator and water boils with fine sands were seen at the downstream of sheet pile line in left under-sluice portion. After the immediate maintenance in 2000, again piping problem was seen in 2009. Although some temporary measures were taken in 2009 to save the structure from piping, the vulnerable condition was noticed on the first week of January 2010. It was seen that the weir structure with it's under-sluice had piping problem. The upstream floor at the left under-sluice was cracked and settled forming a ditch of size 5 m x 3 m x 2 m. Hollow formation was seen beneath the left abutment wall near the settled upstream floor (Prasad, 2010). Hollow formation was also noticed from the upstream floor in weir portion nearby left divide wall to the settled floor at the upstream under-sluice portion. Furthermore, the left abutment wall was settled and tilted towards the East. As a result, the gate at the under-sluice portion was also tilted towards the East and the gap in between the bridge decks above the weir is also increased. It is found that major maintenance works were carried out in the headwork of CMIS in 2000, 2009 and 2010 even after the completion of the scheme.

Overall span of weir = 65 m, Weir portion: clear span = 40 m, crest height = 3 m, gate height = 1.5 m

Undersluice portion: opening = 7 m (on both banks), crest height = 2 m, gate height = 2.5 m

The reduced level of pond level by closing the gates is 70.0 m. Furthermore, the reduced level of downstream deepest floor is 63.9 m. Thus, the head difference is 6.10 m. Floor length at the under-sluice portion and weir portion is 49.75 m and 44.75 m respectively. The sheet piles are provided only at the end of upstream and downstream of floor but not in the sides of the abutment wall. This shows that the sheet piles are not closed. Location and layout map of CMIS is shown in Figure 1 and Figure 2 respectively.

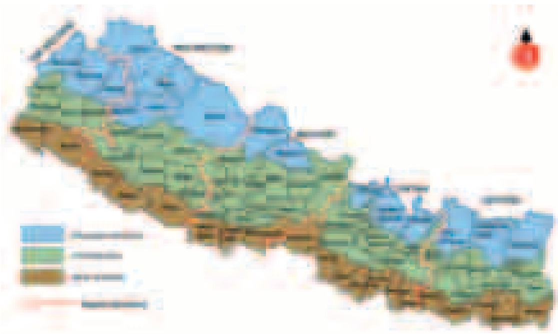


Figure 1: Location map of CMIS

Figure 2: Layout map of CMIS after failure(Google-Earth, 2010)

Development of Problem and Works Carried Out

In 2000

Just after the operation of canal in October 2000, soil subsidence was seen near the Eastern head regulator. It was thought that the subsidence was local due to insufficient compaction of soil. Backfilling was done in the subsidence area. Canal was operated for 10 days as per crop water requirement. Again soil subsidence was seen near previous subsidence area when canal was operated for about a week in December 2000 for wheat. The subsidence area was backfilled. In this period, water boils with fine sands were seen at the downstream of sheet pile line in left under-sluice portion. At every watering period of wheat, due to water ponding in the upstream of weir, soil subsidence was seen near head regulator but entry point of seepage water and seepage path was not known. Considering the suggestions given by different experts, laying of geo-membrane up to 25 m length upstream at existing upstream floor level to increase seepage path by 25 m and 0.3 m earth filling with compaction was done. Geo-membrane was loaded with 0.3 m thick clay and gabion of 0.3 m thick. Excavation in the subsidence area up to depth of seepage hole and filling with clay cement mixture with layer wise compaction, earth fill in old course of Jala Khola was done. Fixation of geo textiles at the joint of abutment wall and stone masonry wall with nut bolts up to height of 2.5 m was also done (CMIP, 2001).

In 2009

Water boiling from the concrete blocks near divide wall at the end of downstream sheet pile line of left under-sluice portion as well as at the end of downstream sheet pile line in weir portion was observed. It was estimated that seepage water was passing from upstream sheet pile line and was escaping from downstream sheet pile line. The maintenance work was carried out for 30 m length upstream from end of upstream sheet pile line to increase the seepage path by 30 m (CMIP, 2009).

In 2010

It was seen that the weir structure with its under-sluice had piping problem where water was seeping through downstream floor. The boiling at the downstream was seen. It had created big hollow at the upstream floor near the left divide wall in under-sluice portion and the upstream floor was cracked and settled (Prasad, 2010).

According to the engineers involved in that scheme, the settlement had an area of about 5 m x 3 m at the upstream of under-sluice portion. After diverting the water into the Jala Khola, it was noticed that the height of hollow was about 2 m and the hollow was beneath the foundation of abutment wall too. Furthermore, the hollow was also formed not only towards divide wall but also towards the downstream portion as well. The connection of hollow along upstream of weir portion near divide wall, divide wall, under-sluice portion and abutment wall was observed. The red rectangular area in Figure 3 shows the hollow formed area at upstream floor. The settlement of abutment wall also observed. Due to this, the gate of under-sluice portion was also tilted towards east. In addition to this, the gaps in the joints of the bridge deck were also increased due to the settlement of floor and abutment wall and this is shown by red rectangles in Figure 4.

Figure 3: Hollow formed area at U/S floor

Figure 4: Increased gap in bridge deck slab joints

Exit Gradient and Factor of Safety

The submerged weight of soil is the resultant of force of gravity and the force of buoyancy. The force of gravity, W acts in downward direction.

$W = \gamma_w * (1 - \varepsilon) * S_s$ **...(1)**

Where, $\gamma_w \gamma_w$ is unit weight of water,

ε ε is porosity of soil material,

$S_s S_s$ is specific gravity of soil particles.

The weight of displaced water, (buoyancy) *B* acts in upward direction =

$\gamma_w * (1 - \varepsilon)$ **...(2)**

The resultant of these two forces, $Ws = W - B = \gamma_w * (1 - \varepsilon) * [(S]_s - 1)$ **...(3)**

This is the submersed weight of unit volume of soil which always acts in the downward direction as the specific gravity of soil (sand) is greater than 1.

The upward disturbing force, F is the pressure gradient at that point.

$$F = \frac{dp}{dl} = \gamma_w * \frac{dh}{dl} \quad \textbf{...(4)}$$

Where, h is residual head to be dissipated.

For critical condition. $F = Ws$ **...(5)**

$$\gamma_w * \frac{dh}{dl} = \gamma_w * (1 - \varepsilon) * [(S]_s - 1) \quad \textbf{...(6)}$$

$$\frac{dh}{dl} = (1 - \varepsilon) * [(S]_s - 1) \quad \textbf{... (7)}$$

Where, $\frac{dh}{dl}$ is the rate of head loss or the exit gradient.

There are large numbers of uncertain parameters in the subsoil. The subsoil may not be homogeneous. The stratification may not be same throughout the foundation area. There may be local intrusion of very porous media or impervious media which may help to concentrate the flow from all around or deflect the flow lines. There may be the faults and fissures in the sub soil. The uncertainties in sub soil formations plays vital role to deviate the results from theory. Failure of any normal structure should be well high impossible if the exit gradients were considered purely from the academic perspective (Khosla *et al.*, 1962).

While designing safe structures, the uncertainties and deviations in subsoil must be considered. So, a factor of safety must be taken to the critical value of exit gradient to get a safe value of exit gradient. Table 1 shows typical safety factors recommended by Khosla.

Table 1: Recommended safety factor for exit gradients by Khosla

S.N.	Soil type	Safety factor
1	Shingle	4 to 5
2	Coarse sand	5 to 6
3	Fine sand	6 to 7

Source:(Khosla *et al.*, 1962)

Methods and Materials

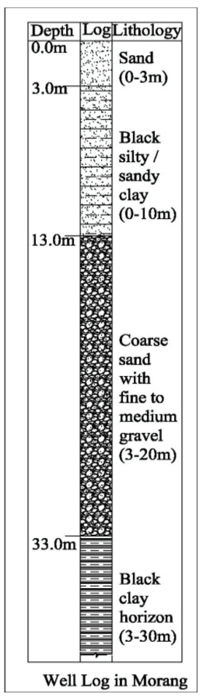
Physical Dimensions of Headwork Site

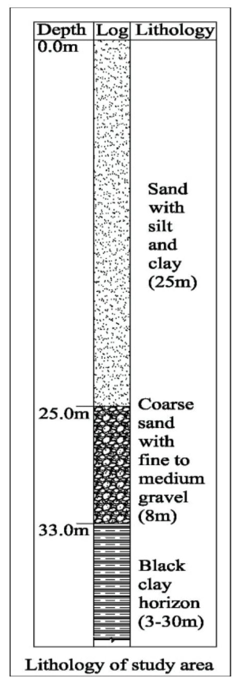
The details of physical dimensions of structures (plan and cross section of headwork structures) were taken during the site visit. It consists of both the primary and secondary data as underground dimensions are based up on as built drawings found in Eastern Irrigation Development Division No.-2, Inaruwa, Sunsari.

Geology of the Study Area

The study area is in the Southern part of the Terai Region. This plain is composed of interlocked alluvial deposits of the Gangetic plain. As the rivers flow from the Northern part to the Southern part, the alluvium was created by the river systems in this zone. The grain size of the sediments in this zone decreases towards south. The sediments consist of gravel, sand, silt and clay. The lithology of the upper 30 m or so is rapidly changing over very small distances (Kanzler *et al.*, 1989).

In Sunsari district, the chances of getting at least 5 m to 8 m of sand and/or gravel deposits are very high, and that a shallow well to supply water to villagers can be constructed without much uncertainty (Kanzler *et al.*, 1989). Test report of well log in Amahibela (X=518,125 m, Y=2,927,750 m), Sunsari nearby study area (X=516,644 m, Y=2,929,186 m) up to 24.4 m depth was reviewed. It shows that the top soil consists of sandy clay with thickness of 3.1 m. Sand of 3 m thick was found below top soil. Below this sand layer, an impervious layer of 1.5 m thick clay was noticed. Sand of 10.7 m thick layer and 6.1 m thick gravel and boulder were observed further below the clay layer (Kanzler *et al.*, 1989). Previous test report of well log in Ramnagar (X=510,875 m, Y=2,932,125 m), Sunsari up to 21.3 m depth shows that the top soil contains sandy clay with thickness of 5.2 m. Sand with gravel and pebbles was found in remaining 16.1 m depth (Kanzler *et al.*, 1989).





Source: (Bhattarai, 1988)

Figure 5: Lithological sections

Earlier studies carried out in Morang district (near to Sunsari district) show that it is also underlain by alluvium. As shown in Figure 5, the thickness of the top soil ranges from few centimetres to 3 m. Black silty to sandy clay of thickness few centimetres to 10 m is encountered below the top soil. The clay content is decreasing towards the North. Below this there is a layer of 3 m to 20 m consisting of course sand with fine to medium gravel. Shallow tube wells tap the water from this zone in the local areas. A black clay horizon of 3 m to 30 m is encountered below this layer. Further below this black clay horizon, 5 m to 40 m thick gravel and coarse to fine sand was observed (Bhattarai, 1988).

The geo-hydrological studies conducted from soil log test at the headwork area of Chanda Mohana Irrigation Scheme shows that different sizes and colour of sand mixed with silt were found up to 25 m depth (CMIP, 2001).

From above information, sand and loamy sand are taken respectively at upstream and downstream of headwork up to the depth of 25 m and remaining 8 m of depth is taken as coarse sand with fine to medium gravel for the lithology of the study area. Below this depth, black clay horizon is considered which has the characteristics of impervious layer.

Laboratory Works for Soil Parameters

Soil samples from both the upstream and downstream of the headwork were excavated from 4 m below the river bed during the site visit. The soil samples were tested in the Central Material Testing Laboratory of Tribhuvan University, Institute of Engineering, Pulchowk Campus, Nepal. The Grain size distribution test, minimum and maximum dry densities, saturated bulk density, hydraulic conductivity and specific gravity were conducted for both the upstream and downstream samples.

The Grain size distribution test: The grain size distribution curves of upstream and downstream samples are shown in Figure 6.

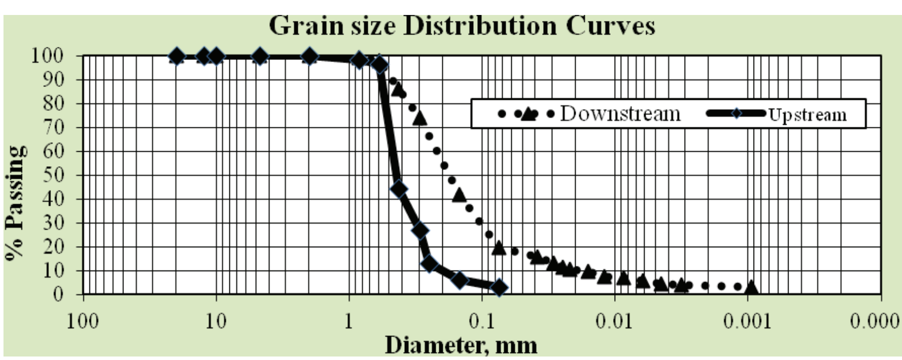


Figure 6: Grain size distribution curves

As per USDA soil classification system, upstream sample belongs to sand while downstream sample belongs to loamy sand. The D60, D50 and D30 of both samples are given in Table 2. The D60 means particle size such that 60% of the soil is finer than this size.

Table 2: D60, D50 and D30 of upstream and downstream sample

S.N.	Parameter	Upstream sample	Downstream sample
1	D60	0.48 mm	0.21 mm
2	D50	0.41 mm	0.19 mm
3	D30	0.31 mm	0.10 mm

Dry Density, Saturated bulk density, Specific gravity

The minimum dry density, maximum dry density, saturated bulk density and specific gravity values of upstream and downstream samples are shown in Table 3.

Table 3: Minimum dry density, maximum dry density, saturated bulk density and specific gravity values

S.N.	Parameter	Upstream sample	Downstream sample
1	Minimum dry density	1324 kg/m^3	1319 kg/m^3
2	Maximum dry density	1433 kg/m^3	1525 kg/m^3
3	Saturated bulk density	1622 kg/m^3	1740 kg/m^3
4	Specific gravity	2.69	2.78

Hydraulic conductivity test

As the hydraulic conductivity depends up the compaction of the soil layer, hydraulic conductivity was found in the laboratory for 30%, 60% and 90% compaction of soil sample for both the upstream and downstream samples. To find the hydraulic conductivity, constant head method was used and the rate of flow was measured. The hydraulic conductivity values are shown in Table 4.

Table 4: Hydraulic conductivity values

S. N.	Relative density (%)	D/S sample		D/S sample	
		Permeability, Ky (m/s)	Permeability, Kh (m/s)	Permeability, Ky (m/s)	Permeability, Kh (m/s)
1	30	$3.43*10^{-05}$	3.75*$^{10-}$05	$6.70*10^{-05}$	$1.26*10^{-04}$
2	60	$3.27*10^{-05}$	$3.47*10^{-05}$	$5.04*10^{-05}$	$5.10*10^{-05}$
3	90	$3.22*10^{-05}$	$3.23*10^{-05}$	$4.33*10^{-05}$	$4.50*10^{-05}$

Hydrology of the Study Area

Rainfall

The daily rainfall data observed at Tarhara Station situated nearby study area was analyzed. The annual average rainfall from 1984 to 2008 is 2006 mm.

Catchment area

The total catchment area of basin is delineated as 112 km^2 from ARCGIS using ARC Hydro. The digital elevation map is downloaded from http://srtm.csi.cgiar.org/ (2010). The catchment area is shown in Figure 7.

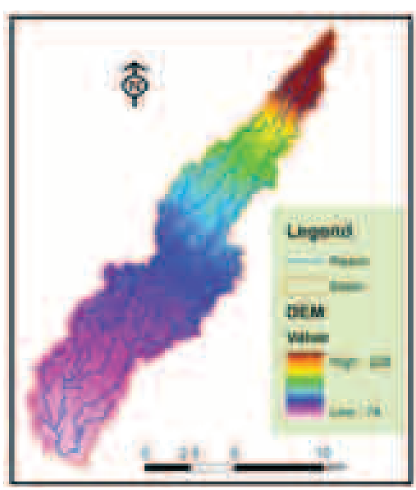


Figure 7: Catchment area of the basin (Budhi and Katle Khola)

High Flood Discharge

The high flood discharge was calculated from SCS method developed by His Majesty's Government of Nepal-Department of Irrigation, UNDP / World Bank (HMG-DoI/UNDP/WorldBank, 1990). It mainly includes the estimation of design daily rainfall and high flood discharge.

The design discharge for 50 years return period is 569 m^3/s. The design discharge considered during design was 550 m^3/s (CMS *et al.*, 1997). The calculated design discharge at present is quite close to that used in design.

MSeep Model Setup

Introduction to MSeep

MSeep model, Version 1.0 was first released by GeoDelft in 1988 and is being used for the two dimensional groundwater flow problems. In this research, MSeep model, version 6.7, developed in 2002 was used for the seepage analysis. Vertical two dimensional stationary groundwater flow in layered soil structures with boundary conditions is analysed by Cross section method in MSeep. An element mesh of iso-parametric triangles is created for the geometry (GeoDelft, 2002).

The cross section model in MSeep is based on Darcy's law and the continuity equation. Two dimensional steady flow in terms of Laplace equation used in MSeep is (GeoDelft, 2002),

$$\frac{\partial}{\partial x}\left(-K_x \frac{\partial \phi}{\partial x}\right) + \frac{\partial}{\partial y}\left(-K_y \frac{\partial \phi}{\partial y}\right) = Q \quad \text{...(8)}$$

Where ϕ is potential (piezometric head), *Kx* and *Ky* are permeabilities in *X* and *Y* directions and *Q* is the discharge of internal sources. Within MSeep, a negative discharge means an outflow which indicates that seepage occurs in that concerning nodal point. Finite element method is used to solve the Laplace equation.

Schematization

The schematization is done to represent the site condition as per the drawings and information found during the data collection. Different layers are created to represent different soil conditions as well as to represent the sheet piles. In contrast, extra layer is created at the end of sheet piles so that node exists at its end which gives the exact length of sheet pile as MSeep calculates the length of sheet pile to its nearest node.

<u>Material Properties</u>

Coarse sand/ fine to medium gravel

The permeability of coarse sand with gravel is taken as 1E-4 m/s (Harr, 1962) for both the upstream and downstream portion. The D60 is taken as 12.5 mm. The porosity and saturated bulk density are taken as the average of sand and gravel for both the upstream and downstream portion. The porosity values are taken as the average of gravel and sand which is 0.415 for both upstream and downstream portion. The saturated bulk density for upstream is 17.1 kN/m^3 and 17.7 kN/m^3 for downstream.

Sand

The horizontal and vertical permeability used for upstream sand was 51.14E-6 m/s and 50.35E-6 m/s respectively. The porosity of 0.48 and saturated bulk density of 16.2 kN/m^3 were used. The D60 was 0.48 mm. Similarly, the horizontal and vertical permeability of downstream loamy sand was 34.7E-6 m/s and 32.7E-6 m/s respectively. The values of porosity, saturated bulk density and D60 used were for calculation were 0.48, 17.4 kN/m^3 and 0.21 mm respectively.

Gravel filter

The average permeability of gravel is 11.6E-3 m/s or 1000 m/day (Zhou, 2009). The average porosity of gravel is 0.35 (USACE, 1999). The D60 and saturated bulk density are taken as 25 mm and 1800 kg/m^3 respectively.

Gabion works with boulder filling

As the permeability of stones having diameter 100-300 mm is 0.3 m/sec (USACE, 2006), the permeability of gabion works with stone filling was also taken as 0.3 m/s. The porosity of gabion works used was 0.3 (http://www.erosioncontrol.com/november-december-2003/gabions-for-erosion-2.aspx, 2011). The D60 and saturated bulk density for gabion works with boulder filling were considered to be 250 mm and 2200 kg/m^3 respectively.

Concrete blocks

The permeability of concrete blocks with gaps in between is calculated considering it as the rocks and joints in between them. The permeability of concrete blocks with gaps in between has been determined assuming it as a rock and joints in between the rocks. Fracture characteristics of rock mass such as rock quality designation (RQD), joint number (Jn), joint roughness (Jr), joint hydraulic conductivity (Jk), joint aperture factor (Jaf) and joint water factor (Jw) were assigned a numerical value depending up on fracture properties and hydropotential value is obtained from them which is again modified into permeability (Gates, 2002).

For cross sectional area of 5.5 m x 1.0 m for under-sluice portion as per as built drawings, the permeability is 1.19E-5 m/s. Similarly, for cross sectional area of 4.5 m x 1.0 m for weir portion as per as built drawings, the permeability is 1.45E-5 m/s. Considering the gap in the joints as 10-20 mm, the porosity of 0.03 is taken. The saturated bulk density is considered as 2400 kg/m^3.

Boundary Conditions

The maximum water depth at the upstream is 4.5 m. So boundary conditions for upstream is given considering water depth of 4.5 m. From geological analysis of study area, the impervious layer is kept at 33 m below the upstream river bed. No flow boundary condition is taken to represent impervious layers. For the downstream portion, water level at the river bed level is considered which follows the boundary with potential with the elevation equals river bed level elevation with respect to impervious layer of aquifer. Boundary conditions for nodes were given accordingly to represent flow or no flow condition.

To analyse the seepage from Jala Khola, a section along the weir portion, under-sluice portion, abutment wall and Jala Khola is considered. The location of Jala Khola 200 m far from headwork site which is the original flow point of the river towards headwork is considered for analysis. This location was chosen as it is preferable for the river to flow in the pre-existing path. The bed level and water level at this location are given as boundary conditions for Jala Khola. As the critical condition for seepage at headwork site is for non flooding season, maximum water level at the Jala Khola during non flooding season is given as the boundary condition. The bed level of Jala Khola at this location as obtained during site visit is 67.70 m amsl. As per local people and member of water users' association, the maximum water level during non flooding season at that location is 1.25 m. So, water depth of 1.25 m is taken for analysis.

Optimization of grid size and river bed length

The Finite element model requires optimization of the element size (grid size). As the minimum element size for maximum exit gradient is found as 0.7 m x 0.7 m, the element size of 0.7 m x 0.7 m is taken for the calculations.

The exit gradient increases until the river bed length is equal to 1.5 times the length of structure and there is no impact on exit gradient in further increment in length of river bed. So, the river bed length is considered as 1.5 times the length of structure.

Modelling for Different Scenarios

MSeep model was run for different scenarios to represent the site condition as different works were carried out in different time periods. Site condition after construction in 2000, after maintenance in 2000, 2009, 2010 were analysed and a new section is recommended. So, five different scenarios were analysed.

The model was run for sections of under-sluice portion and weir portion separately for the flow from upstream to downstream without considering lateral flow. Exit gradients for each section were calculated. The schematization for under-sluice portion without lateral flow is shown in Figure 8. The schematization for weir portion is shown in Figure 9. Different types of materials are shown in different layers. Each layer has its own colour as shown in legend in respective figure. The sheet piles are denoted by vertical green lines. Water levels at upstream and downstream are denoted by horizontal blue lines.

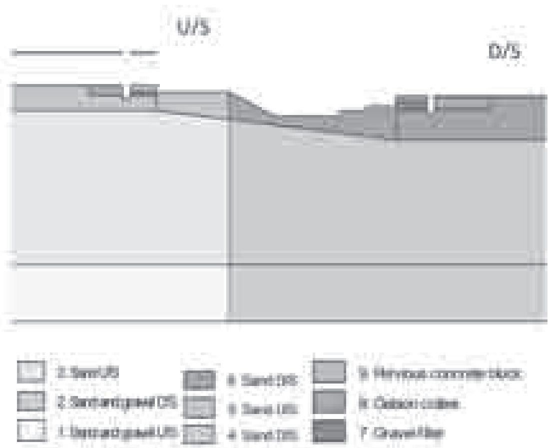


Figure 8: Schematization for under-sluice portion without lateral flow for Scenario-I

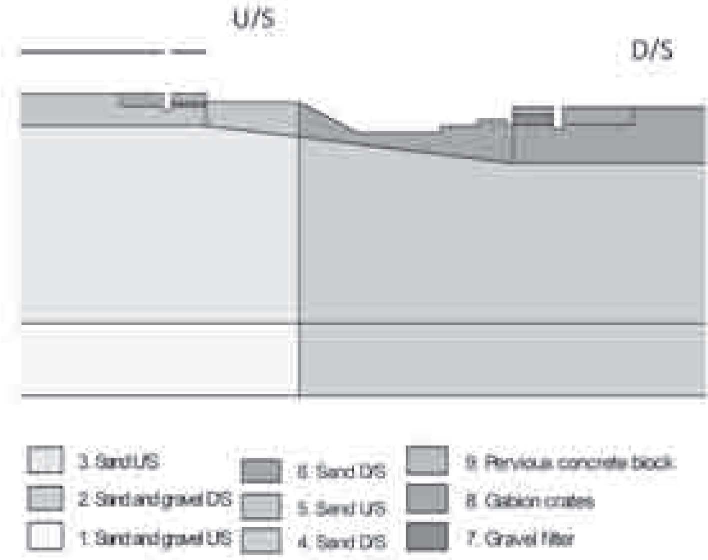


Figure 9: Schematization for weir portion for Scenario-I

For the lateral flow consideration, section along weir portion - under-sluice portion - abutment wall - Jala Khola was considered in upstream weir crest line. The potential (residual head) obtained above from weir portion at the line of weir crest beneath the upstream floor is used for the boundary condition for the seepage analysis along weir portion - under-sluice portion - abutment wall - Jala Khola. The river bed and water level in Jala Khola were the boundary condition for Jala Khola end. The schematization for lateral flow consideration is shown in Figure 10.

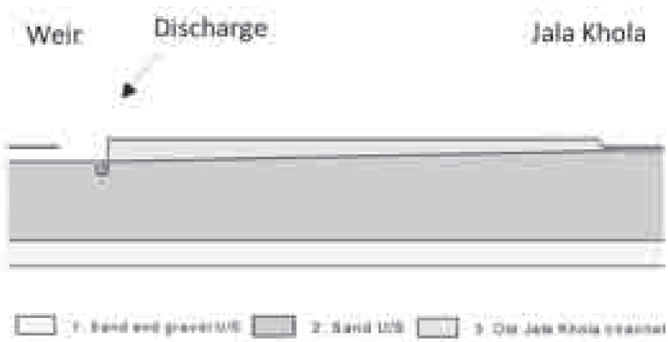


Figure 10: Schematization for lateral flow consideration for Scenario-I

The seepage discharge outgoing from the system from under-sluice portion was simulated until the potential beneath the under-sluice portion from this condition is equal to the potential from upstream to downstream without considering seepage.

This seepage discharge was added at the point at beneath weir crest at under-sluice portion for the flow from upstream to downstream along the under-sluice portion. When a discharge point is added in MSeep, this discharge goes all around the point (even in to upstream of the point). In reality, it does not go to upstream. So, the discharge point is given in sloping portion of weir to reduce this effect. From this, exit gradient at the under-sluice portion was obtained considering lateral flow. The schematization is shown in Figure 11.

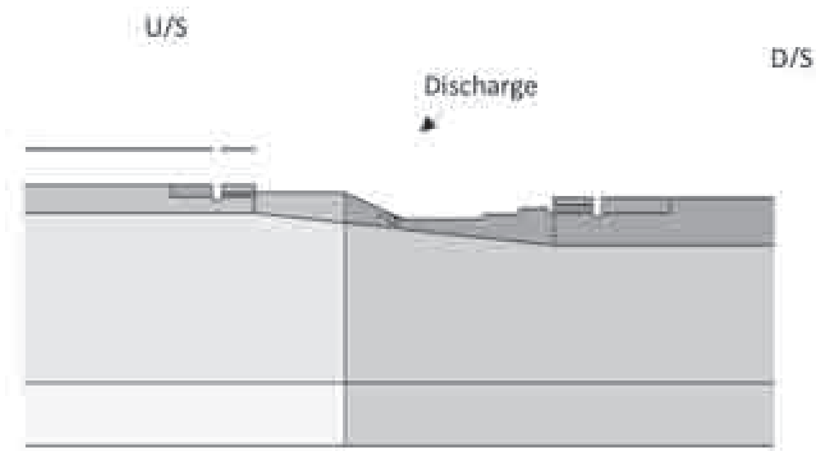


Figure 11: Schematization for under-sluice portion with lateral flow for Scenario-I

Results and Discussion

Scenario-I: As Built Condition in 2000

For undersluice portion, the residual head beneath the structure at the upstream of weir crest line was 35.906 m. The exit gradient at under-sluice portion without considering lateral flow was calculated as 0.151 which is below the maximum theoretical permissible exit gradient i.e. 0.154. This shows that the structure was safe if there was no lateral seepage discharge.

The exit gradients in weir portion with and without upstream sheet piles were 0.144 and 0.146 respectively. The residual head beneath the structure without upstream sheet pile is 36.326 m at the upstream of weir crest line which was used for boundary condition to consider lateral flow.

The residual head at the weir portion (36.326 m) is higher than residual head at the under-sluice portion (35.906 m). This shows that there is possibility of seepage flow from weir portion to under-sluice portion. As the sheet piles near the divide wall in weir portion were not found during upstream floor excavation in 2010, this became a favourable condition for the seepage flow to enter into the under-sluice portion from weir portion.

The higher equipotential values near Jala Khola clearly indicate that seepage flow occurs from Jala Khola towards the structure. Although the Jala Khola was diverted towards east after headwork construction, there is possibility of seepage since impervious barrier was not provided at the bank of Jala Khola.

Lateral discharge flow into the under-sluice portion was found from trial and error until the residual head beneath the under-sluice portion was same as that was found earlier, 35.91 m. The lateral discharge was 2.25E-5 m^3/s. The discharge, 2.25E-5 m^3/s obtained from lateral flow was then inserted into the under-sluice portion.

After the research conducted in the Kafrein dam in Jordan, it was concluded that the seepage water was mainly flowing through faulted bed rock and alluvium deposits beneath the abutment of dam; seepage water was originating from the location used as borrow area during construction, some 1 km upstream of dam (Malkawi *et al.*, 2000). Although the borrow area might have filled by sediments, there was seepage from this area. Similarly, seepage coming from Jala Khola was observed even though earth filling was done in its previous channel after the diversion.

Due to lateral flow, the head is increased and thus the exit gradient is increased from 0.151 to 0.163.

The theoretical minimum and maximum safe exit gradient limit for soil having specific gravity of 2.78 and porosity of 0.48 is;

Lower limit = (1-0.48) x (2.78-1)/7 = 0.132 (considering safety factor of 7)

Upper limit = (1-0.48) x (2.78-1)/6 = 0.154 (considering safety factor of 6)

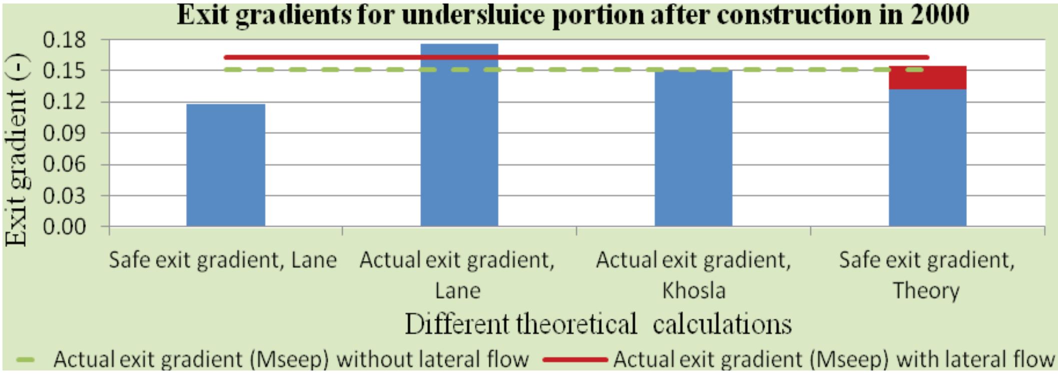


Figure 12: Comparison of exit gradients for under-sluice portion under Scenario-I

The exit gradient as per Lane is also greater than his safe recommended exit gradient. The red dark shaded area in Figure 12 for safe exit gradient, Theory is the maximum permissible exit gradient. Although the lower values of exit gradient are safe for structure, it increases the cost. The red shaded area is the range for economical constructions with safe structure. This shows that exit gradient without lateral flow is within the maximum safe limit. Exit gradient by Khosla does not consider the effect of lateral seepage flow. So, it is lower than the actual exit gradient. The actual exit gradient without lateral flow is almost same with the exit gradient by Khosla. As the maximum limit of safe exit gradient was exceeded with the lateral flow into the under-sluice portion, the structure might have failed due to piping action in 2000 during the commissioning period.

Exit gradients for weir portion are shown in Figure 13. It shows that the upstream sheet pile does not have vital role in reducing the exit gradient. It might be because of the bottom level of upstream cut-off wall and bottom of upstream sheet pile is only 0.60 m. The exit gradient, Lane is higher than recommended by him. The exit gradient from model is within the maximum theoretical permissible limit. Although the exit gradient is not much affected by the absence of upstream sheet pile, it might have provided a path for the seepage water to flow from weir portion to under-sluice portion. Since the residual head at the weir portion was greater than the residual head at under-sluice portion, the absence of upstream sheet pile might have become a favourable condition to flow seepage water into under-sluice portion. This was reflected at site as well at 2010 failure condition as hollow beneath the structure was expanded from under-sluice portion to the weir via this location.

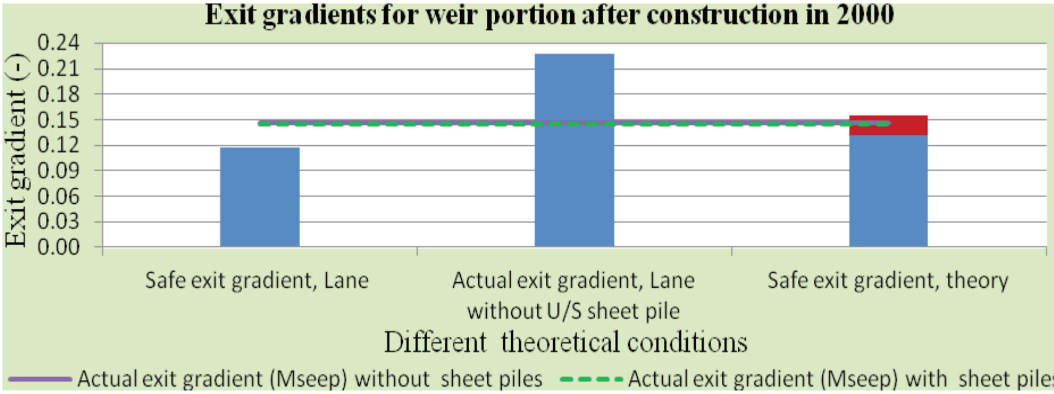


Figure 13: Comparison of exit gradients for weir portion under Scenario-I

Scenario-II: After Maintenance in 2000

The potential beneath the structure at the upstream of weir crest line had decreased from 35.906 m to 35.207 m. As in under-sluice portion, the residual head at weir portion beneath the structure without upstream sheet pile at the upstream of weir crest line had reduced to 35.481 m. The exit gradient without upstream sheet pile was 0.122.

The lateral seepage discharge was computed with same process as in scenario-I. The lateral seepage discharge was 1.95E-5 m^3/s. Because of lateral flow, the head in increased. The exit gradient is increased from 0.130 to 0.143 which is below the maximum theoretical permissible exit gradient.

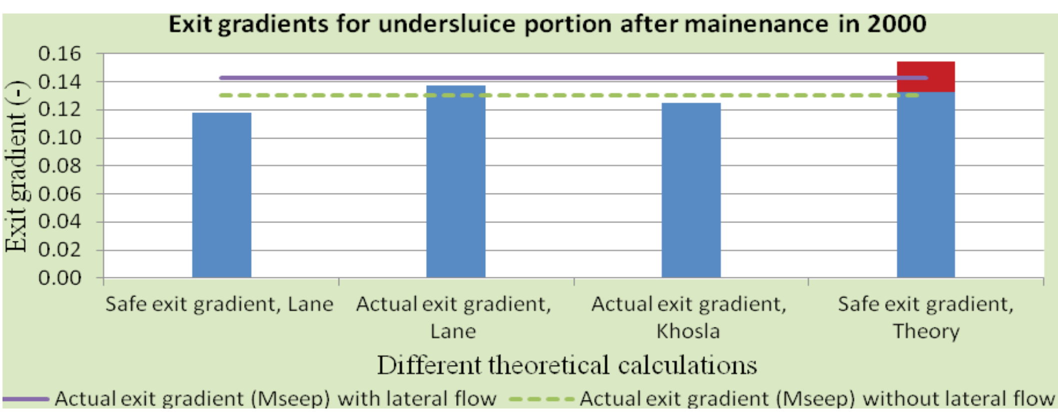


Figure 14: Comparison of exit gradients for under-sluice portion under Scenario-II

Figure 14 shows that the exit gradient according to Lane is greater than his safe recommended exit gradient. The actual exit gradient without considering lateral flow is slightly higher than exit gradient by Khosla. Both exit gradients are less than permissible theoretical exit gradient. Actual exit gradient with considering lateral flow is within the maximum theoretical permissible limit. As the maximum limit of safe exit gradient was not exceeded, the structure was safe. This result supports the site condition as the structure was functioning until 2009 after maintenance works in 2000. This shows that safe exit gradient by Lane assumes a higher safety factor.

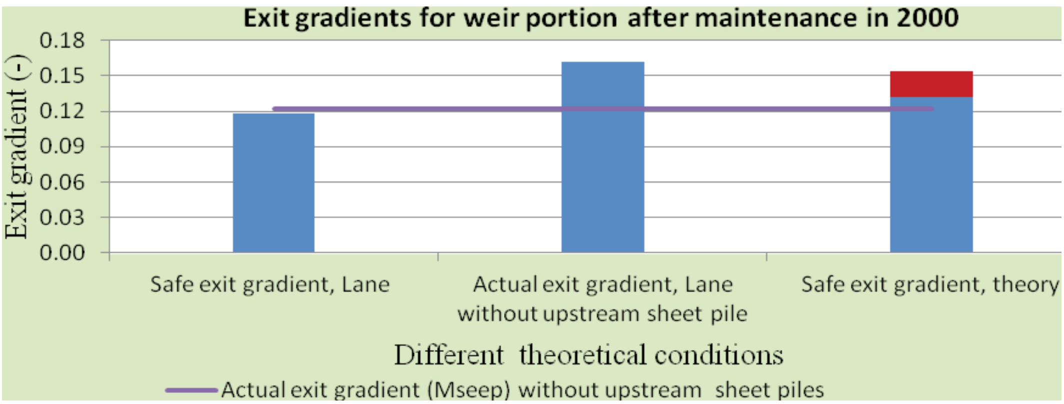


Figure 15: Comparison of exit gradients for weir portion under Scenario-II

From Figure 15, it is clear that the exit gradient, Lane is higher than recommended by him. In contrast, the exit gradient from model is within the safe theoretical permissible limit. It highly supports the site condition because the structure was functioning until 2009 after maintenance carried out in 2000. This illustrates that safe exit gradient by Lane assumes a high safety factor.

Scenario-III: After Maintenance in 2009

As shown in Figure 16, the exit gradient should have decreased after maintenance in 2009 if the soil parameters were same as previous in 2000. An exit gradient by Khosla (0.122) is slightly lower than the exit gradient by MSeep without considering lateral flow (0.126), both being less than permissible theoretical exit gradient. The lateral seepage discharge and actual exit gradient might be 2E-5 m^3/s and 0.140 respectively. Failure in 2010 should not have occurred in this situation as the exit gradient, 0.140 was within permissible limit. But, the headwork failure was seen in 2010 which indicates the change in soil parameters due to sub soil erosion by seepage water.

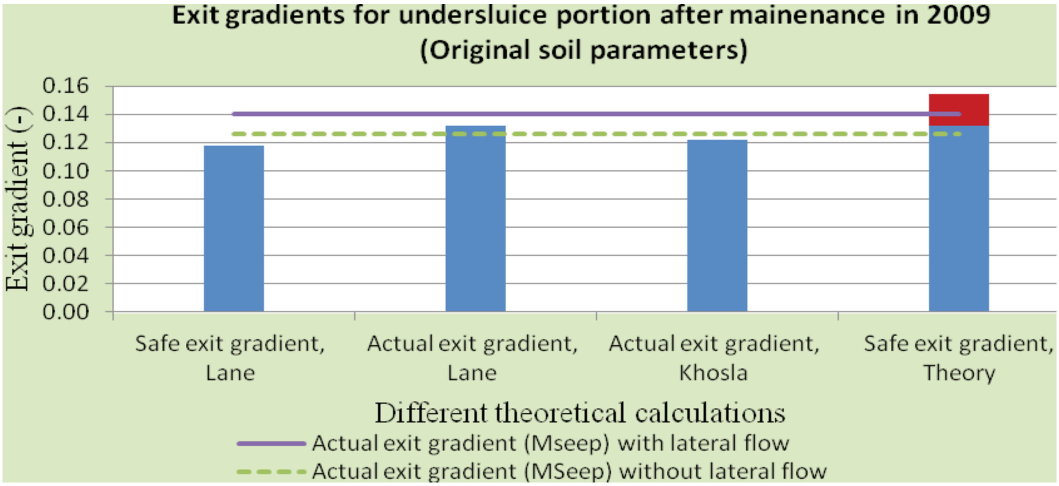


Figure 16: Comparison of exit gradients for under-sluice portion for Scenario-III (Original soil parameters)

Seepage discharge was increased and water boiling was seen in the downstream portion by experiments. The channel (cavity) size increases with higher seepage discharge (Pornprommin *et al.*, 2010). It might have made cavities beneath the structure.

So, new soil parameters as found in laboratory for relative density of 30% were used for analysis. In 2009, the horizontal and vertical hydraulic conductivities might have increased by 2.5 and 1.3 times than previous which reduced the rate of head loss and hence increased the exit gradient. Therefore, the structure was again failed at 2010 although there was a maintenance activity carried out in 2009.

The rise in reservoir water level in Ataturk dam probably eroded clay fillings in karstic limestone and ungrouted locations which resulted in the formation of hollow features and cavities (Unal *et al.*, 2007).

Seepage analysis carried out on Fordyce Dam, Sierra Nevada Mountains concluded that the measured seepage discharge of about 25 cubic feet per second can be achieved if the hydraulic conductivities of the concrete slab and cut-off wall are 25 times higher than that were initially estimated, or the hydraulic conductivity of alluvial channel is 10 times higher than that was initially estimated (Lee, et al., 2006).

The potential beneath the structure at the upstream of weir crest line was 35.897 m. The exit gradient without considering lateral flow is 0.159.The residual head beneath the structure without upstream sheet pile at the upstream of weir crest line was 36.065 m. The exit gradient without upstream sheet pile was 0.151.

The residual head in under-sluice portion (35.897 m) is lower than that at weir portion (36.065 m) and Jala Khola (36.45 m). The higher heads at weir and abutment portion made seepage water flow into under-sluice portion. The lateral seepage discharge was 1.7E-5 m^3/s.

As a result of lateral flow, the head is increased and thus the exit gradient is increased to 0.168. Figure 17 shows that the exit gradient according to Lane is slightly greater than his safe recommended exit gradient. The exit gradient by MSeep without considering lateral seepage flow is much higher than exit gradient by Kholsa. This is due to the fact that Khosla theory does not consider the effect of change in soil parameters like hydraulic conductivity, porosity. So, there is no change in exit gradient by Khosla. Exit gradient with lateral flow (0.168) is above the maximum theoretical permissible limit (0.148). At site, the structure was failed in 2010 because of the exit gradient exceeded the maximum limit of safe exit gradient.

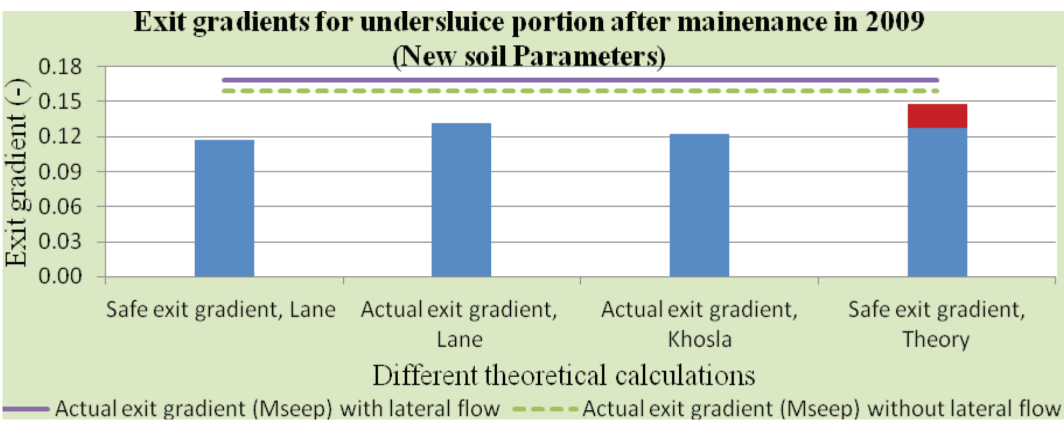


Figure 17: Comparison of exit gradients for under-sluice portion for Scenario-III (New soil parameters)

Exit gradients for weir portion are shown in Figure 18. The exit gradient, Lane is higher than recommended by him. The exit gradient from MSeep (0.151) is also higher than the maximum theoretical permissible limit (0.148) which made the structure fail in 2010.

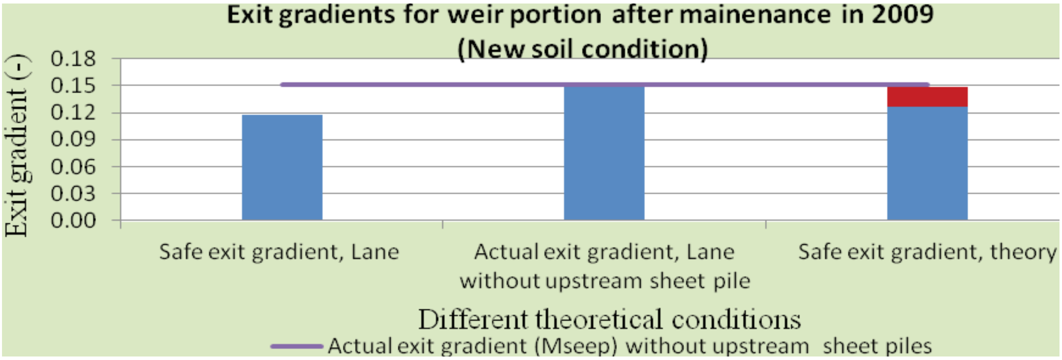


Figure 18: Comparison of exit gradients for weir portion for Scenario-III (New soil parameters)

Scenario-IV: After Maintenance in 2010

After the maintenance work of 2010, the hydraulic conductivity and porosity of sub soil decreases. Different exit gradients for under-sluice portion are shown in Figure 19 considering the soil parameters might have reached into original condition as in 2000. The graph shows that the structure is safe if the soil parameters have reached into original condition as in 2000. The structure is safe for all exit gradients. The exit gradient by MSeep without lateral flow (0.131) is almost same with exit gradient by Khosla (0.134) as the soil parameters are taken as in 2000. The exit gradient with lateral flow is 0.138.

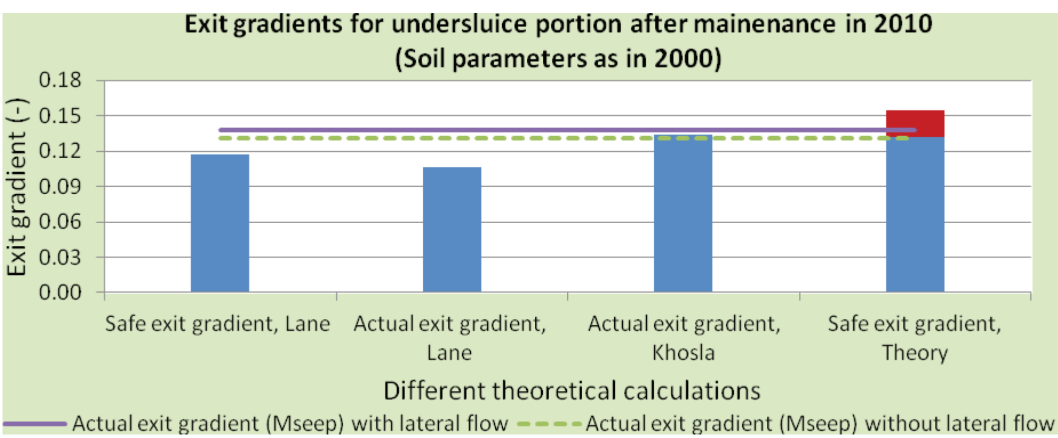


Figure 19: Comparison of exit gradients for under-sluice portion for Scenario-IV (Original soil parameters)

Grouting improves the physical characteristics of the surrounding rock mass which mainly increases the rock mass stiffness and reduces the rock mass permeability (Marence, 2008). Furthermore, permeability can be decreased up to 20 times by consolidated grouting (Marence *et al.*, 2005).

In addition, the efficiency of grout curtain improved in Ataturk dam after additional grout treatment since there was no increase in leakage and a relative decrease as compared to former measurements (Unal *et al.*, 2007). Grouting work was carried out in three different phases in Chanda Mohana Irrigation Scheme in 2010. So, the efficiency of grouting might have been increased and thus the hydraulic conductivity might have decreased after grouting works.

Although about 53,336 kg of grouting material was consumed on the right side of dam below 20 m depth and about 5,666 kg was consumed on the left side of Kafrein dam. It was concluded that the seepage water was mainly flowing through faulted bed rock and alluvium deposits beneath the abutment of dam; seepage water was originating from the location used as borrow area during construction, some 1 km upstream of dam and little seepage contributed by left abutment (Malkawi *et al.*, 2000).

In addition, though 825 tons of cement, 28 tons of bentonite, 4.8 tons of sand and 0.2 tons of sodium silicate has been used for the grouting operations in Kalecik dam, it was concluded that the leakage path moved towards the spillway from dam embankment but the total discharge of the springs did not change (Turkmen, 2003).

Furthermore, drilling and grouting (1989 to 2003) with 17,700 kg of cement, bentonite and sand were done on left side up to 35 m depth in the Armagan dam, Kirklareli, northwestern Turkey. Research showed that grouting on left bank was not completely successful (Ünal *et al.*, 2008). This shows that grouting is not always fully successful to control the seepage problems.

About 175,000 kgs of cement was used to make cement slurry and was sent by pressure grouting in the headwork of Chanda Mohana Irrigation Scheme. The technicians involved in maintenance work claimed that the hollow formed areas are now more or less completely filled. According to Curt, *et al.* (2011), visual inspection (like cracking, differential movements, seepage, surveillance, sinkhole formation etc) is a key item of visual assessments during dam reviews. The construction techniques in developing countries like Nepal are not of high quality. For the safety of structure, the soil parameters after pressure grouting with cement slurry is assumed as medium with respect to the original condition and the condition at the time of failure in 2010. The horizontal and vertical hydraulic conductivities for sand upstream were assumed as 8.86E-5 m/s and 5.87E-5 m/s and for downstream sand as 3.61E-5 m/s and 3.35E-5 m/s respectively. The porosity for upstream and downstream was considered as 0.49.

There is head loss due to new sheet pile at the upstream. In contrast, there is not much effect of new sheet pile at the downstream end. This is logical as the distance between these two piles is only 2 m, stream lines do not reach up to the bottom of impervious floor in the space between two piles. Thus, there is not much head loss in between two sheep piles as it was expected. The exit gradient without lateral flow is 0.147. The potential beneath the structure at the upstream of weir crest line is 36.00 m. Optimization on sheet pile spacing shows that at least 5 m of spacing between two sheet piles results in the head loss between them.

The residual head beneath the structure without upstream sheet pile at the upstream of weir crest line was 36.131 m. Although the additional downstream sheet pile is near to the existing one, as it is deeper than the existing, its effect can be seen. Thus, there is no head loss in between two sheep piles. The exit gradient without upstream sheet pile reduced to 0.116.

Lateral flow is now analysed with additional sheet pile under abutment wall after maintenance in 2010. The higher heads at weir portion (36.131 m) and Jala Khola (36.45 m) than in under-sluice portion (36.00 m) had caused the lateral flow into under-sluice portion.

Due to flow barrier, the seepage discharge has decreased. The lateral seepage flow is 1E-5 m^3/s. Due to additional impervious floor and sheet piles both in upstream and downstream as well as improved soil parameters; the exit gradient at under-sluice portion with seepage discharge is 0.152.

For the porosity of 0.49 and specific gravity of 2.78, theoretical minimum and maximum safe exit gradient limit is;

Lower limit = (1-0.49) x (2.78-1)/7 = 0.130 (considering safety factor of 7)

Upper limit = (1-0.49) x (2.78-1)/6 = 0.151 (considering safety factor of 6)

The comparison of exit gradients for under-sluice portion is shown in Figure 20. As new soil parameters were considered in modelling, the exit gradient without later seepage is much higher than exit gradient by Khosla. The structure seems to be safe from Khosla exit gradient. But, it has not considered the lateral flow as well as effect of change in values of soil parameters. The vertical distance of sheet piles in inner sides is taken to calculate the lane's exit gradient though the stream line do not reach up to floor level in between the downstream sheet piles which can not be known from Lane's theory. It tells us that the exit gradient by Lane is less than the recommended which is safe for structure. The exit gradient including seepage flow is slightly above the maximum theoretical permissible limit. This shows that the structure is still at the verge of failure.

Although major maintenance works were carried out three times after the completion of the headwork, the results show that it is still not safe. If the higher safety factor than that recommended by Khosla had taken for seepage analysis during the design, the structure would not have failed.

It is difficult and quite expensive to control the quantity of seepage that occurs after construction (Uromeihy *et al.*, 2007). The repeated maintenance works due to lower safety factor cost more than one time construction cost resulting from higher safety factor. As the structure is not fully safe even after maintenance in 2010, further additional maintenance works are recommended under Scenario V.

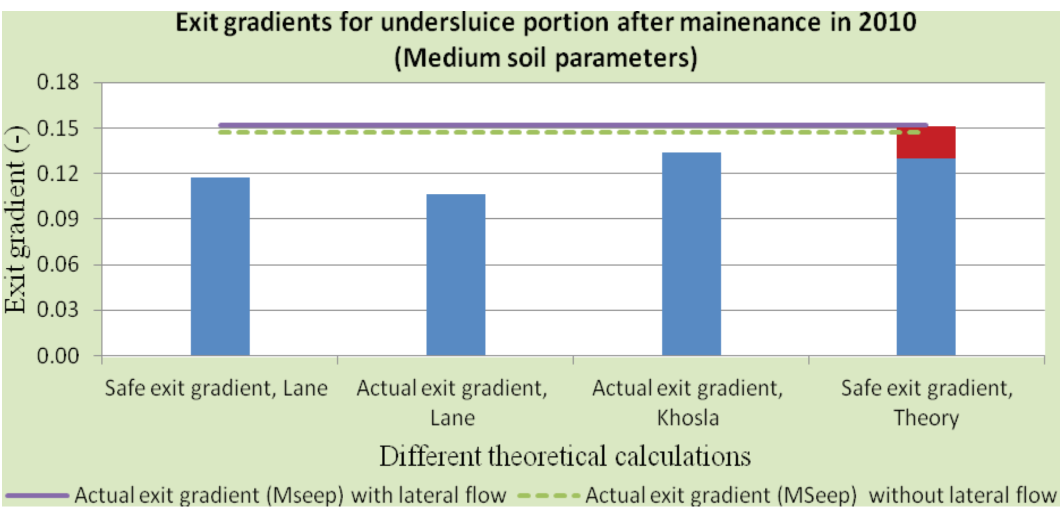


Figure 20: Comparison of exit gradients for under-sluice portion for Scenario-IV (Medium soil parameters)

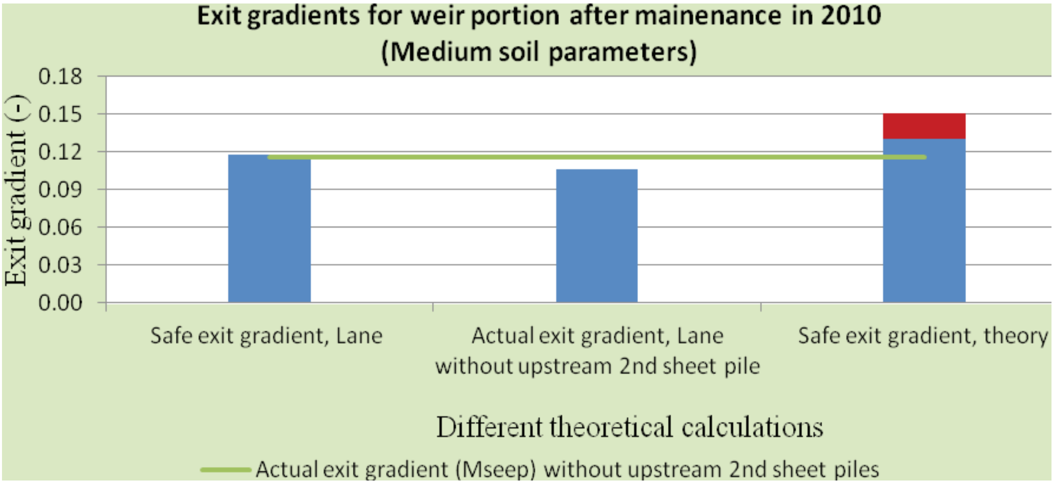


Figure 21: Comparison of exit gradients for weir portion for Scenario-IV (Medium soil parameters)

Figure 21 shows that exit gradient by Lane is less than the recommended exit gradient in the weir portion. In addition, exit gradient from MSeep is also less than theoretical permissible exit gradient after maintenance in 2010. This shows that further maintenance works are not needed for weir portion. So, no maintenance works are suggested for weir portion.

Scenario-V: Proposed Maintenance Works

From Scenario-IV, it is seen that maintenance works are needed in under-sluice portion for the safety of the structure. So, additional maintenance works are proposed herewith.

Instead of the pervious concrete blocks at the downstream of under-sluice portion, impervious concrete floor is considered with additional sheet pile up to the same depth as existing sheet pile depth. At the downstream of additional sheet pile, pervious concrete blocks of 10 m length above gravel filter as proposed in 2010 is analysed. Now, the stream lines reach up to the bottom of impervious floor in between existing and additional sheet pile. It is due to increased distance between the existing and additional sheet piles. The potential beneath the structure at the upstream of weir crest line in under-sluice portion is 36.146 m. So, lateral seepage flow is calculated using residual head of 36.146 m at under-sluice portion and 36.131 m in weir portion. Additional maintenance works at weir portion is not suggested as it is already safe.

The residual heads at weir portion and under-sluice portion are almost the same. In contrast to the previous scenarios, the difference in residual heads at weir portion, under-sluice portion and abutment wall is not much different. This reduced the lateral seepage flow as the head difference is less. The lateral seepage flow is 9.5E-7 m^3/s. This seepage discharge is too less in comparison to the previous scenarios. The exit gradient with lateral seepage flow is 0.127 which is below the safe permissible theoretical exit gradient.

Two more alternative analyses were made. They are:

- Additional impervious floor and sheet pile at upstream instead of at the downstream;
- Additional impervious floor and sheet pile both at upstream and downstream.

The comparison of exit gradients is shown in Figure 22.

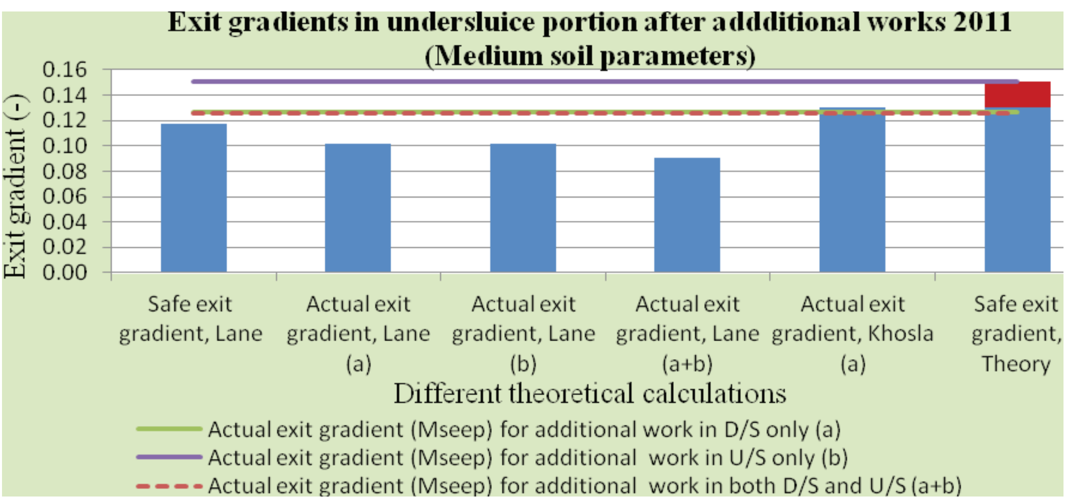


Figure 22: Comparison of exit gradients for under-sluice portion for Scenario-V

Figure 22 shows that there is no significant reduction in exit gradient due to additional work in upstream portion. The sheet piles at upstream mainly reduces pressure at the upstream floor. The upstream pile has little effect in reducing the pressures at the downstream portion as the spacing of the upstream and downstream sheet piles is generally much more than the range of influence of either (Khosla *et al.*, 1962). This argument is supported by Figure 22. As the additional work in upstream as well as in both upstream and downstream is not effective to reduce the exit gradient, it will be more economical to implement additional work in downstream portion only. Therefore, additional impervious downstream floor and sheet pile is necessary for the safety of the structure.

Conclusions and Recommendations

After the results and discussions, conclusions and recommendations are made based on the findings of the analysis. The conclusions and recommendations are as follows:

Conclusions

1. In the headwork structure with weir portion and under-sluice portion, the residual head in lateral direction along the weir axis may not be the same due to different floor length in weir portion and under-sluice portion. The difference in residual head becomes a favourable condition for lateral seepage flow.

2. Although the Jala Khola was diverted into new channel, there is seepage flow from new Jala Khola channel to the headwork. This shows that the flow path before diversion becomes a preferable seepage flow path for the river if impervious barriers are not provided.

3. The headwork structure as built in 2000 was safe if there was no lateral seepage flow. Due to total lateral discharge of 2.25E-5 m^3/s from weir portion as well as from Jala Khola, the exit gradient at the under-sluice portion increased from 0.151 to 0.163, exceeding the maximum permissible safe exit gradient of 0.154. As a result of this, the failure was seen in commissioning period in 2000.

4. After the maintenance works in commissioning period 2000, the exit gradient in under-sluice portion is reduced to 0.143 which is less than the maximum permissible exit gradient, but is still higher than the minimum recommended. As the exit gradient is below maximum permissible exit gradient, the structure was functioning until 2009.

5. Soil parameters might have changed until 2009 due to subsoil erosion. The horizontal and vertical hydraulic conductivities might have increased to about 2.5 and 1.3 times greater respectively with respect to 2000. This reduced the rate of head loss. Due to lateral seepage discharge of about

1.7E-5 m^3/s and reduced rate of head loss, the structure failed within one year after the maintenance in 2009.

6. The ongoing maintenance work from 2010 is only safe if the pressure grouting improved the soil parameters as that in 2000 which is often not possible. The structure is still at the verge of failure considering the soil parameters as medium with respect to that in 2000 and in 2009.

7. Additional impervious floor of 9 m length with sheet pile of 4 m depth is necessary at downstream for the safety of the structure.

Recommendations

1. The results showed that there is seepage water flow from Jala Khola to headwork. So, it is necessary to reduce this seepage flow. Impervious barrier nearby Jala Khola bank might be effective in reducing the seepage discharge from Jala Khola. Providing filter material nearby abutment wall could help for safe exit of seepage water from Jala Khola.

2. The results from the MSeep model suggested that the current ongoing maintenance work is not still safe from failure of headwork. Therefore, the findings of the research strongly recommend to have an additional impervious floor of 9 m with sheet pile of 4 m depth at of the downstream of the headwork.

3. Khosla method is adopted instead of MSeep model in general practice of seepage analysis in Nepal. However, a factor of safety provided by Khosla (1962) could not be considered if there is a lateral seepage flow. Therefore, it is recommended to use higher factor of safety than in current practice for considering lateral seepage flow.

4. Although it was not a part of research analysis, the construction equipments and techniques largely affect the quality of the work. Generally, sheet piles are manually inserted below the foundation. It is difficult to insert the sheet piles manually into higher depth. During the sheet pilling works, joints between the sheet piles may not be fully water tight. The sheet pile may not go vertically downward everywhere when it is done manually. The deflection of sheet pile at higher depth increases the gap between the sheet piles. Furthermore, seepage water may pass through this gap. This process reduces the creep length and the rate of head loss decreases. In addition, the

exit gradient increases. It could be better to adopt mechanical method of sheet piling.

Further Research

1. The results depicted that although the Jala Khola was diverted into new channel, there is seepage flow from new Jala Khola channel to the headwork. This seepage problem becomes 3-dimensional when lateral seepage flow is also considered. As 2-D model is a simplification of 3-D problems, seepage analysis by 3-D model could be a way forward for more accurate analysis.

2. Water chemistry, dye tracer method etc might be useful to estimate lateral seepage discharge at the field level.

3. The time dependent relation of sub soil erosion with varying exit gradient should be investigated to understand the relation among them.

4. The conclusions made in this research are from a case study of Chanda Mohana Irrigation Scheme, Nepal. However, the problem associated with seepage failure is common in other irrigation schemes in Nepal. Therefore, further research is required to explore seepage analysis in other irrigation schemes of Nepal. The outcome of further research from various schemes can provide a guideline to make a general conclusion for seepage failure in irrigation schemes in Nepal.

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References

Bhattarai, T. N. (1988). Groundwater Studies in Parts of Morang District, Koshi Zone, Eastern Nepal. *Master's Thesis in Geology, The Central Department of Geology, Kirtipur Multiple Campus, Kirtipur, Nepal*.

CMIP. (2001). Seepage Problem on Headworks of Chanda Mohana Irrigation Project. *Eastern Regional Irrigation Directorate, Chanda Mohana Irrigation Project, Biratnagar, Nepal.*

CMIP. (2009). Piping Problem in the Headworks of Chanda Mohana Irrigation Project. *Eastern Regional Irrigation Directorate, Biratnagar, Nepal.*

CMS, & TAEC. (1997). Detailed Engineering Works of Chanda Mohana Irrigation Project, Sunsari. *Consolidated Management Services (CMS) Nepal (P) Ltd In association with TAEC Consult (P) Ltd, Kathmandu, Nepal., Volume I: Main Report*.

Curt, C., Talon, A., & Mauris, G. (2011). A dam assessment support system based on physical measurements, sensory evaluations and expert judgements. [doi: DOI: 10.1016/j.measurement.2010.09.042]. *Measurement, 44*(1), 192-201.

Foster, M., Fell, R., & Spannagle, M. (2000). The Statistics of Embankment Dam Failures and Accidents. [doi:10.1139/cgj-37-5-1000]. *Canadian Geotechnical Journal, Volume 37*(5), 1000–1024

Gates, W. C. B. (2002). The Hydro-Potential (HP) Value: a Rock Classification Technique for Estimating Seepage into Excavations. *Kleinfelder, Inc, 2405 140th Ave. NE Bellevue, WA, USA*.

GeoDelft. (2002). MSeep User MAnual. *Release 6.7, November 2002*.

Google-Earth. (2010). *Photo taken on 4th Apr. 2010, Available on 9th Oct.2010*.

Harr, M. E. (1962). Groundwater and Seepage. *McGraw-Hill Book Company, Inc.*

HMG-DoI/UNDP/WorldBank. (1990). Hydrology and Agro-meteorology Manual, M3. *Department of Irrigation, Nepal*.

http://srtm.csi.cgiar.org/. (2010). *Available on 29th Oct. 2010*.

http://www.damsafety.org/news/?p=412f29c8-3fd8-4529-b5c9-8d47364c1f3e. (2010). *Available on 8th Oct. 2010*.

http://www.doanepal.gov.np. (2010). *Available on 5th July 2010*.

http://www.erosioncontrol.com/november-december-2003/gabions-for-erosion-2.aspx. (2011). *Available on 27th Jan 2011*.

Kanzler, A., & Shrestha, R. (1989). Shallow Ground Water Explorations in Terai, Sunsari District. *GWRDB-UNDP Project NEP/86/025, Technical Report No.10, Kathmandu.*

Khosla, R. B. A. N., Bose, N. K., & Taylor, E. M. (1962). Design of Weirs on Permeable Foundations. . *Central Board of Irrigation and Power, Publication No. 12, India*

Lee, S. S., & Yamashita, T. (2006). Finite-Difference Method Three Dimensional Model for Seepage Analysis through Fordyce Dam. *Advances in Geosciences, Volume 6: Hydrological Science*.

Malkawi, A. I. H., & Al-Sheriadeh, M. (2000). Evaluation and rehabilitation of dam seepage problems. A case study: Kafrein dam. [doi: DOI: 10.1016/S0013-7952(99)00117-9]. *Engineering Geology, 56*(3-4), 335-345.

Marence, M. (2008). Numerical modelling and design of pressure tunnels. *Proceedings of Hydro 2008, Ljubljana, Slovenia.*

Marence, M., & Oberladstatter, A. (2005). Design of pressure tunnels of hydro power plant Ermenek. *ITA Conference, 2005, Istanbul.*

Moayedi, H., Huat, B. B. K., Moayedi, F., Ali, T. A. M., Parvizifard, A., & Moghaddam, A. A. (2011). 23 Years Water Level Monitoring Through Earthfill Dam (Case Study). *The Electronic Journal of Geotechnical Engineering, 16, Bund. A*, 41-58.

Pornprommin, A., Takei, Y., Wubneh, A. M., & Izumi, N. (2010). Channel inception in cohesionless sediment by seepage erosion. [doi: DOI: 10.1016/j.jher.2009.10.011]. *Journal of Hydro-environment Research, 3*(4), 232-238.

Pradhan, P. (1988). Patterns Of Irrigation Organization A Case Study of 21 Farmer-Managed Irrigation Systems. *IIMI*.

Prasad, S. (2010). An Inception Report on The Rehabilitation and Restoration of The Headworks of the Chanda Mohana Irrigation Project, Sunsari. *Department of Irrigation, Nepal*.

Richards, K., & Reddy, K. (2007). Critical appraisal of piping phenomena in earth dams. [DOI: 10.1007/s10064-007-0095-0]. *Bulletin of Engineering Geology and the Environment, 66*(4), 381-402.

Schultz, B., Tardieu, H., & Vidal, A. (2009). ROLE OF WATER MANAGEMENT FOR GLOBAL FOOD PRODUCTION AND POVERTY ALLEVIATION. [DOI: 10.1002/ird.480]. *Irrigation and Drainage, 58: S3-S21*

Turkmen, S. (2003). Treatment of the seepage problems at the Kalecik Dam (Turkey). [doi: DOI: 10.1016/S0013-7952(02)00225-9]. *Engineering Geology, 68*(3-4), 159-169.

Ünal, B., Çelik, M., & Yildirim, T. (2008). Evaluation of seepage problems of the Armağan Dam, Kirklareli, northwestern Turkey. [DOI: 10.1007/s10064-008-0141-6]. *Bulletin of Engineering Geology and the Environment, 67*(3), 335-344.

Unal, B., Eren, M., & Yalcin, M. G. (2007). Investigation of leakage at Ataturk dam and hydroelectric power plant by means of hydrometric measurements. [doi: DOI: 10.1016/j.enggeo.2007.02.006]. *Engineering Geology, 93*(1-2), 45-63.

Uromeihy, A., & Barzegari, G. (2007). Evaluation and treatment of seepage problems at Chapar-Abad Dam, Iran. [doi: DOI: 10.1016/j.enggeo.2007.01.012]. *Engineering Geology, 91*(2-4), 219-228.

USACE. (1999). Engineering and design, Groundwater hydrology. *Department of the Army, U.S. Army Corps of Engineers, , Manual no. 1110-2-1421*.

USACE. (2006). Typical Value of Permeability for Stone Materials. *U.S. Army Corps of Engineers,, http://chl.erdc.usace.army.mil/Media/2/0/8/CEM_Part-VI_Chap-5-pt2.pdf*.

Zhou, Y. (2009). Applied Groundwater Modelling. *LN0418/09/1, UNESCO-IHE, Institute for Water Education, Delft, the Netherlands*.

Inter Basin Water Transfer: Opportunity & Challenge

K. Belbase and A.B.Khanal

SDE, Department of Irrigation

Abstract

Inter basin transfer is the process of diverting water from water excess basin to the water deficit basin. In water excess basin there is very low water demand and water is flowing without any utilization whereas, in water deficit basin there is very high water demand for agricultural and economic use. So, it is very purposeful to transfer water from excess to deficit basin.

Till now, we have developed irrigation infrastructure to irrigate 1.252 million ha and year round irrigation is provided only for 0.576 million ha. It is only 46% of total irrigated area. Considering, the availability of water throughout the year, the intensity of irrigation in surface irrigation system in Nepal ranges from about 90% in summer to 29% in spring season. It is due to the variation of river flows throughout the year. The situation is not supportive in future because of erratic rainfall due to climate change.

The population of the country is increasing at a rate of 2.25% annually and the agricultural land is shrinking due to construction of buildings. It is very essential to increase the agricultural productivity to feed growing population. Irrigation is the prime input for increasing the agricultural productivity.

Terai belt is fertile land for agricultural production. Reliable irrigation throughout the year is now necessary in terai belt to prevent the future generation from destitute.

At present, department of irrigation has studied six inter basin transfer project at different levels. Implementation of these six inter basin transfer project will provide about 0.390 million ha to reliable and year round irrigation. Generation of power is the secondary benefit and income obtained from selling produced electricity is sufficient for the maintenance of constructed infrastructure of medium to large irrigation projects.

So, inter basin transfer is the greater opportunity for irrigation department to show competent of its technician and to provide reliable irrigation throughout the year. There are many challenges regarding the implementation of project. The major challenge is the most of the tunnel have to be excavated through fragile land of chure range and is complicated. The lower riparian issue may arise during construction period and this issue cannot be neglected.

1. Introduction

About 2.64 million hectare of land in the country is under cultivation of which about 1,194,628 ha million hectares have irrigation facilities which are about 45 % of total cultivated area and remaining area is under rain-fed cultivation. Most of the existing systems developed so far draw water from small to medium type of rivers which dry up during winter and summer. These systems, therefore, suffer from deficit water during winter and summer. This results to dependence on rainfall even in areas having irrigation infrastructure. This situation has hindered expected growth of agriculture production.

Based on annual availability, Nepal is one among the countries having abundant water resources. It is estimated that about 234 billion cu. m of surface and ground water is available annually. Less than 8 % of available water has been so far utilized in the country. The temporal distribution of water availability seems problematic. About 80 percent of the annual rainfall occurs during the monsoonal months of June to September which is reflected consequently in terms of high flood discharge during these months. The remaining rainfall occurring during the rest of the months of the year seems highly erratic and is not dependable for agriculture. High Himalayan Mountains serve as water reservoir which store water and release it during pre-winter and summer months. This provides great opportunities to make use of the released water during non monsoonal season. Unfortunately, the released water form large rivers and harnessing water from these rivers have been a great challenge from financial and technical aspects. Realizing these facts, Government of Nepal has put great emphasis of making use of these resources to provide year round irrigation to its agricultural land which calls for development of large irrigation infrastructures quite often involving intra basin transfer of water as well as storage reservoir.

Irrigation Master Plan 1990, had identified potential multipurpose projects such as: Kanaki Multi purpose Project, Jhapa (38,000 ha), Kamala Multi Purpose Project, Siraha/Mahottari (33,000 ha), Sun Koshi Kamala Diversion Project, Saptari/Sarlahi (1,38,0000 ha), Bagmati Multi purpose Project, Dhanusha/Bara (76,000 ha), West Rapti Multi Purpose Project, Kapilvastu/Banke (76,100 ha), Karnali Multi Purpose Project , Banke/Kailali (1,91,000 ha) and Bheri Babai Diversion Project, Bardiya ((53,500 ha).

The National Water Plan 2002 of Nepal aims to increase the area under year round irrigation by taking number of actions such as building diversion infrastructures on perennial rivers, making intra basin transfer from large river basins to the deficient areas and developing storage reservoirs. It also emphasizes on the need of implementing multipurpose projects that would bring additional benefits in terms of hydropower generation, drinking water etc. Accordingly, Irrigation Policy, 2003, which was adopted in line with National Water Plan, paved way for the Department of Irrigation (DOI) to undertake multipurpose projects with irrigation as their major use.

This paper mainly focuses the inter basin water transfer for irrigation development in the country.

2. Needs for Inter basin water transfer

The total area of the country is about 147,181 million ha. The cultivable area of the country is 2.6 million ha, out of which only 1.76 million ha is potential for irrigation. So far, irrigation infrastructure is developed to irrigate 1.252 million ha.

The present status of irrigation development is as given in table no.1

S.No.	Status	Area in ha	% of irrigation
1	Ground water irrigation	299,696	24
2	Surface irrigation	570,996	45
3	FMIS surface unintervened	274,203	22
4	FMIS surface intervened	107,611	09

Considering, the availability of water throughout the year, the intensity of irrigation in surface irrigation system in Nepal ranges from about 90% in summer to 29% in spring season. It means water availability in the river varies throughout the year.

Nepal has mainly four types of rivers. They are mainly,

i. Major rivers like: Mahakali, Karnali, Narayani, Koshi, which originates from Himalayas and snow-fed river
ii. Medium rivers: Babai, West Rapti, Tinau, Bagmati, Kamala, Kankai, which originates from Mahabharat range
iii. Siwalik river: which originates from Siwalik range

Irrigation infrastructures are developed mostly all major and medium rivers. Water availability for irrigation is found shortage in irrigation systems built in major rivers, which seems very unusual but it is true. The reason is due to short sighted and unfair agreement with neighboring country. Intensity of irrigation can be increased in these systems through the improvement and rehabilitation of system.

Department of Irrigation has successfully constructed headwork to all medium type of river to draw water for irrigation and construction of other infrastructures to provide irrigation in the farmer field is going on. Medium type of river has sufficient water in the summer season i.e. June, July, August and September. Irrigation intensity is nearly 100 % in this period. After September, discharge of this medium river starts to decrease as a result availability of water to draw for irrigation also reduces. A good potential of irrigable area can be irrigated from medium rivers but due to large variation of discharge throughout the year in these rivers resulting variation of intensity of irrigation.

Small rivers which originate from siwalik range are non-perennial types of rivers and have very low or no water during winter season. Irrigation systems built in these rivers are uitlised to irrigate mainly summer season.

Now, it is felt necessary to add water from excess water basin to deficit water basin and increase discharge of medium rivers. The concept of inter basin water transfer enhance the certainty for irrigation water throughout the year.

3. Year Round Irrigation

The irrigation systems constructed at earlier period are mainly conceptualized to irrigate summer season. The systems did not consider providing water for winter or springing season. However, those irrigation systems which are drawing water from major rivers are providing water for throughout the year. According to WRS-Nepal, Year round irrigation denotes the availability of water when and as required (i.e. demand) for the optimal use of the land for agricultural production. At present, if the land has over 155% cropping intensity on average, it is said to have year round irrigation.

The area under year round irrigation is as given below:

S.No.	Schemes	Area in ha	Percentage
1	Surface irrigation schemes	2,76,000	39
2	Ground water schemes	300,000	100
	Total	5,76,000	

The population of the country is increasing at a rate of 2.25% annually and the agricultural land is shrinking due to construction of buildings. It is very essential to increase the agricultural productivity to feed growing population.

Terai is the food basket area of the country. The total irrigable area of terai belt is 1.338 million ha and irrigation infrastructures are developed to irrigate 1.00 million ha. The irrigated area from the major rivers are only 0.202 million ha which comes out only 16% of the total irrigated area. Remaining irrigated area is from the medium and small rivers and year round irrigation is not possible from these rivers at present condition. The only possibility is to increase discharge of these rivers adding water from other rivers which have more unutilized water.

So, it is very essential to divert water from big rivers to these medium types of rivers so that year round irrigation can be provided from these rivers. Irrigation infrastructures are already built in these river systems and full irrigation is provided during summer season only.

4. Inter basin water Transfer

Nepal is rich in water resources. It is the second largest for the availability of water resources in the world. It has more than 6000 river and rivulet flowing through the country. Mahakali and Mechi act as a boundary river with the India. All the rivers in the country are Trans Boundary River. India is the lower riparian country, which utilizes all trans boundary rivers constructing suitable structures across the rivers for irrigation and other purposes.

Nepal's river can be classified mainly three categories according to availability of water throughout the year and is described in above section. Large and medium rivers are perennial rivers and Siwalik Rivers are nonperennial.

Medium rivers and small rivers do not have sufficient water for year round irrigation throughout the year. However, irrigation infrastructures are already developed across these rivers for irrigation purposes. The irrigation systems range from small to large and also agency managed to farmer managed.

There is always a grievance from farmer side for non availability of water for irrigation as they required for irrigating crops.

On the other side there are many rivers flowing with sufficient water with minimum utilization of water. There are not major structures constructed across these rivers and also not future prospective to utilize these rivers for irrigation purposes because of unavailability of irrigable land along these rivers.

The country has mainly ten river basins.

The details of river basin are as described in tabular form.

S.No.	Name of basin	Catchment area in sq.km.				remarks
		In Nepal	In India	In China	total	
1	Mahakali basin	5317	9943		15260	Sufficient water
2	Karnali Basin	41058	0	2621	43679	Sufficient water
3	Babai Basin	3400	0	0	3400	Water deficit
4	West Rapti basin	6500	0	0	6500	Water deficit
5	Gandaki Basin	29626	0	5334	34960	Sufficient water
6	Bagmati basin	3700	0	0	3700	Water deficit
7	Kamala basin	2100	0	0	2100	Water deficit
8	Koshi basin	27863	0	32537	60400	Sufficient water
9	Kanaki basin	1329	0	0	1329	Water deficit
10	Other southern rivers					Water deficit

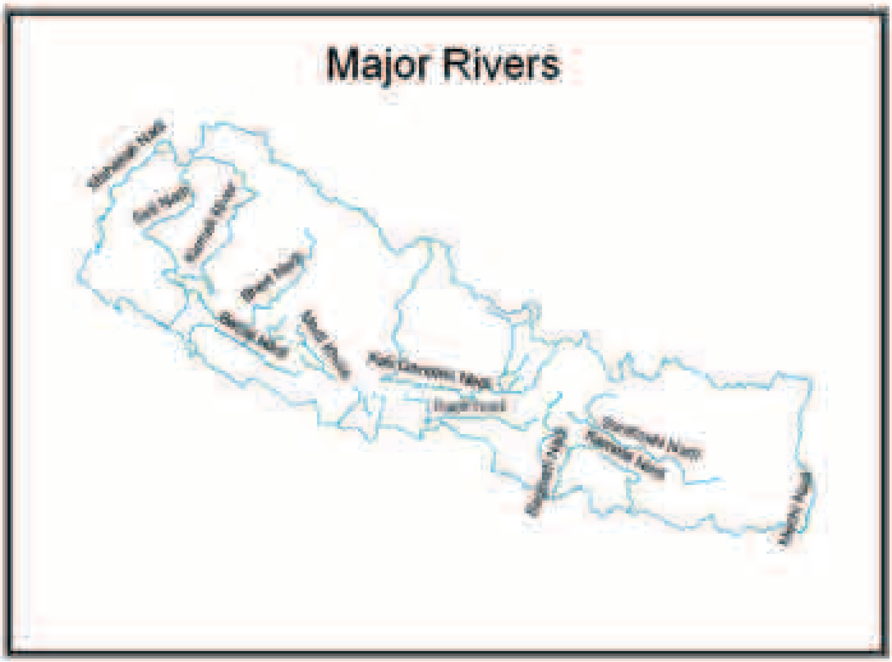
The figure shows the major basin of the country.

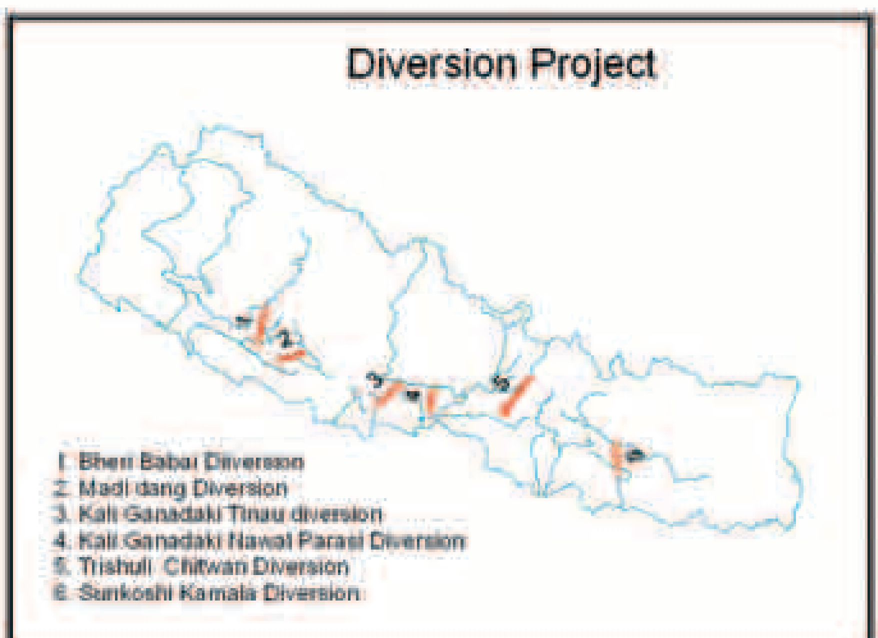
5. Inter basin transfer for Irrigation

The discharge of medium and small rivers vary annually with time and there is also erratic rainfall due to climate change are the main reason for thinking irrigation department to go into inter basin transfer project. The master plan of irrigation, 1990 also conceived for inter basin transfer project. Similarly, Water Resources Strategy, 2002 and National water Plan, 2005 also envisaged to go inter basin transfer project for year round irrigation. Year round irrigation for developed irrigated area is necessary to increase agricultural productivity to feed increasing population.

Department of Irrigation has started to study inter basin transfer project from three years. The list of potential inter basin transfer project utilized for irrigation is listed below:

S.No.	Name of project	Location of intake	Tunnel length, km	CCA in ha	Discharge in cumec	Installed capacity MW	Remarks
1	Bheri Babai Diversion Project	Chiple, Surkhet	12.1	60,000	40	48	Detailed study on going
2	Kali Gandaki Tinau Diversion Project	Ramdi	30	100,000	50	65	Preliminary study
3	Trishuli Chitwan Diversion Project	Richoktar, Dhanding	30	40,000	50	35	Preliminary study
4	Kali Ganadaki Nawalparasi Diversion Project	Kaligandaki	5	12000	16	6	Preliminary study
5	Madi Dang Diversion Project	Purangaun, Rolpa	25	40,000	42	86	Preliminary study
6	Sun Koshi Kamala Diversion Project	Kurele	16.6	1,38,000		93	Detailed study on going
	Total			3,90,000		333	


Major Rivers


Diversion Project
1. Bheri Babai Diversion
2. Madi dang Diversion
3. Kali Ganadaki Tinau diversion
4. Kali Ganadaki Nawal Parasi Diversion
5. Trishuli Chitwan Diversion
6. Sunkoshi Kamala Diversion

Thus, additional 3,90,000 ha can be brought under year round irrigation by developing all inter basin water transfer project and about 333 Mw power can be generated as a secondary benefit.

6. Cost and benefit

The total construction of the project is calculated tentatively as below;

S.No.	items	Area	Per unit cost	Total
1	Irrigation part	3,90,000 ha	3,00,000 per ha	1,17,00,00,00,000
2	Hydropower part	333 MW	20,00,00,000 per MW	66,60,00,00,000
	Total			1,83,60,00,00,000

The total benefit obtained from the project is calculated tentatively as below:

S.No.	Items	Area	Per unit benefit	Total
1	Irrigation Part	3,90,000 ha	8000 per ha	3,12,00,00,000
2	Hydropower Part	333 MW	3,50,00,000 per MW	1,16,55,00,00,000
	Total			1,19,67,00,00,000

If the life of the project is 25 years,

Total benefit from the project = 1,19,67,00,00,000 × 25 = NRs.29,91,75,00,00,000

Let assume 3% of total cost as maintenance cost = 3,59,01,00,000 × 25 = NRs.89,75,25,00,000

Net benefit obtained from the project during its life period = NRs.29,01,99,75,00,000

7. Challenges and Suggestion

7.1 Challenges

The task of inter basin water transfer is not easy. Technically, economically it is very challenging job. The various challenging that irrigation department may face during the implementation of inter basin transfer projects are as described below:

- Managing huge amount of cost
- Lack of technical experience manpower within the department
- Geological problem for constructing tunnel
- Lower riparian issues
- Political commitment
- Melamchi syndrome

7.2 Suggestions

7.2.1 Institutional

- Structuring of Department of Irrigation and Ministry of Irrigation and formation of Ministry of water resources having mandate to implement multi purpose project.
- WECS should be made strong and have a capability to deal with trans-boundary river.

7.2.2 Human resources

- Hydropower sub group in the irrigation department.
- Training programme to enhance the capacity of technical manpower..

7.2.3 Financing

- Government should give top priority to develop such type of project which is useful for irrigation as well as power generation.
- Upper Tamakoshi model can be applied to these projects also.

7.2.4 Legal issues

- All legal issues should be favorable to develop inter basin transfer and multipurpose project.
- Revision of Land acquisition act 2034.
- Revision of water resources act and should mainly focus on infrastructure development.

References:

i. A case study of Bher babai Diversion Project : M.Belbase
ii. Water Resources Strategy, 2002
iii. National water Plan, 2005
iv. Irrigation Policy

Impact of global changes on water resources and agricultural practices in Indrawati basin- preliminary findings from AGloCAP[7] Project

Dinesh Bhatt[8], Suman Sijapati[9], Prem Lasiwa[10], Devaraj Niraula[11] and Uttam Raj Timilsina[12]

Abstract

The paper will include a brief introduction of the project and its objectives. It will then go on to give an overview of precipitation and temperature trend in the Indrawati basin. The impact of agricultural practices and underlying socio-economic variables in the region has been identified according to the agro-ecological zones (tropical and subtropical (<1200 m), temperate (1200-2400m) and cold (>2400m)). However, present data only includes tropical and subtropical region.

The trend analysis of precipitation indicates increasing hot days for winter and autumn associated with increasing trend in mean maximum temperature and mean diurnal temperature range. For precipitation the consecutive dry days have increasing trend for winter and autumn while no significant trend was identified for mean climatological precipitation range. No significant trend was identified for other indices. The preliminary analysis of field data collected from the field so far reveal that global changes has diverse impact on agriculture ranging from change in agro-climatic condition, shifting of cropping areas, change in timing of agricultural activities, change in input levels, outbreak of disease and pests. Similarly, it has been observed that in addition to the changing climatic condition, the underlying social, economical and institutional drivers have a remarkable influence on agricultural production in the region. Overall, the production in the midhills indicates declining trend in production, while, farmers in the foothills are able to improve/maintain their production. Regarding water resources availability, the impact of global change is most significantly observed in areas that largely depend on local (non-perennial) sources as compared to the rain-fed areas and areas extracting water from perennial sources.

Keywords: global change, water resources, impact, Indrawati basin

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7 A research project entitled Adaptation to Global Change in Agricultural Practices Jointly implemented by UNESCO-IHE, AIT and DOI.

8 Dinesh Bhatt is a PhD fellow registered at UNESCO IHE under the AGloCAP Project.

9 Suman Sijapati is a Senior Divisional Engineer. He is a member of the AGloCAP DOI Research Team.

10 Prem Lasiwa is also a member of the AGloCAP DOI Research Team. He is an Irrigation Engineer in DOI.

11 Devaraj Niraula is a Senior Divisional Engineer. He is a member of the AGloCAP DOI Research Team.

12 Uttam Raj Timilsina is a Deputy Director General. He is a Team leader of the AGloCAP DOI Research Team.

1. Introduction

The main aim of AGloCAP project is to develop adaptation strategies in agricultural practices and water resource management based on well validated database and scientifically translated basin scale climate change predictions. In the process, it also tries to assess the impacts of climate, land use and socio-economic changes on water resources availability and crop production. An attempt will also be made to up-scale the impacts to other sub basins of the Koshi basin on the basis of agro-ecological zones.

Evidences of changes in temperature, precipitation and extreme weather events in the scientific basis have solved the issue of occurrence of climate change (IPCC, 2007). However, the extent of its impacts on socio-economic and environmental system is still not well known. Beside the series of non-climatic factors, the vulnerability of agricultural system (mainly small landholders and subsistence farmer) is affected by change in climate (Schmidhuber and Tubiello, 2007). Thus, agriculture systems have been one of the main subjects of analysis to understand the impact of both climatic variability and climatic change. This is of particular importance for the agriculture based population living in the developing world with small land holders and subsistence farming for whom on-farm agriculture and off-farm agricultural labour provide the main source of income (Ito and Kurosaki, 2009). Further, more than 800 million people are already undernourished (UN millennium project, 2005) in the developing world and climate change is likely to cause yield reduction for most of the staple crops, with South Asia being the most susceptible region (Nelson et al., 2009). On the other hand, increasing population and high rates of natural resource degradation are expected to continue to have high rates of poverty and food insecurity for Asia, Sub-Saharan Africa and Latin America (Fischer, 2002).

Farmers are conducting their activities in the risky environment due to fluctuation of climatic variables. Thus, many of the researchers have focused on the effect of the climatic factor on the yield of the agricultural products all over the world (Gunduz, et al., 2011). However, in addition to the climatic factor, farm management practices and underlying socio-economic conditions like availability of labour, institutional support, capital, education level, number of people involved in agriculture etc. can significantly influence the crop production. Further, there is extremely less robust literature how socio-economic factors may buffer or exacerbate the effect of climate change on crop productivity.

The main impetus of this study is to estimate the influence of farm management practices and socio-economic variables in supplement to the influence of climatic variables (precipitation and temperature) on crop yield in Indrawati basin of Nepal. More specifically we analyzed the trends in indices of rainfall and temperature in the region. Next, we estimated the influence of climatic variables (precipitation and temperature) on maize yield. Finally, we analyse the influence of management practices and socio-economic variables on crop yield of the region.

2. Study area

2.1 Overview of climatic conditions of Indrawati basin

Indrawati is one of the subbasin of Koshi having a drainage area of 1239 Km^2. The basin falls under the alpine and subtropical climate zone with an elevation range from 616m to 6359 m above mean sea level (Figure 2.1). The average annual rainfall in the basin ranges from 3,874 mm/a at the higher elevation (Sarmathang) to about 1,128 mm/a at the lower elevation (Dolalghat) with high spatial and temporal variation. The average annual potential evapotranspiration is about 954 mm/a (WECS/IWIMI 2000).The relative humidity varies from 60% in the dry season to 90% in the rainy season thus resulting in an average of 60%. Similarly, the average sunshine is 6.2h/day varying from 3.3 hr/day in July to 8.1 h/d in April. Regarding runoff a study by Rajkarnikar (2000) shows that water flow in the river has significant seasonal variation with 90% of the total annual river flow occurring in the monsoon season (June to October).

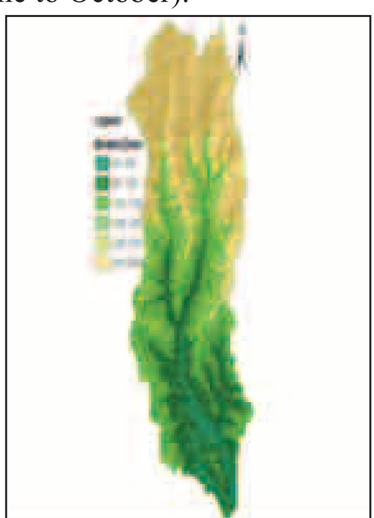


Figure: 2.1 Designation of different elevation zones based on cropping pattern

2.2 Overview of Agricultural practices in Indrawati basin

In terms of land use, 38% of the area is under some form of cultivation while 31% is preserved area and 29% is under natural vegetation. In terms of cropping systems, five distinct systems were observed at different elevation zones during the field visit by DOI research team in 2010 (Table 2.1)

Table 2.1 Change in cropping system with elevation in the Indrawati basin

S. N.	Cropping Systems:	Elevation Range:
1	Early Rice – Rice – Maize/Vegetables	Up to 900m
2	Early Rice – Rice – Local Maize	900m – 1200m
3	Local Maize – Rice	1200m – 1800m
4	Local Maize – Millet	1800m – 2200m
5	Local Maize – Bean (Rajma) – Potato	2200m – 2600m
6	No cultivation	Above 2600m

3. Data and methodology

3.1 Temperature and precipitation indices

3.1.1 Database

Daily precipitation data at 12 meteorological stations (10 precipitation and 2 climatic) and daily maximum and minimum data at 2 stations are used (Figure 3.1). About 30 years data was used for the analysis, 1978-2008 for precipitation and 1979-2008 for temperature. Even though there are 13 precipitation stations with in the basin, observations from only 12 stations were used for the analysis as the observation for the station 1078 spans from 1997-onwards. The missing values of temperature were replaced with the monthly average of the respective year. For precipitation missing values were replaced with the average value of the previous and consecutive years. However, at the latter stage it is proposed to use the IDW method for replacing the missing values.

3.1.2 Rainfall and temperature indices

7 indices for rainfall and temperature each were estimated in order to analyse the change in average and extreme regime of precipitation and temperature (Table 3.1) using the STARDEX software available at http://www.cru.uea.ac.uk/cru/projects/stardex/. Each indices are calculated on seasonal (DJF (December to February),

MAM (March to May), JJA (June to August), SON (September to November)) and on an annual basis. Many of the selected indices have been used in the previous studies (Hu et al., 2011; Moberg and Jones 2005; López-Moreno et al. 2009).

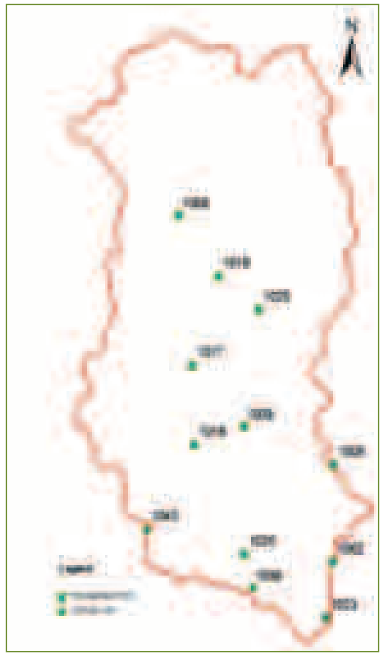


Figure 3.1 Meteorological stations in Indrawati basin

Table 3.1 Temperature and rainfall indices used for analysis

S.N	Indices	Description
1	Txav	Mean daily maximum Temperature (°C)
2	Tnav	Mean daily minimum temperature (°C)
3	Trav	Mean daily diurnal temperature range (°C)
4	Txq90	90th percentile of daily maximum temperature (hot days) (°C)
5	Tnq10	10 percentile of daily minimum temperature (cold nights) (°C)
6	Txf90	% days T maximum greater than 90th percentile
7	Tnf10	% days T minimum < 10th percentile
8	Pav	Mean climatological precipitation (mm/day)
9	Pxcdd	Maximum number of consecutive dry days (days)
10	Pxcwd	Maximum number of consecutive wet days (days)
11	Px5d	Greatest 5 days total rainfall (mm)
12	Pint	Simple daily intensity (rain per rainday)
13	Pfl90	% of total rainfall events greater than long term 90th percentile (%)
14	Pnl90	Number of events greater than long term 90th percentile (days)

3.1.3 Trend Analysis

Trend analysis of the seasonal indices was performed using non-parametric Mann-Kendall statistic test (Mann 1945; Kendall 1975) at 10% significant level. The test statistics S is given by:

$$S = \sum_{i=2}^{n} \sum_{j=1}^{i-1} sign(x_i - x_j)$$

Where, $sign(x_i - x_j) = \begin{cases} 1 & f \quad x_i > x_j \\ 0 & f \quad x_i = x_j \\ -1 & f \quad x_i < x_j \end{cases}$

Under the null hypothesis of randomness the S has a normal distribution with the mean value μ_s and variance σ_s^2 given by

$$\mu_s = 0$$

$$\sigma_s^2 = \frac{n(n-1)(2n+5)}{18}$$

The standardised test statistics Z is computed as

$$Z = \frac{S+1}{\sqrt{Var(S)}} \quad \text{for s} > 0$$

$$Z = 0 \quad \text{for s} = 0$$

$$Z = \frac{S-1}{\sqrt{Var(S)}} \quad \text{for s} < 0$$

Positive value of Z indicates an increasing trend, while the negative value of trend indicates decreasing trend.

3.1.4 Sen slope estimator

The Sen slope estimator (Sen, 1968) was used to calculate the magnitude of the significant trend found. Hirsch et al. (1982) point out that this estimate is robust against extreme outliers and further the confounding effect of serial correlation are unlikely.

3.2 Estimating regression model describing quantitative relation between weather inputs and final yield

The impact of climatic variables in the maize production system in the region has been analysed using regression techniques. The historical data of maize yield and meteorological data (precipitation, maximum and minimum temperature) has been used to develop the multiple regression models using crop yield as the dependent variable and meteorological data of the growing season as the independent variables. The time series data of the yield at district level maintained by Department of Agriculture (DOA), Nepal has been used. The climatic variables at the district level are estimated as the average of the available observation stations with in the district. Detrending was done by using the first-difference time-series for yields and climate variables.

3.3 Influence of agricultural practices and socio-economic variables on crop production

In addition to the biophysical process the socio-economic drivers such as GDP, availability of land, agricultural technology, infrastructure, population involved in farming, land tenure, capital and labor input also play a significant role in the determination of crop yield and productivity. In some cases agricultural production is significantly affected even with slight changes in the environment. While in other cases, major weather anomalies only cause minor problems (Green, 1993). This can be attributed to the underlying socio-economic drivers in the region. To determine the influence of socio-economic drivers. Field work involving focus groups and questionnaire survey of the selected sample sites (Table 3.2). The sample sites were selected to represent different agro ecological zones representing both irrigated and rain-fed agriculture system. The parameters used to conduct the questionnaire survey are presented in Table 3.3.

Table 3.2 Selected sample sites for field data collection

S.N	Name	Lat	Long	Altitude	Irrigation Status
1	Kunta Besi	27.71	85.61	819	Chakhola Maitakunta IS
2	Hinguwa Pati Bhanjyan	27.72	85.62	882	Local kulo
3	Bahun Pati	27.78	85.57	770	Dhadesindur IS
4	Melamchi Bazar	27.83	85.58	820	Melamchi IS,
5	Tipeni	27.88	85.61	930	Irrigation Pond (NITP)
6	Thangpal Dhap	27.92	85.64	1314	(FMIS) Hydropower
7	Bhotang	27.94	85.65	1804	Rain fed
8	Thangpal kot	27.97	85.65	1844	Dhuslung Irrigation System
9	Nangle	27.76	85.51	1697	Rainfed
10	Palchowk	27.9	85.55	1105	Churikharka Churetar IS
11	Timbu	27.95	85.57	1913	Local Kulo
12	Kiul	27.91	85.55	1170	Rainfed
13	ShermaThang	27.94	85.6	2593	Rainfed

Table 3.3 Parameters used to conduct the field survey

Variable	Parameter	Definition
Dependency on agriculture	Highly dependent	75% or more income from agriculture
	Less dependent	Less than 75% from agriculture
Poverty level	Subsistence farming	No crop products are traded
	Better off	Crop products are traded
Education level	Less than secondary level	Most of the family members involved in agriculture have education less than secondary level
	Higher than secondary level	Majority of the family members involved in agriculture have education higher than secondary level
Availability of labor	Within family members	>90% of the manpower required for agriculture are from the family itself
	Need to get from outside	< 90% of the manpower required for agriculture are available from the family
	Effect of migration in fulfillment of labor required	Either the labor required are available within the village or need to be hired from outside the village
Capital (Money + Equipment)	Sufficient	The farmer has more than 90% of the capital required for agriculture
	Insufficient	The farmer has less than 90% of the capital required for agriculture

Variable	Parameter	Definition
Water/ Irrigation, seeds, Fertilizers/ Insecticides	Adequacy level	< 60%, 60-90%, >90%
Land	Adequate	Sufficient to feed the family members
	Inadequate	Insufficient to feed the family members
Expertise	Available within the family members	Family members has obtained technical training
	Dependent on others	None of the family members has obtained general technical training on agriculture
Access to expertise	Easy access	Technical expert visit farmers field frequently or the agriculture office/NGO's working in agriculture sector are within the village
	Difficult access	No visit by the agriculture technician and the agriculture office/NGO's working in agriculture sector are not in the village
Technical institutional support	Sufficient	Farmers are able to get technical support from institutions when required
	Insufficient	Farmers are unable to get technical support from the institution when required
Financial institutional support	Sufficient	Farmers are able to get financial support from the institutions when required
	Insufficient	Farmers are unable to get financial support from the institutions when required
Soil Reaction	Acidic	Ph< 5.5
	Slightly Acidic	5.5-6.5
	Nearly Neutral	6.5-7.5
	Alkaline	>7.5
Nutrient Status	Very low	OM (%) <0.75; Total N (%) <0.03
	Low	OM (%) 0.75-1.5; Total N (%) 0.03-0.07
	Medium	OM (%) 1.5-3.0; Total N (%) 0.07-0.15
	High	OM (%) 3.0-5.0; Total N (%) 0.15-0.25
	Very High	OM (%) >5.0; Total N (%) > 0.25

4.0 **Results and discussion**

4.1 Trends in precipitation and temperature regimes

Change per decade in the precipitation and temperature indices for all the four seasons are presented in Figure 4.1-4.8 (The upward traingle increase increasing trend, downward traingle indicates decreasing trend and the dot indicates no significant trend).

4.1.1 Precipitation

Overall there no pronounced trend in the precipitation regime of the basin except for the consecutive dry days. About 92% of the stations do not show any significant change in the mean climatological precipitation on the annual basis. On the seasonal analysis, the stations with no significant trend ranges from 84% to 91%. While, only 8% of the stations shows increasing trend for winter, spring and Autumn. Similarly, the same percentage of stations indicates decreasing trend for winter and summer. Consecutive dry days were found to be increasing for about 34% of the stations in the annula analysis. On the seasonal analysis, in Winter and Autumn Pxcdd are found to raising, with more pronounced trend in Winter (9d/decade). In contrast, no significant trend was idntified for Spring and Summer season.

For consecutive wet days, in the annual analysis almost 84% of the stations indicates no significant trends and percentage of stations with increasing and decreasing trend is only about 8%. In the seasonal analysis, the magnitude of the trend was significant only for summer season with an increase of 10d/decade for 8% of the stations and 4d/decade decrease for the same percentage of stations. In the rest of the season the magnitude of the trend was insignificant.

Rainfall per rain day has increasing trend for winter, spring and Autumn, with maximum percentage of stations (16%) in spring and maximum magnitude of trend of 2.48mm/decade in Autumn. In contrast decreasing trend of 4.7mm/decade has been observed for 8% of the stations in summer.

The trend in greatest 5 day total rainfall was significant for Spring season with 25% of the stations showing increased trend with the magnitude ranging from 9.8-15.08 mm. In contrast 8% of the stations shows decreasing trend in summer with the magnitude 32.625 mm/decade. The magnitude of increasing as well as decreasing trend in winter is small as compared to Spring and Summer. While, Autumn shows no significant trend. For pnld90, on annual analysis, about 25% of the stations have decreasing trend, while the remaining have no significant trend. In the seasonal analysis, for summer the increasing trend is about 2-3 d/decade for about 16% of stations. While the magnitude of trend was insignificant for the other season.

4.1.2 Temperature

Event through there are only two climatic stations in the indrawati basin which is obviously not representive of the whole basin. The trend of change in temperature indices can provide certain signals of indrawati basin. Overall, significant increasing trend has been identified for mean maximum temperature, mean diurinal temperature range, growing season length. Less significant increasing trend of 90th percentile maxium temperature and percentage of days with maxium temperature greater than 90th percentile has been detected. In contrast, no significant trend has been noted for minimim temperature, frost days, 10th percentile minimum temperature and percentage of days minimum temperature is less than 10th percentile. For mean maximum temperature, the annual analysis has increasing trend for both the stations with the magnitude of about 0.36^{o}C/decade.In the seasonal analysis, for winter and Autumn, increasing trend has been found for both the stations. While, for summer only one station has increasing trend. In contrast, no significant trend was found in spring season. The same trend was found for the mean diurinal temperature range except for spring season, where increasing trend was seen in one of the station.

Figure 4.1 Change per decade in precipitation indices for DJF (winter)

Figure 4.2 Change per decade in Precipitation indices for MAM

Figure 4.3 Change per decade in precipitation indices for JJA (Summer)

Figure 4.4 Change per decade in precipitation index for SON (Autumn)

In contrast, the mean minimum temperature has no significant trend for both annual and seasonal analysis except for spring where one of the station has decreasing trend with a magnitude of 0.29^{o}C/decade.

90th percentile maximum temperature has increasing trend for Winter and Autumn with more pronounced magnitude in winter (0.554 ^{o}C/decade). While no significant trend has been identified in Spring and Summer. Similar, trend was identifed for the percentage of days where maximim temperature is greater than 90th percentile except for winter, where one station has increasing trend while other indicates no significant trend. However, the magnitude of trend is less significant (0.04-0.06 days/decade).

However no significant trend has been detected for 10th percentile minimum temperature and percentage of days minimum temperature is less than 10th percentile. Similarly, no significant trend was found for the number of frost days.

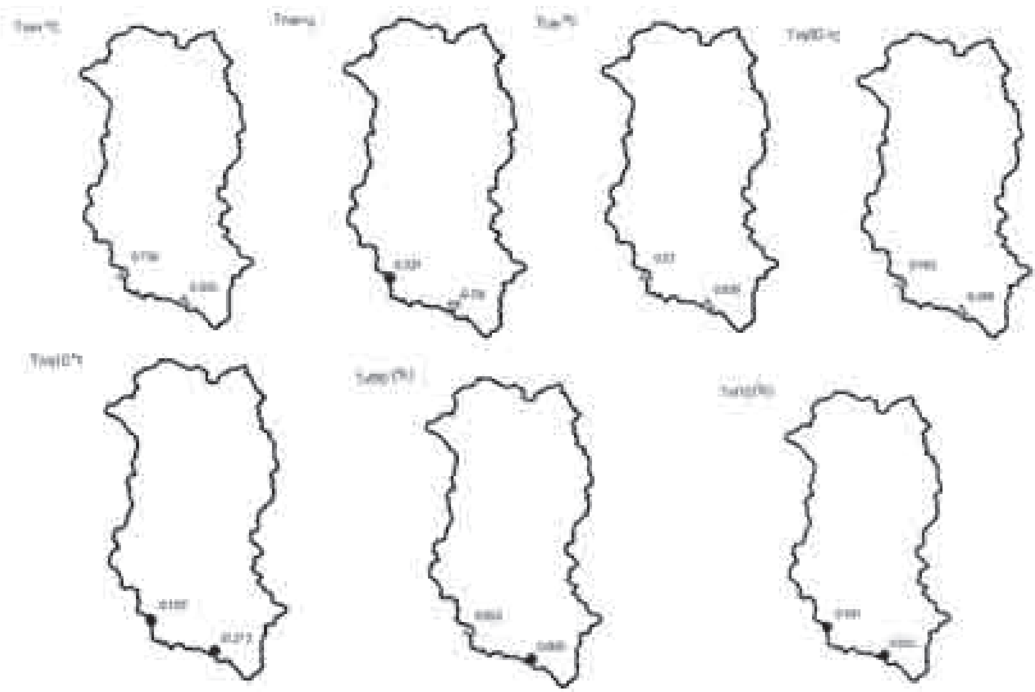


Figure 4.5 Change per decade in temerature indices for DJF (winter)

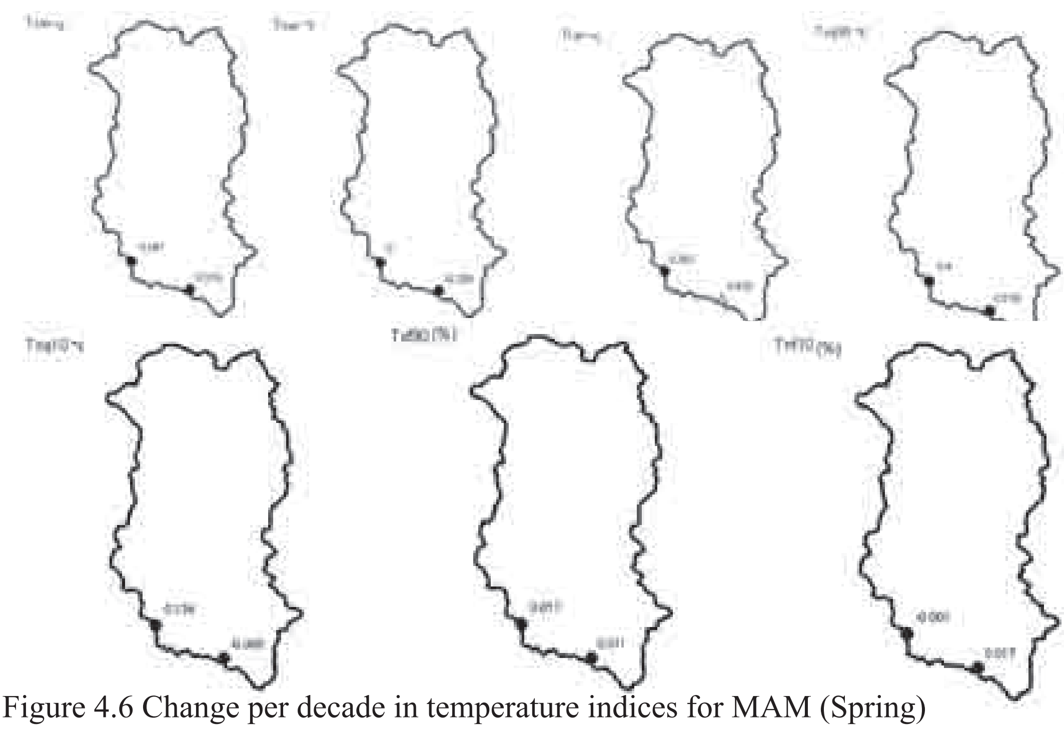


Figure 4.6 Change per decade in temperature indices for MAM (Spring)

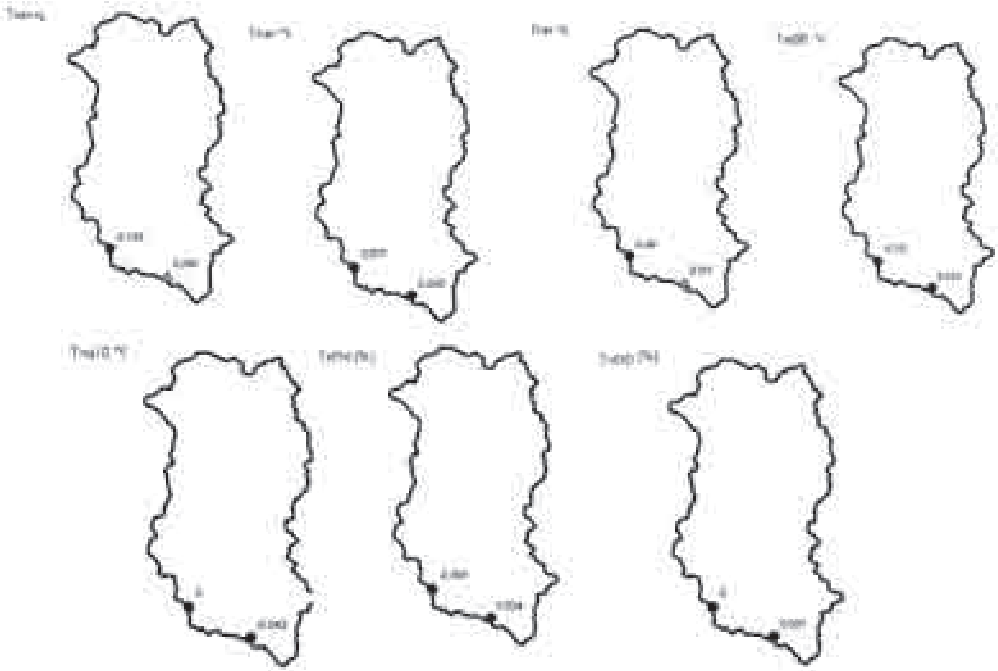


Figure 4.7 Change per decade in temperature indices for JJA (Summer)

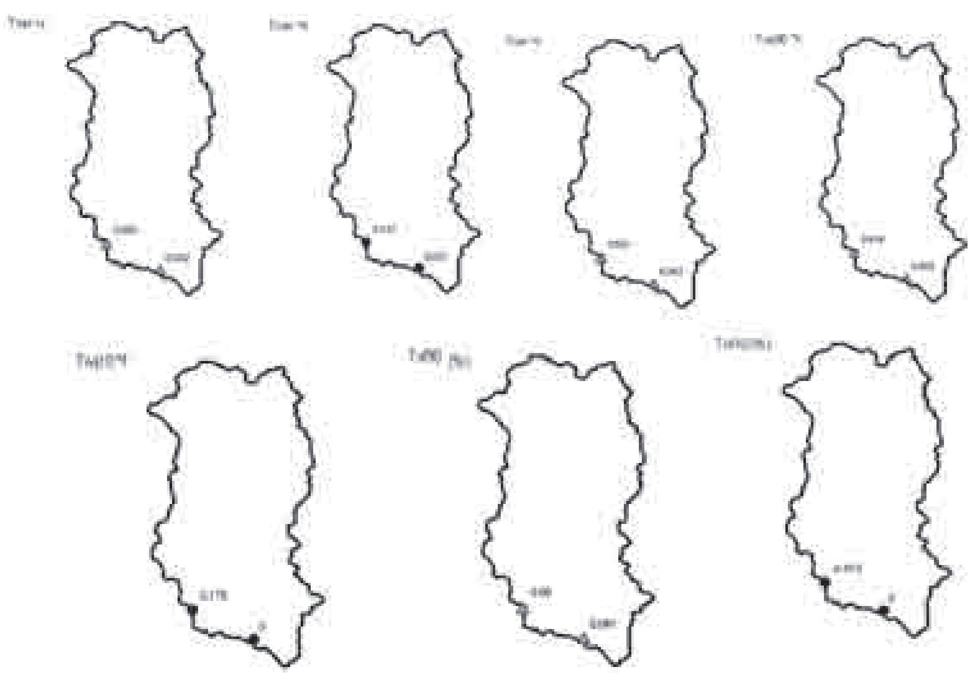


Figure 4.8 Change per decade in temperature indices for SON (Autumn)

4.2 Influence of climatic variables in crop yield

The regression of maize yield against the precipitation, minimum temperature and maximum temperature regime of the months (March-May) for Kavre district is presented in table below.

R square	0.321	F value	1.656	
	Coefficients	Standard Error	t Stat	P-value
Intercept	0.006228	0.03041	0.204787	0.83922
MAYP	0.069936	0.030571	2.287711	0.029912
MARCHMXT	-0.04639	0.032915	-1.40947	0.169708
APRILMXT	0.028206	0.024443	1.153949	0.258276
JUNEMXT	0.05506	0.034131	1.61322	0.117912
MARCHMNT	0.042157	0.029465	1.430746	0.163569
JUNEMNT	-0.08675	0.048671	-1.78237	0.085538

The yield is found to be statistically significantly (t value >2) dependent on the precipitation regime of May (positive impact). However, trend analysis of three precipitation station within Indrawati basin shows no significant trend for the precipitation regime of May. The low R square value indicates that the regression can only explain 32 percent of the variation in maize yield. Thus, it is proposed to develop the regression model including other derived agro-meteorological variables like solar radiation, evapotranspiration etc

4.3 Influence of agricultural practices and socio-economic variables on production

4.3.1 Prevailing agricultural practices, socio-economic condition and production scenarios in the tropical/subtropical and mid hills of Indrawati basin.

The agricultural practices followed by farmers, underlying social and economic conditions and farmers perception on the production of staple crops is presented in Figure 4.9.

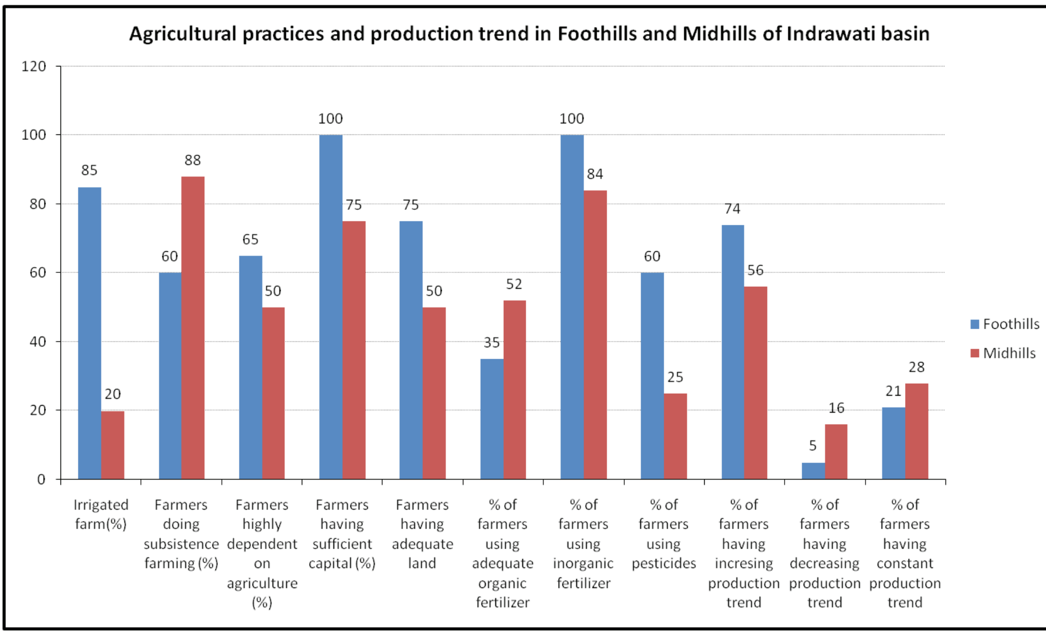


Figure 4.9 Agricultural practices and production trend

4.3.2 Impact of irrigation

In tropical and subtropical region, the irrigated agriculture has increased the economic status of the farmers and nearly 40% of the farmers are generating income from the agriculture. In contrast, in the rain-fed agriculture system almost 82% of the farmers are bound to be involved in the subsistence and not even subsistence farming system. Similarly, in the temperate/mid hills regions the irrigated agriculture systems are relatively more resilient in maintaining the production as compared to the rain-fed agriculture irrespective of the resources availability (Figure 4.10).

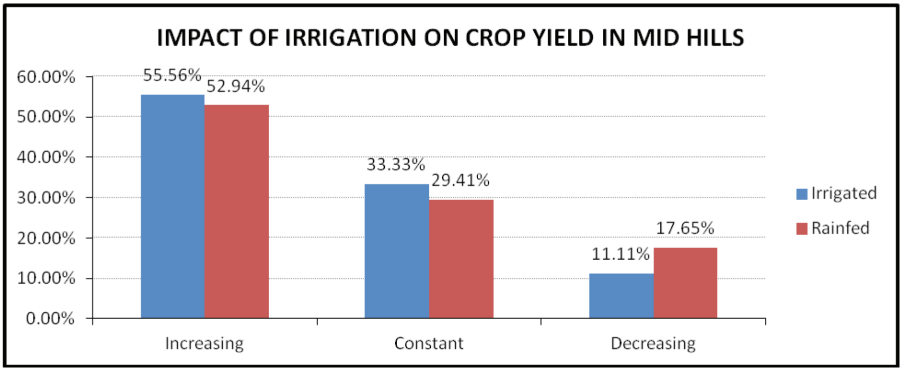


Figure 4.10 Impact of irrigation on crop yield

4.3.3 Impact of fertilizers

It was observed that inadequacy of organic and inorganic fertilizer in temperate and mid hills where farmers are doing subsistence farming in the absence of irrigation, can have significant negative impact on production. The impact seems to more pronounce in the soil with low percentage of organic matter as compared to the soil with medium percentage of organic matter. Interestingly, it is found that switching to suitable crop variety can outperform the negative impact of fertilizers inadequacy even in soil with low percentage of organic matter. Similarly, increasing the input of organic fertilizer seems to minimize the negative impact of fertilizer inadequacy to some extent in slightly acidic soil.

In tropical and subtropical region, for farmers who are less dependent on agriculture and are doing subsistence farming in rain fed farms with sufficient capital and inadequate land. It was observed that the increase in production for the farmers using nearly adequate organic fertilizer is comparatively higher than the farmers who are unable to provide adequate organic fertilizer even though all other resources are adequate for the alkaline soil with medium status of organic matter and vary high percentage of nitrogen.

Field data reveals that the use of pesticides is governed by the adequacy of organic fertilizer. The data collected so far reveal that 80% of the farmers are unable to use the adequate organic fertilizer are using insecticides and pesticides. In addition to this, during the focus group discussion with the farmers of sample sites it was observed that some of the farmers do not use pesticides even during the serious disease outbreak due to realization of degradation of taste of food. Instead they still believe in cultural practices to eradicate disease.

4.3.4 Impact of education level and experts

The field data collected so far indicates that the farmers who are educated and are somehow conscious about the impact of climate change and are adopting climate change coping strategies are experiencing increasing trend in the production since last 15 years. Similarly, farmers whose families members are sufficient to carry out the agricultural activities are able to maintain the production level provided all resources are adequate except institutional (technical & financial) support. In contrast, farmers who are need to get labor to conduct their agricultural activates are having difficulty to maintain the production level. However, the education level and involvement in agriculture are inversely proportional.

4.3.5 Scenario of water resources availability

In terms of water availability, the preliminary data reveals an interesting finding that the different sites can be basically divided into three categories in terms of their water sources: major (perennial) rivers, local sources and rain fed. Those areas which extract water from major perennial rivers seem to be unaffected in terms of water availability through time (probably because they were able to extract more water as required). However, irrigated areas depending on local water sources have reported a decreasing trend in term of water availability, while. Table 4.1 shows the scenario of water availability in the sample sites.

Table 4.1 scenario of water resources availability

S. N.	Sample sites	Water source	Availability	Trend
1	Kunta Besi	Cha River	Enough / deficit (at tail)	Decreasing
2	Hinguwa Pati	Local sources	Insufficient	Decreasing
3	Bahun Pati	Sindhu River	Enough	Stable; recently decreasing
4	Melamchi Bazar	Melamchi River	Enough	Stable; recently decreasing
5	Tipeni	Mahadev River	Enough / deficit (at tail)	Decreasing
6	Kiul	Local Sources	Mostly deficit	Decreasing
7	Thangpal Dhap	Local river	Enough to low	Decreasing
8	Bhotang	None	Rainfed	N.A.
9	Thangpal kot	Chimpti River	Insufficient	Stable; recently decreasing
10	Nangle	None	Rainfed	N.A.
11	Palchowk (Kiul)	Local sources	Enough to low	Decreasing
12	Timbu	Local sources	Enough to low	Decreasing
13	Shermathang	None	Rainfed	N.A.

5. Conclusion

The trend analysis of the daily precipitation and temperature data for the period of 30 years for the region shows some significant trend on the seasonal analysis. Overall precipitation do not show strong trend in the region. However, some regional seasonal trend has been identified. Consecutive dry days have increasing trend for winter and autumn with more pronounced effect on winter. However no change in mean climatological precipitation was associated. Similarly greatest 5 day rainfall has increasing trend for spring season. All other index shows no significant trend. Significant warming trend was observed for winter and autumn. In contrast, no significant trend was observed in any of the temperature indices analysed for spring and summer. Hot days are increasing for winter and autumn while no significant trends were identified for spring and summer. Mean diurnal temperature range has increasing trend for winter and autumn associated with increase in the mean maximum temperature. Rest of the indices have no significant trend.

Analysis of the production data and growing season precipitation and temperature indicates that maize yield has strong correlation with precipitation regime followed by the minimum temperature regime of the growing season. In addition to the climatic variable, the analysis reveals the agricultural practices and socio-economic variables have a great influence on the crop yield. It is found that farmers having facility of irrigation, are more resilient in maintaining production as compared to the rain-fed farms in the same agro-ecological zones. Similarly, farmers in the mid-hills area are facing declining trend in production due to lack of capital, land, adequate fertilizers, and improved seeds. While the foothills farmers are rich in resources hence the decreasing trend in production is almost negligible. Thus, about 40% of the farmers are above the subsistence level. In contrast, about 90% of the farmers in the mid-hills are under the subsistence level.

Regarding water resources availability, the preliminary data reveals that decreasing trend is dominated in the region where local sources are utilized for irrigation. However, no significant trend is found in the region where there exist perennial sources for irrigation. Thus, global change seems to impact first who are already marginal.

References

Fischer, G., Shah, M., van Velthuizen, H., 2002. Climate change and agricultural vulnerability, Special report to the UN world summit on sustainable development, Johannesburg 2002 (International Institute for Applied Systems Analysis, Laxenburg, Austria).

Green, R., 1993. The political economy of drought in southern Africa 1991-1993. Health Policy

Gunduz, O., Ceyhan, V., Bayramoghu, Z., 2011. Influence of the climatic factors on Apricot (Prunus armeniaca L.) yield in the Malatya province of Turkey. Asian Journal of Agricultural Sciences 3(2), 150-155.

Hirsh, R.M., J.R, Slack, and R. Smith, 1982. Techniques of trend analysis for monthly water quality data. Water Resources Research 18 (1): 107:121

Hu, Yurong, Maskey, S., Uhlenbrook, S., 2011. Trends in temperature and rainfall extremes in the Yellow River Source region, China. Climatic Change. doi 10.1007/s10584-011-0066-2.

IPCC, 2007. Climate change-a synthesis report of the IPCC. Technical report, Intergovernmental Panel on Climate Change. and Planning 8, 256-266

Ito, T., Kurosaki, T., 2009. Weather risk, wages in kind, and the off-farm labor supply of agricultural households in a developing country. Am. J. Agric. Econ. 91, 697–710.

Kendall, M.G., 1975. Rank Correlation Methods. Griffin: London.

López-Moreno, J., Vicente-Serrano, S., Angulo-Martínez, M., Beguería, S., Kenawy, A., 2009. Trends in daily precipitation on the northeastern Iberian Peninsula, 1955–2006. Int J Climatol 30:1026–1041. doi:10.1002/joc.1945

Mann, H.B., 1945. Nonparametric tests against trend. Econometrica 13, 245–259.

Moberg, A., Jones, P.D., 2005. Trends in indices for extremes in daily temperature and precipitation in central and western Europe, 1901–99. Int J Climatol 25:1149–1171.

Natl. Acad. Sci. U.S.A. 104, 19703–19708.

Nelson, G.C., Rosegrant, M.W., Koo, J., Robertson, R., Sulser, T., Zhu, T., Claudia, R., Msangi, S., Palazzo, A., Batka, M., Magalhaes, M., Valmonte-Santos, R., Ewing, M., Lee, D., 2009. Climate change: impact on agriculture and costs of adaptation. International Food Policy Research Institute, Washington, DC.

Rajkarnikar, G., 2000. Initial assessment of resource base in Indrawati river basin Nepal. Kathmandu, Nepal: WECS and IWMI.

Schmidhuber, J., Tubiello, F.N., 2007. Global food security under climate change. Proc.

Sen, P.K., 1968. On a class of aligned rank order tests in two-way layouts. Annals of Mathematical Statistics 39, 1115-1124.

UN Millenium Project, 2005. Investing in development. A practical plan to achieve the millenium development goals, Report to the UN Secretary General, New York, NY, 2005.

WECS/IWMI., 2000. Integrated development and management of water resources in Indrawati river basin, Nepal. Inception Report. January 2000.

Downstream Hydrological Impacts of the Melamchi Inter-basin Water Transfer Plan

P. Gurung and L. Bharati
IWMI/Nepal.

Abstract

The Melamchi Water Supply Project (MWSP) is designed to minimalize the shortage of drinking water in the Kathmandu valley. Although the project was supposed to be completed by 2008, due to various problems including the issue of downstream hydrological impacts, it is still difficult to forecast the exact date of completion. This paper quantifies the downstream effects of diverting water from the Melamchi (stage-I), Yangri (stage-II) and Larke (stage-III) rivers. The Soil Water Assessment Tool (SWAT) was used in the analysis. Results show that in the stage-I water transfer plan, average inflow reduction in the immediate downstream sub-basin in the dry and wet seasons are 36% and 6% respectively, where as in stage-II the inflow reductions are 18% for the dry season and 4% for the wet season. In stage-III, inflow reductions are 20% in the dry season and 3% in the wet season. Furthermore, In the Koshi basin outlet, at Chatara-Kothu, cumulative effects of all water transfer stages (I, II and III) on average outflow reduction in the dry and wet seasons are 0.6% and 0.1% respectively.

1. Introduction

In Nepal, migration trends from rural to urban areas are growing. As a result, the population of urban centers, especially Kathmandu is increasing at a rapid rate. Meeting water demands in Kathmandu is therefore a major challenge for the government. There are nearly 2.2 million people living in the Kathmandu valley and their daily drinking water demand is about 220 million liters. Daily available water however, within Kathmandu valley is about 90 million liters in the dry season and 130 million liters in the wet season (Melamchi Project Document, 2008). Hence, the Government of Nepal, the donor community and non-governmental organizations are involved in finding alternative water sources to tackle the water scarcity crisis in Kathmandu. The Melamchi Water Supply Project (MWSP) was identified as a potential solution in 1973. The government of Nepal started the implementation of the Melamchi Water Supply Project in 1998 and originally, expected the project to be completed by 2008. However, due to various problems including the issue of downstream hydrological impacts, it is still difficult to predict whether the project will be completed by the extended date of completion i.e. 2015.

The Melamchi River is located about 40 m North-East from the Kathmandu valley and is one of the tributaries of the Indrawati River. The Indrawati basin is a sub-basin within the Koshi basin Figure 23. The MWSP diversion points of all stages are situated in the Indrawati River Basin which has a catchment area of 1,228 km^2. Melamchi, Yangri and Larke Rivers are major tributaries of the Indrawati River and have about 323, 117 and 116 km^2 catchment area respectively. The project plans to divert 170 MLD (1.97 m^3/s) of water from Melamchi river in stage-I and an additional 170 MLD from Yangri and Larke tributaries of the Indrawati River in stage-II and III (Bhattarai et al., 2002 and Mishra et al., 2001). The project is important and has attracted a lot of attention and interest not only because it is seen as a solution to the drinking water crisis in Kathmandu but also because this is the first inter-basin water transfer project that is in the process of being implemented in Nepal.

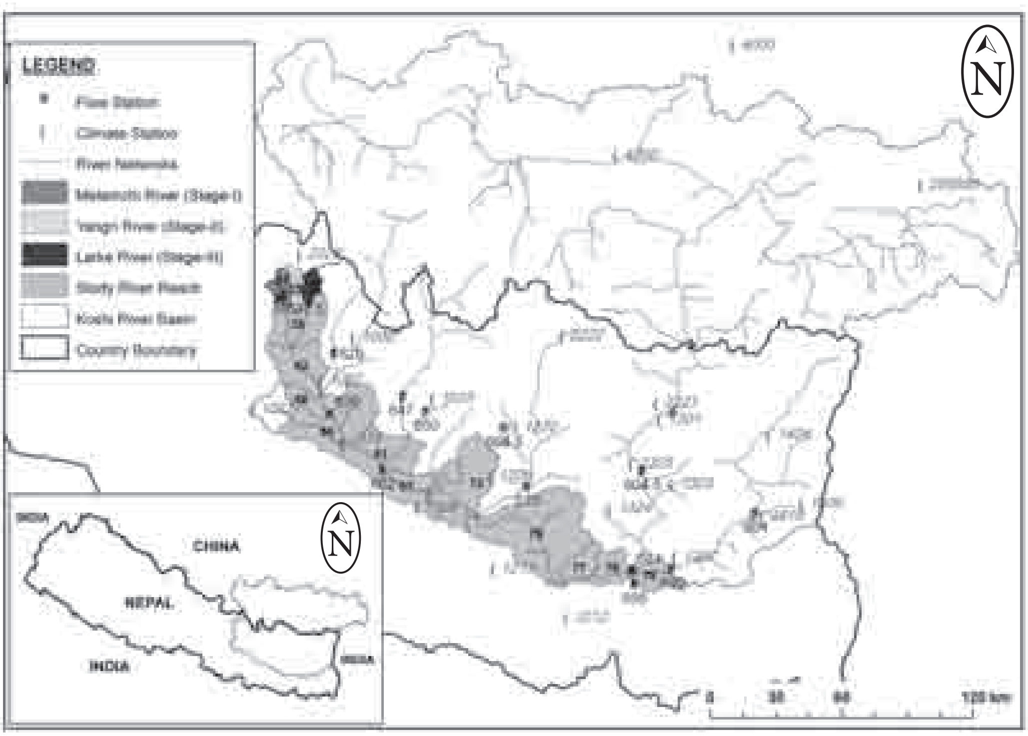


Figure 23: The study basin and observed climate and flow stations

At present, the available water in the Melamchi river basin is being used for irrigation, drinking water supply and sanitation, consumption for forest and vegetation, micro-hydropower generation and water mills (Melamchi Project Document, 2008). The project has a high level of skepticism among the local community and stakeholders, despite the project compensation package as well as the inclusion of minimum flows of 34.56 MLD (0.4 m^3/s) to be released downstream of the diversion (Bhattarai et al., 2002, IUCN, 1999 and Melamchi Project Document, 2008). So far, the project has paid about NRs. 880 million to the local community living in project affected areas as cash compensation (Melamchi Project Document, 2008). The demand and grievances of local people plus political circumstances and challenges in engaging the private sector partner have all contributed to delay the completion of the project (Khadka et al., 2008).

Although, the insufficiency of the prescribed minimum flow releases is one of the main critiques of the project, the few studies that have been carried out to look at water accounting have only focused on the Indravati River basin (Bhattarai et al., 2002, Mishra et al., 2001, Sharma, 2002). Therefore this study makes use of the distributed hydrological model developed for the entire Koshi basin to look at the hydrological impacts of the MWSP until the outlet of the Koshi basin at Chattara (Figure 23).

2. Methods

The SWAT model was setup for the Koshi basin as a part of the Indo- Ganges Basin Focal project (http://www.slideshare.net/cpwfbfp/indoganges-basin-focal-project). SWAT is a continuous, physically based, semi-distributed hydrological model developed by U.S. department of Agriculture in order to quantify impact of land management practices on water quantity, sediment and water quality in large complex watersheds with varying soils, land use and management conditions over a long period of time (Arnold et al., 1998 and Neitsch et al., 2005). For this study, the Koshi basin is divided into 79 sub-basins and delineated with the basin outlet at Chatara-Kothu. Detailed description of the methodology as well as results from the water balance analysis of the whole Koshi basin in preparation. Therefore, in this paper, only the results related to the downstream impacts of the MWSP will be discussed.

The Melamchi Water Supply Project (MWSP)

The downstream impact study is carried out for 11 among 79 sub-basins of the Koshi basin. The sequential order of 15 sub-basins and sub-basin numbers are in Figure 24. The study river reach starts from sub-basin 35 and ends at sub-basin 79. The Indrawati, Sun Koshi, Rosi, Tama Koshi, Likhu, Dudh Koshi, Arun and Tamor Rivers flows into the main river reach (Figure 24). The location of water transfer in stages I, II and III is the outlet of sub-basins 24 in Melamchi, 25 in Yangri and 22 in Larke rivers respectively (Figure 24). In stage-I, the calibrated model is re-run by setting planned monthly water transfer in sub-basin 24 by using the water use option in the SWAT model. The model is then re-run according to the monthly water transfer plan from sub-basins 25 and 22 respectively in stages II and III.

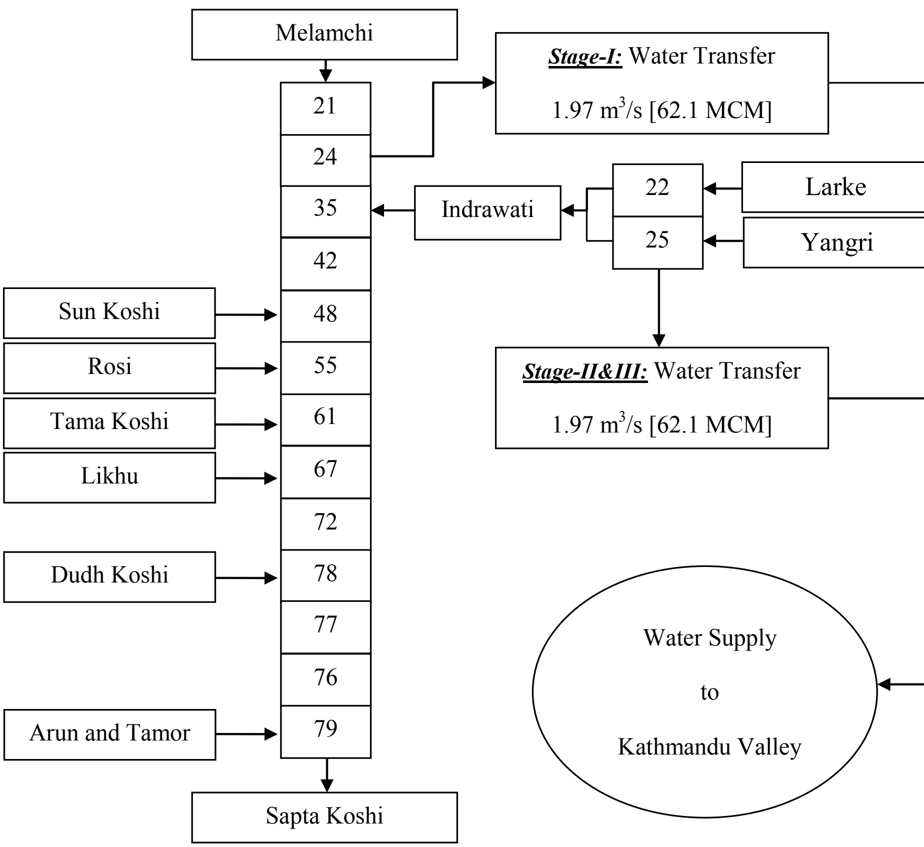


Figure 24: Melamchi inter-basin water transfer plan and flow network in the Koshi basin. The numbers in the figure refer to sub-basin numbers, which can also be seen in Figure 23

3. Result and Discussion

<u>Water Availability in Headwork of MWSP:</u>

As explained above, the outlets of sub-basins number 24, 25 and 22 are the locations for MWSP's water transfer sites in stages I, II and III respectively. The effective catchment areas of the Melamchi, Yangri and Larke River are 148, 110 and 114 square kilometers respectively. Figure 25 represents flow duration curves and monthly flow volume at the 3 water transfer locations. The study result shows that the flow available in downstream at driest month will be approximately 13% of the river flow of that month. The total available annual simulated water is 499 MCM, 443 MCM and 448 MCM respectively in Melamchi, Yangri and Larke river sub-basins. The flow volume of 401 MCM, 348 MCM and 355 MCM only occurred within 5 monsoonal months (June to October). Therefore, seasonal water flow varies significantly in the rivers and more than 80% of the total annual flow occurred within these monsoonal months.

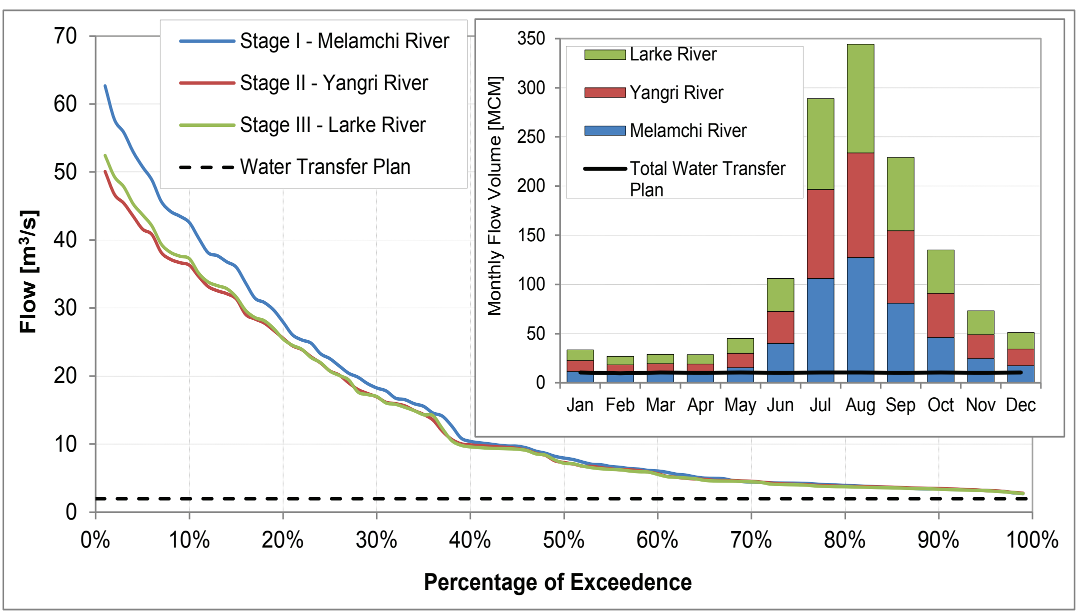


Figure 25: Flow duration curve and monthly flow volumes derived from simulated monthly flows in all three stages of the MIWTP

Impact of MIWTP along Downstream River Reach of Koshi Basin:

The three rivers Melamchi, Yangri and Larke meet at sub-basin 35. Therefore, water transfer in all stages will influence sub-basin 35 as well as the downstream sub-basins. Figure 26 shows the comparison of annual and seasonal average water flow. In the analysis, June to October is considered as wet season and the other seven months are dry season. Reduction in flows will occur in sub-basin 24 after stage I and subsequently it will occur in sub-basin 25 and 22 after stages II and III. Once the MWSP becomes operational, the annual average discharges flowing into sub-basin 35 will reduce by 12%, 7% and 7% due to the water transfer plan of stage I, II and III respectively (Figure 26). Likewise, in the Koshi basin outlet, at Chatara-Kothu, cumulative effects of all water transfer stages (I, II and III) on annual average flow is 0.2%. Seasonal results show that in the stage I water transfer plan, average inflow reduction in sub-basin 35 in the dry and wet seasons are 36% and 6% respectively, where as in stage II the inflow reduction are 18% for the dry season and 4% for the wet season. In stage-III, flow reductions are 20% in the dry season and 3% in the wet season (Figure 26). Furthermore, in the Koshi basin outlet, at Chatara-Kothu, cumulative effects of all water transfer stages (I, II and III) on average flow reduction in the dry and wet seasons are 0.6% and 0.1% respectively.

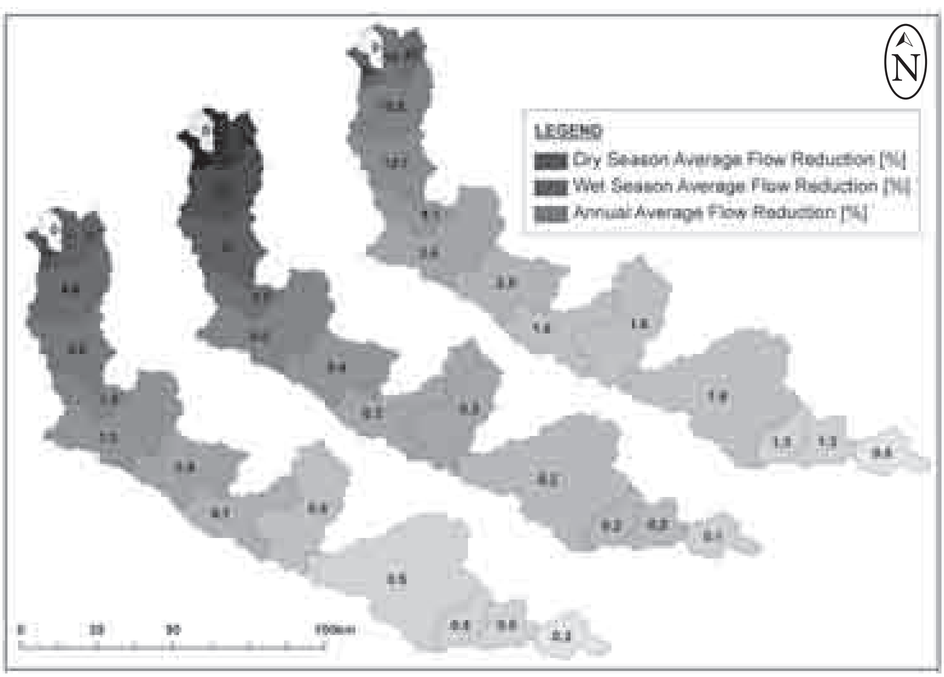


Figure 26: Percent flow reduction due to MIWTP in affected Sub-basins for annual, dry season (Jan-May and Nov-Dec) and wet seasons (Jun-Oct)

Water Balances at the Sub-basins in Study River Reach:

Figure 27 presents simulated annual average water balance for sub-basins downstream of the Melamchi Water Transfer Plan. The hydrological components illustrated in Figure 27 are annual average rainfall, actual evapotranspiration (ET), surface runoff, ground water percolation (water pass from root zone to shallow aquifer), soil water content, return flow (ground water flow from shallow aquifer or base flow) and lateral flow (water flowing laterally within a soil profile).

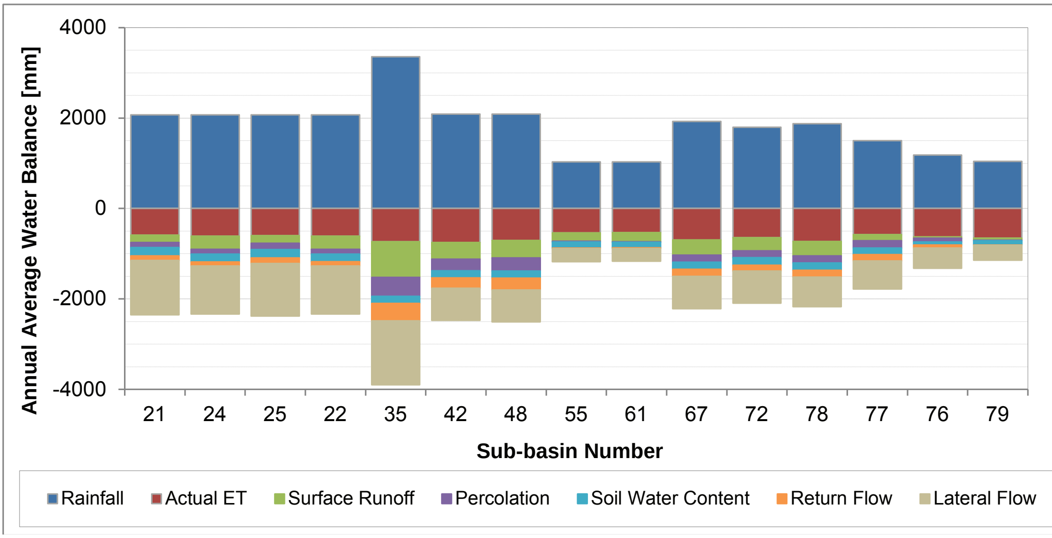


Figure 27: Simulated Water Balance at Sub-basins in Study River Reach

4. Conclusion

Although the debate on downstream hydrological impacts of the MIWTP is affecting the progress of the project, detailed quantification of the impacts in downstream sub-basins have not been done. Therefore, this paper serves to fill this gap. The simulated results show that in the stage-I water transfer plan, average inflow reduction in sub-basin 35 in the dry and wet seasons are 36% and 6% respectively, where as in stage-II the inflow reduction are 18% for the dry season and 4% for the wet season. In stage-III, inflow reductions are 20% in the dry season and 3% in the wet season. Furthermore, In the Koshi basin outlet, at Chatara-Kothu, cumulative effects of all water transfer stages (I, II and III) on average outflow reduction in the dry and wet seasons are 0.6% and 0.1% respectively. Therefore, MIWTP has considerable hydrological impacts on the sub-basin that is immediately downstream of the transfer points but not further downstream towards the basin outlet.

References

Arnold, J.G., Srinivasan, R., Muttiah, R.S. and Williams, J.R. (1098): Large area hydrologic modeling and assessment, Part I: Model development. *Journal of the American Water Resources Association,* Vol. **34(1)**: 73-89.

Bhattarai, M., Pant, D., Mishra, V.S., Devkota, H., Pun, S., Kayastha, R.N. and Molden, D. (2002): Integrated Development and Management of Water Resources for Productive and Equitable Use in the Indrawati River Basin, Nepal. *WORKING PAPER 41.* Colombo, Sri Lanka: International Water Management Institute

IUCN (1999): The World Conservation Union in Association with METCON, EIA of Melamchi Water Supply Project. *Melamchi Water Supply Development Board, Government of Nepal.*

Khadka, R.B. and Khanal, A.B. (2008): Environmental Management Plan (EMP) for Melamchi Water Supply Project, Nepal. *ENVIRONMENTAL MONITORING AND ASSESSMENT, EARTH AND ENVIRONMENTAL SCIENCE,* Vol. **146**, Number 1-3: 225-234.

Melamchi Project Document, (2008): Work Plan and Annual Progress Report of Melamchi Water Supply Project. *Melamchi Water Supply Development Board, Government of Nepal.*

Mishra, V. S. and Shilpakar, R.L. (2001): Water Accounting for Indrawati River Basin, Nepal. *Workshop on "Integrated Development and Management of Nepal's Water Resources for Productive and Equitable Use" organized by WECS/GoN and IWMI Nepal.*

Neitsch, S.L., Arnold, J.G, Kiniry, J.R. and Williams, J.R. (2005): Soil and Water Assessment Tool Theoretical Documentation. *Grassland, Soil and Water Research Laboratory, Agricultural Research Service, and Blackland Research Center, Texas Agricultural Experiment Station, East Blackland Road:* Temple, Texas 76502.

Sharma, C. (2002): Effect of Melamchi Water Supply Project on Soil and Water Conservation in the Indrawati River Basin, Nepal. *PROCEEDINGS of 12th ISCO Conference Beijing, "Sustainable Utilization of Global Soil and Water Resources", organized by Ministry of Water Resources, People's Republic of China.*

Enhancing water productivity with Micro Irrigation

Kailash Sharma and Luke A. Colavito [13]

International Development Enterprises, Nepal

Abstract

Micro irrigation technologies including drip systems, micro sprinklers, low cost water storage, treadle pump, and other technologies offer tremendous opportunities to increase smallholder returns to agriculture by enabling smallholders to produce high-value crops during the off-season, increasing productivity, and making optimal use of available water resources. IDE over the last 15 years has been involved in developing and promoting micro irrigation technologies in Nepal. In the last few years with support from the Bill and Melinda Gates Foundation IDE has designed and tested a new generation of micro irrigation products including low cost drip tape that covers a larger area, low-head high efficiency sprinklers, 5 inch treadle pump, soil cement tanks, Ferro cement tanks, plastic storage bags and high quality plastic for plastic lined ponds, and other technologies. IDE working with the private sector and government agencies is working to introduce these new products to smallholders. There is a tremendous need to promote this next generation of micro irrigation products through a public private partnership. This paper will detail the characteristics and suitability for new micro irrigation products for different applications in Nepal. And propose an approach to public private partnership to promote these products to increase the incomes and productivity of smallholder producers.

1. Introduction

In Nepal a total of 26,041,742 hector of lands are cultivated out of which 17,65,839 ha. are from conventional irrigation systems and the rest 8,75,903 ha. are non irrigable. These non irrigable land are potential for micro irrigation out of which 6,85,739 hector (source; Irrigation Dairy 2006) lands are in hills. This implies that supplying water through an irrigation network to increase production in hill areas is very challenging. The precipitation can be sometimes excessive where as some times very scarce which is causing agriculture productions to decline. The optimum use of water in irrigation can be obtained through the Micro Irrigation Technologies

13 Dr. Luke A. Colavito is the IDE Nepal Country Director and Kailash sharma is Engineering Program Director

(MIT) system which started in terai and hill region simultaneously. The lack of dry season irrigation is one of the most important constraints in the production of dry season high value and marketable crops. To address that constraint, micro irrigation technology is one of the reliable techniques to provide the required amount of water with low cost. Small scale irrigation at micro level is a micro irrigation. It includes all methods of frequent water application, in small flow rates, on or below the root zone in quantities that approach the consumptive use of the plants.

Since 1992, International Development Enterprises (iDE) has been implementing projects in Nepal that focus on linking low-income small plot farmers to markets to increase their incomes. iDE has developed and adapted technologies that are appropriate for Nepali farmers to access one or more sources of water, transfer the water from the source to where it can be used for irrigation, temporarily store the water, and then distribute and apply the water to crops. iDE in Nepal is a pioneer organization in the field of Micro-irrigation Technologies (MIT) and it has been implementing drip irrigation system, micro-sprinkler system, treadle pump, Thai Jar and soil cement lining tank. Except these technologies some other technologies like metallic treadle pump, mechanized treadle pump, Lay flat drip system (KB drip), soil cement pond are under the R & D activities

2. Micro Irrigation Technologies Widely Available in Nepal

IDE Nepal has designed and developed Nepal manufacture and supply chain for a variety of micro irrigation products.

a. Treadle Pump

Treadle pump is a simple, cheaper and effective device for water uplifting for irrigation. Water is lifted by alternate up and down movements of the legs on the bamboo/ wooden treadle when the depth of water is less than 6-7 meters. The pump output is varies from 90 – 34 liters per minutes depends on the depth of water tables and can irrigate up to 1500 sq.m land.

Treadle Pump Outputs		
Depth of Water	Maximum water Output * (l/m)	Daily pumping ** to irrigate 200m^2 (minutes)
1 m	90	18-25
4 m	60	30-40
7m	34	50-70
* Assumes single adult focused on the tasks ** daily pumping hours will vary on the quality of well, strength of operator, soil. Crop type, irrigation method and environmental conditions		

It has widely served as a means of income generating to small farmers of Terai areas of Nepal.

Following points should consider while installing pump:

1) The place should be finalized on the basis of layer of the ground water.
2) Pump should be installed properly and with enough care by trained technician.

The pump is compatible for flood / furrow irrigation, both in manually dug and drilled well, rivers ponds and other surface water but not appropriate for the pressurized irrigation systems. This is a very simple and environmental friendly system for establishing, operation and maintenance and it doesn't pollute environment. In recent years pumps sets have become popular but the treadle pump is lower cost and represents an effective stepping stone to bring smallholders into commercial crop cultivation as they graduate to utilizing pump sets.

b. Simple Drip Irrigation System

It is the simple baffle pre-punch drip irrigation system brings water efficiently to the roots of row crops, tress and other high value crops. It is a low cost environment friendly irrigation device need pressure ranges from 0.75 – 2 meter header tank sufficient for gravity feed. The product comes assembled with small plastic baffles that localize water flow from pre-punched hole of 60cm spacing in drip lines. The system can saved 50-70% of water as compared to traditional surface irrigation methods can improved yield and quality of crops due to appropriate water applications. The customized systems of 90, 125, 190, 250 and 500 sq.m sizes are available,. The drip kits of 6X10 sq.m, 6x15 Sq. M and 6 X20 sq.m sizes are compatible for low cost plastic house system are newly available in market.

Specification	
Emitter flow	2-2.5 liter/hour
Emitter Spacing	60 cm standard (other spacing can be custom ordered)
Pressure operating range	0.75 – 2 meter
Water filter needed	2mm screen filter + 2 X 100 mesh nylon filter at head tank
Maximum field undulation	3-5% slope. Shut off valves and pressure clamps can be deployed on steeper. Rises no taller than 10-15% of total meter head

The drip system is useful for crops in rows and compatible with pressure pump and header tank whereas incompatible for unfiltered water with impurities, heavily undulating land and closely spaced crops. The use of drip system reduces weed growth and soluble fertilizers 7 nutrients can be passed through increasing application. The system need regular vigilance is required to watch blocked emitters that can clog emitters. The standard sizes is available unless on special order.

c. Micro Sprinkler System

Sprinklers are the devices that spray water simulation the precipitation. To achieve this water under pressure is supplied through the sprinkler head to break water into small droplets before falling on the ground. It is a good option for closely spaced crops in area of water scarcity where surface flooding is not an option. The sprinkler system can bring the water to roots of crops that are on undulating fields. The pressure head needed to operate the sprinkler can be obtained by pump or by gravity. The technology is suitable for high value close crop vegetable, flower, and other high value crops. The sprinklers types vary from simple mechanical garden sprinkler to full or part circle ones.

A low head and part circle sprinklers are desirable in hill of Nepal. In hill there is no to create artificial operating head as gravity pressure is sufficient, but there is need to select appropriate size of the system to suit the situation. The micro sprinklers are the one operated in 8-10 meter pressure head and can irrigated 64 sq. m of land from 4 sprinkler head with average discharge per head of 70 liter/ hour. The 4 and 8 sprinkler head micro sprinklers kits are available and able to irrigate 250 and 500 sq.m of land with three shifts. It can irrigate crops of medium height up to approximate height of 0.5 meter.

d. Modified Thai Jar

Modified Thai Jars (MTJ) is large hand built cement tanks that provide an affordable and durable water storage solution in areas where water access can be scare or intermittent. The shape minimizes evaporation and the materials minimize seepages while remaining easy to construct and repair from local materials. MTJ have a relatively small footprint compared with similar sized options, making them ideal for closely spaced smallholders’ farmers. The available sizes are varied from 1000–3000 liters capacity. The 3000 liter MTJ is generally used for collecting domestic water in MUS.

The system is compatible for header tank, domestic use and irrigation through drip/ sprinkler. The tank can be filled with rain, spring fed or pumped. The water stored can use for irrigation, livestock and other purpose. The ferro-cement construction process need 3-5 days for construction from local trained mason and can easily repair. Lifetime expectancy 8-12 years and withstand even hailstone.

e. **Ferro-cement**

It is a buried tank build from ferro-cement technology. The collect water from low flow and/ or intermittent sources and for irrigation is typically pumped into header tanks. If the tank is built at an elevation to the field (up a hill, for instance), A pump may not be required to extract the water. The elevations provide the water pressure for MITs like drip and sprinklers. These tanks can support daily irrigation of fields up to 2000 sq.m or can smaller field through a long dry period. The construction sizes are 6,000 and 10000 liters. The wall of the tank is plaster from soil cement mixture followed by ferro-cement plaster. The system is compatible with MUS.

The simple construction process need 7-10 days of construction time and tanks durable more than 10 years. Regular maintenance is necessary to increase the life span and the risks are high in unstable ground.

Tanks Options		
Capacity	Field Size (Sq.M)	Irrigation water supply
1000 liters (MTJ)	100 250	2.5 days 1 day
1500 liters (MTJ)	100 250	3.75 days 1.5 days
3000 liters (MTJ)	100 250 1000	1.5 Days 3 days 0.75days
6000 liters (FCL)	100 500	15 days 3 days
10,000	100 250 1000	25 days 10 days 2.5 days
* Assumes use of drip irrigation and 4 mm of water per day. Water requirement will vary based soil 7 crops type, crop stage and environmental conditions.		

3. New MIT Product Development and Testing

iDE form the beginning involved in development and testing of water application technologies. From last few years iDE is involved in field testing of 2nd generation drip technologies and development of mechanized pump and storage tanks.

a. Micro Tube Drip Irrigation System (EZ drip): [Field demonstration and testing]

This is the drip irrigation system deliver water to roots of plants through micro-tubes efficiently. - The product is manufactured in India and promoted in KB brand. The system is available in customize size as well as in open system. During the RPI project iDE Nepal has started the field testing and demonstration of the customized sizes ranges from 100 – 1000 sq. m in hills and Terai of Nepal. This drip system can give 2nd generation option for those stallholders farmers waiting for upgrading the technologies and for bigger farmers facing agriculture labors shortage and effective irrigation tools for irrigating lands. There is option to use micro tubes in desire spacing for the first time. The system is compatible in pressure / mechanized pump; gravity feed/ header pump crops in row and fruit plants. The discharge from the 1 mm diameter micro tube is 5 liter/ hour.

b. Motor Operate Treadle Pump (Research and Development)

Using inefficient electric pump mainly 0.5 HP electric pumps is common practices in farmers' field for irrigating and has maximum discharge of 40 liter per minute. To meet the water need for smallholders' farmers' iDE Nepal during Gates Foundation funded project RPI, using 0.5 HP electric motor. Prototype of motor operate treadle pump has been developed and placed in field for testing at Rupandehi. Using belt drive system, motor is joined with treadle pump having revolution of 52 per minute able to discharge 90- liters water from minutes through 1.5” suction pipe in drilled well. There is still need to improve the system but the product may give best alternate option for both low quality electric pump and diesel pump. It is field testing and improvement stage for improving its efficiency.

c. 5” Metal Pedal Treadle Pump (Test marketing)

The 5” metal pedal Treadle pump is developed to meet the more water demand and irrigate larger area. The pump having twin 5” cylinder and its pedal is also made from metal. This pedal makes operation easy compare to ordinary treadle pump. Water lift from 2” suction pipe is limited to 4 meter with maximum discharge of 120 liter per minute and cover around 3000 sq. m of land. The test of the pump had been conducted in southern part of Rupadehi and Kapilbastu.

The pump seems to be useful for nursery raising of paddy field as well as irrigate other crops field like maize and wheat. The improvement in water delivery system may increase the irrigation area as well and minimize the water loss. The pump suction limitation has limited its working area mainly in southern part of Nepal. The system can lift water easily from pond stream etc with slightly modification in design that does not have any significant changes in cost.

d. Soil Cement Lined Pond (Field Testing and Demonstration)

The soil cement technologies are tested for the construction of low cost storage water pond that can be used for storing irrigation water in hills of Nepal. The clay mixed with cement and sand in 1:3:6 ratios for making pond gives the reduction of 50% cost in Ferro-cement lined pond and reduce the seepage by 95% than ordinary pond. The sizes tested on the field are 1, 2, 6 and 10 cu.m pond. The quality of pond is depend on the clay/ soil and should keep empty for its durability. Since it is in field test for last 2 years give some indication of alternate option for irrigation pond for smallholder farmers. The regular repair and maintenance in case of minor cracks formation increase the life of tanks.

4. Market Development

The MIT product itself is not sufficient to sustain unless there is a sustainable market network to supply the MITs and its spare parts. It is important for projects and programs to not only promote MIT projects but also to develop the private sector supply chain for sustainability.

iDE Nepal from the beginning involve private sector for the manufacturing the MITs like treadle pump, drip/ micro sprinkler. The entire product is produced in Nepal and iDE provide technical backstopping for the quality control. It has facilitated the manufacture for developing its supply chain network. In terai, most commonly promoted technologies like treadle pump is available in more than 370 hardware store from east to west of Nepal. More than 6,000 treadle pump are being sold per annum within and out of the project area gives the market scope of such pumps.

Likewise drip supply chain is developed in hills of Nepal having around 50 dealer network mainly agro-vet. The annual sales of the Nepal made simple drip system is 4000 kits per year. The possibilities of using drip and terai also have large scope after successful demonstration of Micro tube drip system (EZ drip) in different parts of country. The market network is developed for importing the system from India and will be available in market from this season.

5. Linking to Agricultural Value-chains with Micro Irrigation and MUS

The full benefit of MIT is not achieved unless there is an associated effort to link farmers to agricultural markets and appropriate inputs including water supply system which allows for efficient use of water. IDE has developed the supply chain for drip irrigation and micro sprinklers in many Nepal hill districts. IDE works with private sector partners building the capacity to manufacture and market low cost micro irrigation systems. The Nepal small drip kit greatly increases water use efficiency and boosts yields by about 30%. MUS are also ideal for the use of low cost sprinklers that require a limited amount of water pressure for operation.

IDE utilizes a value chain approach to develop input and output markets and link farmers with traders and service providers. In partnership with government and local NGOs IDE provides agricultural training and support linking to markets that creates demand and opportunity for profit based local service providers to be established. In Nepal MUS are generally located in weak markets that are remote from major population centers and that lack infrastructure and market access. Under these conditions the establishment of collection centers for aggregating vegetable production is a prerequisite to develop linkages with traders and regional markets. The program establishes and builds the capacity of community selected marketing and planning committees (MPCs) which manage collection centers. The MPCs manage collection centers in a variety of ways including developing cooperatives and selecting traders to act as agents for the producers. The MPCs also become involved in supporting services to farmers including the sale of agricultural inputs, credit, technical assistance, crop planning for market windows and representing farmers to government and development programs.

MUS and MIT are a critical part of any high-value agriculture strategy. MUS enable the density of adoption of micro irrigation and high-value crop production that creates volumes needed to establish local collection centers and sufficient market for the establishment of local input and service providers.

6. Conclusions and Recommendations

Conclusions and recommendations from the IDE Nepal program in developing MIT include:

- It has been shown that MIT have yielded cost effective benefits for smallholder farmers' commercial farmers and should be promoted. Newly introduced MIT cover larger areas and enable commercial scale production.

- It is critical that MIT programs have a complementing agricultural value-chain program to yield the full benefits.

- MIT have a strong impact to empower women through increased income and control over income, improved status within community and reduced workload.

- MIT promotion should include development of the supply chain to ensure that spare parts and product are available and impacts are sustainable.

- Programs should also promote MIT for their environmental and climate change benefits of utilizing water efficiently and increasing productivity and creating healthier plants that require less use agricultural chemicals and more efficient use of fertilizer thru fertigation.

Annex Tables

Cost Benefits of Drip and Treadle Pump

Most commonly promoted MITS are drip and treadle pump and having good rate of return in one crops seasons.

1. <u>Cost Benefits for Treadle Pump</u>

Treadle Pump Irrigated Open Cauliflower							
4000 Plants, 3 Kattha (1000 sq. m)							
Items	Description, Units	Quantity Required	Cost per unit (NRs)	Item Cost (NRs)	Useful Life (Seasons)	Seasonal Cost (NRs)	Total (NRs)
INPUTS							
Long Term							
Treadle Pump							
Pump Head	Standard Head	1	1,350	1,350	5	270	
Tube Well		1	2,500	2,500	10	250	
Bamboo	For Treadle	1	500	500	2	250	
Delivery pipe	40 m	1	1,600	1,600	2	800	
Installation	60 ft deep	1	3,000	3,000			
Nursery Plastic	Sq. Meters	3	40	120	3	40	
Agrotools	Various		2,000	2,000	3	667	
Seasonal							
Seed:				350		350	
Land Prep	Days	1	1,000	1,000		1,000	
Fertilizers:							

Compost	4 Kg/Plant	500	1		500		500	
Urea	1.5 Kg Total		20		0		0	
DAP	2.7 Kg Total		25		0		0	
Potash	1.1 Kg Total		30		0		0	
Boron	0.5 Kg		150		0		0	
Micronutrients			600		600		600	
Bio-Pesticides	Various		500		500		500	
Insecticide			75		0		0	
Fungicide			60		0		0	
						Total Seasonal Inputs:	2,950	
							Total Cost for Start-up and First Season:	14,020
							Total Seasonal Cost:	5,227
Items	Units	Amount Produced Per Plant (Kg)	Household Consumption (%)	Household Consumption (Kg)	Marketable Produce (Kg)	Market Price (RS/ Kg)	Cost of Marketing (Transport, Packaging)	Total
OUTPUTS:								
Vegetable sales	Per Kg	0.75	2%	60	2940	8	2%	23,050
							Total Gross Income:	23,050
							Net Seasonal Profit	17,823

2. Cost Benefits of Drip System

Lattice Drip for Open Field Cauliflower in Mid Hills							
480 Plants- Snow Mystic, Shifting Drip Lines, 0.5 Kattha(166 sq. m) (Jan-Apr)							
Items	Description, Units	Quantity Required	Cost per unit (NRs)	Item Cost (NRs)	Useful Life (Seasons)	Seasonal Cost (NRs)	Totals (NRs)
INPUTS							
Long Term							
Drip System	Large (12 Hose)	1	4,085	4,085	5	817	
Nursery Plastic	Sq. Meters	3	40	120	3	40	
Agrotools	Various		900	900	3	300	
Seasonal							
Seed:				120		120	
Fertilizers:							
Compost	4 Kg/Plant	320	1	320		320	
Urea	1.5 Kg Total	1.5	20	30		30	
DAP	2.7 Kg Total	2.7	25	68		68	
Potash	1.1 Kg Total	1.1	30	33		33	
Boron	0.5 Kg	0.5	150	75		75	
Micronutrients			205	205		205	
Bio-Pesticides	Various			700		700	
Insecticide		2	75	150		150	
Fungicide		2	60	120		120	
					Total Seasonal Inputs:	1,551	

							Total Cost for Start-up and First Season:	6,656
							Total Seasonal Cost:	2,708
Items	Units	Amount Produced Per Plant (Kg)	House-hold Con-sump-tion (%)	Household Consump-tion (Kg)	Marketable Produce (Kg)	Market Price (RS/Kg)	Cost of Market-ing (Transport, Packaging)	Total
OUTPUTS:								
Vegetable sales	Per Kg	1.2	10%	57.6	518.4	15	2%	7,620
							Total Gross Income:	7,620
							Net Seasonal Profit	4,913

Micro Irrigation Mega Impact : A small step towards Social integration and Economic uplifting of the poor, disadvantaged and women

Kishor Kumar Bhattarai
SDE, DoI

Abstract

Non-conventional irrigation system which synonyms micro irrigation at present was initiated to provide irrigation facility to chronically water deficit areas that generally are inhibited by destitute and marginalized people. Rescuing poor from vicious cycle of poverty and uplifting women, disadvantaged and marginalized groups of people economically are the ultimate goals of this project. Written objective of NITP thus are to develop irrigation facility to provide an effective micro-irrigation service delivery mechanism with high value crop production to support poverty alleviation. Apart from basic objective of providing irrigation to otherwise dry lands it has been successful in lessening social discrimination emanating from social and economic inequality such as poverty, illiteracy, gender, and cast system. Applying an option for the poor has never implied advancing a particular strategy for a national economy but they certainly serve important social agendas. Fortunately, some pertinent highly sensitive social agendas are being served even though they are not spelled clearly in project objectives. Thanks to project selection criterion adopted, size of the projects, and implementation procedure for these achievements. Right to development, Social Justice, Women's Empowerment and Development with human face (HDI) are the areas where micro irrigation has achieved. This paper tries to highlight those achievements, already achieved as well as could be achieved, and their importance in the present context of meaning of development.

1. Introduction

Non Conventional Irrigation Technology Project (NITP) was established on 2060 B.S. to promote *other than* conventional irrigation technology/ies and techniques. Its aim is to develop irrigation systems incorporating efficient technologies for both under irrigated areas as well as to areas where conventional irrigation systems is not possible due to reasons like high development cost, insufficient quantity of water, unsuitable geology, land and soil, etc hence designated as non irrigable. Apart from basic objective of providing irrigation to otherwise dry lands it aims to lessen social discrimination between 'have's" and "have not's". Rescuing poor from vicious cycle of poverty and uplifting women, disadvantaged and marginalized groups of people economically are the ultimate goal of this project.

At present NITP is promoting micro irrigation technologies and developing efficient irrigation systems for such technologies. Micro irrigation in Nepalese context is "micro both in terms of command area size as well as in application" rather not only "in application at micro level" as in other developed countries. Hence, very small irrigation systems using simple drip and micro sprinkler for water application are among the non-conventional irrigation systems. However, present understanding of micro irrigation system only as synonym to small irrigation will eventually hamper the progress of non-conventional irrigation development in Nepal.

In the midst of all hues and cries for large conventional projects, non-conventional or micro irrigation is forced to obscurity, at least for the time being. The economical status of majority of people and average land holding per family has left us with little or no choice other than to go for micro irrigation. Undeniably, micro irrigation is the future of the Nepalese irrigation system. However, understanding Non Conventional Irrigation System as synonym to micro irrigation in terms of command area size for forever will be a mistake.

1.1 Overall Status of Irrigation and Scope for non-conventional irrigation schemes

Total agricultural land in Nepal is about 2640 thousand hectares. Out of which there is potential to develop irrigation facility to only 1766 thousand hectares either through surface irrigation or by utilizing ground water. Farmers, mostly poor, of remaining 874 thousands hectare have no other option than to pray "rain god" for timely rain or "irrigate" their farmlands only with their sweat.

Inclusive of irrigation systems for 636 thousand hectares developed by farmers themselves irrigation infrastructures are already built for total 1252 thousand hectares which is 47% of total agriculture land and 71% of total irrigable land. Almost 50% of theses irrigation systems built by farmers have received government assistance for upgrading and maintenance. Only 46% of irrigated land or 22% of total agricultural land has year round irrigation facility.

Based on present scenario it will not be an exaggeration to say that potential agricultural land area for non-conventional irrigation development is around 1000 thousand hectare which is the summation of non irrigable agricultural land and irrigated land with seasonal irrigation only. Further, it is possible to increase irrigation capacity of present irrigation infrastructures drastically with adoption of efficient drips and sprinklers systems for water application.

2. Development, Right to development and Micro Irrigation

2.1 Development

Immediately after war, it was universally accepted that economical development is a historical process bound to take place in almost all societies driven by construction and reconstruction of infrastructures, expansion of industry, increased production and consumption of goods and services. But after 50 or so years people started challenging this assumption that development is a matter exclusively of economic growth and increase in gross domestic product. Terminology "GPH standing for General Peace and Happiness" coined by king of neighboring country found place in eminent economist Amrtya Sen's thought and Mahbub ul-Haq's vision through "Human Development Index" propounded by UNDP. Human welfare approach of development considers human beings as beneficiaries rather than participants in development process.

If the outcomes of development are not accompanied with an improvement of the well-being of all people, if people do not meaningfully participate in the process or if the distribution of benefits is iniquitous and unfair, they will not be regarded as development.

Growth that brings inequality, unemployment and regional disparity cannot be categorized as development. Development is a comprehensive economic, social, cultural and political process, which aims at the constant improvement of the well-being of the entire population and of all individuals, on the basis of their active, free and meaningful participation in development and in the fair distribution of benefits resulting there from. Human development is a process of enhancing human capabilities - to expand choices and opportunities so that each person can lead a life of respect and value.

2.2 Right to Development

Right to Development is conceived on the premise that development is itself a human right. The right to development is an inalienable human right by virtue of which every human person and all peoples are entitled to participate in, contribute to, and enjoy economic social, cultural and political development, in which all human rights and fundamental freedoms can be fully realized.

<u>Poverty is a state of powerlessness in which people are unable to exercise their basic human rights or control virtually any aspect of their lives.</u> Hence any development activity which does not bring any positive changes in poor people's live, which does not tries to bring poor out from vicious cycle of poverty, which does not encourage and motivate them to claim for their rights and which fails to lessen social discrimination and exclusion is not development at all.

Human right and human development share a common vision and a common purpose- to secure freedom, well being and dignity of all people everywhere. Human development is a process of enhancing human capabilities - to expand choices and opportunities so that each person can lead a life of respect and value. The RTD can be described, in this sense, as a human right to human development- the entitlement to a process of enhancing human capabilities and freedom.

The Rights based approach to development includes the following elements.

- express linkage to rights
- accountability
- empowerment
- participation
- non-discrimination and attention to vulnerable group

A. express linkage to rights

Human right is an indivisible and inalienable right. Indivisibility is associated with the principle of interdependence. Two rights are indivisible if one can not be enjoyed if the other is violated. For RTD which is a composite of all civil, political, economic, social and cultural rights, its indivisibility implies that for an improvement of the right, at least one of the constituent rights improves while no other right deteriorates or violated.

Human Rights initially attached itself with the political rights only with special attention on non-interference (freedom from i.e. negative rights) on personal life and thinking of individual by the state. Second generation of thought included social economic and cultural rights in human rights which sought interference or affirmative action on the part of the state. Third generation of thought gave new dimension to human rights by including right to development as a major component of human rights. Every individual has thus right to demand for development as per his need and raise voice if he feels discriminated in terms of development.

B. Accountability and Participation

The RTD approach focuses not only on the ends of development but also on the means of development. Means here is the process, which should guarantee accountability born by all the actors involved in development, decisive participation of all irrespective of their cast, race, religion, gender, social and economical status in each stages of development and their empowerment.

C. Non-discrimination and attention to vulnerable group

Similar to the principle of human rights basic element of RTD approach is also non-discrimination and attention to vulnerable group. Giving attention to certain group is itself contradictory to non-discrimination principle but without positive discrimination problem faced by vulnerable groups cannot be addressed in totality and will not be able to do justice to targeted community. Affirmative actions are needed to correct, offer remorse and compensate for neglect and seclusion of disadvantaged group since historical times. Obviously positive discrimination is their right, not a cry or pleads for sympathy.

2.2.1 Elements of Right to Development and micro irrigation

Fortunately, micro irrigation schemes of NITP are attaching equal and unequivocal support to all of the elements of Right to Development. NITP firmly believes that development is a right not a generosity. Being small and selective in nature projects undertaken never infringe any of the rights at the same time they effectively improve and interlink different rights through different criterion, mandatory provisions, process and equitable benefit distribution set up. Accountability, participation, empowerment, non-discrimination, and attention to vulnerable group all these are ensured through mandatory participation process through user's committee, selection criteria and size and objective of the project. For NITP Development is not only a matter exclusively of economic growth and increase in gross domestic product. In any case, sustainable GDP growth is possible only when there is all-round, balanced development.

NITP believes in positive discrimination and attention to vulnerable group. So, non-discrimination within the boundary set up by the positively discriminatory selection criterion is basic principle of NITP. Irrespective of whatever written in objectives, to be candid enough, for NITP all those who cannot claim their rights or are voiceless are potential beneficiaries. State of being powerlessness resulting from poverty and lack of education, not only the cast are proving to be more detrimental towards the cause of social justice. NITP firmly believes that genuine change is most often rooted in small communities of poor people and NITP through development of micro irrigation schemes can play very important role in this change. Hence, all neglected areas and communities are primary target of NITP development.

2.3 Achievements in Social Sectors

Social inclusion and women empowerment are other two areas of major achievements of NITP's micro irrigation schemes. Objective of social inclusion is being achieved through overall participatory process. Through this process decisive participation of all irrespective of their cast, race, religion, gender and economical status is ensured in each stages of development. Mandatory provision of 33 percent women in WUA's (Water User's Association) executive committee is helping in women's empowerment by installing confidence in them and providing opportunity for leadership.

2.3.1 Social Justice

Discriminations of any nature or of any origin i.e. cast, gender or economic status based are ultimate source of all kinds of social injustice. Hence, Social integration or inclusion is a first major step towards social justice. Social mobilization, which is by-product of overall mandatory participation process starting from planning stage continuing in operational stage, is most effective tool for social integration in reality much more effective than all laws, political dictates and coercive actions. Human right frequently becomes a surrogate for social justice, the assumption being that what contributes to social justice in the context of development is also a contribution to human rights.

2.3.2 Women Empowerment

Lack of sense of self-respect and feeling of non-identity both are main source of, oppression and discrimination against women. At the same time they are the cause of scourge among women also. Economic independence is vital in awakening sense of self-respect and feeling of individual identity.

Leadership ability and sense of economic independence are very important in women's empowerment as these two factors have direct impact on individual identity, dignity, self-respect and social standing. Leadership ability comes from knowledge and capability to demonstrate and implement such knowledge.

Economic independence is achieved through control over resources i.e. by selling agro products and controlling the returns. In small micro enterprises such as small micro irrigation supported agricultural activities women benefit in particular, because their say over the output of homestead based activities tends to be stronger than for other sites of agricultural production. By selling their agri-products directly and controlling returns, no matter how much tiny the amount is, it is imparting a sense of financial independence in women. Though not appreciated to the level it deserves this is a precious surprise gift in the list of achievements of micro irrigation schemes of NITP.

NITP is instrumental in increasing women's confidence level by giving them leadership opportunity through WUA, improving their leadership quality by involving them in various micro irrigation and agriculture related trainings, participation in user’s committee activities, interaction programs and introducing sense of freedom in them by including them in "away from home" farmers tour program.

2.3.3 User's Committee in micro irrigation schemes

User's participation in overall project implementation process through user's committee is key to social mobilization process in all projects but it is much more effective in small micro irrigation schemes. User's participation throughout different phases of project implementation is establishing sense of ownership among them, which is the main stated objective of participation. At the same time this process is successfully creating awareness among the disadvantaged group (poor, women, so called lower cast and ethnic group) in the community, helping them to organize, empowering them for decision-making so that they can identify and prioritize their needs. It is also building up user's capacity for preparation, implementation, operation and management of subprojects in other areas as well to enhance their livelihoods.

Democratic process adopted in electing executive committee of User's Committee is another important aspect. Inclusiveness through mandatory provision of at least 33 per cent women members in the WUC is major achievement in social sector and has greater than expected impact on overall task of women's empowerment. In the form of user's committee micro irrigation schemes of the NITP is providing platform to poor, dalits, janjatis and women to mingle with others, which is invaluably instrumental in raising their level of self confidence.

In fact it can be said that main goal of the micro irrigation development is to implant sense of economic independence among the poor peoples of detached community especially women. Keeping the target communities poor, women, *Dalits* and *Janjatis* at the driving seat, NITP through micro irrigation schemes encourages them to take initiatives to improve their livelihoods.

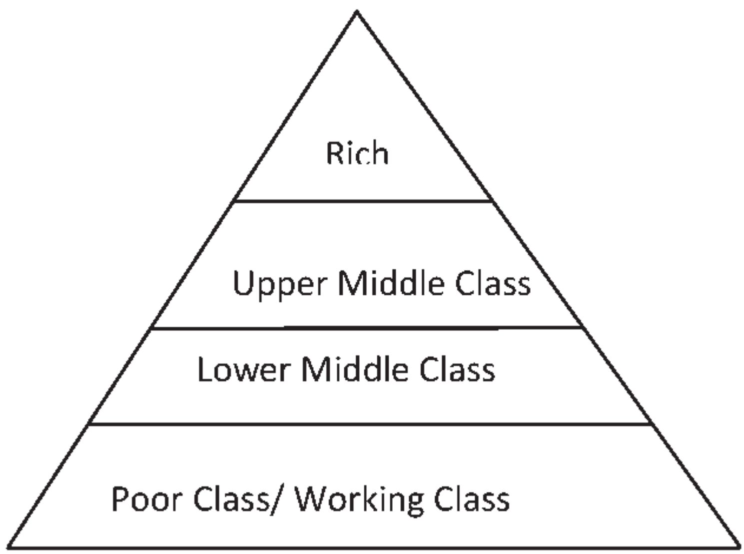
3. Assuage pressure on poor and ensuring socio-economic stability

Throughout the history, agriculture has been the engine of economic growth in most of the middle and high-income countries. Rural economy since long back has always acted like a catalyst in economic growth and played crucial role in overall economic growth of any country. Both Chinese and Indian economic growths were fueled by growth in agriculture based rural economy and are still main force behind their robust growth. It still can do miracle in today's low-income countries. For

Nepal it is natural that economic health of a country where nearly 80% it population are dependent on agriculture is so much reliant on agriculture based rural economy.

3.1 Price rise: Impact and Opportunity

Present food crisis with unprecedented price rise and economic hardship thus faced by urban and peri-urban poor who are the hardest hit is a challenge faced by all nations that is threatening to destabilize scio-economic fabric of the society. But, is it a bane only or can be turned into boon for small farmers?



However assuming that all poor people are merely passive victims in the same circumstances may harm even more. Those who are the hardest hit are poor net food buyers who tend to spend up to 80% of their incomes on food. But even many peri-urban and few urban poor net food buyers already grow some food or hold livestock for self consumption. Urban agriculture and small-scale enterprise by an estimated 800 million farmers contributes to 15 to 20% of the world's food needs. This trend is likely to continue under food price hikes.

Rich and upper middle class in pyramid depicting economic status of any society (or country or whole world as a whole) always find ways to transfer this negative impact of the price rise to lower class. It is middle class, who act like cushion as far as price rise effect is concerned. Lower middle class absorb some of this impact. But larger percentage of impact is transferred to lowest level in pyramid depicting economical status. To avoid social unrest and tension between “haves” and “haves not” safe mechanism must be there to redistribute this burden either back to the society reciprocally among all in different tiers of pyramid or prepare solid base to act as a "foundation" to transfer this burden to "firm ground below". Small scale agricultural enterprises envisaged and promoted by NITP is both preparing ground for this foundation as well as playing role in redistributing this burden among the different economic class tiers.

If handled properly in rural areas where a significant proportion of the poor are either net food producers or have potential to become net vegetables producers, the crisis could in principle lead to nothing less than a historical turning point towards poverty eradication. NITP is doing the same by putting small-scale farming in forefront.

4. Conclusion

Without deviating from its stated objectives and being focused on targeted community NITP, through development of micro irrigation schemes, has been successful in encompassing some of the pertinent sensitive issues in its objectives even without mentioning about it. These achievements in Socio-Economic sectors and for that matter in Rights are indeed remarkable. Economic independence, leadership quality, self-identity and confidence, which are key ingredients in achieving women's empowerment, are major self-satisfactory moral boosting achievements. Similarly, micro irrigation schemes are playing very important and effective role in lessening social discrimination, exclusion and seclusion of deprived and destitute populace.

Development induced by NITP kind of projects are in real sense "development with human face" where most deprived, marginalized and excluded sect of people are benefited and experience positive changes brought by it. The achievements of NITP in Socio-Economic sectors are indeed remarkable. These achievements in Socio-Economic sectors are indeed remarkable.

Topography of the country, poverty level, land fragmentation etc makes it imperative to promote micro irrigation in Nepal.

More training and motivational programs are needed to convince more farmers to adopt these technologies and switch over to high value crop farming. Either by government or through I/NGOs with government support this initiative must continue.

References

1. Bhattarai, K. 2010. Non conventional Irrigation Technology Project: An Introduction. Irrigation News Letter. 58: 4-5.

2. Bhattarai, K, 2011, Climate Change and Non Conventional Irrigation Technologies, Irrigation News Letter, 60:4-7

3. Pandey, N. and Adhikari,D,L.,2007. Non conventional Irrigation Technology (NIT) An encouraging effort for Economic and Social Inclusion of the Disadvantaged Poor, National Seminar Proceeding, PP 14-19

4. The Right to Development A Primer, Centre for Development and Human Rights, New Delhi,(Sage Publication, New Delhi)

Annex 4

Photos of Workshop


Micro to Mega: Irrigation for Prosperous Nepal


Micro to Mega: Irrigation for


Micro to Mega: