

National Irrigation Seminar

May 23-24, 2014

Dhulikhel

Proceedings

On

Irrigation to all Cultivable Land:
Challenges and Opportunities



Government of Nepal
Ministry of Irrigation
Department of Irrigation



International Network on Participatory
Irrigation Management-Nepal



International Water Management Institute-Nepal



Department of Irrigation
Jawalakhel, Lalitpur

Proceedings of National Irrigation Seminar

Irrigation to all Cultivable Land: Challenges and Opportunities

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FOREWORD

Irrigation policy, 2070 has envisaged providing sustainable and year round irrigation service to all the agricultural land of the country to help increase agricultural productivity. Department of Irrigation has been constantly working in irrigation development and management since its establishment in 2009 B.S. It is imperative to provide year round irrigation service from the irrigation infrastructures developed in the past without major changes in line with the development and management of irrigation systems in sustainable manner. Inter-basin water transfer and reservoir based irrigation projects shall be started to develop on the basis of their feasibility, conjunctive use of locally available surface water and groundwater shall be judiciously used, small sources in the hills and mountains shall be utilized optimally and the ad hoc system of irrigation management shall be transformed to maximize their capability. In addition, to make water users' associations responsible and accountable in the development and management of irrigation systems for the effective implementation of participatory system, need of effective programs cannot be shadowed. The concern of adverse effect caused by population increase, immigration, climate change, and water induced disaster to the water sources and their use in irrigation and implementation of suitable resilience programmes has to be well planned and incorporated in the programs. Additionally increasing capability and involvement of local bodies in the development of small irrigation systems as per the concept of decentralization is important. To explore the roadmap for the development and management of irrigation sector in the changed context, DOI is organizing a national level irrigation seminar each year from last few years. In continuation to it, national irrigation seminar with theme "**Irrigation to all Cultivable Land: Challenges and Opportunities** " was organized on 2071/2/09-10 (23-24 May, 2014) to bring national level stakeholders from government and non-government sectors in one forum to discuss the various issues of irrigation. This proceeding is a collection of findings of the seminar and hope that it will be helpful in fulfilling the future need for planning 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. I would like to thank Consolidated Management Services (CMS) Pvt. Ltd, Multi-Disciplinary Consultants Pvt. Ltd, Silt Consult Pvt. Ltd, Environmental Resources Management Consultancy (ERMC) Pvt. Ltd, Fullbright Consultancy Pvt. Ltd, Geoce Consult Pvt. Ltd, Project Engineering Consultancy and Research (PRECAR) Pvt. Ltd. for their support. My special thanks goes to Hon. Minister Mr. Narayan Prasad Saud, Ministry of Irrigation for his support and guidance for overall irrigation development and management. I am very much thankful to Mr. Madhav Prasad Regmi, Secretary, and Ministry of Irrigation for his constant encouragement and support in conducting the seminar. Paper presenters are well acknowledged for their valuable technical papers and presentations. I am equally thankful to the participants for the active participation and lively discussions. I would like to thank Mr. Sagar Kumar Rai, DDG, DOI and the members of 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.

Shiv Kumar Sharma
Director General
Department of Irrigation

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Acronyms

AWDI	Alternate Wet and Dry Irrigation
BCM	Billion Cubic Meters
DOI	Department of Irrigation
DWIDP	Department of Water Induced Disaster and Prevention
FMIS	Farmer's Managed Irrigation Systems
GMIS	GIS based Management Information System
GWDB	Ground Water Development Board
ICIMOD	International Centre for Integrated Mountain Development
INPIM	International Network for Participatory Irrigation Management
IWMI	International Water Management Institute
IWRM	Integrated Water Resources Management
M&E	Monitoring and Evaluation
MHP	Micro Hydro Power
MIS	Management Information System
MOI	Ministry of Irrigation
NCIT	Non-Conventional Irrigation Technologies
NFIWUAN	National Federation of Irrigation Water Users' Association
SMTP	System Management and Training Program
SRI	System of Rice Intensification
STW	Shallow Tubewell
WECS	Water and Energy Commission Secretariat
WUA	Water User's Association
O&M	Operation and Maintenance
GON	Government of Nepal
GLOF	Glacier Lake
FMIST	FMIS Trust
ISF	Irrigation Service Fee
NITP	Non-Conventional Irrigation Technology Project
RBO	River Basic Organization
NGO	Non Government Organization
NPC	National Planning Commission

1. INTRODUCTION

1.1. Background

Department of Irrigation (DOI) has been organizing National irrigation seminar every year since 2007 A.D. The aim of the workshop is to review the achievements and explore future opportunities and challenges for the development of Irrigation sector. Senior Level officials from Ministry of Irrigation and its line agencies participate in the workshop. Eight edition of the National seminar was held on 09-10 Jestha, 2070 at Dhulikhel Resort, Dhulikhel. It was jointly organized by Department of Irrigation (DOI), and International Water Management Institute– Nepal (IWMI-Nepal). 14 technical papers were presented in four different subthemes. The workshop was attended by more than 130 experts and intellectuals from Ministry of Irrigation and Water sector.

1.2. Rationale of Workshop

Nepal has the glorious history of irrigated agriculture. From many centuries, Nepalese farmers have practiced to divert water from the river for irrigation using conventional technologies. With increasing population, demand of increasing production and productivity has increased. In such, Nepal Government also saw the need of planned irrigation development to fulfill the need of food security. Chandra Canal in the year 1985(BS) was the first initiative of the Government towards the development of modern irrigation system in the country. After the start of periodic development from the year 2013(BS), Government of Nepal has been investing sufficiently in this sector by implementing different policies, plans and programmes. Though past efforts have made substantial improvement in the irrigation technology, available irrigation infrastructures, and human resources and institutional built up in the public and private sectors but still the need to provide sustainable and year round irrigation service to all the agricultural land of the country to help increase agricultural productivity is imperative. Taking above mentioned concern into consideration, Irrigation National Seminar, 2071 was formulated to review and assess the future roadmap of DoI activities to achieve its objective to provide Irrigation services to all Cultivable Land.

1.3. Seminar Objectives

The overall objective of the seminar was to review the achievements and assess the opportunities and challenges in irrigation development to all cultivable Land. In this context, the specific objectives of the seminar were to:

- Assessment of Water Management for efficient Irrigation
- Comprehensive assessment of Socio-economic aspect of Irrigation

- Assessment of the multiple use of Water and Year Round Irrigation
- Assessment of Innovative methods in Irrigation

1.4. Content of the Seminar

“Irrigation to all Cultivable Land: Challenges and Opportunities” was the theme of the Seminar. It was divided into four subthemes to meet the objectives that were set along with a plenary session.

Subthemes were:

1. Water Management for efficient Irrigation
2. Socio-economic aspect of Irrigation
3. Multiple use of Water and Year Round Irrigation
4. Innovative methods in Irrigation

Irrigation and water resources experts presented the following fourteen technical papers on four sessions and seven presentations on plenary session and focused in the above mentioned subthemes.

Agenda of the program is attached in Annex 1.

S.no	Paper Title	Authors
Session I : Water Management for efficient Irrigation		
1	Assessment of suitable energy options in pumping groundwater for irrigation: A case study from Nepal	Dr. Ram C Bastakoti and Mr. Romulus O Okwany and Mr. S A Prathapar
2	Integrated Water Resources Management: A Way Forward	Dr. Prachanda Pradhan
3	Issues and challenges in Land acquisition	Mr. Krishna Dev Rai
Session II : Socio-economic aspect of Irrigation		
4	Irrigation Development and Management from Gender Equity and Social Inclusion Perspective: a reflection of LILI's approaches	Mr. Vinod Kumar Barai
5	Impact of Socio-economic status on cropping intensity in Tarawali Irrigation Scheme, Lamjung, Nepal	Mr. Santosh Kaini
6	Men, women and irrigation: looking up from the fields	Dr. Floriane Clement, Ms. Neha Rayamajhi
7	Environmental Flows and Climate Change	Dr. Luna Bharati ,Mr. Utsav Bhattarai
Session III: Socio-economic aspect of Irrigation		
8	Irrigation Modernization, the way of Year Round Irrigation and Water Utilization in Nepal	Mr. Uttam Raj Timilsina

9	Water Harvesting Dam and Hillside Irrigation: Experience from Rwanda in Upper Nile River Basin	Mr. Basistha Adhikari
10	Benefit Multiplication through Multiple Water Use System: Comparison of Single Functional and Multi Functional Irrigation System in the Mid Hills of Nepal	Mr. Anand Gautam
11	Impact of Arjun Khola Irrigation Project after 20 years of Implementation	Mr. Lok Bahadur KC
Session IV : Innovative methods in Irrigation		
12	GMIS for Sustainable Planning and Management of Irrigation Systems	Mr. Sushil Chandra Tiwari
13	Improving Irrigation Efficiency through alternate wet and dry method of water management for paddy cultivation	Mr. Ramashraya Shah and Dr. Indra Lal Kalu
14	Spill Energy From Micro hydropower Plants for Small Scale irrigation in hill and Mountain region– An Untapped Synergy	Mr. Suraj Baral
Plenary Session : Irrigation to all cultivable Land		
15	Policy Aspect in Irrigation Development	Mr. Shital Babu Regmee
16	Multipurpose Irrigation Projects	Mr. Som Nath Paudel
17	Non-Conventional Irrigation Technologies	Mr. Deepak Lochan Adhikari
18	Groundwater Irrigation Development: Prospects and Constraints	Mr. Siddhi Pratap Khand
19	Role of FMIS in Production Enhancement	Mr. Nabin Mangal Joshi
20	Operation and Maintenance of Irrigation System	Dr. Khem Raj Sharma
21	Innovative Irrigation Technologies	Dr. Bishnu Chapagain and Mr. Khoj Raj Katuwal

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 contribution
- Special invitees
- Official representation from Ministry of Irrigation (MoI)
- 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
- Official representation from Auditor General
- Consultants and water resources experts

List of Participants is attached in Annex 2.

2. PROCEEDING

2.1. Registration and Opening session

The seminar was formally inaugurated by Chief Guest Hon. Minister, Mr. NP Saud, Ministry of Irrigation (MOI) on 9th Jestha, 2071 morning in Dhulikhel Lodge Resort, Dhulikhel by irrigating a plant. Mr. Madhav Prasad Regmi, Secretary, MOI; Mr. Sriranjana Lacaal, Secretary, WECS; Mr. Kamal Prasad Regmi, Director General, DWIDP; Mr. Basu Dev Aryal, Executive Director, GWDB; Dr. Luna Bharati, Chief, IWMI/Nepal were the special guest for the session. The session was chaired by Mr. Shiv Kumar Sharma, Director General, DOI. Mr. Sagar Kumar Rai, DDG, DOI was the seminar coordinator and Mr. Basudev Timilsina, SDE; DOI was the Master of Ceremony. 130 personal participated in the program from Ministry of Irrigation, different government agencies, National and International agencies and freelancing water resource experts.

Mr. Sushil Chandra Tiwari, DDG, DOI welcomed the participants and paper presenters. He briefly highlighted the rationale of this seminar in the present context. Mr. Tiwari stressed on the importance of the workshop's theme for addressing the need of irrigation services to all cultivable land for National food security. Mr. Tiwari encouraged participants for active participation in workshop sessions to contribute their respective roles, scope, possibilities and challenges towards effective of Irrigation Development.

Mr. Bashu Dev Lohane, Chief, SMTP, DOI presented the design and content of the seminar in brief. He presented the different activities, highlighted the overview of the session structures and their objectives, content, and expected outputs that could influence the future decision making.

Dr. Luna Bharati, Head of Office, IWMI/Nepal highlighting on the activities of IWMI in Nepal said that IWMI has been working from last 3 decades in water resources research and its outcome has contributed in policy formulation. She added IWMI/Nepal program and activities has continuously focused on exploring the water resources sector and contribute on the issues of national food security and collaboration in such activities like seminar will further strengthen the cooperation of IWMI/Nepal and MOI.

Mr. Basu Dev Aryal, ED, GWDB highlighted on the status and uses of groundwater in Country. He stressed on the role of Ground Water Development Board in ground water development and management and associated constraints behind it.

Mr. Kamal Prasad Regmi, DG, DWIDP on his inaugural speech said that it has always been challenges in developing the irrigation infrastructure in all cultivable land. He

expressing his best wishes for the seminar said that this seminar will draw conclusion for exploring challenges and opportunities for MOI in irrigating all cultivable lands.

Mr. Sriranjana Lacaal, Secretary, WECS said that there are different type of challenges in developing irrigation facilities to all cultivable land. He added WECS has always worked on development of water sector in the country. To supplement the National Policy to secure the food sufficiency, Irrigation sector development cannot be overlooked thus WECS looks forward to collaborate with MOI in developing this sector and wishes participants for the fruitful workshop.

Mr. Madhav Prasad Regmi, Secretary, MOI in the inaugural speech said that majority of the Nepalese population is engaged in agriculture for livelihood in such it is very important to explore new technologies to improve the irrigation facilities and incorporate those in programs. He added water user participation is must in every stage of project identification to construction if we want to develop the sustainable irrigation systems. He said, gathering on such seminar will provide common platform to exchange the experiences of past failure, shortcomings and success and also provide opportunity to open window for the new technologies, approaches for the irrigation development. He stressed to actively take part in discussion to bring the fruitful outcomes from the seminar.

Mr. NP Saud, Chief Guest, Minister, Ministry of Irrigation said that in the present context of political transition where drafting constitution is the primary objective of the nation, issues of food and nutrient security cannot be neglected. In such, it is now imperative to identify the potential Mega irrigation projects alongside giving equal importance to the small irrigation projects for the marginalized people. In addition, equal importance must also be given to the operation and maintenance of the irrigation system and explore the opportunities to make them sustainable by strengthening Water User's Associations.

Finally, Chairperson Mr. Shiv Kumar Sharma, DG, DOI welcomed all the participants. He stressed in different dimensions of irrigation development in country. Department of Irrigation has always given priority from micro to mega irrigation projects in Country. He said, working modalities of the Department of Irrigation is for providing Year Round Irrigation services. He added that these two days spend in vigorous discussions in the workshop will bring some fruitful outcomes for DOI working strategies.

2.2. Session I: Water Management for Efficient Irrigation

This session was chaired by Er. Sarada Prasad Sharma, Ex- DG, DOI and Rapporteur for this session was Mr. Kalanidhi Paudel, Senior Legal Officer, DoI. Three Papers were presented in the session. Sub-theme of this session was Water Management for Efficient Irrigation. The first paper highlighted on assessment of suitable energy options in

pumping Groundwater for irrigation: A case study from Nepal, second paper on Integrated Water Resources Management: A way forward. The third paper was focused on Issues and challenges in Land acquisition.

2.1.1 Assessment of Suitable energy options in pumping groundwater for irrigation: A case study from Nepal

Dr. Ram Chandra Bastakoti presented outcomes of the research carried by IWMI on assessing the suitable energy options in pumping groundwater in Hattibangai VDC in Rupendehi District where 90 % of the HH are still dependent of agriculture for their livelihood. Installation of Shallow Tubewells (STW) were started two decades back with limited external support and without Government Subsidy. Shallow Tubewells installed with 5 horsepower (HP) were capable to irrigate 2 ha area in average and 95 % of them were operated diesel pumps. It was observed that higher gross margin with low pumping cost in case of STW owners in comparison to water purchasers. Similarly on comparative analysis of cost and return across energy options, electric pumps seem efficient compared to diesel but the easily availability of diesel in market and frequent loadshedding has created more inclination towards diesel operated pumps. Soaring diesel price and fragmentation of farms has created difficulty in operation of pumps. On that note, Presented opened forum to suggest few options like possibility of collective farming, group installation of STWs, harnessing solar energy to overcome the energy issues widespread in Nepal.

2.2.2 Integrated Water Resources Management: A Way Forward

Dr. Prachanda Pradhan Presented a paper on Integrated Water Resources Management and its way forward. This paper analyzes the evolution of the concept of Integrated Water Resources Management (IWRM) over the past three decades and addresses the prospects of IWRM in responding the growing water scarcity causing water crisis at local, regional and national level. It also identifies several crucial challenges to implementing IWRM. He said, IWRM refers to an approach whereby management of water resources is systematically implemented through proper arrangement of organizations at the regional level with the promotion of participation of stakeholders at all levels of organizationd. He highlighted on the fact that the treatment of IWRM has to be in multi-disciplinary approach, perspective of integration, components of IWRM and implementation issues.

He added that in context to Nepal, Small scale Integrated Water Resources Management were in practice at the local level as in integrating local water resources to drinking, irrigation and environment protections but in policy level, in Water Resources Strategy 2002 and National Water Plan 2005, it defined policy principle for water sector as "development and management of water resources shall be undertaken in a holistic and systematic manner relying on Integrated Water Resources Management (IWRM)" and added Concept and mandate of River basin Committee was approved by 54th meeting of

WECS chaired by Minister of Energy on 23 Nov, 2009 and thereafter different River Basin Offices are established with the mandate to implement integrated water resources management policy. Recently, on Irrigation Policy of Nepal, 2013, IWRM principle is adopted for irrigation planning.

2.2.3 Issues and Challenges in Land acquisition

Mr. Krishna Dev Rai presented paper on issues and challenges in land acquisition faced by Government in Irrigation system Development in context of Sikta Irrigation Project. He drew attention on four major aspects of land acquisition process; First assessment of the trends and causes of the land acquisition and compensation issues and problems; second on compensation parameters, challenges in land acquisition and the existing law also place stringent restriction on the exercise of eminent; third provision of a framework for effective and systematic land acquisition management on large irrigation project in Nepal, and fourth on present essential features of land acquisition and compensation problems in large irrigation project.

2.3. Session II: Socio-economic aspect of Irrigation

This session was chaired by Er Mahendra Bahadur Gurung and rapporteur was Er Hari Ram Shrestha, SDE, Department of Irrigation. There were three presentations in this session which was mainly focused on socio-economic aspect of irrigation. The first paper, entitled “**Impact of Socio-economic status on cropping intensity in Tarawali Irrigation Scheme, Lamjung, Nepal**” was presented by Er Santosh Kaini (Division Chief, Irrigation Development Division, Lamjung). The second paper “**Men, Women and Irrigation: Looking up from the fields**” was presented by Dr. Floriane Clement. Mr Utsav Bhattarai and Dr Luna Bharati presented the third paper “**Environmental Flows and Climate Change**”.

2.3.1 Impact of Socio-economic status on cropping intensity in Tarawali Irrigation Scheme, Lamjung, Nepal

Mr Santosh Kaini presented the paper on case study of impact of socioeconomic status on cropping intensity carried out in Tarawali Irrigation scheme, Lamjung district. He stated that rapid population growth pressured on food production and created the need of higher cropping intensity In Nepal (Pokhrel et. al., 2013). Out of 72 households in the study area, 71 households are Gurungs and only one household is dalit (Bishowkarma). Those farmers who have less land can grow potatoes and vegetables in others' field that have more land. They should not give money or crops to the land owner but they just need to put manure in the field where they grow the crops.

Usually the cropping intensity is comparatively high at the head reaches than the tail end (Rahman et. al., 2012) but In Tarawali Irrigation Scheme, the cropping intensity is found higher in the middle reaches of the command area. Farmers are using two mini-tractors given by the project in 50% subsidy which has helped to increase the cropping intensity of the scheme. Er Kaini emphasized that the cropping intensity can further be increased in the Tarawali Irrigation Scheme by:

- changing the conventional thinking of subsistence farming into market oriented,
- increasing agricultural inputs,
- providing more training and exposure visits to other successful schemes for the farmers

2.3.2 Men, Women and Irrigation: Looking up from the fields

Dr. Floriane Clement has presented the paper on the above topic. She stated that irrigation is increasingly under women's responsibility in Nepal but they often have less formal access and less influence on the decision making to the irrigation resources that is why gender issues in irrigation development and management is important. The objective of the study was how can women's participation level in Water User's Association (WUAs) and influence over irrigation development and management be improved. The study was carried out in three districts of Kavre, Lalitpur and Saptari and semi structured interviews and group discussions with irrigation division office, executive committee members and water users was adopted. She said that although 33 percent quota for women in WUA has been provided, their representation in WUA has not been influential in and benefiting from decision making as they lack confidence and doesn't speak in the meeting. Creating a favorable and safe working environment for women, Creating incentives (e.g. performance evaluation) and M&E system to avoid professional discrimination and promote gender-sensitive behaviors, providing locally-adapted training for Irrigation Division Office staff on pragmatic ways to understand women's needs and communicate with women and support them to influence decisions on irrigation in WUAs or in private and Increasing the number of women staff in non-administrative positions were some of her recommendations to improve the women's participation level in WUA and influence in irrigation development and management.

2.3.3 Environmental Flows and Climate Change

Mr Utsav Bhattarai and Dr Luna Bharati were the presenters of this paper. Mr Utsav Bhattarai, presenting the first part of presentation, stated that the presentation is based on part of the ongoing study **“Water Availability and Agricultural Adaptation Options**

of the Koshi Basin under Global Environmental Change” In collaboration with ICIMOD and funded by AusAID. The preliminary result shows that the temporal variability has been seen and is expected to increase in the future. There is no significant change in the annual water availability but the frequency of extreme event has increased due to climate change. Dr Luna Bharati, presenting the second part, discussed on the environmental flows. She stated that environmental flow is the compromise between Water Resource Development and the maintenance of a river or wetland in agreed/prescribed condition which is expressed as a set of flow releases which in a modified river mimics the elements of naturally occurring flow regimes. Different methodologies for calculating Environmental flows were also discussed. She emphasized on the need to maintain the natural flow variability of the river considering the various environmental requirements.

At the end of the session, the floor was opened for the discussion. Many questions were raised to the presenters related to their presentations and each presenter responded to the respective queries. The chair then summed up the presentations and thanked all four presenters for their excellent presentation, participants for their participation making the session vibrant, and DOI for giving the opportunity to chair the session and closed the session.

2.4. Session III: Multiple use of water and Year Round Irrigation

Technical Session III was chaired by Dr. Umesh Nath Parajuli, Ex DG, DOI and rapporteur for the session was Dr. Kishor Kumar Bhattarai. Four technical papers were selected for the session and among them two were presented and presenter of two were absent for the presentation, however their full paper is included in the proceeding. 1st paper presented was on Irrigation Modernization, the way of Year Round Irrigation and Water Utilization in Nepal by Mr. Uttam Raj Timilsina and 2nd on Impact of Arjun Khola Irrigation Project after 20 years of Implementation by Mr. Lok Bahadur KC.

2.4.1 Irrigation Modernization, the way of year round Irrigation and Water utilization in Nepal

Mr. Uttam Raj Timilsina presented paper on Irrigation Modernization, the way of Year Round Irrigation and Water utilization. He said that Irrigation modernization is a process of technical and managerial upgrading of irrigation schemes combined with institutional reforms, with the objective to improve resource utilization and water delivery service to farms. He discussed about the various modes of Irrigation Modernization like Physical rehabilitation of irrigation infrastructures, Intervention of micro irrigation, Institutional reform of irrigation agencies as well as Water Users Associations (WUAs), Use of

modern technologies and computerized software in irrigation service delivery management. He elaborated about the areas (technical, socio-institutional, financial, economical and environmental) that demands for the intervention for irrigation modernization.

2.4.2 Impact of Arjun Khola Irrigation Project after 20 years of Implementation

Mr. Lok Bahadur KC presented paper on livelihood impact of Arjun Khola Irrigation Project after 20 years of Implementation where he outline the impact of irrigation infrastructure improvement and development to compare cropping intensity, cropping pattern, food situation, occupation, expenditure and energy situation of 1988, 1994 and 2012 and the assessment of physical status of irrigation infrastructures, water management. Arjun Khola Irrigation Project, is a farmers managed irrigation scheme, modernized in 1994 by the Department of Irrigation from the grant assistance of European Union. The project covers an area of 568 hectares of which 475 hectares are under the command of irrigation network. Mr KC said that the Arjun Khola Irrigation System is smoothly functioning with farmer's regular maintenance. Farmers availed continuous supply of water except March to May where the supply dropped below 50 l/s in the river and rotational water distribution is in practice. Water availability and irrigation management improved showing immediate increment in crop yield and productivity after the project completion. Project Impact Study (PIS 2012) revealed 81.1 percent of the sample households have expressed satisfaction with the system performance meeting their requirement timely and adequately even after 20 years of project completion.

2.5. Session IV: Innovative methods in Irrigation

This session was chaired by Er. Madhav Belbase, Deputy Director General, Department of Irrigation and Rapporteur for this session was Er. Min Raj Dhakal, Senior Divisional Engineer, Bheri Babai Diversion Multipurpose Project. Three Papers were presented in this session. The first paper highlighted on use of **GMIS for Sustainable Planning and Management of Irrigation Systems** and the second paper described about the **Improving Irrigation Efficiency through alternate wet and dry method of water management for paddy cultivation**. The third paper was focused on **Spill Energy from Micro Hydropower Plants for Small Scale Irrigation in Hill and Mountain region– An Untapped Synergy**.

2.5.1. GMIS for Sustainable Planning and Management of Irrigation System

Er. Sushil Chandra Tiwari, Deputy Director General of Department of Irrigation, presented first paper of the Session IV on GMIS for Sustainable Planning and Management of Irrigation Systems.

Mr. Tiwari, started with highlighting the present scenario of Irrigation Development in Nepal and explained the challenges of the irrigation Sector faced by the country. Then, he suggested some measures to address the challenges such as more investment/annual allocation, optimal utilization of the limited resources, implementation capability, prioritize the investment with proper planning etc.

Mr. Tiwari described in detail the scope of GMIS in Irrigation sector. He told that GMIS tools are helpful in Inventory Mapping, Planning with Prioritization of Irrigation project, Maintenance Management of Irrigation systems. In the concluding, Mr. Tiwari focused on the importance and application of GMIS and emphasized it as efficient tool for the sustainable planning and management of irrigation systems.

2.5.2. Improving Irrigation Efficiency through alternate wet and dry method of water management for paddy cultivation

Following the first paper, Dr. Indra Lal Kalu, Irrigation Expert, presented a paper jointly prepared by him and Mr. Ramashraya Sah on Improving Irrigation Efficiency through alternate wet and dry method of water management for paddy cultivation. Starting with presentation on irrigation coverage at different season, Dr. Kalu described the causes of low irrigation coverage in Nepal.

Dr. Kalu explained the water requirement for paddy in conventional irrigation method. He then described the process of watering in Alternate Wet and Dry Irrigation (AWDI) method and presented the comparison of paddy yield and water application between AWDI and traditional practice as well as AWDI and SRI Practice. He showed that paddy yield is more in AWD Irrigation method than in conventional method. Finally, he presented the pros and cons of AWDI and concluded that AWDI is promising technique and recommended to promote training with demonstration.

2.5.3. Spill Energy from Micro hydropower Plants for Small Scale irrigation in hill and Mountain region–An Untapped Synergy

Mr. Suraj Baral from Management Innovation and Technology Solutions (P) Limited, Nepal, gave a presentation on **Spill Energy from Micro Hydropower Plants for Small**

Scale Irrigation in Hill and Mountain Region–An Untapped Synergy as a third and last speaker of the session IV.

Mr. Baral opened his presentation with issues in sustainability of Micro hydro Projects (MHP) in Nepal. He told that more than 700 MHPs exists in Nepal, its utilization is 25-40%, and these MHPs are not able to cover operation and maintenance cost and added that Sustainability of MHPs are very big concern. In such, he suggested in using spill energy of MHP to lift water for irrigation purpose. He explained about the Nishi Dovan Micro Hydro Power Plant Project, Baglung in which the community is going to implement to use spill energy of the plant to lift water for irrigation. He added that if the people of the project area cultivate vegetables crops, then it will fulfills the demand of nearby market such as Burtibang bazaar, Galkot bazaar, Wami bazaar etc. He explained different Socioeconomic benefit to the community such as generation of two full time employment per household around the year, five people will get full time job in cooperative and irrigation equipment maintenance, Organization development, Knowhow and technology transfer etc.

Discussion session

After presentations, the chairperson opened the floor for discussion and comments.

Irrigation Expert and former Deputy Director General of Department of Irrigation Er. Somnath Paudel suggested updating Land Resources Map for the effective implementation of GMIS. Similarly, former Secretary of Ministry of Water Resources, Er. Bhuvnesh Kumar Pradhan raised the issue of delay in starting storage scheme and consumptive use. Er. Ashish Bhadra Khanal, SDE, Chief of Irrigation Unit of Bagmati Improvement Project suggested strengthening the Management Information System (MIS) branch of DoI.

Er. Shiv Kumar Sharma, Director General of Department of Irrigation appreciating the third presentation, said that DoI has started the consumptive use of ground water and surface water in Mahakali Irrigation Project -stage III and planned to start lift irrigation scheme in one river corridor of each Development Region. Er. Mahesh Pradhan, Superintendent Engineer, DoI also supported the Integration of MHP and lift Irrigation to use spill energy in Baglung District.

Paper presenters responded to the queries and comments and Chairperson formally closed the session appreciating the paper presenter for highlighting different dimensions of innovative irrigation technologies and active and lively participation from audience.

2.6. Planery Session: Irrigation to all Cultivable Land

Mr. Shiv Kumar Sharma, DG, DoI, was the chairperson of the session and Mr. Madhukar Prasad Rajbhandari and Mr. Shisir Koirala were the rapporteur for the session. Mr. Uma Kanta Jha, Mr. Bhuwanesh Kumar Pradhan, Dr. Umesh Nath Parajuli and Dr. Prachanda Pradhan were the panel of experts. Mr. Shital Babu Regmee, Mr. Som Nath Paudel, Mr. Deepak Lochan Adhikari, Mr. Siddhi Pratap Khand, Dr. Khem Raj Sharma, Mr. Nabin Mangal Joshi and Mr. Khojraj katuwal were the key note speakers for the session.

Mr. Shital Babu Regmee, Ex-secretary of GoN, discussed about the policy aspects regarding the development of irrigation in Nepal. He referred about the historical development of irrigation and highlighted the contributions of FMIS and need of government intervention. Assurance of year round irrigation with 100% coverage through new technologies, groundwater utilization, storage projects, inter basin transfer etc. are today's burning issues. He emphasized the need of proper information and data and indicated the difference in data between Department of Irrigation and Agriculture. Data regarding irrigation need to be updated. Constrains regarding budget, ensuring quality and quantity of irrigation, uncertain agricultural return should be addressed. Close coordination between farmers, government and Donors is essential. Mr. Regmee gave examples about the developed countries like US, Japan and Korea and necessitated the need of committed policy. He recommended for practical and inclusive policies for effective resource mobilization, multipurpose technological interventions in irrigation and disaster mitigation sectors with strong monitoring and evaluation techniques.

Mr. Som Nath Poudel, in his session, argued about the need of integrated management of water, land and forest in Nepal. Millions of USD have been spent in producing various reports but we are lagging behind in implementation. He suggested for the formulation of integrated water resource policy, Basin Master Plan and Integrated River Basin Management Plan to back up the multipurpose projects. He said that the surface flow in winter (900-1000 cum/sec) in Nepal is not enough to irrigate the entire land. This arises the need for storage projects and inter-basin transfer projects. 18 large multipurpose projects like Saptakoshi, Kaligandaki, Dudhkoshi, Bheri etc have been identified till date that can store 126 BCM of water and produce about 38000 MW of electricity and irrigate round 8,34,000 hectare of land. There are potentials for development of multipurpose reservoirs in Mahabharat range, Mid Hills and Chure. He also shared the issues regarding these multipurpose projects like GLOF, earthquake, erosion, siltation, and need of large investment funds. He urged that at least 5 multipurpose storage projects, 1 in each development region, be launched as soon as possible. He discussed the historical events behind some projects like Koshi High Dam and concluded that we should not just wait for the foreign support and aids, instead start out with few of these projects on our own.

Mr. Deepak Lochan Adhikari presented and highlighted about “where, how and why” aspects of Non-conventional irrigation technologies. Today’s changing context of water resource like “too much, too little, too difficult and uncertain water” demanded a technological need different than conventional practice of irrigation. He said that NCIT is effective in solving these issues by minimizing conveyance and application losses. In Nepal, works regarding NCIT have been proved effective from abstraction of water to conveyance and distribution systems. But as we come to application, we are lagging behind. The practice of NCIT is increasing trend but the need of planned promotion persists. NCIT is limited only in small plots. Nepal has potential to irrigate around 5 -6 lakhs hectare of land through NCIT and has a target to irrigate 70,000 ha by 2030. Mr. Adhikari said that a uniform policy is necessary for promotion of NCIT. He necessitated the need of awareness programs among farmers, strong implementation modalities for the promotion of NCIT. He said that DOI should emphasize on action oriented researches on NCIT.

Mr. Siddhi Pratap Khand highlighted about the present scenario, prospects and potential of ground water irrigation in Nepal. He started his presentation with the history that ground water investigation started in Nepal in Western Terai (Newalparasi to Kanchanpur) under the funding of USAID (2024-2031). He gave a brief introduction about ground water projects and their coverage. He said ground water irrigation is possible in all parts of Terai except 15% of its cultivable land. Groundwater Irrigation development (mainly STWs) is only alternative in absence of Reservoir based or Inter-Basin Water Transfer Projects. He mentioned that the main constrain behind ground water irrigation development is the unavailability of proper energy sources (electricity). The overlapping of works by different implementing agencies has also created complications and confusion among donors. Scattered and improper distribution of Deep tube-wells is the main cause of non-functioning and under-utilization of most of deep tube-wells. He said a benchmark should be established to picture present ground water utilization and develop groundwater model under different scenario of land use and cropping pattern for optimal use of groundwater resource and design projects accordingly. A legal framework and regulatory authority is required to be established to address the issues of groundwater use.

Dr. Khem Raj Sharma, on his presentation “Operation and Maintenance of Irrigation System” portrayed that O & M is must to attain “Irrigation to all”. He said operation and maintenance of any system is a cyclic phenomenon in which resource is generated by successful operation of an irrigation system which in turn can be used to maintain the system and continue the operations. He highlighted the roles of DoI and farmers for an irrigation system to be successful. Giving examples of both successful and failure projects, he discussed the reasons why the O&M suffers. He said inadequate budget, improper O&M plans, lack of farmers participation and low ISF collection are the main

causes behind the failure. He urged a need to establish norms for O&M investment. Performance indicators could be developed and budget allocation could be linked with system performance. Whole life costing approach can be practiced for planning large projects.

Mr. Nabin Mangal Joshi started his presentation with the present scenario of Farmers' Managed Irrigation System in Nepal. He said GoN and donors started recognizing FMIs only after 1980s and started funding for rehabilitation of FMIS. All irrigation systems are ultimately meant to become FMIS. He also gave a brief introduction about the FMIST and its activities. At the end, he gave information about the Sixth International Seminar on Feb15 -16, 2015 on "Small Scale Irrigation: Challenges to Sustainable Livelihood".

Mr. Khojraj Katuwal gave introduction about Maha Agriculture and described about its functions and services. He highlighted the objectives and goals of Maha Agriculture and its working modality. He also shared the information regarding technologies being used in Israel. He gave information on drip irrigation technology, its technical aspects and different parts and equipments.

After the presentations by speakers, Chairperson opened floor for the key note from the panel of experts.

Mr Uma kanta Jha said that the new Irrigation Policy 2070 will liven up the irrigation sector. Multipurpose and Inter basin transfer project should be given priority and launching of Bheri Babai Diversion Project will be a milestone. He added new programs and projects are needed to be introduced according to country's new federal model. NCIT should be promoted in sloppy areas and Ground water development should be given priority in possible areas of Terai and Chure. He also said that land acquisition is emerging as a critical issue and long term solution should be discovered earliest possible. Discussions are necessary to identify new models for management transfer and Operation and Management and to increase irrigation efficiencies. He suggested that it is better if external financing is sought only after completing headwork and major structures of major projects on our own.

Mr Bhuwanesh Kumar Pradhan said that its an important achievement to develop irrigation infrastructure for 13.31 lakhs hectare land as compared with only 4 irrigation systems before 2013 B.S. Better O&M of irrigation demands additional budget. He suggested that Ministry of Irrigation and Agriculture should be integrated and act jointly. Riparian Issue may persist in multipurpose projects, so, DoI need to be focused on inter-basin projects and medium scale projects. Water harvesting technology should also be included in NCIT. He said proper data should be maintained regarding the irrigation development. Finally, he thanked and congratulated all the presenters of the session.

Dr. Prachanda Pradhan said that governance is an important component to attain “Irrigation to all” and the present discussion is missing governance aspect. It would be difficult to extend the irrigation facility to remaining 27 lakhs hectare by DoI alone. So, government needs to include other parties as well in this endeavor. DoI can act as a regulating body while other sectors can be involved for irrigation development. It would be difficult to attain “Irrigation to all” with the conventional management and development practices. Concepts of privatization can also be introduced in irrigation as well. He also added that to get benefit of “prior rights”, surface water utilization should be maximized as earliest possible.

Dr. Umesh Nath Parajuli said that we have more or less enough plan and policies but implementation is what we are lacking behind. Focus should be given to provide quality service, ensure proper O&M and manage irrigation data base. Promotion of NCIT is must to achieve “Irrigation to all” and inclusion of other partners can be an additional tool. DoI should be service oriented instead. He added, for better O&M, pilot/trial schemes can be launched with management contract or operation contract mode.

2.7. Closing Session

The seminar concluded on the evening of the 24th May, 2014. Mr. Shiv Kumar Sharma was the chairperson of the session and Mr. NP Saud, Hon. Minister, Ministry of Irrigation was the chief guest of the session. Mr. Madhav Prasad Regmi, Secretary, MOI and Mr. Sriranjana Lacaal, Secretary, WECS, Mr. Basu Dev Aryal, ED, GWDB and Mr. Ram Prasad Meheta, Chairman, NFIWUAN were special guest of the session.

Closing Session started with the overall remarks on the seminar by Mr. Madhav Belbase, DDG, DOI. He highlighted the different dimensions of irrigation development raised in the seminar. He added, summarizing the seminar, in the present context substantial increases in agricultural production and productivity is needed for national food security, pivotal role of irrigation is realized. Over the last decades the emphasis in the irrigated sector has been laid on expanding the irrigated area. However, the productivity of the existing irrigated area is stagnating at a very low level. He added different papers presented in this seminar has given an opportunity to explore and understand water Management for efficient Irrigation, analyzing the Socio-economic aspect of Irrigation , Multiple use of Water, Innovative methods in Irrigation and scope of Year Round Irrigation to all cultivable land. He summarized the issues raised on papers which are put in conclusions of the Proceeding.

Mr. Ram Prasad Meheta, Chairman, NFIWUAN said that National Seminar gives platform to share experiences, lesson learned and way forward for irrigation Development. He stressed that WUA are the major players for the sustainability of

Irrigation system thus Department of Irrigation should give enough orientation, training, resources before handing over management to WUA.

Mr. Sriranjana Lacaal, Secretary , WECS said that its now imperative to focus on Large Scale Irrigation projects like Bheri Babai which can influence the cropping intensity of the command area thus contributing in food security but in doing so, it is important to equal emphasize the middle scale irrigation system. He said, WECS will be cooperate and coordinate in developing any projects.

Mr. Madhav Prasad Regmi, Secretary, MOI on his closing remarks said that seminar was fruitful in exploring the opportunities and challenges in developing irrigation facilities to all cultivable land. He said, seminar outputs and recommendations will be executed accordingly and stressed on making WUA more proactive in management overtaking and strictly execution of Landuse Policy.

Hon. Minister NP Saud congratulating DOI for successful organization of National Seminar said that seminar has provided a platform to assess the past performance, explore the present and given way forward for the future activities. He on the context of newly endorsed Irrigation Policy said that he is determined to legally formulate Irrigation Policy. He said that it is now necessary to attract private sector in irrigation development and Management. He said he is equally concern on the encroachment on Sunsari Morang Main Canal and said that is determined to resolve the case soon. By saying so, on conclusion he instructed that irrigation need to be an integrated approach together with agriculture and hydro energy sector for ensuring the food security issue in country.

Mr. Sagar Kumar Rai, DDG, DOI and Co-coordinator seminar organizing committee thanked all participants for active participation and lively discussion.

Mr. Shiv Kumar Sharma, DG, DOI concluded the seminar by saying that this seminar created an opportunity in exploring the different dimensions of irrigation to provide the service to all cultivable land. He thanking all the participants for active and lively discussion expressed sincere gratitude towards Secretary WECS, Secretary MOI and Hon. Minister MOI for guidance during the seminar.

3. CONCLUSION AND RECOMMENDATIONS

3.1. Conclusions and Recommendations

Conclusions and recommendations generated from the seminar are highlighted below:

1. With population growth, urbanization, dietary change and increasing consumption and climate change has increase stress on water resources with increase and conflict demands from agriculture, industry, urban water supply and energy production. Thus for efficient, equitable and sustainable development and management of this limited resources, Integrated water Resources Management is essential. Thus IWRM is an important tool for efficient use of water and conflict management so it needs to be implemented through the appropriate institutional reformation.
2. It has been observed that due to climate change, rainfall pattern is changing and there is less rainfall in monsoon and more in dry, thus future irrigation system design criteria need to follow the issue accordingly.
3. Land acquisition for irrigation system development has always been challenge for DOI thus land use policy needed to be implemented and accordingly before irrigation project implementation, land acquisition need to be done.
4. DOI along with developing new irrigation systems should also focus to increase cropping intensity and upgrading the socio-economic state of the beneficiaries of the irrigation facilities. There is need to change the conventional thinking of subsistence farming into market oriented, providing proper market facilities, using machineries (thresher machine, more mini-tractors), increasing sources of organic manures and providing farmer training as well as exposure visits to other successful schemes. It is also felt necessary to do the socio-economic impact study of the constructed Irrigation Project allocating sufficient budgets in annual projects.
5. Irrigation modernization is a process of technical and managerial upgrading (as opposed to mere rehabilitation) of irrigation schemes combined with institutional reforms, with the objective to improve resource utilization (labour, water, economic, environmental) and water delivery service to farms. In Nepal, The long-term sustainability of the irrigation system is in question, as the farmers do not demonstrate the skills necessary to maintain new structures or the ability to mobilize cash resources to purchase the materials required for maintenance. In such, to ensure efficient use of water and cost

effective O &M of irrigation system, DOI should focus on irrigation modernization for that DOI need to formulate a team to make irrigation modernization plan and give it a logical end.

6. Shallow tubewell has contributed year round irrigations service to remarkable agriculture land but energy has always been a hindrance factor thus solar energy need to be promoted to overcome this issue. Options of community managed shallow tubewells, community farming needed to be explored.
7. Innovative irrigation methods like Alternate Wet and Dry irrigation has shown the remarkable results in saving water in water scare regions. Similarly, Spill energy need to be tap for sustainability of micro hydro project and can be very advantageous in irrigating the remote and Tars patches in River corridors. Scope and opportunities of such innovative methods need to be assessed.
8. Groundwater and NITP projects need to be given priority.
9. The fact that Women have less formal access and less influence on the decision making to the irrigation resources is being realized over the time that is why gender issues in irrigation development and management are important. Creating a favorable and safe working environment for women, Creating incentives (e.g. performance evaluation) and M&E system to avoid professional discrimination and promote gender-sensitive behaviours, providing locally-adapted training for Irrigation Division Office staff on pragmatic ways to understand women's needs and communicate with women and support them to influence decisions on irrigation in WUAs or in private and Increasing the number of women staff in non-administrative positions were some of recommendations to improve the women's participation level in WUA and influence in irrigation development and management.
10. In context of agricultural commercialization, it is important to empower role of private organization and Local NGOs in O &M of Irrigation System.
11. GIS based Management Information System (GMIS) is a well-structured information management system, has capability to integrate, analyze and visualize all the spatial and attribute information related to planning, management and prioritization and hence can be used as an efficient tool for the sustainable planning and management of irrigation systems thus DOI must adapt and endorse the use of it.
12. Multipurpose projects in a federal structure is going to be very complicated thus such projects needed to be formulated and developed focusing on regional balance of the resources.

3.2. Identified themes for next workshop/seminar

- Year Round Irrigation
- Modernization of Irrigation System
- IWRM: New tools and Approaches
- Scope and Potential of Multipurpose Projects
- Scope and Potential of Ground water Irrigation
- Scope and Potential of Non-Conventional Irrigation technologies
- Impact of Climate Change
- Farmers Managed Irrigation Systems
- Challenges in Irrigation Financing
- Irrigation system Privatization
- Human Resources Management in Irrigation
- Irrigation Development and management from Gender Equity and Social Inclusion

ANNEX -1
PROGRAM SCHEDULE

“Irrigation to all Cultivable land: Challenges and Opportunities”

Program Schedule

Venue: Dhulikhel Lodge Resort, Dhulikhel

Date: 2071/2/9-10(2 days) (23-24 May, 2014)

Master of Ceremony: Mr. Basudev Timilsina

DAY 1 (Jestha 09, 2071, Friday)		
9:30-11:00	Registration of Participants and Breakfast	
Inaugural Ceremony (11:00-12:15)		
Chairperson: Mr. Shiv Kumar Sharma, DG, DOI		
Chief Guest: Hon. Minister Narayan Prakash Saud, MOI		
Special Guest: Mr. Madhav Prasad Regmi , Secretary, MOI		
Special Guest: Mr. Sriranjana Lacaal, Secretary, WECS		
Guest: Mr. Kamal Prasad Regmi , Director General, DWIDP		
Guest: Mr. Basu Dev Aryal , Executive Director, GWDB		
Guest: Dr. Luna Bharati, Chief, IWMI/Nepal		
Guest: Ram Prasad Mehata, NFIWUAN		
Inauguration by Hon. Minister		
Time	Activities	Resource Persons
11:00-11:05	Welcome Address	Mr. Sushil Chandra Tiwari, DDG,DOI
11:05-11:15	Introduction to the seminar design and content	Mr. Bashu Dev Lohane, Chief, SMTP
11:15-11:20	Few words from guest	Representative, NFIWUAN
11:25-11:30	Few words from guest	Dr. Luna Bharati, Head of Office, IWMI/Nepal
11:30-11:35	Few words from guest	Mr. Basu Dev Aryal , Executive Director, GWDB
11:40-11:45	Few words from guest	Mr. Kamal Prasad Regmi , Director General, DWIDP
11:45-11:50	Few words from Special guest	Mr. Sriranjana Lacaal, Secretary, WECS
11:50-11:55	Few words from Special guest	Mr. Madhav Prasad Regmi , Secretary, MOI
11:55-12:05	Few words from Chief guest	Hon. Minister Narayan Prakash Saud, MOI
12:05-12:15	Few words from Chairperson	Mr. Shiv Kumar Sharma, DG, DOI

12:15-13:50 Lunch Break		
Technical Session I (Water Management for efficient Irrigation)		
Chairperson: Mr. Sarada Prasad Sharma		
Rapporteur: Mr. Kalanidhi Paudel		
13:50- 14:10	Assessment of suitable energy options in pumping groundwater for irrigation: A case study from Nepal	Dr. Ram C Bastakoti and Mr. Romulus O Okwany and Mr. S A Prathapar
14:10-14:30	Integrated Water Resources Management: A Way Forward	Dr. Prachanda Pradhan
14:30-14:50	Issues and challenges in Land acquisition	Mr. Krishna Dev Rai
14:50-15:10	Discussion on the session	
15:10-15:30 Break		
Technical Session II (Socio-economic aspect of Irrigation)		
Chairperson: Mr. Mahendra Bahadur Gurung		
Rapporteur: Mr. Hari Ram Shrestha		
15:30- 15:50	Irrigation Development and Management from Gender Equity and Social Inclusion Perspective: a reflection of LILI's approaches	Mr. Vinod Kumar Barai
15:50- 16:10	Impact of Socio-economic status on cropping intensity in Tarawali Irrigation Scheme, Lamjung, Nepal	Mr. Santosh Kaini
16:10-16:30	Men, women and irrigation: looking up from the fields	Dr. Floriane Clement, Ms. Neha Rayamajhi
16:30-16:50	Environmental Flows and Climate Change	Dr. Luna Bharati ,Mr. Utsav Bhattarai
16:50-17:10	Discussion on Session	
18:00 Onwards Reception Dinner		
DAY 2 (Jestha 10, 2071, Saturday)		
7:30-08:30 Breakfast		
Technical Session III (Multiple use of Water and Year Round Irrigation)		
Chairperson: Dr. Umesh Nath Parajuli		
Rapporteur: Dr. Kishor Kumar Bhattarai		
08:30- 08:50	Irrigation Modernization, the way of Year Round Irrigation and Water Utilization in Nepal	Mr. Uttam Raj Timilsina
08:50-09:10	Water Harvesting Dam and Hillside Irrigation: Experience from Ruwanda in Upper Nile River Basin	Mr. Basistha Adhikari
09:10-09:30	Benefit Multiplication through Multiple Water Use System: Comparison of Single Functional and	Mr. Anand Gautam

	Multi Functional Irrigation System in the Mid Hills of Nepal	
09:30-09:50	Impact of Arjun Khola Irrigation Project after 20 years of Implementation	Mr. Lok Bahadur KC
09:50-10:10	Discussion on Session	
Tea Break 10:10-10:30		
Technical Session IV (Innovative methods in Irrigation)		
Chairperson: Mr. Madhav Belbase		
Rapporteur: Mr. Min Raj Dhakal		
10:30- 10:50	GMIS for Sustainable Planning and Management of Irrigation Systems	Mr. Sushil Chandra Tiwari
10:50-11:10	Improving Irrigation Efficiency through alternate wet and dry method of water management for paddy cultivation	Mr. Ramashraya Shah and Dr. Indra Lal Kalu
11:10-11:30	Spill Energy From Micro hydropower Plants for Small Scale irrigation in hill and Mountain region– An Untapped Synergy	Mr. Suraj Baral
11:30-11:50	Discussion on Session	
Lunch Break (11:50-12:40)		
Plenary Session (Irrigation to all cultivable Land)		
Chairperson: Mr. Shiv Kumar Sharma		
Rapporteur: Mr. Madhukar Prasad Rajbhandari, Mr. Shisir Koirala		
Panelist : Mr. Uma Kanta Jha Mr. Bhuwanesh Kumar Pradhan Dr. Umesh Nath Parajuli Dr. Prachanda Pradhan		
12:40- 13:00	Policy Aspect in Irrigation Development	Mr. Shital Babu Regmee
13:00-13:20	Multipurpose Irrigation Projects	Mr. Som Nath Paudel
13:20-13:40	Non-Conventional Irrigation Technologies	Mr. Deepak Lochan Adhikari
13:40-14:00	Groundwater Irrigation Development: Prospects and Constraints	Mr. Siddhi Pratap Khand
14:15-14:35	Role of FMIS in Production Enhancement	Mr. Nabin Mangal Joshi
14:35-14:55	Operation and Maintenance of Irrigation System	Dr. Khem Raj Sharma
14:55-15:15	Innovative Irrigation Technologies	Dr. Bishnu Chapagain and Mr. Khoj Raj Katuwal
15:15-15:35	Discussion on session	
15:35-15:45 Tea Break		

Closing Ceremony		
Chairperson: Mr. Shiv Kumar Sharma, DG, DOI		
Chief Guest: Hon. Minister Narayan Prakash Saud, MOI		
Special Guest: Mr. Uma Kant Jha, Former Minister, MOI		
Special Guest: Mr. Madhav Prasad Regmi , Secretary, MOI		
Special Guest: Mr. Sriranjana Lacaal, Secretary, WECS		
Guest: Mr. Basu Dev Aryal, Executive Director, GWB		
Guest: Mr. Ram Prasad Meheta, Chairman, NFIWUAN		
Time	Activities	Resource Persons
17:30-17:40	Overall remarks of the seminar	Mr. Madhav Belbase, DDG,DOI
17:40-17:45	Remarks from guest	Mr. Ram Prasad Meheta, Chairman, NFIWUAN
17:45-17:50	Remarks from Special guest	Mr. Sriranjana Lacaal, Secretary, WECS
17:50-17:55	Remarks from Special guest	Mr. Madhav Prasad Regmi, Secretary, MOI
17:55-18:00	Remarks from Special guest	Mr. Uma Kant Jha, Former Minister, MOI
18:00-18:10	Few words from Chief guest	Hon. Minister, Narayan Prakash Saud, MOI
18:10-18:15	Vote of Thanks	Mr. Sagar Kumar Rai, DDG, DOI
18:15-18:25	Concluding remarks from Chairperson	Mr. Shiv Kumar Sharma, DG, DOI
Hi-Tea		

ANNEX -2

FULL PAPERS

Integrated Water Resources Management: Way Forward

Prachanda Pradhan¹

Abstract

This paper on Integrated Water Resources Management (IWRM) analyzes the evolution of the concept of Integrated Water Resources Management (IWRM) at international conferences over the past three decades and addresses the prospects of IWRM in responding the growing water scarcity causing water crisis at local, regional and national level. It also identifies several crucial challenges to implementing IWRM. Our rivers and aquifers are the life-blood of the planet. Water has special value in all society. To achieve sustainable development, there is need to manage our most vital natural resource, water, in an integrated manner, or precisely called Integrated Water Resources Management (IWRM). Since water is fundamental to many aspects of life, and to the surrounding natural environment, there is a need not only to review IWRM's evolution in the last three decades, but also to identify future challenges to its implementation. Hence, the issue is to be looked at not only from physical solution or sectoral solution but so many other factors like religious, cultural and social perspectives are to be taken into consideration.

It is also equally important to see the transformation of concept on water resources management, its context in South Asian countries, the treatment of IWRM from multi-disciplinary approach, perspective of integration, components of IWRM and implementation issues.

(Key words: water resources, water management, integration, water conservation, water allocation, social and cultural issues, implementation procedures and participatory approach)

Context and its development:

Practices of IWRM exist in many countries for centuries. Spain adopted basin approach in her water management long time ago. Planning for integrated water resources development in Tennessee Valley Authority (TVA) took place in USA in 1930s. This authority was then considered as the model organizational structure for integrated resources development.

Water Resources Planning in Germany took place in 1960. In 1977, at UN Conference on Water in Mar del Plata (Argentina), Integrated Water Resources Management (IWRM) was the recommended approach to incorporate the multiple competitive uses of water resources. The approach of IWRM started from this international conference. However, this approach had ups and down in the following years.

¹ Patron, Farmer Managed Irrigation Systems Promotion Trust (FMIST), Nepal

IWRM over period of time

The issue of IWRM disappeared from political agenda in 1980s. Only in early 1990s, onward, a number of international conferences and forums brought back IWRM in the center of political issue. Water was back in the agenda in the following international conferences and forums.

International Conference on Water and Environment (known as Dublin Conference) 1992, II World Water Forum (Netherland), 2000 -International Conference on Fresh Water, 2001, Bone, World Summit on Sustainable Development (WSSD), South Africa, 2002, World Water Forum, Kyoto, Japan 2003

Issues on water resources development principles as proposed in Dublin had long term impact in the subsequent international conferences and forums. Those principles put forward by Dublin conference were:

- that fresh water is finite so water management has to take care in an integrated manner
- that participatory approach in planning is to follow
- that women's role in management and safeguarding water is to recognize, and
- that to accept water as economic good.

Followed these basic principles of water resources management in Rio Conference on Sustainable Development and UN Conference on Environment and Development, 1992

Dublin conference had greater impact on water resources management along with greater degree of controversy as well specially the question of water as an economic good was not accepted by many developing countries. Addressing shortcomings of Dublin Conference

- Water as economic good has created problem in many developing countries. It brought the socio-cultural value and equity issue relating water. Many developing countries did not follow water as an economic good.
- Later on, shortcomings of Dublin Conference were addressed by subsequent international conferences like WWF 2000, WWF III, 2003 in Kyoto, Japan
- It established the Vision to Action Plan. In order to implement them in the developing countries, Global Water Partnership and Regional Water Partnerships were established.

What is this? As defined by GWP

- TAC of GWP defined IWRM as “A process which promotes the coordinated development and management of water, land and other resources in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital eco-system” World Summit in Sustainable Development (WSSD ,2002), South Africa
- Water should be managed in a basin wide context under the principle of good governance and public participation.

IWRM: What is it? It contains following features;

- IWRM is a process of better management of water resources
- Encompassing governance and stakeholders participation
- Balancing development for resource sustainability

With the introduction of IWRM, transformation of concept on water resources management has taken place.

Traditionally, management philosophy was based on supply side. However, management philosophy has changed towards demand adjustment. Management of IWRM aims to distribute water resources appropriately in response to scarce world water resources.

Water Usage Volume of Worldwide

Water sources use by purpose and regions:

Non –Agriculture: 30%

- 20.3% in Non-Asian countries
- 9.5% in Asian countries

Agriculture : 70 %

21.3 % in Non- Asian countries

48.7 % in Asian countries

In total: 40 % in Non-Asian countries and 60% Asian countries

(Nepal has over 90% in agriculture use)

(Source: *Japanese Institute of Irrigation and Drainage, Toyko, 1996*)

South Asian countries have different scenario facing the severe water management problem due to;

- Unequal spatial water distribution causing hardship to women and economically disadvantaged groups,

- Rapid urban population growth putting pressure on water supply and sanitation, increase of water borne diseases (Shrestha, A. et.al. (2014)
- Pressure on rural water availability due to high demand in urban area

IWRM– Multi-disciplinary Approach

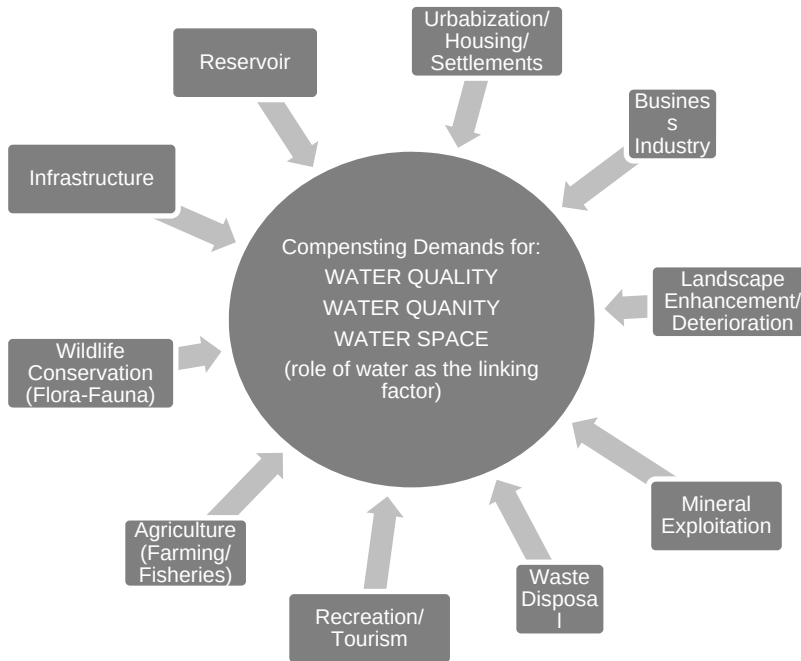
Focusing water resources at the center, it has to take into consideration people and their needs in relation to other natural resources like land use and agriculture production, legal framework, organizational set up, participation of the people at different level of organization, allocation of water and distribution mechanism as well. These aspects are to take into consideration in IWRM. How can there be integration?

The meaning of integration in IWRM consists of;

- 1) Land use planning and water resources use,
- 2) Surface water and ground water management,
- 3) Upstream and downstream conflict resolution,
- 4) Freshwater system and coastal waters management,
- 5) Urban and rural water management,
- 6) Central government and local government's water policy armonization, and
- 7) River basin organizations and apex bodies.
- 8) Defining the role of gender in water resources management
- 9) water, sanitation and health
- 10) Water and culture (role of indigenous people) IWRM is an inspiring and relevant theme for the practitioners on the ground.

Features of IWRM

IWRM does not have general blueprint suitable for each and every country. IWRM process has to be adjusted according to the socio-economic, political and cultural condition of each particular country. In many countries, it is just evolving and long way to go. Therefore IWRM is the exercise to prepare a road map or action program to put IWRM in action. The following diagram indicates the competing use of water in different sectors and water acts as linking factor for many activities for the benefit of human beings and environment where they live.



Following conditions are important for the effective implementation of IWRM in a country.

- There is need of promotion of enabling environment for the implementation of IWRM. They include appropriate legal framework (example , Law relating River management (Japan), initially it was about flood management, secondly , flood management and water use as well, thirdly, flood management, water use and environment protection). Hence the existing water law has to adjust with the changing situation and new demands.
- Along with promulgation of appropriate law, institutional roles are to be refined. Central Agency is to assign responsibility to look after multi-sectoral activities of water, not to encourage sectoral agencies for planning of water resources (Ministry of Water Resources, instead of Ministry of Irrigation, Ministry of Electricity etc) and establish units of activity at River Basin Committee or River Basin Organizations.
- Management tools are to be employed to design and plan the IWRM. Following management tools are suggested to be effective for the planning of IWRM through participation of all stakeholders. It is necessary to follow participatory approach, involvement of all stakeholders, decentralized water resource management, etc. (at the grass-root, actors make effort to integrate Water Resources management) like integration of irrigation , ground water recharge by irrigation and ponds, drinking water supply from water spouts and wells, waste

and drain water for agriculture use: Example from Bhaktapur, Nepal (Pradhan.2012)

It is necessary to define who are the stakeholders? Those people who are affected and who can affect are the stakeholders. Hence, officials, academics, private sector, water users and NGOs etc become stakeholders.

- IWRM is different from sectoral approach. Hence there is need to institutionalize IWRM and make it part of the government policy.

Multi-stakeholders exercise:

In order to come to a consensus on IWRM, following steps are to follow.

- Getting involved different actors (multi-stakeholders) through workshops and seminars. The conclusions of such exercises result into policy.
- That Policy is to be endorsed by the government
- The endorsed policy is to translate into Water Policy with IWRM component.
- Acceptance of National Water Policy by multi-sector stakeholders

IWRM takes place at different levels

- National level
- River Basin Organization or Sub –River Basin Organization (Regional level within country)
- Local level activities
- Trans-boundary level as well? (In the discussion, only the national levels will be discussed)

Stages of IWRM Implementation

- 1. Preparation of appropriate units for IWRM Implementation like RBO(?). Involvement of the stakeholders in the preparation process
- 2. Seek the help of experts/ consultants to work to-gather with various stakeholders (grass roots stakeholders), assessment of problems and potentialities.

Technique of information collection like involvement in information collection, RRA, PRA etc can be used)

Institutional Reforms

While implementing IWRM, corresponding institutional changes and reforms appropriate to IWRM have to take place.

- IWRM implementation expects consolidation of Water related agencies like Ministry of Water Resources or Ministry of Natural Resources and Environment
- The Central Agency acts as regulatory body for water resources management
- Number of agencies will be established outside Ministry
- National Water Law will work as master law of water resources management

Experiences of Implementation at the initial stage

At the initial stage, it will be marked by top-down approach in implementation of IWRM. The stakeholders are usually at the stage of dormancy at different level. Hence, there is need to undertake study to identify the ways and means to have active participation of stakeholders both of men and women at different levels of IWRM implementation at sub-basin level, local level etc. Efforts have to be initiated by the government to break the dormancy and promote grass root level participation of the stakeholders. In such exercises, the external consultants can play creative role as facilitators between the central agency and local stakeholders. With their help, River Basin Committee (RBC) or River Basin Organization (RBO) and Sub River basins would be activated. With the creation of such organization, then Participatory Planning of RBC, RBO, Sub-River Basin takes place and Participatory Programs would be formulated,

Since the adoption of IWRM as tool for Water Resources Management, the active involvement of gender and stakeholders at different levels is strongly recommended. It has important values in the implementation of IWRM. They are;

- Participation reduces the dormancy of IWRM Implementation
- Public Participation is important for sustainable development
- IWRM requires decentralization of decision making and responsibility to the stakeholders in the RB as an evolving process of involving stakeholders

Factors that Make IWRM Success:

- Effective IWRM requires full support of key stakeholders- specially the communities at the river basins
- Support can be achieved through the involvement and participation of the communities at all levels of activities
- Community knowledge, community ownership is prerequisite
- Need for effective participation in IWRM Process
- IWRM refers to an approach whereby management of water resources is systematically implemented through proper arrangement of organizations at the regional level with the promotion of participation of all levels of organization and stakeholders.

Nepali Context

Small scale Integrated Water Resources Management were in practice at the local level in many parts of Nepal. The local people attempted to integrate local water resources to drinking, irrigation and environment protections. IWRM on many occasions have entrenched the local religious value and cultural practices (Amatya. 2006). There has not been expressed policy of the Government of Nepal about IWRM until the promulgation of the National Water Plan in 2005. The National Water Plan, 2005 has specially mentions that “ policy principle for water sector development and management of water resources shall be undertaken in a holistic and systematic manner relying on Integrated Water Resources Management (IWRM).” It is also stated that River Basin shall be the base unit of water resources development. (WECS. National Water Plan. 2005) . Progress towards this direction has yet to achieved. Enabling environmental build up, institutional reforms and development of appropriate tools for IWRM have yet to be in place. In 2007, Irrigation and Water Resources Management Project (IWRMP) supported by World Bank had among others an important components was Component C called “Institutional and Policy Support for Improved Water Management” to be implemented by Water and Energy Commission Secretariat. The project component is to prepare base for river basin data collection through the establishment of Information Center, WECS is to create enabling environment for institutional reform and a development of appropriate tools for the implementation of IWRM (WB.2007. IWRMP).

A High Level IWRM Policy Steering Committee under the Chairmanship pf Vice-Chairman of National Planning Commission (NPC) was held on 8 September, 2009. The meeting was to discuss the future process of formulation of water policy. The meeting assigned the responsibility to prepare Water Resources Management Policy document to WECS by utilizing its own resources and expertize. Document in Nepali language was prepared by highlighting the problems in water sector and suggested to formulate water resources development policy to address the identified problems. Water Resource Development Policy is to address (a) conserve water, (b) to mitigate water induced disaster, (c) to undertake comprehensive water resources development and (d) to strengthen water resources management policy. Within the context of water resources policy, framework for Integrated water Resources Management (IWRM) was prepared.

Based on IWRM policy, experimental river basin offices were established. The concept and mandate of river basin committee was approved by the 54th meeting of WECS chaired by Minister of Energy on 23 November, 2009. As the initial stage of activity towards implementation of water resources management policy, establishment of River basin Offices (RBO) at Nepalgunj for Karnali basin and at Narayanghat for Gandak Basin had been established jointly by WECS and Department of Hydrology and Metrology. These offices were established in mid 2010. The RBOs will initiate to activate District Water Resources Committees (DWRC) to form Sub-basin Committees. The RBOs of Nepalgunj and Narayanghat prepare guidelines, framework and training programs to sub-basin units. Bsed on the experiences of RBOs of Nepalgunj and

Narayanghat, Basin office will be established in Biratnagar for Koshi River Basin (Based on Interview with Mr. Sanjay Dhungel, SDE, WECS, March 2010)

Recently, Irrigation Policy of Nepal, 2013, stated in its policy that while irrigation planning is done, the IWRM principles will be adopted. During the time of National and District level Irrigation Master Plan is prepared, it will be done at the River Basin or Sub-River basin will be taken as the operational unit of activity. However, a few efforts were made to establish sub-basin units for IWRM. Preliminary exercises are undertaken in water resources planning in Bagmati Basin, Three sub-basin committees of Jhimruk, Madi and Rapti were formed in West Rapti. Similarly, Babai sub-basin unit is established. Similarly, initial exercises were initiated for the establishment of basin units in Gandaki River Basin (Khanal, 2013). There is need of legal and appropriate institutional arrangements to be worked out. Within Irrigation and Water Resources Management Project (IWRMP), WECS was made responsible for Integrated Water Policy formulation, establishment of Water Resources Information Center (WRIC) at WECS, establishment of River Basin Office and establishment of basin and sub-basin committees. Progresses are made in these activities by the project through WECS (DOI/IWRMP, May, 2012). It is necessary to put the legal and institutional arrangements in place for the river basins and sub-river basins to be effective to make integrated water resources plan with participatory mode at the basin and sub-basin level.

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Issues and challenges in Land acquisition

Krishnadev Rai

Abstract

This is an overview paper based on the contemporary literature of land acquisition and compensation problems in the large irrigation project in Nepal which has become the most vexing problems for project implementer. This paper, in general, makes an endeavor to demonstrate what problems are facing and how the problems raised in this project. More specifically, this paper is intent on dealing with four objectives, viz, (i) to access the trends and causes of the land acquisition and compensation issues and problems (ii) to defining compensation parameters, challenges in land acquisition and the existing law also place stringent restriction on the exercise of eminent, (iii) to provide a framework for effective and systematic land acquisition management on large irrigation project in Nepal, and (iv) to present essential features of land acquisition and compensation problems in large irrigation project, in the context of Sikta Irrigation Project. This paper also present what challenges are facing in acquisition process and specific attention to the institutional influences by agencies, acquiring land for a public purpose and their impact on the legal and administrative framework in the land acquisition process for Sikta IP. The rest of this paper is analysis of land acquisition procedures for irrigation project and ascertain fact concerning land compensation offered to farmers, whose land will acquire for the project. Paper also explores alternative policy option for dealing with all issues so as to provide a sustainable framework for managing to reduce the tension between the project and land owners.

Introduction

Acquisition of private land by the government for public purposes is a common practice globally. But in a land hungry country like Nepal, land acquisition means something threatening and frightening to landowners. Overpopulation and a scarcity of land put enormous pressures on land property. Land thus becomes the most valuable asset in Nepal, and not only a means of livelihood but also a great sign of social power, pride, status, and happiness. Significantly, owning a vast tract of land bears testimony to a person's great wealth. Most families are tied to their ancestral land, which is very much a psychological bond, and the feelings and emotions they experience with the ownership of their land can never be compensated for through any means if they should lose it. Thus, land acquisition by any organization, whether a governmental or a non-governmental entity, and for any purpose is seen as a vital issue in Nepal. In almost all cases, owners are completely against land acquisition. But land acquisition is essential for infrastructural development, which is crucial to accelerating economic growth. Moreover, in order to meet the growing demand of its huge population, the government needs more institutions, which in turn requires the acquisition of land. Therefore, there is no way to stop land acquisition; however, the amount of land thus acquired can be reduced by prudent analysis and relevant considerations. In addition, the entire process of land acquisition can be accomplished within a certain legal framework to ensure transparency

for all the stakeholders. A vital issue concerns the current policy responses against land acquisition and how the government's policy might be able to give the best returns to those who lose their land due to various development projects. In light of this vital issue, the paper will analyze the present status of land acquisition and resettlement in Nepal with a special reference to Sikta, Mahakali and Rani Jamara Kulariya Irrigation projects.

The trends and causes of the land acquisition and compensation issues and problems

Due to lack of proper implementation of Acts and Rules relating to land acquisition as well as difficulty in approaching the concerned offices at the right time, it becomes difficult to acquire required land. Further, given the population density and the type of land use in the country, there is more problem in land acquisition in Nepal. Thus, it is a big challenge for Government, to generate greater access of land to the people at large, including landless rural poor.

For setting up huge industrial projects, dams, factories, refineries, etc., more and more land is being used. As a result, the people/ community residing there, face many problems. They are forced to leave their resident place and move to other places. First, there is problem in searching proper place to live in. Secondly, land acquisition for industrialization and related projects highlight the issues of adequate compensation that need to be given to the displaced people for protecting their living standards. This is one of the common problems in land acquisition.

Further, there is need to rehabilitate the lost productivity of available lands so that they can be effectively put in use for various purposes like agricultural, industrial, residential, office buildings, etc. as land is scarce resource. The Government is also running its various policies and schemes for this purpose. Also, efforts are being made not only to restore fertility of the land or to provide shelter to displaced people, but also to create conditions so as to bring in focus the land resources which are not yet tapped and utilized.

Hence, there are many such and other related issues and problems relating to land acquisition, resettlement and rehabilitation in Nepal, both in rural and urban areas. They need to be dealt with great care for future availability and use of land/ properties. The land acquisition problems have been facing by some irrigation projects in Nepal including Sikta Irrigation Project, Banke.

There are numbers of development projects including national pride that has been implementing in Nepal. It is almost impossible to obtaine statistic on land acquisition and displacement due to the implementation of the irrigation, roads and others projects. These projects are Sikta Irrigation Project, Rani Jamara Kulariya and Banepa-Nijgadh Fast Track road. These projects required large amount of land and evicted large members of landowners arbitrarily. For example, one of the biggest irrigation project, Sikta Irrigation Project and Rani Jamara Irrigation project under construction and large amount of compensation were distributed for land acquisition. Nepal is a developing, and it has

been attempting to accelerate economic growth, which requires physically dynamic infrastructures. In order to carry out this process, these projects are being undertaken and many are being proposed that requires vast amount of land. It is highly dense and overpopulated; therefore, any project with a footprint means the displacement of population. Therefore, land acquisition and development projects related to displacement are no longer a subtopic but rather vital issues. However, to date, the government still has no fixed, clearly formulated resettlement policy.

The Sikta Irrigation Project, Banke have the most vexing problems on land acquisition and compensation matter since its beginning. The alignment passes through government land (*ailani*), private land and community forests and displaces private and public assets. The difficulties that come in the process of land acquisition in Sikta IP are immense. This is evident from the fact, the fundamental in increase of number of top stories in the past year. The construction works of main canal of Sikta have been stopped several times due to the weakness of project implementer and enthusiasm to demand high price of assets and private land by landowners.

Compensation parameters, challenges in land acquisition and the existing policy and law

The compensation of lost land and property by construction of project have to be distributed by following prevailing rules and regulation. Some provision for land acquisition and compensation has been described in the following:

The Interim Constitution of Nepal, 2063 (2007) guarantees various socio-economic and political right and the fundamental rights of a citizen. Article 17(1) establishes the right to property for every citizen of Nepal, whereby every citizen is entitled to earn, use, sell and exercise their right to property under existing laws. Article 19(2) states that except for social welfare, the state will not acquire or exercise authority over individual property. Article 19(3) states that when the state acquires or establishes its right over private property, the state will compensate for loss of property and the basis and procedure for such compensation will be specified under relevant laws.

As per the prevailing government rules, the compensation to be provided for land acquisition needed to be in cash as per current market value. However, there is also a provision under Clause 14 of the Land Acquisition Act, 2034 (1977) to compensate land for land provided government land is available in the area. As per the regulatory provision, while acquiring land, GON forms a Compensation Fixation Committee (CFC) under the chairmanship of Chief District Officer (CDO) of the restrictive districts. The other members to be included in the Committee comprise of – Chief of Land Revenue Office, an Officer assigned by CDO, representative from District Development Committee (DDC) and concerned Project Manager. While determining the compensation, the Committee has to consider relevant acts and periodic guidelines of GoN in compliance with ADB Policy and Guidelines.

Apart from the constitutional safeguards, the Land Acquisition Act, 2034 (1977) is the core legal document to guide tasks related to land acquisition and resettlement activities in Nepal. There is provision in Clause 3 of the Act to acquire land for any public purpose, subject to the award of compensation. Besides, any institutions seeking land acquisition may also request GoN to acquire the land under the regularity provisions subject to be compensated by such institutions' resources. As per the prevailing government rules, the compensation to be provided for land acquisition should generally be in cash, as per current market value. However, there is also a provision under Clause 14 of the Land Acquisition Act, 2034 (1977) to compensate land for land provided government land is available in the area.

The *Malpot Aien* or Land Revenue (land administration and revenue) Act, 2034, act to carry out land administration including maintenance and updating records, collection of land revenue and settlement of the disputes after completion of survey and handing over of the records to Land Revenue Office by the Survey Parties. It authorizes the Land Revenue Offices to registration, ownership transfer and deed transfer of land. This Act also authorizes the Land Revenue Offices to transfer ownership and deeds of individual land, if any person applied for the ownership transfer of his/or land with mutual understanding for public use with recommendation of relevant committee.

The Land Revenue Office (LRO) is responsible for land administration and registration of all types of land in Nepal. The Survey Offices prepares land records through cadastral mapping. The three major types of land ownership are in practice; i) registered private land, ii) registered public land and iii) unregistered (but cadastral mapped) government land (*ailani*).

Similarly, the World Bank policy further states that the absence of formal legal title to land on the part of affected group should not be a bar to compensation and that special attention will be paid to households headed by women and other vulnerable groups. According to World Bank policy, the date of the census will be eligible for compensation. Finally WB policy states that the planning and implementation of any compensatory and resettlement measures should be appropriately monitored and evaluated.

Framework for effective and systematic land acquisition management on large irrigation project in Nepal,

For effective and systematic land acquisition management, land acquisition and resettlement plan should be prepared before starting the project implementation in order to provide the policy and procedures of land acquisition, compensation and resettlement of affected persons. It is necessary to identify the impact on property and income sources of affected persons with documentation of loss of land, houses, trees, and other assets.

The framework for land acquisition process is to be developed to guide planning to address such possible impacts of land acquisition. All this measures to be adopted in instances where the following types of losses are inevitable: acquisition of private and

public land; temporary loss of land/crop; loss of residential, commercial and other structures; loss of community structures/resources; loss of tree and crops; and loss of time and travel expenses. The framework, in turn, recommends strategies for the design of: Resettlement Action Plans; information, consultation, participation and disclosure; and grievance redress mechanisms. The following action is to be carried out while preparing the land acquisition and resettlement plan:

- **Assets Inventory**

As part of census, the inventory survey is very important for land acquisition & resettlement. The affected households also participated in the survey. The engineering staff identified the centerline of the canal and likely areas of land to be acquired. A detailed inventory of affected persons/ households, land houses and other structures, private trees, public properties and common property resources is to be prepared and verified with the owners and related persons on site. The photograph of the affected houses and structures should be also taken to calculate its cost and discourage further encroachment after census of project affected persons.

- **Census, Socio-economic Survey and Asset Verification**

Socioeconomic survey, Community Consultation Meeting and Focus Group Discussion should be carried out and prepare profile of affected persons, assess household income and expenditure, identify productive assets and income generating activities and plan for income restoration, develop relocation options and develop social and economic support measures for vulnerable groups. The income generation and sensitization related training would be important tools. This survey also records demographic features and verification of public and private structure in consultation with project affected person, their neighbor and other key informants.

The social impact assessment can be undertaken as a part of resettlement impact assessment. The study be in the following key social issues for investigation:

- i. Loss of private property and other assets (land, houses and trees) and Compensation modalities for these lose.
- ii. Population displacement
- iii. Construction employment opportunities
- iv. Potentiality for social development

Conclusion

Under the project activities, the land acquisition part will be on the critical path as without this activity, construction work cannot go ahead and land acquisition and compensation is the matter of concern of the affected people. Keeping in view the various issues and problems involved in land acquisition, resettlement and rehabilitation, a wide variety of steps are being taken by both the project, from time to time, so as to promote overall development of landowners.

First, all the detailed survey should be carried out and fixation the alignment. After fixation canal passes area, an inventory should be prepared including losses of land and public and private assets. The cadastral survey, Assets inventory, socio economic survey, assets verification, consultation with stakeholders and landowners and the social impact assessment works are should be done and preparation of resettlement plan for people those who would be displaced due to construction of any development work. All these work including pre-construction work will complete then land acquisition and compensation should be started. After completing the land acquisition and compensation process, canal and its structures are start to construction. It makes in future very effective and the construction works will go ahead without delay and compensation cost also be low.

Irrigation Development and Management from Gender Equity and Social Inclusion Perspective: a reflection of LILI's approach

-Vinod Kumar Barai²

Key words: Gender equality, Social Inclusion, Disadvantaged Groups, User Committee

Abstract:

Inclusive Development is a global agenda, issue and commitment of all stakeholders engaged in development activities. Government of Nepal is committed towards inclusive development for reducing poverty. The high economic growth, peace and good governance are the core of the current TYP, which commits to government a long term vision of ending “all forms of discriminations and inequalities (UNADF 2013-2017). Nepal is a predominantly agricultural country where about 66% of the population is engaged in agriculture. Irrigation is the most essential input of agriculture production system which contributes to increase the yield of agricultural crops up-to 56% to 62% in staple cereals. The social issues related to the “Gender Equality and Social Inclusion” are prominently experienced during or after the construction phase. Irrigation policy 2060 has provision to strengthen the capacity of local users and NGOs involved in irrigation management. However, women’s participation in UC has been only 19% (draft social assessment of Rani Jamara Kulariya). The key social issues related to women and social inclusion are; capacity to forward irrigation demands; effective participation in decision making; social support and security during work and cash handling, support from family and society for proper empowerment; challenges in continuation of operation and maintenance fund, managing conflicts related to the water source and in water distribution. A comprehensive analysis of social issues with practical approaches can bring a positive result in terms of management, functionality and sustainability of the irrigation systems.

LILI applied some specific approach to strengthen Gender Equality and Social Inclusion at both the demand and supply side during different stages of irrigation development and management i.e. at pre-construction stage, construction stage and post construction stage. As a result of which, LILI has been successful to include 51% of the disadvantaged groups, with 43% Dalit and Janjati and 43% women in the users committee. The annual report of LILI 2012/13 showed that out of the total budget expenditure of NRs 210.6 million, discriminated groups received 40 % of the total fund and the women beneficiaries received 45%. This result was achieved by committed and inclusive team of LILI project.

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1. INTRODUCTION

Nepal is a predominantly agricultural country where agriculture sector contributes to 66% employability and 36% to the total GDP of Nepal (*Source: <http://www.moad.gov.np/>*). However, 25% of the Nepalese population still lies under poverty. This figure goes up-to 46% in terms of multiple poverty index (*HDR 2013*). Inclusive Development is a global agenda, issue and commitment of all stakeholders engaged in development activities to foster a better socio-economic life of the poor and vulnerable groups of people. Government of Nepal is committed towards inclusive development for achieving millennium development goals and reducing poverty. The three Year Plan aims to create a prosperous, peaceful and just Nepal by transforming the country from least developed country into a developing nation within two decades. The high economic growth, peace and good governance are the core of the current TYP, which commits to government a long term vision of ending “all forms of discriminations and inequalities such as legal, social, cultural, linguistic, religious, economic, ethnic, physical, gender and regional” (*UNADF 2013-2017-United Nations Country Team Nepal @ 2012*).

Since irrigation is the most essential input to the agriculture sector that contributes to increase the productivity of key cereal crops, like in paddy and wheat by 62% and 57% respectively, including improved and local varieties. However, it is the most discussed and disputed issue regarding its development and management on GESIP aspects. Rural women’s input in farm activities is 9.91 hours/day, nearly double to that of men i.e. 5.86 hours/day (Women and irrigation in Nepal, Suraj Ghimire). Though, there is no clear guidelines and approaches to measure the women’s contribution in irrigation, however, it can be much more in development and management of irrigation in a context of high out migration rate in Nepal where 7.2% population is abroad (Census, 2011, CBS, Nepal). There are several factors related to the development and management of the irrigation system in Nepal, i.e. technical, economic and social aspects. The technical and economic aspects are prominently visible and are generally well planned and taken into consideration since the beginning, whereas the social aspects are often less analyzed during the inception or design phase. The social issues, mainly the “Gender Equality and Social Inclusion” are prominently experienced during or after the construction phase i.e. benefit sharing.

As per Local Self governance Act 1999, agriculture sector has been devolved to the local bodies (DDC, VDCs and municipalities). Many of the local development activities like development and management of irrigation systems, community forests, local roads, drinking water system etc are being developed and managed by user committee (UC)³ in social and technical support of key agencies. Though the devolution of management and decision making authorities to UC looks sound, it can widen the social disparity in terms of GESIP due to social stratification and power structures in Nepalese society. The land holding has highly skewed distribution in Nepal, more lands are occupied by less people, i.e. about 5% farmers owning 37% of total agricultural land against 47% of the farmers

³ User Committee is a formal unit comprising 9-11 members of the users, formed to take formal decisions and steer the implementation of the planned activities.

owning just 15 % of land (<http://www.ngofederation.org/index>). About 19.7% of the women have some sort of land in Nepal (CBS 2011), however, women share just 8.1% of agricultural land in Nepal (Rao Nitay, *Women's Access to Land: An Asian perspective, 2011*). Similarly, the major and water sources are under the access and control of the elite groups of farmers. Thus, if control over resources is devolved to “traditional” institutions, it should be realized that these may be male dominated (Ruth Menzen *et al*, *Gendered Participation in Water Management, 1998*). Irrigation policy 2060 has provision to strengthen the capacity of local bodies, and user association and also involving NGOs in irrigation development and management. Management of irrigation itself has tremendous scope and challenges, despite several efforts the women's participation in UC was just 19% (*draft social assessment of Rani Jamara Kulariya*). Formation of inclusive UC has been a challenge due to passive policy guidelines and social structures of the Nepalese society.

The irrigation regulation 2056 has provision to form user association of 11 members, if possible with 33% of women and two members from Dalit, Janjati and disadvantaged groups, but was taken mostly as a formality. However, “Local Body Resource Mobilization Guideline-2069” developed and adopted by MoFALD is more progressive in terms of formation of inclusive user committee, with at least 33% women and with at least one woman at key position like chairperson, treasurer and secretary (*article 25*). This supports for strengthening participatory planning process and equitable resource allocation for the excluded groups; specifically for women related at least 10%, children related 10% and for other disadvantaged and socially excluded groups 15%, however, effective, participation of the underrepresented groups is always a challenge in irrigation development and management.

The challenges and disparity of inclusive development are observed at both the demand and supply side and at different stages of irrigation development and management. The key GESI challenges at the demand side are; capacity of the underrepresented groups to forward irrigation demands; effective participation in decision making process, discouraging stereotypes and lack of proper family and social support mechanisms to take key responsibilities, like of treasury, cash handling etc; continuation of operation and maintenance and social conflicts at the water source and in water distribution. Similarly, the key challenges at the supply side are; weak policy instruments, institutional and technical capacity to support the irrigation users; fragile local socio-political context and personal motives of the officials to deliver citizen centric services.

As a result of which there is no equal access and control over the resources and benefit of irrigation. Development efforts are not equitably distributed making repetition of resources to certain schemes and failure of functionality of the schemes due to lack of care and social conflict among the irrigation users. A comprehensive analysis of the gender and social inclusion aspect of the irrigation users and addressing it properly with practical approaches can bring positive result and increase functionality and sustainability of the irrigation schemes. Reflection of LILI's approach to strengthen Gender Equality and Social Inclusion in small scale irrigation development and management can be a role model.

2. GESI IMPLEMENTED BY LILI

Local Infrastructure for Livelihood Improvement (LILI) is a bilateral project funded by SDC and is a joint undertaking of HELVETAS Swiss Intercooperation Nepal and the Ministry of Federal Affairs and Local Development of Government of Nepal. LILI is implemented through the local bodies (DDC/VDCs) in active participation of irrigation user committee (UC) in technical and social assistance of Local Service Providers (LSP). The program aims at improving the food security situation of small farmer in 8 hilly districts viz. Achham, Kalikot, Dailekh, Jajarkot, Khotang, Okhaldhunga, Ramchhap and Dolakha, through implementation of the Farmer Managed Irrigation Schemes (FMIS).

2.1 LILI's practices to streamline GESI in irrigation development

Helvetas Swiss Intercooperation Nepal (LILI) has Gender Equality and Social Inclusion (GESIP) policy with focused targeting approach applied across its projects with priority to excluded groups. In addition LILI adopts existing policies and procedures of the Government of Nepal implemented by local bodies to promote GESI in irrigation development and management. LILI implements several activities for strengthening demand and supply side at different stages of project cycle management i.e. pre-construction, survey design and formalization, construction stage following 8-steps implementation process.

2.1.1 Pre-construction stage:

Pre-construction stage completed in two steps. Step-1 starts with collection of community demand for irrigation, followed by Step -2, Socio-economic and Technical Surveys. The community awareness programs are launched as an entry point at VDC and ward level, so that, all groups of the people can get information about the scope of the project and they can forward their demands with due process. All the demands follow the planning process of the local bodies starting from the ward level to the district level. The local service providers (local NGOs) in collaboration with DDC and VDCs are supporting agencies for information dissemination to the community.

The demands are prioritized primarily with social and economic criteria of the irrigation users, like; at least 50 % of the FMIS users must have land area below 9 ropani (~0.5) hectares, 50% HHs must be poor (having food sufficiency <6 months), in the beneficiaries there must at least 50% HHs from socially discriminated groups (i.e. Dalit, Janjati, Women headed). Thus at the very beginning inclusion of at least 50% of poor, Discriminated and small farmers is ensured which makes the foundation for the GESI in irrigation development and management.

2.1.2 Survey design and formalization stage:

The step-3, starts with detail survey design and cost estimate of the proposed irrigation schemes. The social, economic and technical information collected in the step-2 are verified and finalized to ensure the beneficiaries and total cost with technical aspects. External service providers with multiple teams are involved in this process. The social issues and likelihood of any conflict also assessed during this step. Thus the voice of the disadvantaged groups is indecently raised and discussed to come into common understanding and consensus. Step-4 starts with a downward accountability mechanism, by organizing a public hearing in a wider participation of all the stakeholders and concerned beneficiaries. At this step all the community people and stakeholders can raise their concerns. The key discussions are formation of inclusive user committee (UC). Development of equitable policies, training to empower beneficiaries, registration process, and signing of formal community agreement between UC and DDC.

- a. Construction Management Training: is organized for the users to discuss the details of irrigation system construction and management, roles and contribution of different stakeholders, and policy development. This training comprises observation visit to the nearby completed schemes which empowers to all the members even the women and social discriminated one to raise their confidence to participate in the irrigation development and management process.
- b. Formation of inclusive user committee: A 9-11 members inclusive user committee is formed, where at least 40% women and proportionate number of all social groups are included, with mandatory inclusion of 1 women, 1 discriminated candidate (Dalit, Janjati, Minorities etc.) and 1 tail-user at the key positions (Chairperson, Treasurer and Secretary) of the UC. The inclusive UC ensures the access and control over the decision making process for resource mobilization, utilization, and distribution of irrigation water.
- c. Formulation of equitable policies: the users are facilitated to develop and adopt equitable contribution policy for equitable contribution in labor and operation maintain fund, and also for water sharing based on the land holding under the irrigation command area.
- d. Registration of the water sources, users groups in the district water resources committee (DWRC, DADO and NIFUWAN) is facilitated in order to establish the right the users on the water source, conflict mitigation and to get coordination from concerned agencies.

2.1.3 **Construction and finalization stage:**

This stage starts with Step-5, collection of local construction materials, excavation of the pipelines, followed by Step-6, supply of non-local materials and Step-7, review of activities completed and realized during the construction period, this stage is concluded by the last Step-8 i.e. completion of the construction works, finalization of the labor payment and other payments, operation and maintenance training and public audit. The key GESI related activities implemented during this stage are;

- a. Support in management cost to the UC: based on the actual need (1.5% of the total budget later adopted) is paid to the community to visit to the district headquarters for signing agreement, registration and to withdraw cash from the banks. Since, the women are sometimes less encouraged to visit district headquarter for cash withdrawals from the banks due to family, social and physical reasons, they can take support from somebody to accompany them to the headquarter who they find trusty. Thus their hesitation to be unable to read and write and be unable make frequent visit is facilitated positively.
- b. Equal wage for the equal work policy. In the community the women are considered to be physically weak and are generally less paid than the men. However, LILI has successfully promoted equal wage policies that have benefitted women. In addition, equal wage for equal work policy for men and women empowers and develops self confidence of the women to perform their responsibility.

3. **GESI STATUS IN LILI**

All the above approaches have yielded good result in terms of irrigation development and management from gender equality and social inclusion perspective in LILI.

- 3.1 The summary of monitoring sheet of LILI shows that 41% (6970) women participated in community training related to irrigation development and management, 2247 (44%) women with at least one at key positions in all 543 UC. Further, 4% (21) of those 543 hold the position of chairperson in UC (Table#1).

Table#1: Women in community training, in UC and at the position of chairperson

Social Groups	Community Training Participants (5028)		UC members		UC chairperson	
1. Women	6970	41%	2247	44%	21	4%
2. Men	9900	59%	2830	66%	522	96%
Total	16870	100%	5077	100%	543	100%

Source: *LILI monitoring sheet, April 2014.*

- 3.2 Further, in terms of the caste and ethnic inclusion, in the beneficiaries 27% Dalit and Janjati each, 46% Brahman, Chhetri and Newar and 0.2% Minority. Their participation in the community training was as 23% Dalit, 34% Janjati and 0.2% minorities and 43% Brahman, Chhetri and Newar. In User committee, the representation of those social groups was 25%, 32%, 0.2% and 41% respectively. However, the participation of Dalit at the position of chairperson was about half of their presence in the beneficiaries i.e. about just 12.2%.

Table#1: Women in community training, in UC and at the position of chairperson

Social Groups	Community Training		Beneficiaries		UC members		Chairperson	
1. Dalit	1156	23%	7,368	27%	1277	25%	66	12.2%
2. Janjati	1712	34%	7,490	27%	1629	32%	144	26.5%
3. Minorities	100	0.2%	550	0.2%	1	0.2%	1	0.2%
4. BCTN	2160	43%	12,112	46%	2171	41%	331	60.0%
Total	5028	100%	27470	100%	5077		543	100%

Source: LILI monitoring sheet, April 2014.

- 3.3 Altogether there were 51% of disadvantaged⁴ HHs and 1.4% women headed households. The Fund flow analysis (FFA) of 2012/13 showed that 45% of the fund receivers were women in which in case of workers, women received 65% of the total fund released.

4. KEY REFLECTION

- 4.1 Inclusive irrigation development and management increases strong accountability and ownership of women in construction, benefit sharing and maintenance of FMIS.
- 4.2 Involvement of women and socially discriminated groups is difficult at the beginning, however shows very impressive result afterwards with less social conflict, timely completion of the schemes and good transparency in resource management;
- 4.3 Women trained and involved in skill-labour works like mason and plumbing for skill works support in income as well. The discriminated groups of people get work opportunity at the local level.

⁴ Disadvantaged groups are the group of people or individuals who are poor having less than 6 months of food sufficiency and socially discriminated i.e Women, Dalit, Janjati and minorities.

- 4.4 Women are the regular user of water resources for drinking purpose, domestic use and also for the irrigation purpose and are less likely to migrate than the men, which supports to the functionality of the irrigation schemes;
- 4.5 Women make the best use of the available resources and the funds that reduces fiduciary risk and promotes good governance.
- 4.6 Downward accountability mechanisms to empower the community and to ensure quality services from implementing stakeholders are essential.

5. KEY CHALLENGES

- 5.1 Confusion or wrong interpretation of affirmative action approaches at social and institutional level. The prioritization of the irrigation demands based on social and economic criteria sometimes takes time to clarify among all social groups. It needs a clear communication approach.
- 5.2 Relatively low number of feasible irrigation demands are received from certain social group and geographic regions due to inbuilt inclusive process of demand screening.
- 5.3 Harmonization of the key approaches among all concerned agencies, like, affirmative action in demand screening, UC formation etc, in favor of socially discriminated and underrepresented groups (women, Dalit, Janjati and minorities)
- 5.4 Difficult to convince the users to replace their traditional practices of equal contribution and unequal water sharing with equitable policies for contribution in labor and operation and maintenance fund and for equitable water sharing.
- 5.5 Challenges in getting proper coordination among different working agencies involved in small scale irrigation support due to differences in their mandate and modality of action that can make duplication of resources in one and lack of coverage in another community
- 5.6 Wider gap in the capacity and capability of different groups of people to put their voice and forward the irrigation demand and involve in the process. As a result of which, some groups of people may have domination in access and control over resources.

6. CONCLUSION:

Gender and social inclusion in irrigation development and management needs to strengthen at both the demand and supply sides; and at different stages, like; at preconstruction phase (for demand), during construction phase (implementation), post construction phase (operation and maintenance, income generation. With multiple

interventions and approaches to empower the demand side and strengthen the supply side, LILI's results were impressive in terms of gender equality and social inclusion. As a result of which participation of different social groups (Women, Dalit, Janjati and Minority) was encouraging (51% coverage of disadvantaged HHs) and nearly proportionate in access (training participants, coverage of beneficiaries), control over the resources and decision making (at key positions of UC, chairpersonship, cash) authority. The position of chairperson of irrigation users committee was held by Dalit (12%), Janjati (26.5) and women (4%). The equal wage policy for women and men was successfully applied in the construction of the small irrigation systems. The women were trained and participated in technical skill oriented activities like for mason and plumbing works required for the small scale irrigation. Social conflicts were resolved and some schemes having delayed at the initial stage due to migration of the men was well taken up and completed timely in the leadership of women as a chairperson of the user committee. The annual report of LILI 2012/13 showed that out of the total budget expenditure of NRs 210.6 million, discriminated groups received 40 % of the total fund and the women beneficiaries received 45%. This result was achieved by committed and inclusive team of LILI project where the composition was 12% Dalit, 20% Madheshi/ Terai, 24% Janjati and 44% BCTN with 32% women in total.

However, the key social issues related to women and social inclusion like; capacity to forward irrigation demands; effective participation in decision making during construction phase; social support and security while taking key responsibilities, like of treasury, cash handling etc, support from other counter parts; empowerment challenges due to social stereotypes and level of empowerment; post construction phase; continuation of operation and maintenance systems due to conflicts needs to address properly during irrigation development and management process.

7. ANNEXES:

7.1 Annex: LILI's 8-step Implementation Process

Project Document Phase II, 2009 – 2013			
8-Step Approach			
Phase	Steps		Responsibility
PREPARATION	1	Demand collection from community's through local body's planning process and first screening.	Community, LSP, LILI, DDC
	2	Socio-economic and technical survey of screened demands and prioritization of projects.	Local Service Provider (LSP) and LILI/DDC
SURVEY, DESIGN & FORMALISATION of PROJECT	3	Detail Survey, Design, Cost Estimate and Evaluation Establish linkage to Agricultural Service Providers	External Service Provider (ESP) and / or LSP LILI/DDC / DTO
	4	Communication of Evaluation - Results to the Communities and VDCs concerned. for feasible schemes; • Conduct public hearing • Sharing detail information about Design, Cost, Contributions, Agricultural Plan • Preparation of Operation & Maintenance Fund System • Formation of Inclusive User Committee (UC) • Community Agreement	LILI/DDC, LSP ESP Agriculture Service Provider
CONSTRUCTION & FINALIZATION	5	Collection of local materials and start of excavation of trenches, ponds or foundations. Monitoring and Verification of required community contribution.	Community DDC / LILI / LSP
	6	Supply of non local materials Simultaneous completion of excavation	DDC / LILI / LSP / Community
	7	Project construction, site supervision and public review	DDC through DTO / LILI / LSP / Community
	8	Project completion and reporting including public audit	DDC / VDC / LILI / LSP / UC
It is assumed that each project can be completed within 1½ years including preparation. Detailed surveys of irrigation projects need to be done in the driest periods – i.e. in the pre-monsoon months (February to May).			

7.2 Annex: Few Photographs:



a. Women involved in skills and unskilled works of irrigation system construction (Kalikot)



b. Women involved kitchen gardening activities (Okhaldhunga)

IMPACT OF SOCIO-ECONOMIC STATUS ON CROPPING INTENSITY IN TARAWALI IRRIGATION SCHEME, LAMJUNG, NEPAL

Santosh Kaini, MSc (Land and Water Development), MA(Sociology)⁵

Abstract

The natural increase in world population is 86 million per year. On the other hand, agricultural land is decreasing due to urbanization, natural disasters, climatic variations and other reasons. This shows that there is an urgent need to increase cropping intensity of irrigation schemes. This research is focused on how the socio-economic status of farmers influences the cropping intensity in an irrigation scheme. The Tarawali Irrigation Scheme located in Ghermu VDC of Lamjung district is taken as the study site. Interview checklist, observation and interview with key informants were used for the primary data collection. Census survey was done in all 72 households of the irrigation scheme. It is found that those farmers who have less land or no land to grow crops use others' field that have more land, without giving money and crops to the landowner. However, they just need to put manure in the field where they grow crops. Only vegetables and potatoes can be grown in such fields. This system has increased cropping intensity in the Tarawali Irrigation Scheme. It is concluded that if there is majority of low land holding farmers, they utilize more land which finally increases the cropping intensity. The system of growing crops (without giving money or crops to landowner) in others' field who have relatively more land can be used in other irrigation schemes to increase cropping intensity depending upon the socio-economic settings of the community which ultimately helps to ensure the food security.

Key words: Socio-economic status, Cropping intensity, Tarawali Irrigation Scheme

1. Background

It is obvious that world population is increasing day by day. During mid-2013, the world population was 7,137 million and natural increase in population is 86 million per year (Population Reference Bureau, 2013). On the other hand, agricultural land is decreasing due to urbanization, natural disasters, climatic variations as well as other reasons. About 80-90% of the required increase in food production will have to be realized on existing cultivated land in coming decades and it is necessary to introduce or improve effective water management, increase cropping intensity and increase the application of fertilizer and pesticides (Schultz, Tardieu, & Vidal, 2009). This shows that there is an urgent need

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to increase the cropping intensity of irrigation schemes by effective irrigation management. In Nepal, rapid population growth pressured on food production and created the need of higher cropping intensity (*Pokhrel & Pokhrel, 2013*). The more the farmers use the land in farming, the more the cropping intensity is. In Nepal, when the irrigation scheme has more than 155% of cropping intensity, it is said to have year round irrigation in 2002 (*WECS, 2002*).

Agriculture sector plays a critical role in the Nepalese economy as this sector still contributes more than one third to Nepal's Gross Domestic Product (GDP), and more than two-third of its population depend on it for their employment and livelihood (*GoN, 2012*). Nepal has total irrigable land of 17,66,000 hectares. Out of total 1,69,200 ha land of Lamjung district, only 36.5% (i.e. 61,819 ha) is agricultural land and 26,272 ha (42.5% of agricultural land) is irrigable. Although agricultural works are carried out in 45,050 ha, only 13,970 ha of land get some sorts of irrigation (*DDC, 2069*).

Cropping intensity

The cropping intensity denotes the extent of the land used in farming. It is the ratio of net cropped area to the net command area of the scheme. The net cropped area refers to the area of each crop sown.

$$\text{Cropping intensity} = \frac{A_c}{NCA}$$

Where, A_c is the sum of area cropped in a year and NCA is the net command area of the scheme. This is conventional method which focuses on the frequency of cropping rather than the land used for cropping. If three crops having short crop periods (say three months) are grown in a farm, the area is counted thrice even the land is fallow for remaining three months. In contrast, if a crop (say sugarcane) having long crop period is grown; the area is counted only once even though the land is used throughout the year.

Dayal (1978) proposed time dependent method to calculate cropping intensity incorporating the effect of the duration of the crop in the field as (*Chhetri, 2011*),

$$I_c = \frac{\sum_{i=1}^n A_{ci} * d_i}{Q}$$

where, I_c is the cropping intensity index, A_{ci} is the area under crop i , d_i is the duration of crop in the field, and Q is the net sown area (arable land). Dayal's method does not consider the crop production potential of the area as the arable land is not always available for cultivation throughout the year in every climatic condition (*Chhetri, 2011*).

Due to climatic factors, land in temperate climates remains unsuitable for cultivation for almost six months while land in warm tropical areas is available for cultivation

throughout the year. The new approach which is adjustable to different climatic settings is given by (Chhetri, 2011),

$$CPI_j = \frac{\sum_{i=1}^n DC_i * Ha_i}{Ha_r * GS}$$

where, CPI_j is the crop potential index for region j, DC_i is duration of crop i per year (including double cropping and single crops overlapping two growing period), Ha_i is hectares planted to crop i, Ha_r is total arable hectares, GS is number of months of the frost-free growing period and n is number of crops planted annually.

The factors affecting the cropping intensity are consistently changing. So, both the cropping pattern and cropping intensity of an irrigation scheme are dynamic phenomenon (Rahman, Khan, & Ali, 2012). The most ten crucial factors affecting the crop patterns and rotations are as follows (Raghuvanshi, 1995):

1. Agro-climatic conditions
2. Soil properties
3. Existing agricultural and irrigation practices
4. Socio-economic conditions
5. Surface and sub-surface drainage
6. Availability of agricultural inputs
7. Demand for various crops
9. Infrastructure, trainings and agricultural demonstration
8. Market facilities and

Cropping intensity is one of the variables along with size of irrigated area, land productivity and labor productivity in determining the effects of irrigation in rural poverty (Gebregziabher, Namara, & Holden, 2009).

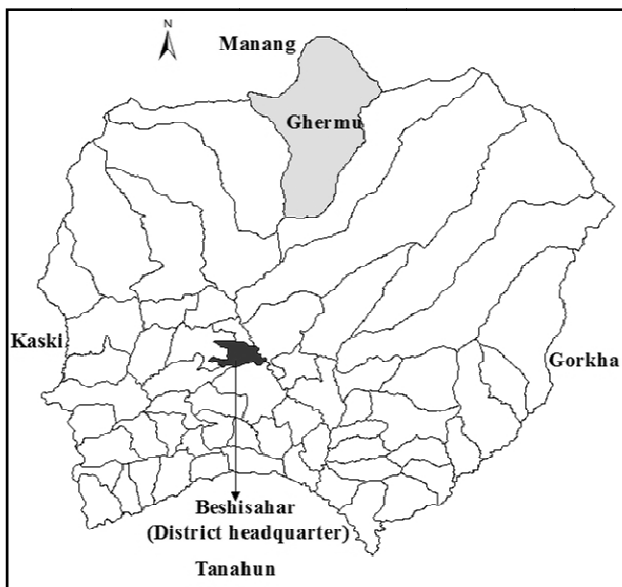
2. Study Site

2.1. Ghermu VDC

The Tarawali Irrigation Scheme is located at Ghermu Village Development Committee (VDC) ward no. - 5 in Lamjung district, Western region of Nepal. Ghermu VDC lies in the Northern part of Lamjung district which is also the boarder VDC of Lamjung and Manang district. Geographically the scheme is confined at 28°13'15" N to 28°25'30" N and 84°24'40" E to 84°26'30" E. We can visit the project area by driving 42Km black topped road from Dumre to Beshisahar and 29Km earthen road from Beshisahar to Syanghe. From Syanghe, project area is about 1Km far by foot trail. Location of Tarawali VDC in the map of Lamjung district is shown in Figure-1.

There are 42,079 households with 1,67,724 number of population in Lamjung district (C.B.S., 2012). Total households in Ghermu VDC are 402 and total population is 1776. Out of them, there are 822 males and 954 females inhabited.

Figure 1: Location of Ghermu VDC in the map of Lamjung district



The average temperature of Lamjung district ranges from 4°C to 30°C at Khudi Bazar Station. The air temperature of the command area is suitable for cultivating paddy, winter vegetable, maize, wheat, potato, summer vegetable and soybean. The average yearly rainfall of the nearest rainfall station in Khudi Bazar Station is 3271 mm.

Ghermu VDC is inhabited by Gurungs, Brahmins, Chhetries, Magars and others. However, Gurungs are in the majority. Most of the people in the Ghermu VDC believe on Buddhism and Hinduism.

2.2. The Tarawali Irrigation Scheme

As Ghermu VDC lies in the Northern part of the Lamjung district, most of the land is forest where upper part is covered by snow most of the time. The lower part is used for the agricultural purpose. The Tarawali Irrigation Scheme is also at the lower part of the Ghermu VDC.

The Tarawali Irrigation scheme was rehabilitated in 2012 under Irrigation and Water Resources Management Project (IWRMP) funded by World Bank and Government of Nepal. The Tarawali irrigation scheme has net command area of 25 ha. It has been providing irrigation service to 72 households. Altogether 448 numbers of people are benefitted from this scheme. Out of 72 number of household, only one household is dalit (Biswakarma) and rest of the households are gurungs.

The Tarawali irrigation scheme is named from its source, the Tarawali khola, a perennial source. The canal alignment starts at the right bank of the source and crosses to the left bank as the left bank is landslide prone area at the head reach. The command area lies in the left bank of Tarawali khola. The canal system consists of 1.5 km main canal. The expected cropping intensity after the rehabilitation of the project was 216% (WIDD-1, 2009).

3. Research Methodology

Both the primary and secondary data were collected for this research. The primary data collection was done during the site visit. Extensive discussions were carried out with the local farmers, Water Users' Association (WUA) members and officials from Irrigation Division Office. Similarly, secondary data were collected through different reports, publications and related websites.

Interview checklist, observation and interview with key informants were used for the primary data collection. Census survey was done in all 72 households of this irrigation scheme.

4. Results and discussion

4.1. Household and Population

72 households are benefitted from the Tarawali Irrigation Scheme. As per the National population and housing census (2011), Ghermu VDC has total households of 402. The Tarawali Irrigation Scheme provides irrigation service to about 18% of households of Ghermu VDC. Out of total 72 households of this scheme, 58 households are headed by males and rest 14 households are headed by females.

The number of population benefitted from this scheme is 448 which include 227 males and 221 females. The average population per household in Tarawali Irrigation Scheme is 6.2. As per the National population and housing census (2011), Ghermu VDC has total population of 1776 including 822 males and 954 females and the average population per household is 4.4.

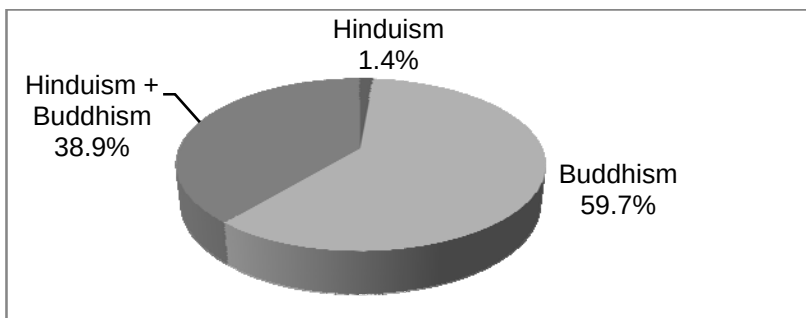
4.2. Ethnicity

The Tarawali Irrigation Scheme is dominated by Gurung community. Out of 72 households in this scheme, 71 households are Janajatis (gurungs) and only one household is dalit (Bishwakarma). This proves that 98.6% of the households are from gurung family and only 1.4% of the households are from dalit family.

4.3. Religion

As the Tarawali Irrigation Scheme is dominated by Gurungs, most of the households (43 households) believe on Buddhism. However, 28 households of Gurungs family believe on both Hinduism and Buddhism. The Bishowkarma family believes on Hinduism. Figure-2 shows the majority (59.7%) of the households believes on Buddhism, least (1.4%) of the households believe on Hinduism and 38.9% of the households believe on both Hinduism and Buddhism as expressed by farmers during the data collection.

Figure 2: Pie chart on religious belief



Although they believe on different religions, they mentioned that they celebrate the festivals of both Hinduism and Buddhism which helps them to be united in social works in the community.

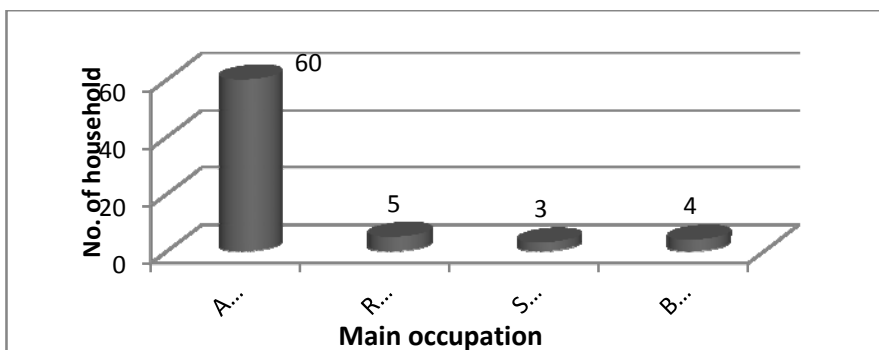
4.4. Education

The educational status was measured in terms of illiterate, literate, below School Leaving Certificate (SLC) and above SLC. The literate refers to those people who can at least do the signature but do not have any certificate of education from schools. Out of 448 number of population, 15.85% are illiterate, 33.93% are literate. 32.81% of population has education level below SLC while 17.41% of population has education level of SLC and above.

4.5. Occupation

The main occupation of people of this area is agriculture. Figure-3 shows that 60 households have reported agriculture as their main occupation. The main occupation of other 5, 3 and 4 households is remittance, service and business respectively.

Figure 3: Main occupation of people under study area



This shows that more than 83% of the households are depending on the agriculture as it is the main occupation. The significance of irrigation in the Tarawali Irrigation Scheme can be justified from this data. In contrast, only about 4% of the households are engaged in service as their main occupation. As the Tarawali Irrigation Scheme lies in the remote part of the Lamjung district, very few households have access to service.

4.6. Type of House

Most of the households have house made up of stone masonry with mud mortar. About 79% of the total households have such type of houses. In contrast, only about 7% of the total households have RCC type of house. Almost 14% of the total households are built with stone masonry in cement mortar.

4.7. Land Holding

There is large variation in land holding among the households. The land holding type was divided into 5 categories which are shown in the Table-1.

Table 1: Land holding

S. N.	Land holding	No. of household	Percentage	Remarks
1	< 0.25 ha	23	32%	
2	0.25 ha to < 0.50 ha	33	46%	
3	0.50 ha to < 0.75 ha	9	13%	
4	0.75 ha to < 1.0 ha	3	4%	
5	> 1.0 ha	4	6%	
	Total =	72	100%	

This shows that most of the households (46%) have land in between 0.25 ha (5 ropani) and less than 0.5 ha (10 ropani). In contrast, only 4% of household have land in between 0.75 ha (15 ropani) to less than 1.0 ha (20 ropani). 32% of households have land less than

0.25 ha (5 ropani) and 13% of them have land in between 0.5 ha (10 ropani) and 0.75 ha (15 ropani). There are only 6% of households who have land greater than 1.0 ha (20 ropani).

4.8. Food Sufficiency from the Land

As most of the farmers have command area less than 0.5 ha as mentioned above, very few households have food sufficiency round the year. Table-2 shows that 4 households (6% of total household) have food sufficiency for 4 months only. 54 households (75% of total household) have food sufficiency for 8 months only and 14 households (19% of total household) have food sufficiency round the year.

Table 2: Food sufficiency of farmers

S. N.	Food sufficiency	No. of household	Percentage	Remarks
1	4 months	4	6	
2	8 months	54	75	
3	12 months	14	19	
	Total =	72	100	

This shows that most of the farmers have food sufficiency for 8 months only. Farmers reported that food sufficiency has increased after the rehabilitation of the Tarawali Irrigation Scheme than it was before.

4.9. Yearly Income and Secondary Occupation

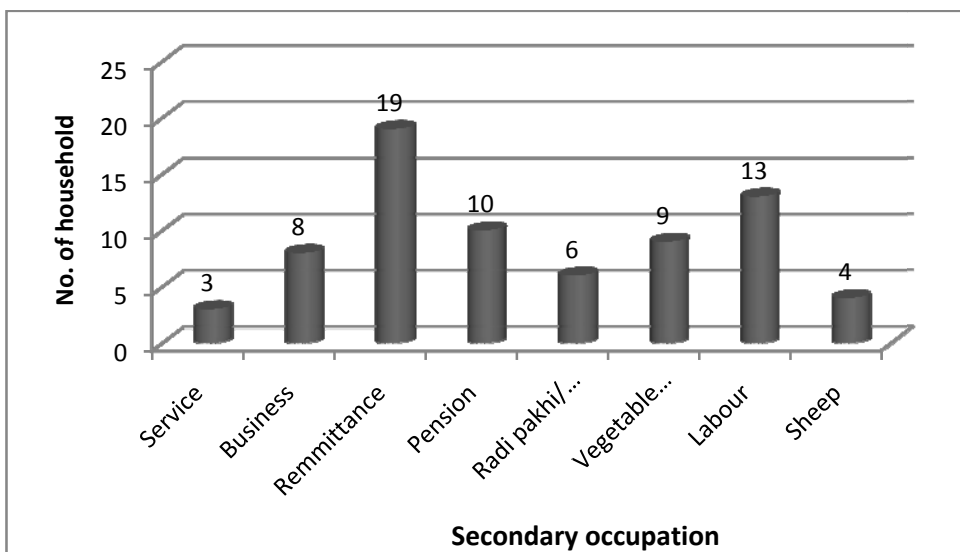
The yearly income of each household was also taken during the field visit. There are only 2 households having yearly income less than NRs. 25,000. More than 65% of the household (47 households) have yearly income greater than NRs. 1, 00,000. 7 households have yearly income in between NRs. 25,000 and NRs. 50,000 while 13 households have yearly income in between NRs. 50,000 and NRs. 75,000. Similarly, 3 households have yearly income in between NRs. 75,000 and NRs. 1, 00,000. The yearly income range and number of household is shown in Table-3.

Table 3: Yearly income of households

S. N.	Yearly income (NRs.)	No. of household	Remarks
1	Less than 25000	2	
2	25000 to less than 50000	7	
3	50000 to less than 75000	13	
4	75000 to less than 100000	3	
5	Greater than 100000	47	
	Total =	72	

Although the land holding of farmers is relatively less, the yearly income of most of farmers is greater than NRs. 1,00,000. This is due to the secondary source of income such as remittance, pension, business etc.

Figure 4: Secondary occupation of households



Among the secondary occupations, the remittance is in the first rank (19 households) while least (3 households) of the households are engaged in service. 9 households are engaged in the professional vegetable farming. Chame, the district headquarter of Manang and Beshisahar are the market places for vegetables. Figure-4 shows the number of households and secondary occupation.

4.10. Farming Practice and Cropping Intensity

All the farmers work in their field. Generally farmers grow rice (paddy), vegetables, wheat and maize in their fields. Mr. Aaeta Bahadur B.K. from dalit group has the least land among the farmers. He has only 0.05 ha (1 ropani) of land within the command area. As per cropping season, he grows paddy, cauli-flower, potatoes and onion in his land. However, the product from his land is not sufficient for his family.

Those farmers who have fewer fields to grow crops use to grow vegetables in others' field that have more land. They should not give money or crops to the land owner but they just need to put manure in the field where they grow the crops. Mr. Aaeta Bahadur B.K. has grown potato in the field of Mr. Shankar Ghale. A photograph of Aaeta Bahadur B.K. growing potatoes in Shankar Ghale's field is shown in Figure-5.

Figure 5: Aeta Bahadur B.K. growing potatoes in Shankar Ghale's field



It was found that 9 households give their field to others to grow potatoes and vegetables. Mr. Shankar Ghale is one of them who gives his land to grow vegetables to others. He has given his land to Aeta Bahadur B.K. to grow potatoes and Mana Maya B.K. to grow vegetables. Mr. Shankar Ghale has grown potatoes and vegetables in his own land. He not only uses the potatoes for his own household purpose but also sells the potatoes in the nearby market. Most of the time, people come to his land to buy potatoes. Photographs of researcher with Mr. Shankar Ghale in his (Ghale's) own potato field is shown in Figure-6.

Figure 6: Researcher with Mr. Shankar Ghale in his (Ghale's) own potato field



More interestingly, farmers who do not have any land within the command area of the scheme can also grow potatoes and vegetables in the land of farmer who have more land. Mana Maya B.K. who does not have any field within the command area, is also growing vegetables (Reddish and onion) in others' field. She does not need to give money or crops to the land owner but just need to put manure in the field where she grows the crops. This system makes the land fertile where the landowner grows another crops after she harvests the vegetable. Mr. Shankar Ghale has given his land to Mana Maya B.K. to grow vegetable. Photograph of researcher with Mana Maya B.K. growing her own vegetables in Shankar Ghale's land is shown in Figure-7.

Figure 7: Mana Maya B.K. growing reddish in Shankar Ghale's field



However, only vegetables and potatoes can be grown in such fields. If it is done in paddy field, half of the product must be given to the land owner. Nowadays, farmers are using the mini-tractor (power trailer) to plough the land which was provided under the IWRMP. As per Mukta Bahadur

Gurung (farmer), the yield is above the farmers' expectation which is due to proper irrigation facility after the rehabilitation of the scheme.

This system of growing vegetables in others land has increased the cropping intensity in the Tarawali Irrigation Scheme. Irrigation increases crop production by increasing the cropping intensity which increases the annual output of the land. Research in China showed that crop revenues in the poorest areas increased more than those in richer areas (Huang, Rozelle, Lohmar, Huang, & Wang, 2006). This system also increases the cooperation among the farmers and develops the social stability in the society. This is also reflected in the society as there is no conflict among the farmers yet.

The climatic condition of the Tarawali Irrigation Scheme is favorable for all crops throughout the year. Farmers use land for monsoon paddy in rainy season; Potatoes, Wheat and Vegetables (Onion, Garlic, Cabbage etc.) in winter season; and Maize and legumes in spring season. The cropping intensity is found 100%, 90.2% and 36.08% in rainy season, winter season and spring season respectively in the year 2012/2013. Hence, total cropping intensity in the Tarawali Irrigation Scheme in the year 2012/2013 is 226.28% which is greater than the expected cropping intensity by 10.28%. Crop rotation with legumes not only increases the cropping intensity but also increases the total food availability and the net return from selling it (Pokhrel & Pokhrel, 2013). In the Buchari command area of the Chashma Right Bank Irrigation Project, Pakistan; the cropping intensity reached to 169% which is higher than the proposed cropping intensity of 143% (Rahman, Khan, & Ali, 2012). Monsoon paddy cultivation in the command area of Tarawali Irrigation Scheme is shown in Figure-8.

Figure 8: Command area covered by monsoon paddy



In most of the irrigation systems where farmers have more land than they need to fulfill their food requirement and possess high socio-economic status, most of the land is left fallow. They rarely grow the crops round the year. In this case, the cropping intensity is less. Farm size is crucial factor and inversely related to cropping intensity (Agrawal, 2002). It has been concluded that if there is majority of low land holding farmers, they work more in the land and grow more crops in the land which finally increases the cropping intensity.

The cropping intensity is not generally same in the head, middle and tail reaches of the command area. As per Khan and Ali (1998), the cropping intensity is comparatively high at the head reaches than the tail end (Rahman, Khan, & Ali, 2012). However, this is not always true. In case of Tarawali Irrigation Scheme, the cropping intensity is found higher in the middle reaches of the command area. 6.6% of the total command area is left fallow in the head reach except in the monsoon season as it lies near the forest area and there is problem of monkey encroachment. Monkeys not only destroy the vegetables but also eat the maize. So, this portion of land is used for monsoon paddy only. Likewise, 2.2% of the total command area is left fallow in the tail portion except in the monsoon season due to the same problem.

The farmers are using two mini-tractors given by the project in 50% subsidy. This has helped to increase the cropping intensity of the scheme. Similar result was also seen in the Indian Punjab. Tractor owning farms are found to have higher cropping intensity than the bullock farms (Agrawal, 2002). Figure-9 shows the Mini-tractor that farmers are using in Tarawali Irrigation Scheme.

Figure 9: Farmer showing the Mini-tractor to the monitoring team



Farmers mentioned that cropping intensity can be further increased if the conventional thinking of subsistence farming is changed to market oriented farming system. For this, farmers demanded more training, exposure visit to successful schemes and proper market facilities. Efficient and judicious use of water as well as replacing the conventional irrigation practices by modern means

by arranging farmers meetings at farm level help to grow more crops per drop of water (Mahmood, Ahmad, & Maan, 2012). There is an acute problem of labor shortage in Ghermu for agricultural activities as the labor rate for this is low compared to other works. Farmers of the Tarawali Irrigation Scheme have also demanded the Thresher machine and one more mini-tractor. Almost one-fifth of the total labor input is required for ploughing in the staple crop (rice, maize, millet, wheat) in Nepal (Thapa, 1996). So, the use of more mini-tractors helps to address the labor scarcity in the Tarawali Irrigation Scheme. Labor has become scarce from the same village as an increasing number of younger generation people are diverting into non-farm activities, leaving less people in the farm sector and the hired labor from other villages cannot increase the cropping intensity (Manandhar, Osanami, & Kondo, 2002). Mechanization of agriculture not only helps to increase cropping intensity but also the crop yield by substituting for labor, which is becoming increasing scarce resource in rural areas due to rural-urban migration (Nepal & Thapa, 2009).

Farmers of the Tarawali Irrigation Scheme use organic manure for farming. They have not used chemical fertilizers yet. They pointed out that there is scarcity of organic manure for further intensification of crops. Research conducted in Kaski district shows that extension agents should conduct programs to convince farmers to make compost using manure, crop residues and other organic wastes (Thapa, 1996). The cropping intensity has gradually increased due to introduction of irrigation canal and better use of agricultural inputs and availability of scientific farming technology will ultimately accelerate the cropping intensity in the Chashma Right Bank Canal, Pakistan (Rahman, Khan, & Ali, 2012). If the problems of uneven distribution of water, lack of water user association, lack of agriculture extension support services and credit facilities, improper maintenance of canal are addressed in the Mattani Aza Khel Dam District Peshawar, Pakistan; more benefits can be reaped from the dam water as the traditional cropping pattern has been shifted to market oriented crops (Wajid, Usman, Khan, & Chaudhry, 2013).

5. Conclusions and recommendations

5.1 Conclusions

The cropping intensity of the irrigation scheme is somehow linked with the social practices in the community. In many irrigation schemes in Nepal, all the farmers do not grow the vegetables in their entire land. In case of Tarawali Irrigation Scheme, farmers who have less land or no land, grow vegetables in others' field that have more land without giving money and crops to the land owner but they just need to put manure in the field where they grow the crops. This system of land sharing which rarely exists in other community has increased cropping intensity in the Tarawali Irrigation Scheme.

Regarding the economic status of farmers, in most of the irrigation systems where farmers have more land than they need to fulfill their food requirement and possess high socio-economic status, most of the land is left fallow. They rarely grow the crops round the year. In this case, the cropping intensity is less. It is concluded that the cropping intensity is inversely proportional to the land holding of the farmers. This is justified from the Tarawali Irrigation Scheme. The cropping intensity in the Tarawali Irrigation Scheme in 2012/2013 is 226.28% which is higher than the expected cropping intensity of 216%.

The cropping intensity can further be increased in the Tarawali Irrigation Scheme by changing the conventional thinking of subsistence farming into market oriented, providing proper market facilities, using machineries (thresher machine, more mini-tractors), increasing sources of organic manures, solving the problems of monkey encroachment and providing farmer training as well as exposure visits to other successful schemes.

5.2 Recommendation

The system of growing vegetables by low (no) land holders in others' field who have relatively more land can be used in other irrigation schemes to increase cropping intensity depending upon the socio-economic settings of the community. The Department of Irrigation, Department of Agriculture as well as other stakeholders should address the problems of proper market facilities, agricultural machineries (thresher machine, mini tractor), organic manure and monkey encroachment. In addition, more training and exposure visits to other successful schemes should be provided to the farmers for further increment in cropping intensity.

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Men, women and irrigation: looking up from the fields

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INTRODUCTION

Today more than ever is the time to reconsider and rethink gender relationships in irrigation development and management in Nepal. An obvious reason is the unprecedented extent of male out-migration in most rural areas of the country, which have led women to take over many of the agricultural responsibilities.

In this context, it has become even more evident that the performance and sustainability of farmer managed irrigation systems (FMIS) depends on women's successful involvement in decision-making over the use and management of these systems.

The Nepal Irrigation Policy (2060, 2070) made an important step in this direction by fixing a quota of 33% of women members in registered water user associations (WUAs). However, this legal requirement has been implemented with difficulty on the ground. This study reviews some of the barriers and opportunities for increasing women's participation in decision-making on irrigation development and management, looking 'up from the fields', e.g. looking beyond the community to consider how gender-sensitive actions and decisions at the Division office level can support greater performance and sustainability of irrigation systems.

Whereas gender norms have certainly contributed to the difficulties in involving women in WUAs, we argue in this paper that the public irrigation agencies in Nepal also can play an important role in considering both men's and women's needs in project design and in operations, and in ensuring that their services reach both men and women farmers.

This is not to say that irrigation officials are responsible for changing gender norms – of course they are not and it is not their role. However, none of the actions and activities of irrigation agencies and irrigation officials are 'gender-neutral', e.g. whether irrigation officials speak with men or women farmers in the field, whether they consider the norms that hinder women farmers from speaking in public meetings or speaking to a male irrigation official, whether the design of irrigation systems also responds to women's

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needs, etc. In this area, it is the role and responsibility of irrigation officials to create, through their interaction with farmers, a gender-sensitive relationship that will ultimately enhance the system performance and sustainability.

WHY GENDER AND IRRIGATION?

Although women are water users, they are often not recognized as such. In the case of irrigation, irrigation systems have traditionally been managed by men in Nepal but they have often been used informally by women for other uses, e.g. for domestic uses and livestock. For the past decade, many farming responsibilities, including irrigation, have been transferred, to women because of the increase in male-out migration. However, women are still not formally recognized as irrigators and decision-making on irrigation management still often falls within the hands of the few men left in the village (*Aubriot, 2009-2010*).

Yet, principles of collective action and management of common pool resources indicate that a lack of participation of a group of users (in this case: women) in management might result in poor performance due to reduced accountability and limited representation (*Ostrom, 1992*). Indeed, several studies have shown that the non-recognition of women as irrigators and their limited influence on decisions related to irrigation often lead to underperforming systems as the needs of a large share of the water users are ignored (*Zwarteveen and Neupane, 1996*).

Another reason for promoting women's participation in irrigation management is that women's participation is said to lead to greater equity, enhance women's status and support their empowerment through increased self-esteem and self-confidence (*Harris, 2009, Ivens, 2008*).

As of today, efforts to include women in WUAs in Nepal, i.e. the quota of 33% of women members, which is not only a legal requirement but also often imposed by funding agencies in their projects, has rarely translated in women users having influence on the decisions taken by the WUA executive committee (*Aubriot, 2009-2010, Upadhyay, 2010*). This is not specific to Nepal but observed across all South Asian countries.

Table 1 below shows the different types of levels of participation of women in WUAs, ranked from least to most influence in decision-making and least to most benefits for women users in general. For each type of participation level, the main barriers for greater participation are listed, based on a review of studies on WUAs in South Asia (*Meinzen-Dick and Zwarteveen, 1998, Sultana, 2009, Upadhyay, 2010, Cleaver, 1998, Krishnaraj, 2011*).

Table 1. Types of participation level of women in WUAs

Participation level	Barriers
Being member	Norms on women's roles and capabilities, land ownership
Attending meetings	High workload, norms on women's mobility and presence in public, time & location of meetings
Speaking during meetings	Lack of education and confidence, norms, male dominance
Influencing decisions	Men's perceptions on women's capabilities, male dominance in higher positions, lack of education and confidence
Making decisions benefiting other women users	Politics, caste/class clivage

The research question guiding this study is how can the Department of Irrigation and Division Offices support women to move from lower to greater participation in their daily activities of irrigation development and management.

METHODOLOGY

Three case studies were chosen in three districts: Kavre, Lalitpur, Saphari. Initially, the study aimed at selecting one district from each of the three agro-ecological regions (mountains, hills, plains) but that was not possible due to time constraints and meteorological conditions (monsoon season). Each case study included a farmer-managed irrigation system and a Division Office (DO) whereby each system/organization was studied both separately and in relation to each other.

The case study does not aim to produce a large account of statistical data but rather to provide an in-depth understanding of the situation, in this case, we particularly focused on: 1) the gender norms at the community level and involvement of women in decision-making; 2) the relationships between men and women farmers and the DO staff; and 3) the working environment in which DO men and women staff evolve in the three districts. Although we can certainly not generalize in its statistical meaning, such in-depth understanding helps to draw general lessons on some of the constraints and barriers for greater women's involvement in decision-making.

Prior to the fieldwork, a literature review was conducted based on a search on 'gender mainstreaming' and on 'gender and irrigation' done by the IWMI headquarter library searching the following databases: CAB Abstracts and Water Resources Abstracts and using the following search engines: PROQUEST and Google Scholar Search. Information was also collected from the official websites of the Ministry of Irrigation and the Department of Irrigation, Nepal as well as documents found at the library in the Irrigation Department were used. Field Observation, focus groups, and semi structured interviews.

The fieldwork consisted of meetings with the:

- Irrigation Development Division Office (DO) (semi-structured interviews)
- WUA executive committee (semi-structured interviews)
- Water users (semi-structured interviews and group discussions)

Overall the fieldwork lasted around 3-4 days in each district.

In addition to interviews, data collection also included observations, which is a major tool for qualitative research, especially on sensitive issues such as gender norms in the work place. Observations paid attention to physical characteristics of the working environment in DOs (e.g. size of the quarters allocated to women vs. men staff, resources such as transportation etc.). In villagers, observations recorded the spaces where women and men farmers were present, e.g. either in fields, tea shops, kitchens, playgrounds, etc. During all interviews, particular attention was paid to physical gestures, tones, and general behaviors – e.g. what was the general reaction and attitude of the respondent when being asked to discuss about gender. Interviews and the notes from the observations were then transcribed and coded.

FINDINGS

Role of men and women in the fields and in the work place

We first looked at the representation of women in WUAs and in DOs across the three case studies (Table 2).

Table 2. Women's representation WUAs and DOs across the three case studies

	Kavre	Lalitpur	Sapthari
WUA members	30%	50%	11%
Staff in DO	18%	25%	11%

Source: Neha Rayamajhi's fieldwork, July-August 2013

Lalitpur shows for both WUA and DO staff the highest representation while, unsurprisingly it is lowest in Sapthari District where strong gender norms restrict notably women's participation in irrigation management, women's mobility and women's professional opportunities. Women's representation in DOs is overall quite low.

Both men and women working at the DO were asked why so few women work in the office. The reasons given are presented below (Table 3) disaggregated between men and women respondents.

Table 3. Disincentives for women to work at the DO

Sex of persons interviewed	Male	Female
Reasons given	• Women's obligations in the home as wife and mother • Cultural and traditional taboos • Women's education and reluctance to work outside women's professional sphere • Women's reluctance to progress	• Women discouraged to apply for non-administrative jobs • Male-dominated professional environment are uncomfortable and feel insecure • Discrimination in offices • Education

Source: Neha Rayamajhi's fieldwork, July-August 2013

The responses show that men and women have very different views on the barriers for women to work in public irrigation agencies. Men attribute it mostly to gender norms about women's role as mother and wife and women's own reluctance to work as irrigation professionals. Women on the other hand perceive strong disincentives within the family and professional environment to work in what is still considered to be 'men's jobs'. This includes discrimination against women in offices, e.g. in terms of allocation of resources for transportation and accommodation, and a feeling of incomfort and insecurity in working spaces due to a male-dominated environment.

We then examined women's role/position within the community, WUAs and DOs (Table 4)

Table 4. Women's position/role among farmers, WUA executive committee and the DO

	Kavre	Lalitpur	Sapthari
Farmers	All agricultural works except plowing and irrigation of major crops		
WUA executive	Vice chairperson	Chairperson and vice chairperson	Vice chairperson and secretary
DO	1 engineer, 1 janitor	Mostly admin staff	1 typist

Source: Neha Rayamajhi's fieldwork, July-August 2013

Despite men having migrated and women managing the farm, women still haven't been given the responsibility of irrigating major grain crops which remains in the hands of the few men left in the village. According to field observations, women's lack of involvement in irrigation results from the importance and political nature of irrigation, which is itself rooted in a masculine identity (Zwarteveen, 2008). Irrigators typically have to show masculine characteristics such as physical strength and toughness, thereby irrigation management is a form of power which, in men's view, can't be given to women. It however does not mean that women are not using irrigation water for other needs than for irrigating major crops.

Women are relatively well represented within the WUA executive committees in the three districts. In the DOs, except in Kavre, women staffs fulfill administrative tasks and have either no interaction with farmers nor no decision-making influence in the office.

Despite women's relatively good representation in the executive committee of the WUA, women seem to have a low influence on decision-making during WUA meetings (Table 5) – which conforms to findings from earlier studies conducted in Nepal (Aubriot, 2009-2010, Ghimire, 2004). It means women's views are not much considered during WUA meetings when deciding how to allocate water and to whom, how to mobilise the resources necessary for system maintenance or how to solve a conflict among users.

Table 5. Women's level of participation in WUA meetings

	Kavre	Lalitpur	Sapthari
Level of participation	Speaking up during meetings: Low attendance of women members. Women talk but have to be prompted and encouraged	Attending meetings High attendance of women members but women do not speak much in meetings.	No meetings

Source: Neha Rayamajhi's fieldwork, July-August 2013

Interestingly, although women in the FMIS studied in Lalitpur reported not speaking up during WUA meetings, women do talk about irrigation issues in private with their husband – which means they might have some influence on decisions taken indirectly, but still have to rely on men to report and express their concerns during the WUA meetings.

Lastly, we looked at interactions between the DO and men and women farmers.

Interaction between DO and men and women farmers

The interaction between DO and men and women farmers was examined along two issues:

- The formal and informal interaction between DO staff and farmers
- The type of services provided by the DO to farmers

Interaction between the DO staff and farmers greatly varied across districts (Table 6) – which indicates that there are either no accountability mechanisms towards farmers in some districts or if in place, that these are ineffective. For instance, in Sapthari, none of the farmers interviewed had seen a DO staff come to their village – women farmers were even unaware of the existence of the DO.

In the two other districts, there was a marked difference between the DO-men interactions and DO-women interactions – which is as expected, along prevailing gender norms. Even when there is interaction taking place as in the case of Lalitpur, our findings suggest that there is a limited attention from the DO staff to the expectations and concerns of women farmers.

Whereas in Lalitpur, the spaces where the DO staff interacts with farmers are open to both men and women, in Kavre and Saphari, they are culturally reserved to men only.

Table 6. Views of men and women farmers interviewed on their interaction with the DO across the 3 visited districts

	Kavre		Lalitpur		Saphari	
	Women	Men	Women	Men	Women	Men
Respondents' views	Most interactions are about the canal system, so they don't talk a lot. The DO has never asked them what they need.	Earlier, DO engineers did not talk but they do nowadays	Know about the DO but never interacted with them. Only few farmers who are the political or community leader know about the DO.	Very friendly interactions. Refer to each other by familial titles.	Do not know about the existence of the DO	DO officers have never come to the village.
Spaces of interaction	In the fields, where both men and women are visible		Houses, social settings, shops, etc.		Once in a while in bars or tea shops in evenings, where women are absent	

Source: Neha Rayamajhi's fieldwork, July-August 2013

In order to help bridging the communication gap between farmers and the DO, it is mandatory for the DO to hire a female Community Organizer. The selection requirements for the community organizer include: married, local to the village, minority caste, and passed School Leaving certificate (Grade 10). Out of the three districts, only one community organizer is active (Table 7). However in the case of Lalitpur, a complaint was filed by the WUA to the DO, which shows that there are accountability mechanisms available in this district (though these were not shown to be effective).

Table 7. Activity of the community organizer across the 3 visited districts

	Kavre	Lalitpur	Saphari
Fulfills the requirement	Yes except for the caste	Yes	No
Active	Yes	A complaint for being inactive / was filed by the WUA to DO	

Source: Neha Rayamajhi's fieldwork, July-August 2013

Lastly, we looked at the type of trainings organized by the DO across the three districts (Table 8).

Table 8. Trainings organized by the DO and demanded by men and women farmers across the 3 visited districts

	<i>Kavre</i>		<i>Lalitpur</i>		<i>Sapthari</i>	
	Women	Men	Women	Men	Women	Men
Demanded by farmers and relevant to the DO mandate	Travel opportunities to learn from other villages for both men and women.	More technical support and help with the maintenance of the canal.	Traveling opportunities to see what other districts are doing and learning from them	Technical trainings to take better care of the irrigation canal	First requirement is less politics among and from the bureaucrats	
	Agricultural-based trainings.	Less politics among the bureaucrats.				
Organized by DO	The educational travel grant provided by the DO prioritizes women and girls interested in learning about agriculture		The technical trainings organized give priority to women but are attended by men.		None	

Source: Neha Rayamajhi's fieldwork, July-August 2013

In both Kavre and Lalitpur, the trainings prioritize women. In Lalitpur, the trainings seem to respond to women's expectations whereas in Kavre they mostly respond to men's expectations and are attended by men. In Saphari, where no training is organized (and interaction was null), both men and women farmers expect politics to play a lesser role in the way irrigation services are provided.

Gender at the work place

Gender at the work place is a sensitive issue which is difficult to assess in a one-day visit. The first section on representation of women in DO offices has shown that women staffs are under-represented and mostly hold administrative positions. Qualitative observations help to further broaden the picture. For instance, the Chief DOs across the three visited districts showed different attitudes towards gender and towards a female student coming to interview them. Whereas one of them showed interest and was helpful to guide the student for her fieldwork, the two others either dismissed the student as soon as she mentioned 'gender' or ignored her during the interview.

All field officers interviewed showed interest to discuss about gender and female staff suggested ways to improve gender relationships in the office and with farmers. Women also reported difficulties to work in a male dominated environment, in terms of feeling safe and comfortable. Because women hold lower positions in the hierarchy and the office is male dominated they also mentioned facing great difficulties to report any misconduct of other staff towards them.

DISCUSSION

The study first shows that women's membership in WUAs does not adequately capture women's influence on decisions made about irrigation management. Women can be member of the executive committee but still having little influence on the decisions made on irrigation. On the other hand, women might use indirect ways to communicate their needs and influence decisions, notably through male relatives. For DOs to respond adequately to women and men's needs in irrigation systems, it is important to develop monitoring and evaluation systems that capture not only women's membership in WUAs but also women's formal and informal influence on decisions within their irrigation systems. Such assessment is necessary to define services for men and women in these areas that are adapted to the cultural and social context.

The interaction between the DOs and farmers greatly varies across districts. In all districts however, women felt there was no space for them to voice their concerns and needs either because the irrigation staff did not interact with them or because they did not show concern for non-technical issues. Findings indicate that there is considerable room for more greatly involving women users in irrigation management, e.g. by proposing trainings better responding to their expectations. For instance, all the women farmers interviewed mentioned their lack of technical knowledge on irrigation canals, and regretted having to depend on male members of their families, or from the neighborhood, for maintenance and repair.

The mandatory recruitment of a local female community organizer, when adequately enforced, marks a positive step to bridge the communication gap between the DO and farmers, and particularly women farmers. However, for women's needs to shift from being heard to being responded to requires an additional step: create a favorable professional environment within DOs which recognizes an important role for women in irrigation.

This brings us to the last issue discussed in this study – but which should be the first to be addressed by the DOI and DOs to enhance their services to farmers and to make their activities more responsive to all water users, including women. This is also the most sensitive one which will require a strong political and administrative commitment: the need to create a professional environment respecting women both as irrigators and as irrigation engineers.

This will require a change in professional norms, beliefs and behaviours within the DOs and upper level organizations, i.e. the DOI and MOI. Although such change is susceptible to be met with resistance, there are modest and simple actions to start with, which could already help to create a better working environment (*SaciWATERS, 2011*):

- Increase the proportion of women in each DO, including at the top of the hierarchy
- Create a favourable working environment with special rules (e.g. flexi hours), basic amenities and facilities for women and ensure that these rules are well enforced
- Offer training and capacity building to women professionals
- Create a network of Women Water Professionals in the organization

It would however be naïve to expect that such steps – if not implemented together with a strong political commitment make a significant shift in gender relationships in public irrigation agencies. For instance, past efforts to 'mainstream gender' at the DOI have overall not met the expectations of the donor agencies that were pushing for it (e.g. ADB, World Bank). Mainstreaming gender is a political exercise which also requires changing the incentives (e.g. performance evaluation) for staff to behave and act in certain ways. Gender norms at the work place do also depend on gender norms in the society – it would however be wrong to think that the changes need to start from the society. Significant changes do happen at the work place when a strong will and strong signals are in place.

CONCLUSION

Whereas it is not the role of public irrigation agencies to induce social change, there is however a great scope to enhance the influence that women water users currently have on irrigation management:

First, by creating a favorable professional environment for women irrigation professionals in the DOs and a professional culture where women are respected as irrigators and irrigation engineers;

Second, by better understanding current women's role in irrigation management and their formal and informal influence on decision-making, in WUA meetings and in other spaces;

Third, by increasing the reach and relevance of DO services to women water users, through a better understanding and considering women's and men's needs and constraints in irrigation.

Creating more space for women farmers to have a stake on irrigation decisions will therefore first require inducing changes within public irrigation agencies.

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Irrigation Modernization, A way of Year Round Irrigation and Water Utilization in Nepal

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Abstract

Nepal has a diverse topography, climatic variation and sensitive crop environment. The rainfall during the 8 months of dry season is mere 10-20 percent that results in severe water scarcity. Similarly, out of equivalent to 225 Billion Cubic Meter (BCM) annual surface runoff, the utilization is only 7 percent from medium and small rivers and rivulets for irrigation and other social purposes. Nepal has very long history of Farmers Manages Irrigation System (FMIS) with traditional flooding type of irrigation culture. Even now, irrigation coverage by FMIS is more than 60 percent. The irrigation service delivery performance in Nepal is poor and affected by social, financial, and institutional factors. The overall performance and irrigation efficiency of traditional flooding type surface irrigation systems is only 30-40 percent with about irrigation coverage of 80 percent in summer, 40 percent in winter and 20 percent in spring season. Due to huge losses and wastage of irrigation water in off-farm and on-farm systems, poor physical condition of canal systems, poor operation and maintenance, less water available in sources during dry season and perception, tendency, attitude of head reach farmers to capture or to occupy more water than requirement, there is need of overall modernization of traditional irrigation culture. The modernization should shift flooding type irrigation culture to soil saturation culture for effective water utilization. The government strategy to provide year round irrigation in Terai areas is focused on massive utilization of ground water as well as Inter Basin Water Transfer but there is lack of similar strategy for irrigation in hills and mountain. Therefore there should be a strong voice for way-out or options to provide year round irrigation with effective water management in hills and mountains to sustain the livelihood of the people. Though donor funded support programs for rehabilitation of FMIS have been implemented since 1980 and is ongoing, the performance to provide year round irrigation is not achieved and will not be achieved even in future by only physical rehabilitation of canal system. One of the way-out or options to provide year round irrigation and effective water utilization with local water resources utilization in hills and mountains is the modernization of FMIS. The modernization includes development of in-system multi spaced water storage tanks along canal delivery and distribution points, adoption of micro irrigation technology with water delivery from those storage tanks for dry season water application, and replacement of traditional flooding type of surface irrigation. The time has come for setting up vision, mission, goal and objectives of irrigation modernization to achieve year round irrigation with effective irrigation service delivery.

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Background

Nepal has a diverse topography, with three parallel ecological zones Terai, Mountains and Himalaya, running east to west within a narrow width of 200 Km. and wide range of elevation from 100 meter in Terai to 8000 meter in Himalaya. Such geography results in vast climatic variation and sensitive crop environment. The annual rainfall occurrence during rainy season of June to September is almost 80-90 percent whereas during dry season of 8 month is only 10-20 percent causing severe water scarcity. Similarly, out of total annual surface runoff equivalent to 225 Billion Cubic Meter (BCM) from more than 6000 rivers and rivulets, nearly 70 percent flow is carried out by major snow-fed river systems and is almost unutilized. Only 15 BCM or 7 percent, from medium and small rivers and rivulets have so far been utilized for irrigation (6 percent) and other social purposes (1 percent) with extreme seasonal variation of water availability during winter and dry season. Total land areas of Nepal being 14.718 million ha., arable land is 4 million Ha or 27 percent and actually cultivated land is 3 million Ha or 21 percent. According to ecological zoning terai and inner terai area is 27 percent, mountain and high mountain area is 50 percent and Himalayan area is 23 percent. The plain areas which is known as food production basket is a narrow strip of only 50 km wide throughout the length and rest of the ecological zone is mostly suitable for fruits, vegetables and pasture land. Out of total population of Nepal nearly 84 percent live in rural areas and 65 percent are involved in agricultural profession. The land holding position of Nepalese farmers is not so suitable and profitable to adopt mechanized farming technologies. About 75 percent house hold occupy about only up to 1 ha of land, 24 percent occupy 1 to 5 ha and about only 1 percent occupy more than 5 ha.

Scenario of Irrigation Service Delivery

Out of 3 million ha cultivated land of Nepal, the irrigation infrastructure developed so far is only for 1.33 million ha with irrigation coverage of 80 percent in summer, 40 percent in winter and 20 percent in spring season. The irrigation service delivery performance of irrigation systems is poor and affected by social, financial, and institutional factors. The driving forces of sustainable irrigation service delivery to all water users are identified as ownership feeling of WUA towards irrigation service delivery rather than operation and maintenance fund, sufficient resources allocation for systems operation and maintenance management, decentralized irrigation authority tied-up with WUA, irrigation governance. The irrigation development in planned way as government program had been initiated from 1957 A.D. Irrigation development project were initiated for supplementary type of irrigation facilities. Though Nepal has very long history of Farmer Management Irrigation System (FMIS) with traditional flooding type of irrigation culture, even now irrigation coverage by FMIS is more than 60 percent of total irrigated areas. The overall performance and irrigation efficiency of traditional flooding type surface irrigation systems is about 30-40 percent. There are many reasons behind poor irrigation service delivery such as huge losses and wastage of irrigation water in canal systems as well as in on-farm systems, poor physical condition of canal systems, insufficient operation and maintenance fund available, less water availability in water sources during dry season, perception, tendency, attitude and tradition of head reach farmers to capture or to occupy more water than requirement causing wastage in head reach portion and no water to the

tail enders, encroachment to irrigated agriculture from unplanned urbanization, industrial expansion. These are vital constraints for decreasing year round irrigation service delivery performance in all most all irrigation systems. Though donor funded support programs for rehabilitation of FMIS and AMIS have been implemented since 1980 and is ongoing, the performance to provide year round irrigation is not achieved and will not be achieved even in future by only physical rehabilitation of canal system.

Irrigation Modernization

Irrigation modernization is a process of technical and managerial upgrading of irrigation schemes combined with institutional reforms, with the objective to improve resource utilization and water delivery service to farms. It can be interpreted in different ways depending on the local circumstances. One type of modernization is the application of modern technologies, such as micro and sprinkler irrigation with water application and distribution through pipes rather than open channels, and the use of computerized soil-water sensors to trigger water applications. However, it also comprises of older capital-intensive techniques, such as canal lining and land leveling. These techniques can only be introduced and used successfully where farmers can be trained in their use or if they already possess the necessary skills. However, the technical side is only one aspect of modernization. Equally important are fundamental changes in the institutional arrangements and regulations and improvements in the performance and efficiency of water users and their organizations.

Rationality of Irrigation Modernization

The present world's population of 6.7 billion is expected to reach to 9.2 billion by 2050 A.D. With fast and higher growth rate mostly in developing countries which will create a situation to increase global food production by 70 percent more. According to FAO estimation, total arable land used for crop production is about 1.5 billion ha, which is only 11 percent of global land areas of 13.6 million ha. Out of that arable land, the irrigation infrastructures developed land is 318 ha and irrigated land is 300 million ha which is only 20 percent of that arable land followed by being 70 percent in Asia, 11 percent in North America, 8 percent in Europe, 5 percent in Africa, 4 percent in South America, 1 percent in Oceania. Today, about 55 percent of total food production of the world comes from 20 percent irrigated land whereas 80 percent rain-fed crop land is able to produce only 45 percent of total food production. From the view point of technologies and modernization, 82 percent irrigated areas is covered by surface irrigation where as the coverage of modernized irrigation technologies focusing pressurized irrigation or micro irrigation or mostly drip and sprinkler is only 18 percent followed by regional coverage being in Europe 61 percent, America 47 percent, Africa 30 percent, Asia 14 percent and in Nepal it is less than 1 percent. It is also realized that the situation of food availability in developing countries is 0.16 Mt. per capita per year in comparison to global data of 0.34 Mt. per capita per year. During 1970-1980 irrigated area increased rate was 2.3 percent per year while during 1982-1993 it was decreased to 1.5 percent per year and during 1995-2020 it is expected to decrease further to 0.6 percent per year due to declining trend of investment of large capital cost required in irrigation sector. About 80-90 percent of required increment in food production is dependent in productivity of

existing cultivated land. In most developing countries, investment in irrigation has not produced the expected results.

In the present context of Nepal, development of new irrigation project for further expansion of irrigated areas is not so easy because large number of feasible water resources are already being used. Further expansion of irrigated areas requires relatively large investment to establish new infrastructures and might cause environmental destruction/deterioration. Other constraints of present irrigation service are poor irrigation practices, failure to recover operation and maintenance cost, and failure to innovate and integrate modernized irrigation technologies. The reasons behind these are describe as the early 1970s and 1980s, the irrigation projects were developed for supplementary type of irrigation facility without the concept of irrigation modernization. Several irrigation development projects were implemented, including command area development, with the belief that physical improvements would automatically lead to better performance. Various improvement works like rehabilitation and development of the physical system, construction of tertiary canals, water courses, drains and link roads to markets were undertaken for development. But as soon as the projects were completed, operation and maintenance were neglected, participation of water users and related stakeholders were not practices properly, WUA's were not properly organized and trained to take their responsibilities and irrigation policy, rules and regulations were not properly established. In some Agency Managed Irrigation Systems (AMIS) water courses and fields channels were demolished, gates were stolen or broken, and drainage ditches were again converted to fields. In the design of the structure, beneficiary farmers were hardly consulted, and the design reflected the engineers' wishful thinking rather than the farmers' needs; besides, operation rules were not properly taught to the farmers or even to the staff. With the impacts of those, there is increasing trend of gap between irrigation potential created and utilized. Therefore irrigation modernization including improvement of existing irrigation system performance is now perceived as a more pressing need than developing new irrigated areas. Therefore there is a great scope and necessity of irrigation modernization to increase land and water productivity of existing irrigated agriculture for food security, food rights and poverty reduction.

Mode of Irrigation Modernization Interventions:

- Physical rehabilitation of irrigation infrastructures: which includes design and development of deficient infrastructures for water storage, distribution and efficient water application as well as remodeling of existing physical system, construction of tertiary or field channels, drains, service canals and link roads to markets etc. to suit for equitable water delivery and distribution focusing towards year round irrigation.
- Intervention of micro irrigation: which includes suitable design and development of water saving and efficient water application techniques like sprinkler irrigation, drip irrigation and other modern techniques of water delivery, distribution intervening in the process without changing the rules of the water

management. For instance, the introduction of modern techniques is a process improvement.

- Institutional reform of irrigation agencies as well as Water Users Associations(WUA,s): which includes sustainable irrigation service delivery oriented institutions for irrigation governance with enforcement of rule and regulation, irrigation extension and research services .Similarly establishment of institutionalized WUA, dedicated to take ownership of irrigation management transfer to maintain year round irrigation service, financial resources, social and human resources with capacity development of WUA's to enhance their knowledge, skills, for sustainable irrigation service delivery management, including farm level water and land management, with the intension to shift towards soil saturation and moisture conservation culture rather than traditional flooding type of irrigation culture.
- Use of modern technologies and computerized software in irrigation service delivery management: which includes canal automation, application of Geographic Information Systems (GIS), Satellite remote sensing to monitor seasonal irrigation coverage, discharge measurement, communication and information dissemination management, soil water/soil moisture sensors to maintain irrigation scheduling and water application.

Area of Irrigation Modernization Intervention

The irrigation modernization is expected to cover overall issues of irrigation development and management related activities/ works/processes which are categories as:

- Technical issues,
- Socio-institutional issues,
- Financial and economical economical issues
- Environmental issues.

The technical issues are related to:

- Water availability :including water acquisition, allocation, distribution and drainage,
- Irrigation infrastructures: including design, construction, operation and maintenance,
- Water management: including system/canal water management and on-farm water management ,crop water management including suitable water application practices,

- Agronomic cultural practices: including, soil plant-water relationship, appropriate cropping patterns, cropping intensity and proper use of farm equipment etc.

The socio-institutional issues are related to:

- Irrigation governance: including the existence or lack of both governmental rules and regulations,
- Farmers organizations: the role of WUA including participation/representation for decision making, resources mobilization, communication,
- **Conflict management:** intimately linked to farmers and government entities, the non-existence of rules, sanctions and enforcement mechanisms to deal with water stealing or illegal trading, structures tampering, vandalism and other such performance hampering behavior.
- Human resources: as expertise of intervening actors- government staff, system administrators, farmers associations and individual farmers, impacting negatively on system sustainability etc.
- Policies and legal-related issues: creating impediments to enhancing food security, fostering rural employment or in seeking to minimize the widening rural-urban livelihoods gap, and therefore rendering void the desired social role of the system.

The financial/economic issues are related to:

- Water fee structures: concerning, unclear composition or inadequate irrigation service fees and O&M cost recovery mechanisms and directly affecting financial stability.
- The O&M costs: related to operation and maintenance of the system as derived from excessive cost levels of O&M activities or lack of transparency or not compatible to the level of service received impinging on financial sustainability.
- The subsidies or funds mobilization issues: emerging from lack of or low levels of financial support, including outside investments or deficient fund mobilization mechanisms.
- Agricultural profitability: leading to the need for reassessment of agricultural cost effectiveness, benefits and costs, farm income levels, and the irrigation system profitability in general.
- Land value: it play a determinant role in the need for reassessment of the existing conditions of the irrigation system.

Finally the environmental issues are related to :

- Ecosystem conservation: dealing with the need to protect natural resources with water at the forefront to assure the ever increasing demands for natural environments,
 - Soil degradation: with direct negative impact on the environment, including, salinity, alkalinity, erosion, physical deterioration, chemical imbalances and special soils problems etc.
 - Water degradation: associated with the water quality, pollution, contamination, water logging, runoff, sedimentation etc. as well as the situational use of green water, blue water, grey water as agricultural water
- from national budgets and irrigation service fees collection from water users is achieved to fulfill operation and maintenance recovery cost.
 - **Increasing the reliability in irrigation service deliveries:** Farmers will get a reliable water supply, i.e. as initially planned or expected, in order to properly plan their cropping pattern, to maximize the use of other inputs and to intervene in time with the appropriate practices. Wherever reliability is low, modernization should first focus on how to (re)establish a reliable irrigation service to farmers.
 - **Increasing the flexibility of irrigation deliveries:** With a flexible service users can intervene and supply water to crops whenever they think it is required. When improved level of flexibility is achieved then cropping patterns become more and more diversified.

Consideration of other uses of water: Competition for water is increasing and the modernization of irrigation is expected to deliver water for other uses in the catchment in terms of quantity as well as of quality. For example, many domestic supplies rely entirely on irrigation water, either directly through canal supply or indirectly through groundwater recharge.

Obstacles in the way of modernization

Successful modernization is not straight forward and failure to achieve targeted performance objectives, in some instances, requires further investigation of the underlying causes. As far as the technology is concerned, significant hardware and software progress has been made in irrigation system operations in the past decade, including computer facilities, information techniques, measurements, and canal control concepts. However in developing countries the adoption of these techniques in the fields has in general been slower than expected. Irrigation authorities/departments are facing many constraints that may explain the gap between the available and the applied technology, including:

- Technical gaps between the requirements needed to implement the improved method (availability of expertise, technical maintenance of equipment) and available local resources.
- Financial constraints resulting from the gap between the cost of equipment for the improved method and the gain in water savings and improved services, as water is generally not priced or charges are low.
- Social constraints as human resources are relatively less expensive in developing economies than alternative technological solutions. An irrigation agency, often a large employer in the area, has some obligation to maintain local staff.
- Institutional constraints. Bureaucratic centralized irrigation administrations are not well suited to service-oriented activities.

In addition, failure is likely if the public irrigation organization continues without the involvement and participation of the water users in the system's operation and management. Only through their involvement from the beginning of a modernization project farmers can develop a sense of ownership and be likely to care for the system. This sense of ownership should prevent several of the problems that often arise after a short time like field channels being demolished; gates being stolen or damaged; field drainage systems becoming blocked; open drains filling with sediments and weeds.

Expected achievements of irrigation modernization

- **Increasing water productivity** : In Nepal, irrigation is the largest water user, therefore an improvement of water use efficiency is expected from on-farm water management activities with large quantities of water saving for tail end water users.
- **Increasing the benefit/cost effectiveness**: As irrigation service delivery is reliable, land and water productivity is improved, overall farm production is increased, allocation of required funds for irrigation service delivery management
- **Increasing knowledge and human resources development**: Irrigation managers, staffs, technicians and WUA would be well educated to have skills and knowledge for irrigation services delivery management, water utilization and management, canal operation and maintenance. Therefore they need appropriate professional training and also links with applied research institutes which explore and test alternative solutions for canal operation and water management.

Lessons learned from irrigation modernization projects from other countries.

A set of conditions for the success of irrigation modernization are drawn from an analysis of recent irrigation modernization projects in Argentina, Mexico and Peru:

- Modernization is more likely to succeed if the ideas come from the farmers.
- Pressure irrigation is 'in' and gravity irrigation is 'out'; future irrigation development should be for pressurized irrigation/micro irrigation.
- Much attention needs to be given to efficient water distribution; otherwise, high water losses, water theft, and unscheduled irrigation will continue.
- Payment of water service fees remains a problem unless farmers are taught and accept that water cannot be free.
- Providing farmers with appropriate technical assistance requires considerable attention. Despite the training provided, there are still large gaps in knowledge about farming practices, water requirements and irrigation scheduling.
- Each system requires tailor-made solutions. Modernization always includes improving the physical infrastructure, but how this is done and all other needs are site-specific.

The case studies indicate that, because of severe competition for water, the water delivery system in irrigation has to become more efficient soon or the system will cease to exist. In the long run, reliance on government contributions and subsidies is no longer an option, although the transition phase to modernized management may still require substantial public investment. The three cases of modernization were successful in the sense that farmers became aware that business as usual is no longer possible. However, as technology is changing so rapidly, it may be necessary to modernize more or less continuously in order to adjust to the changing circumstances.

Conclusion

From the view point of necessity and scope of irrigation modernization to enhance food security in Nepal, it is realized that the scope for productivity improvement on the existing cultivated land is higher than agricultural area expansion. Similarly productivity improvement in irrigated areas has better scope than irrigated areas expansion. Capital cost required for irrigation area expansion/new irrigation projects development is higher in comparison to cost required to improve water productivity of existing irrigation systems through modernization process. Focus on irrigated agriculture with modernized irrigation service delivery depends upon government strategy, socio-economic condition and understanding level of water users. Among the mode of irrigation modernization intervention, micro irrigation intervention in FMIS in hill and mountain of Nepal is best suited.....Therefore the development of micro irrigation is assumed to provides opportunity for year round irrigation with water saving and better water utilization in hill and mountain of Nepal by minimizing the losses and wastage of irrigation water. By shifting from flooding type surface irrigation to the use of micro irrigation the

efficiencies can be increase from 30-40 % to up to 90% with decreasing losses and wastage to minimum. Worldwide, the micro irrigation is expanding rapidly in many countries. The micro irrigation coverage has increased from 3.0 million ha in 2000 A.D to about 11 million ha in 2012 A.D. and is likely to grow faster in coming years. The micro and sprinkler irrigation coverage together up to 2012 A.D. is increased to 54.0 million ha, which is 18% of world's total irrigated areas of 300 million ha. Similarly region wise status of micro and sprinkler irrigation coverage as compared to total irrigated areas in that region is as Europe-61%, America-47%, Africa-30%, Asia-14%. In Nepal even with a great scope and suitability of micro irrigation specially in hill and mountain areas ,the coverage is below 1% of total irrigated areas due to lack of technology transfer, farmer's perception, attitude, knowledge, tradition and government's passive strategy towards irrigation modernization. It is realized that there is need to shift traditional flooding type irrigation culture to modernized soil saturation culture, moisture conservation culture wherever suitable with the adoption of micro irrigation to increase irrigation efficiency and equitable irrigation service delivery. The government's strategy to provide year round irrigation in terai areas is focused on massive utilization of ground water as well as Inter Basin Water Transfer from snow-fed river to nearest terai areas wherever possible, but there is lack of similar strategy for year round irrigation in hills and mountain. Therefore there should be a strong voice for way-out or options to provide year round irrigation in hills and mountains to sustain the livelihood of the people. One of the way-out or options to provide year round irrigation and effective water utilization with local water resources utilization in hills and mountains is the modernization of FMIS. The modernization would include development of in-system multi spaced water storage tanks along canal delivery and distribution points and adoption of micro irrigation technology with water delivery from those storage tanks for seasonal water application replacing traditional flooding type surface irrigation whenever and wherever possible. The time has come to set up vision, mission, goal and objectives of irrigation modernization for year round irrigation focusing towards micro irrigation as a greater opportunity for water saving and efficient water utilization.

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Water Harvesting Dam and Hillside Irrigation: Experience from Rwanda in Upper Nile River Basin

Basistha Adhikari⁹

Introduction

The Nile River spreads over the ten countries of the African continent: Egypt, Sudan, Ethiopia, Kenya, Uganda, Rwanda, Burundi, Congo, Eritrea and Tanzania. The watershed area of this largest river system covers 2.90 million Km² of land area of which about 20,000 Km² belong to Rwanda. The Nile river generates its water from three catchments: Plateau of Equatorial Lakes, Bahr El Ghazal, and Ethiopian high lands. Situating in equatorial part, the Lake Victoria is the one of the lake-origins of the Nile River. The rivers from Kenya, Uganda, Tanzania, Burundi and Rwanda drain to the Lake and form Victoria Nile River.

Rwanda is small hilly country at the center of Africa (Figure 10). The country is known for 1994 genocide when about one million civilians were massacred in the ethnic violence. Despite history of ethnic violence Rwanda has made considerable progress in rebuilding its economic and social infrastructure since the end of last century. Its achievements towards establishing nationwide security and less corrupt Government are acknowledged by the most international donors.

Figure 10: Location Map of Rwanda



Agriculture is the backbone of Rwanda's economy, which is constrained by less potential irrigable lands, small land holdings, lesser water resources, and lack of institutional and

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technical capacity. Based on Agricultural Strategic Plan and Rwanda Vision 2020, Government has developed Land Husbandry, Water Harvesting Dam and Hillside Irrigation (LWH) Project to address critical agenda of agriculture intensification. In addition, LWH Project aims to transform subsistence agriculture to commercial platform in 101 watersheds of the country covering about 30,000 ha of cultivated lands.

Under the World Bank's financial and technical support LWH Project envisions the production of high-value crops with strong marketing potential on proposed irrigated land. Land husbandry component is designed and being implemented to improve hillside agricultural management, to protect agricultural lands from soil erosion, and enhance sustained crop productivity and ecosystem conservation. Water harvesting measures include construction of low height valley dam and store water from surface runoff during rainy seasons. Hillside irrigation measures include construction of two parallel contour canals along the valley slopes, water distribution structures and canals and establishment of Water Users Organizations for system operation and maintenance.

This article aims to share the experiences on the design and implementation of LWH project with water harvesting dam and hillside irrigation networks. The paper also highlights the design parameters of low height dam and hillside irrigation structures. Finally, it analyses the usefulness of small dams for year round irrigation and tries to compare them with Nepalese bio-physical settings.

Irrigation in Rwanda

The history of irrigation in Rwanda goes back to the Belgian colonial rule in 1945 when 8-km long canal was constructed in Ntaruka to address the famine of 1943/44. Unlike Asian countries, Rwanda has no experience of indigenous irrigation systems developed and managed by local beneficiaries. Rather farmers have been practicing rice and vegetable farming in marshlands by lowering water table. In 1964 reclamation of swamp area was initiated for rice cultivation. Since then donors from several countries had provided support to uplift the country's economy through irrigated agriculture.

In 2003, the Government of Rwanda embarked on swamp reclamation under the Rural Sector Support Project (RSSP) under the World Bank's financial and technical support with major focus on large-scale rice production. By the end of 2006 almost 11,000 ha of swampland had been rehabilitated and utilized for rice cultivation twice a year.

Rwanda has sufficient water resources in the form of natural lakes, rivers, groundwater, marshlands, and surface runoff. The estimated renewable water resources is about 32 billion cubic meters (FAO, 2005) and estimated potential irrigable land is 580,000 ha which comprises about 22 percent of the total land area. The present total irrigated area comes to about 24,000 ha with schemes being developed in three broad categories: hillside irrigation, marshland reclamation and small scale irrigation.

Marshland irrigation schemes are being developed by reclaiming state owned swamp lands and farmers are allocated plots on lease. The improved surface irrigation systems

with gravity flow are used for rice cultivation with diversion weirs or having low height dams. Marshland irrigation covers more than 90% of the irrigated area. Small scale irrigation focuses on small garden plots for individual farmers and tree nurseries where rain water is harvested into small plastic lined ponds using simple drip technologies or siphons. In most cases the small irrigations are privately owned with the support from the Government. Hillside irrigation is mostly characterized by pressurized systems developed on hill slopes. Technologies such as sprinkler, drip, and improved surface systems are predominant in the hillside schemes. The LWH project is focusing hillside irrigation to promote commercial horticulture crops.

Socio-economic Conditions

The population of Rwanda was 11.68 million in 2012 with the growth rate of 2.75 percent per year. The population density is the highest in Africa with 419 persons per square km. The Gross Domestic Product has risen dramatically from 6 percent in 2006 to 11.80 percent in 2010. In 2011 the GDP growth rate was 8.8% and the value added to GDP by agriculture sector has been in the range of 32 to 38%.

Feasibility Study of Hillside Irrigation

The feasibility study of LWH project that comprises land husbandry, water harvesting and hillside irrigation is carried out with the following objectives:

- i. To review, modify and complete hydrological study of the water catchment area of three sites to determine maximum potential reservoir volume and area to be irrigated;
- ii. To consider alternative dam sites and command areas up or downstream of the existing sites in each watershed;
- iii. To review, modify and complete feasibility studies for the modified dam site areas;
- iv. To ensure compatibility with international dam safety standards;

The expected outputs of the three sites are associated with the requirement of command area and safeguard policy of the World Bank to the safety of dams. The features of the work scope are tabulated in *Table 4*.

Table 4: Scope of Feasibility Study

Description	Kayonza-4	Rwamagana-34	Rwamagana-35
Previous Command Area (Ha)	65	95	70
Expected Command Area (Ha)	340	251	140
Previous Dam Height (m)	8	11	9
Proposed Dam Height (m)	14	16	12

Data Availability

Dislike other African countries, Government officials in Rwanda are easily accessible and very cooperative in providing required data and information. The main data available from the Office were topographical maps, Ortho-photos, Digital Elevation Model (DEM), soil maps, geological maps, and climatic data.

Topographical Survey

The topographical survey has been carried out to assess the physical features of the dam site, reservoir area and command area. The survey has transferred the benchmarks from the national grid, and prepared contour maps in 1:5000 scales with 0.50 m contour intervals.

Selection of Appropriate Dam Site

Selection of dam site was the first step in the feasibility study of the project. The potential dam sites were first selected on the topographical maps and verified on the field. Later the dam sites were reassessed on the contour maps of the site which has helped to ascertain the minimum length of the dam crest, sufficient catchment area for the runoff yield, storage capacity of the reservoir, command area for irrigation, spillway location, foundation of the dam, and availability of construction materials.

Geotechnical Investigation

A detailed geotechnical investigation has been carried out for all three dam sites. The major activities performed in the field are: excavation of 7 test pits up to 5 m depths, dynamic cone penetrometer (DCP) tests at test pit locations, drilling of three bore holes up to 15 m depth along the dam axis, and in situ permeability tests. Soil samples were taken for the laboratory tests which comprised of standard compaction tests, permeability tests, unconfined compressive strength on weathered rock cores, Triaxial shear on undisturbed soil samples, Atterberg limit tests, and sieve analysis.

Design of Water Harvesting Dam

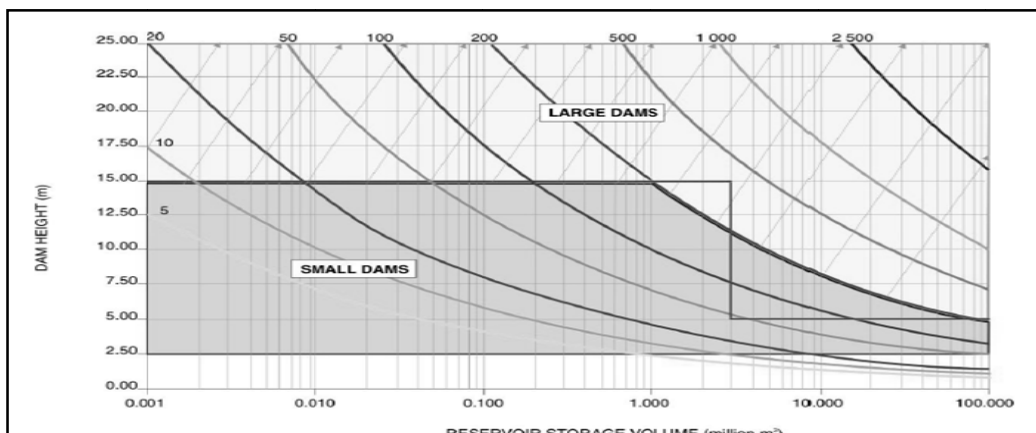
Criteria for small dams

The International Commission on Large Dams (ICOLD) defines the large dam as per following criteria (Figure-2):

- A dam which is more than 15 m height (measured from the lowest point in the general foundations to the crest of the dam), or
- Any dam between 10 m and 15 m in height which meets one of the following conditions;
 - Dam with crest length more than 500 m,
 - The capacity of the reservoir formed by the dam is more than three million cubic meters,

- The maximum flood discharge dealt with by the dam is more than 2,000 m³/s,

Figure 11: Classification of Small and Large Dams



Source: ICOLD, 1995

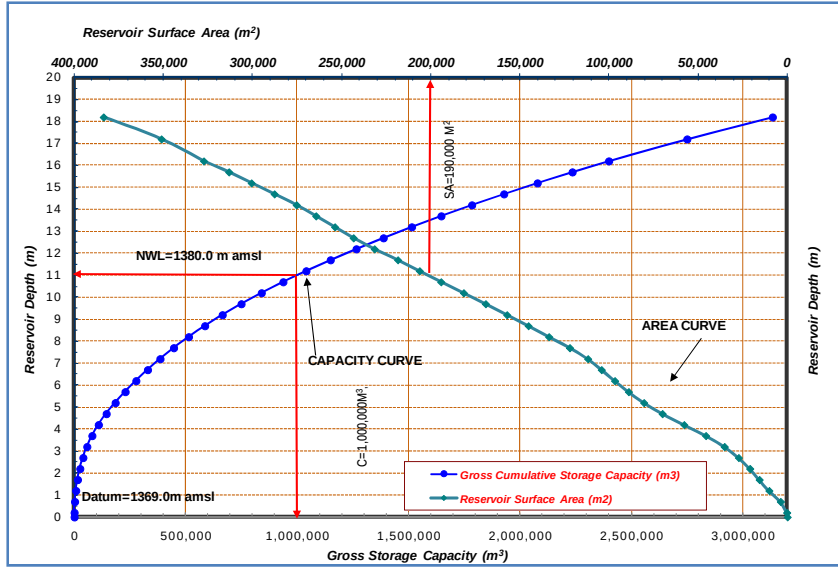
Dam Geometric Section

Depending upon the availability of the construction material and topography of dam site, earthen homogeneous dam has been selected meeting the criteria of small dams. The design of dam geometric section consists of determination of dam height, crest width, free board, and embankment slopes. According to USBR Design of Small Dams the crest width has been determined as $W = H/5 + 10$ where H is the height of the dam in feet. The adopted crest width ranges between 4m to 6 m which is sufficient for vehicular movement. Embankment side slopes have been fixed to suit the characteristics of the available material which are 2.5:1 (H:V) upstream and 1:2 downstream (H:V). The free board has been fixed from the consideration of rise in reservoir level due to flood routing, wind set up on the water surface, and wave action on reservoir dam. The designed parameters of the dam section have been checked for stability and seepage analysis.

Reservoir Capacity

The reservoir capacity has been determined with the help of elevation-area-capacity curves prepared for each sites based on the topographical survey of the dam and reservoir area. The capacity of the reservoir for each site is analyzed on the basis of the inflow data carried out from hydrological study. The results of the elevation-area-capacity curves are presented separately for each site (Figure 12). The reservoir live storage capacity is calculated with the consideration of dead storage volume of the reservoir, which is assessed with prediction of possible sedimentation of reservoir.

Figure 12: Elevation-Area-Capacity Curves



Estimation of Sediment Yield

Estimation of sediment yield from the catchment runoff is carried out using empirical formula developed by HR Wallingford. This guideline is based on research of the small dams of South and East African regions, which considers the catchment characteristics such as soil type and drainage, vegetation, and signs of active soil erosion. The formula used for the estimation of sediment yield is:

$$S_y = 0.0194 \times CA^{-0.2} \times MAP^{0.7} \times Slope^{0.3} \times SASE^{1.2} \times STDR^{0.7} \times VC^{0.5}$$

Where,

S_y is sediment yield in $t/km^2/year$,

CA is the catchment area in km^2 ,

MAP is the mean annual precipitation in mm,

Slope is the river slope from the catchment boundary to the dam axis,

SASE is the signs of active erosion (score from catchment characterisation),

STDR is the soil type and drainage (score from catchment characterisation), and

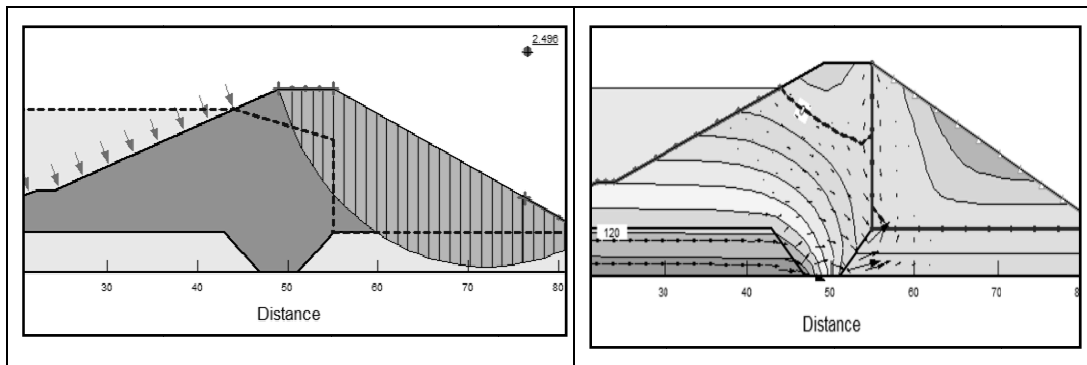
VC is the vegetation condition (score from catchment characterisation)

With the site specific catchment characterization, the sediment yield comes to the range of 220 to 350 $ton/km^2/year$. However, sediment yield of small mountainous catchments in Africa are often in the order of 120 to 3400 $ton/km^2/year$ (HR Wallingford, 2004). The possible accumulation of sediment is calculated using reservoir trap efficiency curves based on capacity inflow ratio. The capacity of reservoir is determined with the Elevation Area Capacity curves and WEAP water balance model.

Sediment yield rate in Indian reservoirs are bit higher in the range of 420 ton/km²/year to 2450 ton/km²/year (Garg, 2011). The sediment yield rate of large Nepalese rivers ranges from 229 ton/km²/year to 7074 ton/km²/year (DOI, 2004). However, there is no sediment data for small rivers where small dams are feasible in Nepal.

Slope stability analysis has been carried out for three critical conditions: rapid draw down condition, steady-state seepage condition, and end of construction condition. The analysis has been carried out using Geo Slope software taking the factor of safety of 1.5 (Figure-4).

Figure-4: Stability and Seepage analysis of dam

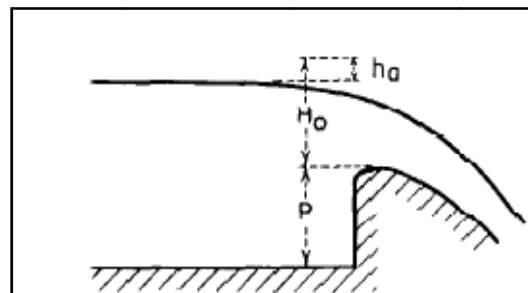


Seepage Analysis has been carried out with SEEP/W a finite element Computer Aided Design software product from GEOSLOPE International. It analyses seepage and pore water pressures in the homogenous dam and its foundation. Horizontal and vertical blanket drains are provided on the downstream side which starts at the start of the cut-off trench to the edge to the downstream slope. A sloping blanket is also provided on the downstream side of the cut-off trench to trap any leakage from the cut-off trench.

Filters are used to prevent soil particles from migrating between various zones of embankment dams and are designed in two zones: fine zone and coarse zone. The fine filter zone prevents erosion of the embankment material while coarse zone filter drains any seepage passing through the fine filter and prevents erosion of the fine filter material. The filter design used is based on the method outlined in USDA guidelines.

Design of Spillway

The location of spillway is determined according to the topography and geology of the dam site. Side channel spillway is selected for all three sites. Design of spillway involves the estimate of design flood and hydraulic design of spillway structure. The spillway structure further involves design of spillway crest, design of



chute, and design of energy dissipater. The design flood is estimated as equivalent to 100 years return period flood and the capacity of the spillway is checked for 200 years return period flood.

Ogee type spillway weir is designed with a crest width of 2 m to 4 m. The discharging capacity of the spillway is calculated using equation:

$$Q = C \times L_e \times H_e^{3/2}$$

Where, Q is the discharge in m³/s,

C is the discharge coefficient, from U.S. Army Corps of Engineers,

H_e - total specific energy above the crest in m,

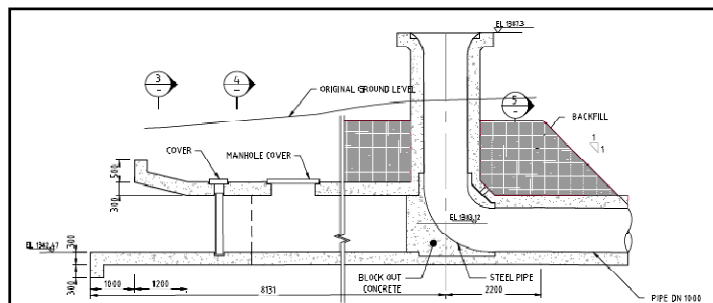
L_e - effective length of the crest in m,

The design of chute section is carried out using varied flow profile and no hydraulic jump in chute profile. The chute section is rectangular with varying width. An impact type stilling basin is designed to dissipate energy based on the Froude number of the incoming flow of the spillway chute.

Design of Outlet Works

The design of outlet works is carried out with the multi dimensional functions. First function is to divert the water of the river during dam construction and the second function is to serve as irrigation outlet. The third function of outlet works is to release environmental flow of the river continuously. The fourth function is to release water during drawdown of the reservoir dam. The diversion pipe shall be plugged after the construction of the dam to let the irrigation intake open (Figure-5).

Figure-5: Outlet Works and Irrigation Intake

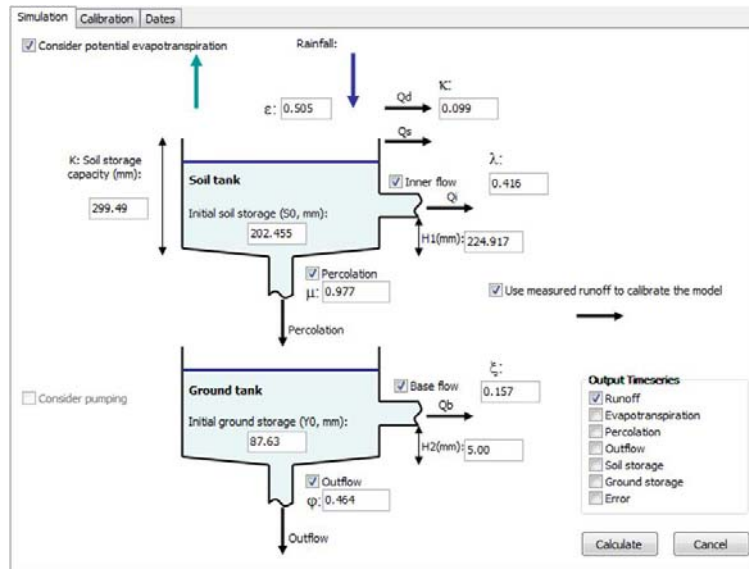


Assessment of Potential Irrigation Areas

Assessment of potential irrigation area involves determination of several parameters. The first aspect is to determine the irrigation water requirement based on proposed cropping pattern and canal system efficiency. The second aspect is availability of sufficient water in catchment area for irrigation according to water demands. The third aspect is the

assessment of cultivated land under the irrigation command downstream of the proposed dam site.

Figure 6 Conceptual Diagram of ZYGOS Model



The source of water for reservoir dam is the surface runoff to be generated during rainy seasons. Due to lack of measured flow data at the source stream, the assessment of water availability has been carried out by model generated runoff which is assessed using a conceptual monthly rainfall-runoff model, ZYGOS model. It models the hydrological processes of a watershed using a lumped approach in a conceptual soil moisture accounting scheme extended with a groundwater tank (Figure-6). Model simulates each components of runoff: direct runoff, surface runoff, interflow and base flow as hydrological processes. The initial runoff coefficients, which account catchment characteristics such as slope, vegetation, and soil profile, have been taken from previous studies. The typical runoff coefficient is considered as 0.10 and the base period for the modeling extends from years 1971 to 2011. The results of the model calibration provide the estimated volume of runoff for the given probability of exceedence.

The net total area of irrigation is converted to gross command area which is verified from the survey data of the cultivated area downstream of the proposed dam site. The area has also been examined with the help of available othophotos.

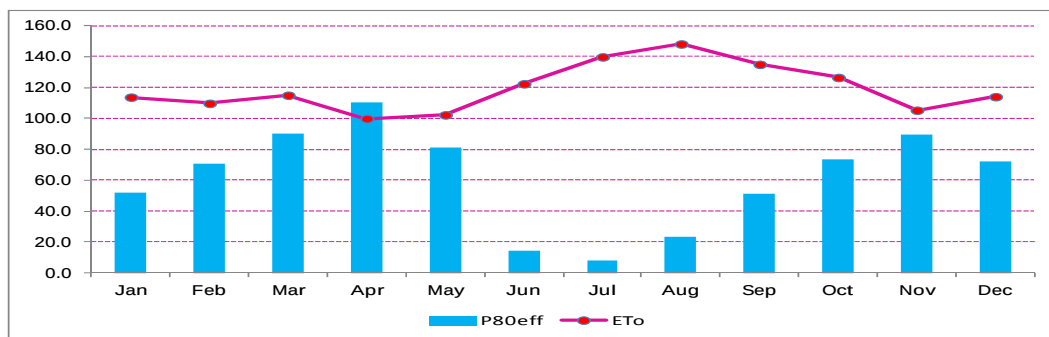
Design of Hillside Irrigation

Design of hillside irrigation involves the assessment of crop and irrigation water requirements, selection of irrigation method, irrigation system layout, hydraulic design of canals and structures, and design of access road networks.

Assessment of Crop Water Requirement

The crop water requirement has been assessed with the calculation of potential evapo-transpiration (ET_o) using Cropwat-8. The calculated potential evapo-transpiration and effective rainfall is compared on the monthly basis (Figure-7). The comparison shows that the rainfall is less than that of ET_o except in the month of April. The overall irrigation system efficiency has been taken as 60 percent considering the lined primary canal and piped distribution system. The monthly water demands in volumetric unit have been assessed to simulate the rainfall runoff model for the assessment of the net irrigation area based on the available water to be stored in the reservoir. The unit water requirement of the designed project is about 1 l/s/ha with the cropping intensity of 200 to 230 percent.

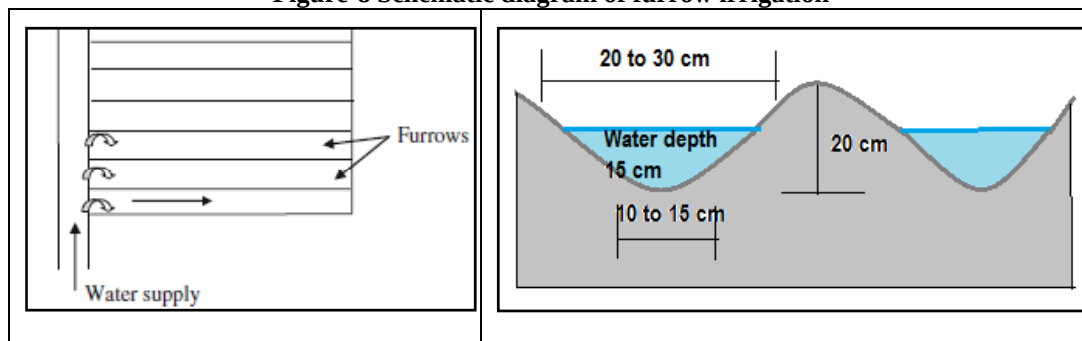
Figure-7 Comparison of Effective Rainfall with Potential Evapo-transpiration



Design of Furrow Irrigation

In furrow irrigation system, as infiltration occurs along the furrow, flow with constant inflow discharge is unsteady and gradually varied. The velocity of water on the surface of the furrow should be higher than the infiltration rate. The performance of furrow irrigation system depends upon soil characteristics, stream size, length of run, cutoff ratio and wetted perimeter. The design of furrow involves the determination of its length, shape, and size of the stream or flow rate.

Figure-8 Schematic diagram of furrow irrigation



The length of the furrow depends upon slope, soil type and stream size. Row length should not exceed 400 m on heavy soil and in medium textured the row length is designed as 50 m to 100 m. The slope of the terrace shall be maintained to achieve the maximum flow slope of 0.5%. Row slopes should be between 0.05 to 0.50%. Where the

command area falls in more than 6% slopes terraces shall be constructed and furrows should be constructed along the terraces.

The shape of the furrow involves the centre to centre distance of furrows and depth of the furrow. The width of the furrow shall be 20 cm to 30 cm with the bottom width of 10 cm to 15 cm (Figure-8). The shape of the furrow might be V-shaped, parabolic depending upon the type of soil. In clayey soil wide shaped furrow are preferable while in sandy soil narrow shaped furrow is needed. The spacing of the furrow shall be 30 to 60 cm. In some cases the spacing might be as wide as 80 cm.

The ideal flow rate of the furrow is 0.50 l/s for medium sized furrow. The flow rate shall not exceed 3 l/s in any case so as to avoid erosion. The non-erodible flow rate is given by the formula:

$$Q_m = 0.60/S$$

Where, Q_m is the maximum non-erosive flow rate in individual furrow in l/s, and

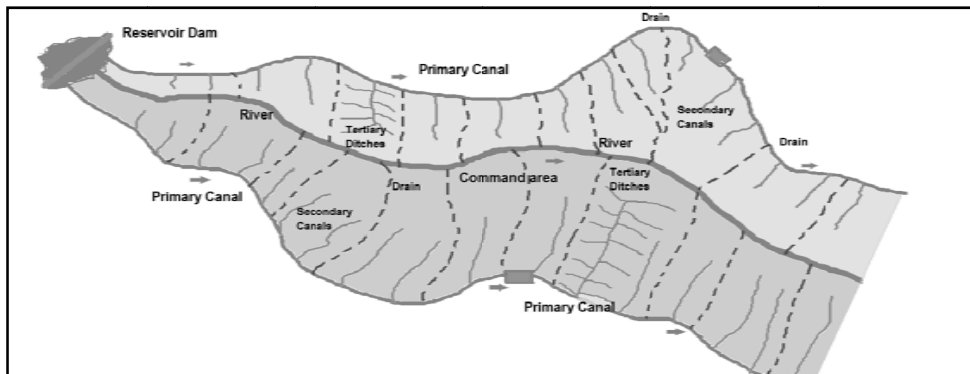
S is the slope of furrow in percentage

Irrigation System Layout

Layout is the arrangement of canals, drains, and structures required to achieve water distribution and remove surplus water. Layout planning establishes the optimum arrangements, positions, levels of canals and structures with the consideration of physical, technical and social constraints.

Layout network of irrigation scheme consists of reservoir dam on the river, two primary canals on either side of the valley, piped secondary canals down to the slope, earthen tertiary ditches and drainage system. The internal drainage systems are planned in between secondary canals and joining to the main river at the spacing of 200m to 300m (Figure-9). The secondary canals take off water from the butterfly valve intake located on the primary canals and tertiary canals take off water from secondary pipe through the butterfly valve.

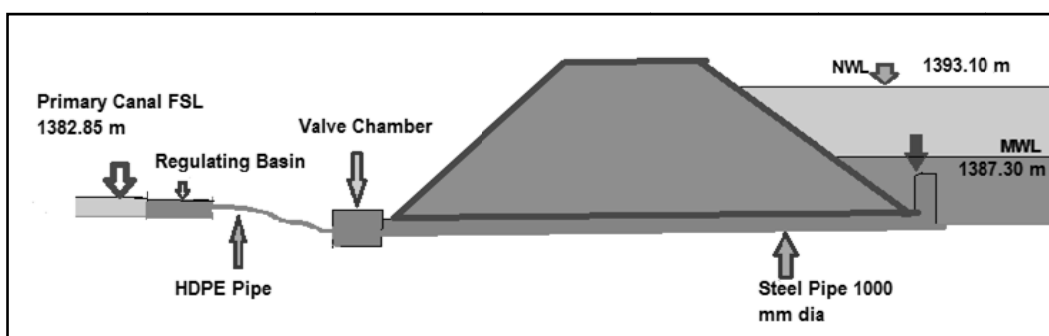
Figure 9 Typical Layout Diagram



Irrigation Intake

The irrigation intake is a vertical bell-mouth entry intake with a steel pipe of 1000 mm diameter surrounded in concrete. At the downstream toe of the dam section a valve chamber is provided to control the flow of irrigation intake. Outlet stilling basin and valve chamber is a combined structure, which has two compartments: first for valve chamber and second for stilling basin. Valve chamber accommodates two valves: one butterfly valve for bottom outlet works and another needle valve for regulating flow to the irrigation pipes bifurcated in two sides. A schematic diagram of irrigation intake and dam is presented here.

Figure 10 Schematic Diagram of Intake and Dam Reservoir

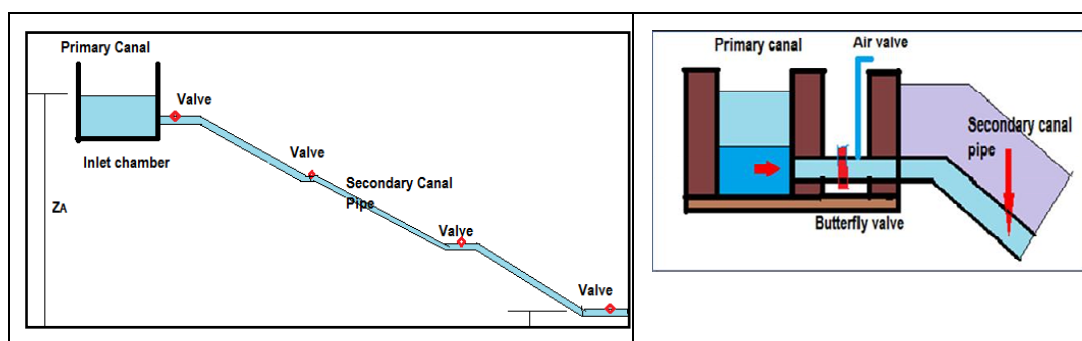


Canal System

Two primary canals take off water from reservoir dam through control valve and regulating basin located at the downstream side of the dam. Primary canals are of trapezoidal shape with concrete lining. The length of left primary canals range from 3 km to 12 km having no idle length as the command area starts immediately at the downstream of the dam. Primary canals have cross several drains and roads where structures are provided to convey the water to the downstream. The primary canals have two on-canal reservoirs at the two-third part of the alignment to store the excess water of the canal. There is tail escape structure at the tail end of the primary canal.

Secondary canals take off water from primary canal and feed to tertiary canals along the valley slope. They are designed for 90 mm diameter HDPE pipes buried under the ground along the natural slope (Figure-11). The discharging capacity of secondary canals is of 7 l/s and the control of flow will be carried out with butterfly valve located at the head of each secondary canal. An air valve is also provided to release the pressure of the pipe flow just downstream of the butterfly valve. The length of secondary pipes varies according to the topography of the site. The spacing between two secondary pipes is kept between 50 m to 500 m interval depending on topography.

Figure 11 Schematic Diagram of Piped Canal



Water Users Association

In order to sustainably manage the irrigation schemes Government has decreed the law on Water Users Association. All farmers using irrigation water are required to form an association under prevailing legislation. The Water Users Association is the sole body that is responsible for the operation and maintenance of irrigation infrastructure. In light of this requirement each project involved in the development of irrigation is required to assist the farmer beneficiaries in setting up legal water user associations which can be bound in performance agreements with the local District Authorities and also to Ministry.

Lessons Learnt

Despite tremendous challenges related to the past history and economy of the country, the progress in irrigation development is very encouraging in Rwanda. The main reason behind the success is the governance system which is worth praising since last 10 years. There is no corruption the procurement process as well as at the construction sites. The source of water in Rwanda is the rainfall which is being harvested through the construction of reservoir dams and being utilized for irrigation. This technique not only utilized scarce water sources but also provides adaptation to the climate change. In addition, the introduction of new pipe irrigation technology along the hill terraces is another encouraging aspect of Rwanda's irrigation development.

Small Dams in Nepal

Most of the irrigation schemes in Nepal are run-of –the river type and depend on the seasonal flow availability of the rivers. Storage schemes are very few in Nepal for irrigation purpose. Begnas Irrigation System, Phewa Irrigation System in Kaski district and Banganga Irrigation System in Kapilvastu district are only few irrigation schemes from storage sources. The salient features of the existing dams are presented here (Table-2).

Table 5 Salient Features of Small Dams in Nepal

Scheme name	Dam type	Catchment area (km ²)	Dam height (m)	Crest length (m)	Storage capacity (MCM)	Command area (ha)
Phewa Irrigation, Kaski	Concrete	120.0	14.5	43.5	13.3	320
Begnas Irrigation, Kaski	Earth fill	18.6	5.0	540.0	4.6	580

Due to recent trend of climate change the water availability of these run-of- the river schemes is in question. In this context the scope of developing year round irrigation through the construction of storage reservoir dams is paramount important to address the impacts of climate change and thereby enhance productivity of irrigated agriculture.

The potential locations for the small dams are foothills of Chure and Mahabharat ranges in Terai and inner Terai regions. The irrigation schemes to be served from each dam may range from 50 ha to 500 ha depending upon the capacity of the dam and availability of the cultivated lands. Assuming an average irrigated area of one scheme be 200 ha, unit water requirement for Terai be 1.5 l/s/ha the gross water requirement comes to be 6.5 million m³ per year. The average annual precipitation of Terai is 900 mm and runoff coefficient of 0.20 the required catchment area of the river at the proposed dam site comes to be about 36 Km².

Hence, we can plan reservoir dam at each feasible site which catchment area exceeds 36 Km² that can irrigate at least 200 ha of land. It is recommended that Department of Irrigation should initiate to carry out identification and pre-feasibility study of such water harvesting dams at the foot hills of Chure range. For the first time DOI can propose a project of 20 small dams with a total irrigation area of 4000 ha.

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Impact of Arjun Khola Irrigation Project after 20 Years of Implementation

Lok Bahadur KC¹⁰

Key Words: livelihood, irrigated agriculture, non-agriculture activities, water resource management

ABSTRACT

This study on "Impact of Arjun Khola Irrigation Project after 20 Years of Implementation" located in Chailahi VDC, Dang, compares the livelihood of the project prior to 1988 with the changes incurred up to 2012. Arjun Khola Irrigation Project is a farmers' managed irrigation scheme, implemented in 1994 by the Department of Irrigation from the grant assistance of European Union. The project adopted an integrated development model comprising irrigation infrastructure development, agriculture extension and training, appropriate technology, road construction, sanitation and water supply for improving the living standard of subsistence agriculture based indigenous Tharu community. The objective of the study was to outline the status and major impacts of irrigation infrastructure improvement and development on the rural livelihood. Both quantitative and qualitative methodologies were used in the investigation of the impact of the scheme on rural livelihoods. A sample of 90 respondents was selected using two stage random sampling method. Data were collected using interviews, questionnaires and observation. Then, analysis were done using descriptive statistics. The results of the study were then compared with the base line information of 1994 and 1988 to outline the major impacts, shifts, physical status of the project. The study unveils continuity of adequate and reliable water availability, reasonable water management and functional but deteriorated irrigation infrastructures. Furthermore, the survey results show food surplus, ample non-farm employment and income generating opportunities. Food deficit situation prior to 1988 transformed into food surplus situation after completion of the project in 1994 and continues to remain surplus there onwards generating multiplier effects. However, contrastingly, the overall contribution of irrigated agriculture has declined from 80 percent in 1994 to meager 18.36 percent in 2012 because of more profitable non-farm economic opportunities in nearby locations. The cropping intensity of 201 percent has considerably declined to an average of 137 percent in 2012 for small size landholdings. Despite increasing non-farm sector economic opportunities, intervention in irrigation continues to remain pivotal and rural people continue agriculture as a

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primary means of livelihood. In future the economic recovery programs like system automation, improved water management, farm mechanization and commercial farming are recommended to ensure the viability and sustainable irrigation on rural livelihood. Study on construction of Dam in the upstream of Arjun Khola or augmentation of Parganna Irrigation Water to Arjun Khola to meet the shortage in the winter months are recommended.

I - INTRODUCTION

A majority of population in Nepal continues to face food insecurity, malnutrition, vulnerability, conflict and injustice despite efforts to reduce these problems. Growing population, increasing demand for food, scarcity and degradation of natural resources, and subsequent social unrest are major concern among development policy makers. Another unavoidable concern is the limited access to quality of land and water resources impinging against food security for the poor perpetuating poverty.

Agriculture is the mainstay of national economy. But through subsistence and rain fed agriculture the economic growth of the country as prevalent continues to remain marginal. According to CBS statics the land uses includes 17 percent arable, 42 percent forest and woodlands, pastures 15 percent and 26 percent others and the per capita income of the country is \$735. Further, 33 percent of GDP comes from agriculture sector. The country envisions irrigated agriculture to bring multiplier effects in poverty reduction through increased agricultural productivity and employment.

It is commonly accepted that irrigation infrastructure development promotes agricultural production, improving the livelihood of rural communities, having the immediate potential to alleviate poverty. Further, irrigation infrastructure development, inter alia, in general helps small and presumably poor farmers, to manage risk and reduce income variability caused by untimely and unevenly distributed rainfall. Irrigation can help reduce transient poverty by reducing sudden fluctuations in income. Opportunities offered by irrigation can enable poor farmers to mitigate or skirt the adversities associated with water scarcity, floods, drought, or personal shocks.

The Arjun Khola Irrigation Project involves rehabilitation and improvement of the existing traditional canals that receive water from Arjun Khola near the village of Chhotki Devpur, located in Chailahi Village Development Committee of Dang District in the Mid-Western Region of Nepal. The project area includes ward no 2, 3, 4, and 5 of Chailahi Village Development Committee. It lies approximately

between latitudes 27° 50' and 27° 53' and longitudes 82° 29' to 82° 32'. The altitude of the area varies between 209 to 240 m above sea level.

The project is situated at 400 kilometers west of Kathmandu adjacent to the East-West Highway about 2 kilometers West from Lamahi Market. The East-West Highway passes by the northern boundary of the command area. Lamahi, a local market, is linked to Ghorahi, the district headquarter, 23 km towards North, Nepalgunj 120 km to the west and Butwal 120 km to the East. In addition, bridge at Rapti River on the way to Gadhawa links with boarder market Koilabas and Indian market Tulsipur. All weather gravel road inside the command area links to the E-W Highway and to Lamahi.

The project covers an area of 568 hectares of which 475 hectares are under the command of irrigation network.

Farmers of Chailahi VDC had constructed the system more than 120 years ago. The traditional system had a simple brushwood type diversion headwork to divert water into the 21 km long canal network operated and maintained entirely by the farmers. Major problems encountered in the system were frequent washout of temporary diversion headwork, uncontrolled entry of water into the system during floods, difficulties in distribution, inequitable sharing and inadequacy of water. Among these, the temporary diversion headwork was the most serious problem for the farmers which needed standby attention throughout the monsoon season.

The project experiences homogenous sub-continental climate. The monsoon season starts from June and ends mostly in September. The project area receives approximately 90 percent of total annual rainfall during these four months. Rest of the year the climate remains dry. Average annual precipitation of Dang valley is 2017 mm. June and July are very hot and humid months.

OBJECTIVE AND SCOPE

The study addresses water resource management in Arjun Khola Irrigation Project from a livelihood prospective to understand the interface between the irrigation, resource management and rural livelihood. The overall objective of the study is to outline the impact of irrigation infrastructure improvement and development. The specific objectives of the study are to outline the physical status of irrigation infrastructures, water management and to compare food situation, occupation, expenditure and energy situation of 1988, 1994 and 2012 i.e. impacts after 20 years of implementation.

The comparison study involves the results of Household Benchmark Survey, HBS (1988), Project Benefit Evaluation Study, PBES (1994) with the results of Project Impact Study, PIS (2012) to justify the investment and future improvement and modernization of the system.

REVIEW OF BASELINE STUDY OF THE PROJECT

The Arjun Khola irrigation Project intended to increase agricultural production and improve the income of farmers leading to an improvement in the standard of living of the households in the project area. Primarily the intended improvements were to be accomplished by providing irrigation water on a reliable and sustainable basis to the farms which will help to increase the agricultural production and cropping intensity. In addition to this, agricultural extension service, prevention of land losses, strengthening of institutional credit and promotion of appropriate technology were embedded in the project execution to further improve irrigated agriculture.

Determination of baseline status of the project through a household benchmark survey was carried out in 1988 just prior to the commencement of project implementation. Then project benefit evaluation were conducted in 1994 after the project completion. The results of these two studies are compared with the outcome of the project impact study of 2012.

The comparison of results on water availability, water management, infrastructure status etc. will provide insights for future improvement needs. Then, food situation, income, expenditure, assets, energy consumptions, access and mobility in the project will explain the livelihood changes induced situation from the irrigation infrastructure development.

MATERIALS AND METHOD

A two stage stratified simple random sampling procedure was adopted where the village represents the primary units and the household as the ultimate sampling units.

The households were randomly chosen and were then interviewed in detail. The research methodology of this "Project Impact Study" (PIS 2012) has attempted to maintain previous two Household Benchmark Survey 1988 (HBS 1988) and Project Benefit Evaluation Study 1994 (PBES 1994). In the previous two studies 79 households and same key informants were considered. However, in this study same households could not be picked up but some of them could be included in the study. For the PIS 2012 a baseline household sample size of 90 households have been considered.

The sample households were interviewed by using a standard questionnaire to collate various benchmark information on demography, labor use, land tenure, agricultural yields, cropping intensities, cropping pattern, use of inputs, livestock, marketing and credit, drinking water, use of appropriate technology, source of energy, food situation, living standards, income, expenditure, irrigation management and other support services.

PROJECT DEVELOPMENT

The construction of Arjun Khola Irrigation Project was started in 1988 and was completed in 1994. The major irrigation infrastructure development in Arjun Khola Irrigation Project include construction of 115.4 m wide concrete gravity weir across the river with under-sluice 22.0 m long installed with 4 steel gates; construction of head regulator installed with 2 steel gates; a compound wall, railing, fencing and a WUA house near the headwork site. Likewise, the project constructed 186 m lined canal and improvement of 1.5 km of earthen main canal to convey a design discharge of 1.96 cumecs. The construction and improvement of branch or sub branch canals in the command area are outlined as in the Table 1. Further, the project constructed 40 auxiliary structures like off takes, drops cum off takes, drops, drops cum flow dividers, aqueducts, escapes etc. for smooth regulation of flow in the command area.

Table 1: Canal Length and Command Area

S. No	Branch/Sub-branch Name	Length (m)	Command Area (Ha)
1	Maherwa	500.0	10.0
2	Lahawani	780.0	35.0
3	Lamahi	1550.0	40.0
4	Piparhawa	600.0	12.0
5	Kholwa	1120.0	11.0
6	Devpur	2460.0	120.0
7	Kolahi-Madhenagar	5740.0	90.0
8	Langadi	2060.0	55
9	Khairi	3500.0	102

Source: PBES 1994

The project has constructed a 5 km long gravel rural road including associated structures like pipe culverts, slab culverts to facilitate transportation of agricultural goods within and outside the command area.

In order to control bank cutting and to restore the flood plain a 2.5 km long boulder packed gabion embankment along the Arjun Khola river in combination with 11 spurs have been constructed.

The program included boring, construction of pump house, and electrification of 3 shallow and 3 deep tube wells to facilitate farmers for paddy seed plantation. Likewise, 12 new dug wells were constructed and 13 dug wells were repaired. Farmers were encouraged to construct low cost latrines and the project constructed 136 such latrines in the command area. Further, the project constructed 37 biogas plants of 10-15 m³ capacity with 50 percent grant and 85 smokeless chulos. Not only this, with 50 percent grant, the project distributed 182 seed bins, 19 pesticide sprayers and 3 multi-crop threshers to the farmers. The project focused on agricultural extension, training and research programs in the command area to motivate farmers to use improved/hybrid seeds, fertilizers and technology for more intensive agriculture practices.

MAINTENANCE AND OPERATION

After completion of the project the system was handed over to WUA in 1994 for operation and maintenance. Since then, the system is managed by the farmers. WUA has appointed a Chowkidar. He is responsible for gate operation and diversion of water into the main canal and to maintain the system. In addition to this, he works as a messenger of the WUA chairmen informing about the system during the flood season. The entire maintenance of headwork, main canal, branches and outlets are done from internal resource mobilization. All the branches, canals or respective villages raise irrigation fee towards maintenance of the system. A portion of the collected fund is provided to maintain and operate the main canal and headwork in addition to maintaining the branches and outlets by WUG's.

Farmers with their long experience, have pointed out that the crest level of the weir has been slightly lower than the intake level and they have difficulties in diverting water during winter months. They have to raise the crest level by 30 cm to completely divert the lean flow towards the main canal intake or else the winter flow passes over the weir to the river downstream.

II - COMPARATIVE ANALYSIS: PAST AND PRESENT

In this section distinct changes in the baseline information of 1988, Project Benefit Evaluation information of 1994 and Project Impact Study 2012 will be discussed and presented. The impacts of irrigation infrastructure development on rural livelihood interestingly appear positive and significant.

A - CHARACTERISTICS OF THE RESPONDENTS

HOUSEHOLD SIZE

The household size is smaller in 2012 as revealed from the study, in overall national, regional and district level also the household size is decreasing. The traditional living in large joint family has declined considerably over the years. On an average of 9.5 member per household in 1994 has come down to 6.43 in 2012 with shrinkage in medium and large farm sizes. The average household size has decreased from 6.44 in 2001 to 4.88 in 2011 at the national level and 4.82 and 4.75 at VDC and District level respectively (CBS 2011).

Table 2: Comparison of Average Household Sizes

Farm Size	Average household size		
	1988	1994	2011
Small	7.4	6	5.84
Medium	10.4	11.2	7.39
Large	16.4	11.1	7.6
Overall	10	9.5	6.43

POPULATION AND LITERACY

The population has increased more than two folds in 24 years from 1988 to 2012. The population growth from 1994 to 2011, appears rapid and abrupt influx of people can be attributed to increasing economic activities in Lamahi and influence of insurgent activities which forced people to migrate to Lamahi as a safe haven. The population of Chailahi VDC is 20,696 with 9,874 males and 10,822 females living in 4,291 households. Tharu's are traditionally dominant dwellers of the area but in recent years rapid influx of migrants from the hills has diluted the dominance of these indigenous communities.

Substantial improvement in literacy rates of sample households have been observed in the command area. The sample household respondents average literacy rate computed to be 80.28 percent with 76.3, 86.47 and 82.89 percent for small, medium and large farm sizes respectively. The literacy status among small and medium farm size groups has shown tangible improvements. Furthermore, significantly high male and female literacy rate of 85.5 and 73.1 percent were revealed respectively. The literacy level of project area thus appears remarkably higher than the national literacy figures of 75.1 and 57.4 percent for male and females respectively. The average national literacy rate of Dang stands to be 65.9 percent as of 2011.

ECONOMICALLY ACTIVE POPULATION

The people from 15 to 59 years of age group are termed as economically active population in this study. In some studies the economically active age begins from 10 onwards. It was revealed that 60.5 % of the sample household population were in the economically active population age group.

OCCUPATION

Sample household respondents show only 18.36 percent depend on agriculture and 81.64 percent households were reported to be involved in non-agricultural works. One or two members of family have a job mostly outside the project area. The non-agricultural jobs are categorized as service; which include public service, teaching, armed force, banking and security jobs; high skilled labors include mason, plumbers, carpenters, welders, painters, mechanics and drivers; general labors; business and foreign jobs. The rapidly growing Lamahi market and ample construction works in the town consume unskilled and high skilled labors. In addition to this, large construction projects like Bhalubang-Rolpa highway, Parganna Irrigation Scheme and Lamahi-Tulsipur Highway also provided employment to the locals. Likewise, business is brisk in Lamahi, a small economic hub of Deukhuri valley, and gateway point of Ghorahi, Tulsipur, Salyan and Rukum.

B - THE ECONOMY OF HOUSEHOLD FOOD SITUATION

Significant crop yield is revealed from the sample household farms. The yields of paddy, wheat and maize have more than doubled to that of 1988 and 1994 yields. No significant increment in yields of mustard and lentil revealed. The paddy yield of small farmers in 2012 is higher than medium and large farm holding farmers. The average yields of paddy, wheat and maize in 2012 were 5.23, 3.79 and 3.75 metric ton per hectare.

Prior to 1988, the project area was food deficit. Most of the areas were dependent on rain fed and traditional agricultural practices. After the project implementation in 1994 the project has become overall food surplus and continues to be food exporting and one of the successful projects.

About 39 percent of the sample respondent reveal food surplus and 61 percent small farmers reveal buying one or two staple food items mainly paddy, wheat and mustard. Agriculture alone is not adequate to sustain small farms is also revealed. But it's noted that deficit food items are purchased inside the project itself.

About 38 percent of the respondents reveal no selling of food grains and 62 percent report selling food items. Small farmers are marginal producers but medium and large farms considerably contribute large agricultural production.

IMPROVEMENT IN LIVING STANDARD

Standard of living refers to level of wealth, comfort, material goods and necessities available to a certain socio-economic class in a certain geographic area. Rural awareness improvement, development activities like infrastructures, power, communication and income generating activities assist in enhancing rural living conditions.

Noticeably, it appears over the years farmers have leaped from irrigated agriculture to more profitable non-agricultural economic activities. Although agriculture remains profitable a significantly higher income comes from non-agricultural activities.

Living conditions of people of Arjun Khola Irrigation Project have improved substantially over the years compared to baseline information of 1988. During 1994, having a radio or player was a luxury in the project area but not anymore. Modern electronic gadgets, internet and cable television are the luxury at present in the command area.

Among the 90 sample households, 61 percent have bio-gas plants, 79 percent have bicycles, 27 percent have motor bikes, 17 percent own tractors, 81 percent have latrine facilities and 69 percent households have electric facilities. Some people have started using gas stoves and electricity for domestic purpose. Prior to 1994 these facilities were very limited and project had constructed some bio-gas plants, low cost latrines and tube wells to motivate farmers which in reality proved to encourage and motivate the locals to adopt more appropriate technology.

Furthermore, 65 percent respondents have reported having both pucca and kacha house. While travelling in the command area also one can see beautiful buildings. Traditional thatched straw roofed houses are being replaced by modern buildings. Family savings are spent on house constructions and purchasing land within the village or beyond.

Peoples affordability has increased considerably. Mobility of the people has also increased and people have started spending considerable amount in travelling, social ceremonies along with clothing and health.

Table 3: Household Assets of Sample Households

Asset	Farm Size			Total	Percentage
	Small	Medium	Large		
Radio	27	18	10	55	61
Bicycle	43	18	10	71	79
Sewing Machine	7	9	3	19	21
Motorbike	8	11	5	24	27
Tractor	6	3	6	15	17
Bullock cart	4	3	1	8	9
Irrigation Pump	2	1	1	4	4
Electricity	35	18	9	62	69
Bio-gas Plant	28	20	7	55	61
Metal seed bin	10	13	7	30	33
Low cost latrine	40	23	10	73	81
Smoke less oven	3	1	1	5	6
Television	30	18	9	57	63
Gas Stove	3		4	7	8
Sprayer	15	16	7	38	42
Thresher	1			1	1

Source: PIS 2012

INCOME

Flourishing economic activities in the nearby Lamahi market has opened numerous employment opportunities, in particular, for daily wage earners both skilled and unskilled labors. Skilled labors include masons, carpenters, plumbers, painters, mechanics and electricians. Furthermore, daily wage rates are much higher than the farm labor rates. The farm income used to be 80 percent from the agriculture sector in 1994 but this study reveals only 18.36 percent income comes from agriculture sector. Prior to 1988, 86 percent of the income came from agriculture alone. Non-agricultural activities are rapidly growing and contributing to the economy of rural livelihood of the project area.

Service sector is the main source of income followed by agriculture, business and daily wages earners.

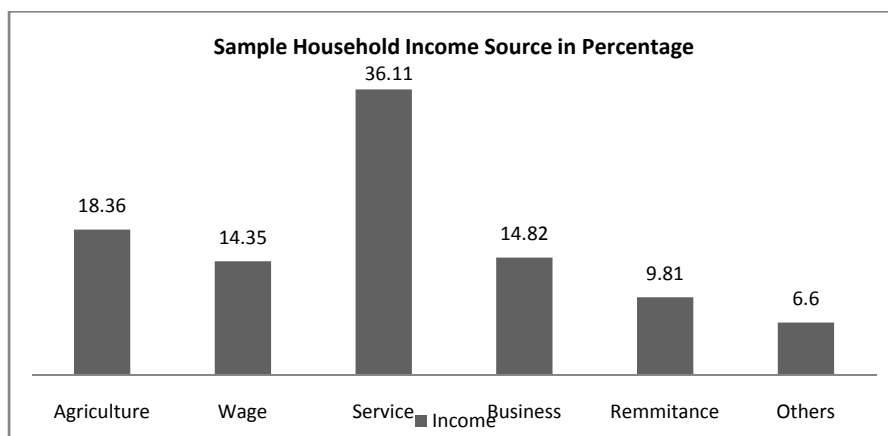


Figure 1: Sample Household Income Source in the Project Area

Lamahi has transformed itself as the gateway market of Ghorahi, Tulsipur of Dang district, then Salyan and Rukum with abundant non-agricultural economic opportunities in the recent years. At the same time, integrated project development has remarkably contributed in time saving of locals through reliable irrigation infrastructures; nearby dug well for drinking water; installation of bio-gas plants for cooking; low cost toilets, seed bins for preserving seeds; and all weather access road to connect the project area to the east-west highway. Thus, considerable time saving of locals has been utilized for income generating activities in the nearby town Lamahi.

Furthermore, construction of Lamahi-Tulsipur highway, Parganna Irrigation Project, in addition to the construction activities of the town planning provided significant non-agricultural employment opportunities to the locals.

Because of lucrative opportunities, in the non-farm sectors, farmers interest in agriculture has declined, in particular, the cropping of wheat has significantly declined over the years. Only crops with least input and attention like lintels, mustards and linseed seem to be grown during winter.

Gross farm incomes have increased from NRs 28450 in 1988 to NRs 235766 in 2011.

Table 4: Household Gross Annual Income

FARMS SIZE GROUPS	GROSS INCOME			DIFFERENCE 1988 AND 2011
	1988	1994	2011	
SMALL	10850	24645	206243	195393
MEDIUM	24486	39467	399243	275757
LARGE	81811	169591	552936	471120
OVERALL	28450	75955	235766	207316

EXPENDITURE

As the income increased, the average annual expenses of the households have also significantly increased from NRs 24940 in 1988 to NRs 137452 in 2011.

Prior to 1988, the small farm size households annual income were lower than the annual expenditure but the 2012 study reveals average surplus of NRs 112012.

Table 5: Household Gross Annual Expenditure

FARMS SIZE GROUPS	EXPENDITURE			DIFFERENCE 1988 AND 2011
	1988	1994	2011	
SMALL	15514	23520	99979	84465
MEDIUM	23767	30460	146823	123056
LARGE	52368	107535	203920	201552
OVERALL	24940	52656	137452	112012

Family expenditure includes food expenses, clothing, house repair or construction, education, health, social ceremonies and other unforeseen expenses. Most of the earnings about 59 percent is utilized for food supplies followed by education and clothing's.

Sample Respondents Annual Expenditure

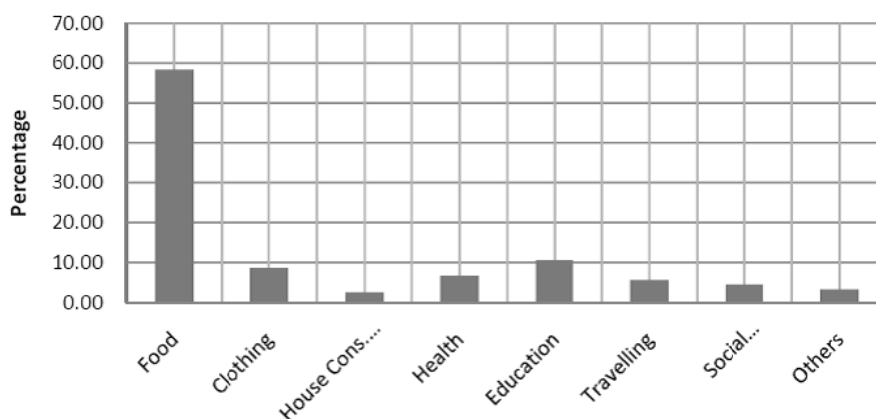


Figure 2: Sample Household Annual Expenditure in the Project Area.

The small farm households comparatively spend more on food items than the medium and large farms. It's very conspicuous that expenditure for education and health has been greatly realized and no hesitation for spending has been observed i.e. the respondents awareness level has considerably increased. Large size households spend significant portion of their earnings on travelling in comparison to small and medium size farm households. Annual expenditure have, over the years, increased significantly.

SOURCE OF ENERGY

Firewood and bio-gas are the main source of energy for domestic food processing. It is revealed that 34.4 percent of the respondents completely depend on firewood fuel. Likewise, 16.7 percent of the households utilize bio-gas only for the domestic consumption. Interestingly, not a single sample household revealed using kerosene for cooking. It appears people were gradually shifting from firewood to bio-gas and LPG and within the sample households; one family has revealed using electricity for cooking in combination with Bio-gas and LPG. Firewood in combination with bio-gas is cheaper and popular.

Considerable time, about 4.52 hours were expressed by the respondents in fetching firewood from the jungle. On an average 78 kg of firewood per family for a week seem adequate and to be hauled from an average distance of 3 km was reported by the respondents. Small farm size households consume more time in collection of firewood revealing that these households are more dependent on traditional energy consumption. Moreover, firewood consumption of large farm size household is significantly lower than the small farm size households.

A rapid decline of forest due too large consumption for firewood, construction activities, illegal encroachment, recurrent forest fires and over grazing have worried the local sample household residents. 65 sample households expressed concern about the unavailability or declined firewood from the forest. With declined forest product, a longer distance and consequently more time has to be spent to fetch firewood.

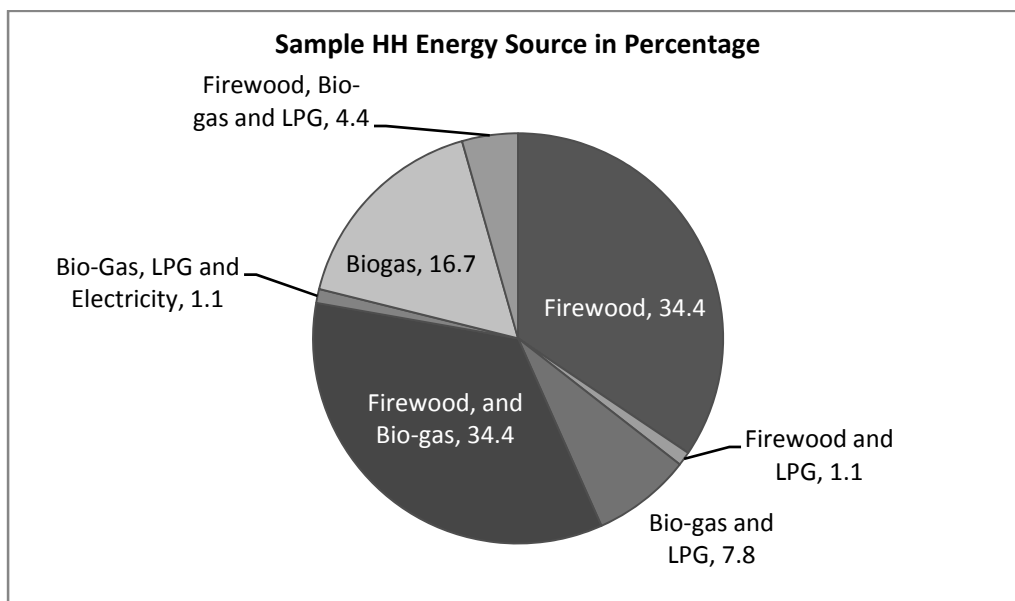


Figure 3: Household Energy Source in the Project Area

III- Economy of Farm

Farm Size

The land holding size of small and medium farm size have increased however, a considerable decline in large farm land holding were revealed in 2012 compared to that of 1994. Apparently, a redistribution of land within the project seem to be likely because of relatively better income of small and medium size households who likely seem to invest in land.

Table 6: Comparison of Average Landholding Size in Ha

Farm Size	Average Landholding size in Ha.		
	1988	1994	2011
Small	0.87	0.51	0.58
Medium	2.02	1.77	2.27
Large	5.64	5.52	3.75
Overall	2.1	2.56	1.36

CROP YIELD, CROPPING PATTERN AND CROPPING INTENSITY

Significant increase in crop yield mainly paddy, wheat and maize has been revealed from the sample households however with no substantial yield increment in Mustard and Lintel. The substantial increment is attributed to timely and adequately available irrigation, inputs and technology. However, for lintels and mustards conventional farming practice prevail i.e. low fertilizer input and mostly cultivated on the uplands without irrigation. Reliable irrigation supplement seem assured in the command area for the cereal crops.

Table 7: Comparison of Crop Production

Year	Paddy	Wheat	Maize	Mustard	Lintel
1988	2.176	1.05	1.3	0.685	0.799
1994	2.176	1.95	1.9	0.702	0.835
2011	5.23	3.79	3.75	0.735	0.81

There is no substantial change in the cropping pattern, the sample households still follow similar cropping pattern of Paddy-Wheat, or Maize-Mustard with two major crops. Paddy-Wheat or Maize - Mustard pattern of cropping has remained same for 1988 to 2012. A new cash crop, linseed, is popularly grown in the project area which was non-existent during 1988. Farmers are gradually shifting

more to vegetable farming and according to the sample respondents, cropping intensity of wheat is significantly declining over the years may be because of more people involved in non- agricultural jobs.

The overall cropping intensity reported by the sample household has significantly declined compared to 1994 except for large farm size. The revealed average cropping intensity of 156 percent is slightly lower than that of 1988 which was 161 percent. The cropping intensity has largely declined from 201 to 137 percent for small farms with small landholding. Likewise, the cropping intensity has declined from 207 to 141 percent; a decrease of 66 percent for medium farmers. Contrastingly to these, the cropping intensity for large farms apparently remains consistent with slight increasing trend over of 1994 cropping intensity. The massive decline in cropping intensity of small and medium farmers indicates ample and lucrative off-farm economic opportunities available in rapidly growing Lamahi market and nearby places.

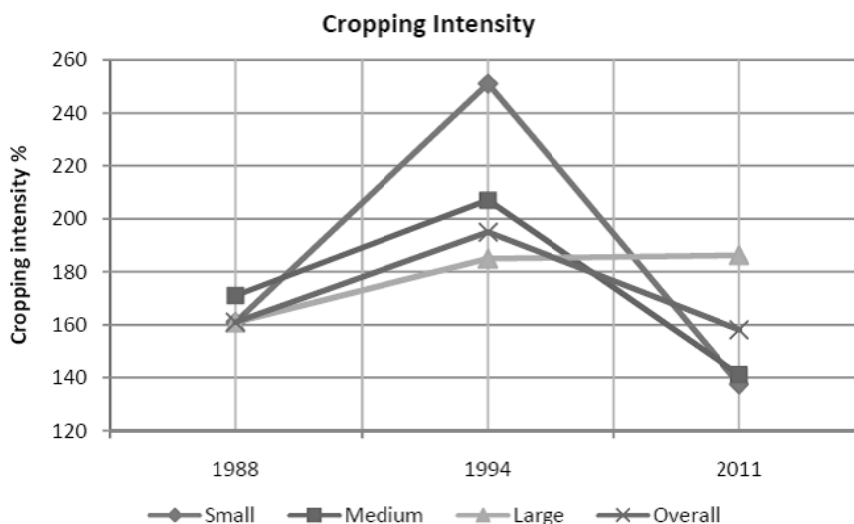


Figure 4: Comparison of cropping intensity.

LIVESTOCK INFORMATION

Livestock were part of the subsistence rural livelihood each household raising animals to meet their own requirements. No commercial farming except one or two small scale commercial poultry farming. Raising goats and pigs were common followed by he-buffalos and bullocks.

INPUT USE

Seeds

In overall 84.4 percent households use improved seeds with 38.9 percent purchasing from the market. Some 21 percent of the households purchased seeds from neighbor as well. Varieties of seeds for paddy commonly grown were Loknath, Sarjoo, Radha4, Gorakhnath, Hybrid, Shankar, Prithivi, Meghdoot, Chandani, US312 and D469. For maize Rampur, Arun and Pioneer were popular varieties whereas for wheat S-7B6 is popular in the project area. Using of hybrid seed is increasing.

Fertilizers

Use of chemical fertilizers has become popular among the farmers, with a reporting of 94.4 percent sample household farmers using chemical fertilizers in their farms. Chemical fertilizer is mainly used for paddy and wheat crops.

An average of 144 kg of chemical fertilizers appears to be used per hectare of farmland. Contrastingly, 18 percent of sample households expressed difficulties in obtaining fertilizers.

Manure

Production of manure mainly depends in the livestock per household and family size. In the project the sample households utilize manure mainly for growing vegetables followed by maize and other crops. It was revealed that in overall 82.2 percent of the households use an average of 208 kg of manure per Katha.

Pesticides

Farmers use pesticides very commonly to protect their crops as reported by 82.2 percent sample household farmers of the project. These pesticides are mostly used for vegetables and paddy crops. The commonly used pesticides in the project are Meta-cid. Anumet, Novan, Thyodine, Malathin etc.

Credit

Institutional credit facility users are increasing and according to the sample households 35.56 percent of farms have taken credit from the bank or from the co-operative. Most of the farms are using credit facility for crop production and livestock along with loan for business, education, foreign jobs, appropriate technology and social activity. Further revelation is that larger number of small farm size households utilizes institutional credits.

TRANSPORT, MARKET AND PROCESSING

Average distance of the sample households to the road head is 52.5 m and mostly linked by a vehicle road to the compound of the house. All the sample household farmers reveal that graveled road constructed by the project remarkably improved the transportation in the project area.

Nearest market from the project is Lamahi. The average distance to Lamahi is 2.4 km and mostly 51.5 percent of the farmers use tractors to transport their agricultural products to the market followed by porters. Mostly small size farmers carry their products to the market.

PROCESSING

Processing of farm goods is mostly done in the village mills and some farmers process their food grains in Lamahi market.

STORAGE LOSSES

Use of metal seed bins seem effective in preventing losses of food and seed grains. With use of metal seed bins the losses were about 2 percent. There was remarkable protection of seeds and grains. Among the sample households 33 percent of the respondents reported using metal bins to store seeds.

MARKET PRICES

The market price appears to increase unpredictably over the years. Paddy, wheat and maize and mustard prices have gone up significantly. An average of 648% percent price rise of agricultural commodities was noticed from 1988 to 2011. Shooting market prices have been observed with an increment up to 1755 percent in livestock as presented in Table 8.

Table 8: Comparison of Retail Prices

Details	Price increment in percentage from 1988 to 1994	Price increment in percentage from 1994 to 2011	Price increment in percentage from 1988 to 2011
Agricultural products	79.34	345.1	648.3
Animal products	65.72	436.9	808.2
Livestock	209.4	537.5	1755.4
Construction Material		380.5	

C - STATUS OF IRRIGATION SYSTEM

The Arjun Khola Irrigation System is smoothly functioning with farmers' regular maintenance. No major maintenance issues so far have been encountered. WUG support WUA for annual maintenance and repair works of main canal, head regulator and headwork.

The system however looks old and the gabion protection works of canal structures have been completely damaged and few drop cum outlets appear inappropriate and outflanked despite the sound quality of stone masonry and concrete structures.

No additional structures have been built to improve the water availability in the system. No discharge measuring devices installed in the river and intake head regulator. Volumetric assessment of irrigation supplies and relating to crop production, on farm water management and integrated crop water management were absent.

The access gravel road is maintained through VDC budget allocations. Expansion of internal roads links connecting to this main road were noted through individual initiatives of farmers.

The sample households study revealed satisfactory response except demand for improving water availability through additional supplement from Rapti. A link canal from Sonpur VDC, an extension of Parganna system dropping water at the upstream location of Arjun Khola Headwork was indicated as the new option. Few sample households suggested making a dam in Arjun Khola and making water available to Satbariya VDC in addition to supplementing Arjun Khola project.

In an overall response the sample households opine that the system needs major integrated rehabilitation with more focus on agricultural extension, training, and infrastructure automation and upgrading of the existing gravel road to a black topped one.

III- IMPACTS OF IRRIGATION DEVELOPMENT

Significant impacts in the project can be observed and revealed through the comparison of the project status of 1988 and 2012. Major impacts are broadly in irrigation management, living standard, irrigated agriculture and non-farming employment.

IMPROVEMENT IN IRRIGATION WATER MANAGEMENT

With improvement of irrigation infrastructures; headwork, intake, canal network and road, water could be swiftly diverted into the system without any technical hindrances and interruptions throughout these years. Farmers availed continuous supply of water except March to May where the supply dropped below 50 l/s in the river and rotational water distribution was practice. Water availability and irrigation management improved showing immediate increment in crop yield and productivity after the project completion. Project Impact Study (PIS 2012) revealed 81.1 percent of the sample households have expressed satisfaction with the system performance meeting their requirement timely and adequately even after 20 years of project completion.

Further, WUA expressed no difficulties in collecting the funds for maintenance of the system. The Water Users Group, WUG, collected water charges and a portion allocated to main canal and headwork maintenance. Branch and water course all were maintained by the respective WUG's. Internal resource mobilization appears to meet regular and simple maintenance activities. But after so many years with only minor maintenance works the system looks significantly old, damaged, deteriorated and inappropriate needing a major rehabilitation and improvement of the system.

The system operates on a traditional supply basis. All the branches and outlets should be installed with water measuring devices. The flow should be measured at the head regulator and in the river and allocation should be made more equitable. Water availability in the context of climate change have to be assessed for future time horizons to ensure consistent agricultural activities.

INCREASED NON-AGRICULTURE EMPLOYMENT

The PIS 2012 shows that 81.64 percent income of the sample household respondents comes from non-agricultural activities which include services, daily wages, business, remittance and others. During Project Benefit Evaluation Study, PBES 1994, non-agricultural income was only 20 percent which indicated little off farm economic activities available and people had no time other than agriculture.

But increased agriculture activities "with project" situation, increased the income level and significant time saving, which could be utilized in non-agricultural employment opportunities available in nearby Lamahi bazaar for additional income.

About 21 % of the sample respondent members worked as general or unskilled labors in Lamahi and around. Likewise, 15 % of the respondents work as high skilled labors such as masons, carpenter, electrician, plumbers etc. More importantly 38% of the respondent had at least one member involved in service in one or the other mainly as teachers, armed forces, government service etc.

So, improved irrigation infrastructure, adequate water availability, water management, improved inputs and technology increased the agricultural production, and ultimately the livelihood of the people. But in the recent years irrigated agriculture has remained stagnant or decreased slightly due to more profitable non-agricultural activities. However, it has to be realized that irrigated agriculture has built a strong and sustainable foundation of livelihood.

DECLINE IN IRRIGATED AGRICULTURE

Agriculture is the main stay of Nepalese economy. Together with agro-industries it continues to contribute about 60 percent of GDP. In Arjun Khola Irrigation project also, agriculture remained to be the mainstay of livelihood with more than 80 percent of income coming from Irrigated agriculture (PBES, 1994).

However, according to the latest Project Impact Study of 2012, this is no more true for Arjun Khola Irrigation Project. The study indicates significant decline in cropping intensity of irrigated agriculture despite considerable increase in per hectare crop yields. The average cropping intensity of 195 percent of 1994 has contrastingly dropped to 156 percent in 2012. It appears non-agricultural economic activities are more dominant sectors contributing to livelihood.

Traditional farming practices is losing importance and commercial farming using recent technology might be the need to be addressed to improve the cropping intensity and productivity in the pressing context of agricultural labor scarcity in the area. Farmers have started vegetable cultivation in small scale despite ample scope of benefits from irrigated agriculture.

IV - CONCLUSION

The population of Chailahi VDC has more than doubled in 24 years. The influx of migrants in Lamahi is rapidly increasing. Education status of the project area has remarkably improved from an average literacy rate of 17 percent in 1988 to towering 80 percent in 2012. Household size of average of 10 in 1988 has reduced to 6.43 in

2012 with an average land holding size of 1.36 ha per family of sample household taken in consideration.

Land tenure practice have been reduced to owner operators, tenants, and owners cum tenants. Few Kamaiya, a tradition despite having been abolished in 2000, still exist in the project area. Paddy- Wheat is the main cropping pattern in the area, along with maize, pulses and oilseeds. Cropping intensity appears to decline notably despite increment in crop yields. The average cropping intensity of 195 percent in 1994 has declined to 156 percent in 2012 which is lower than the cropping intensity of 161 percent of household benchmark survey of 1988. Well-paid non-agricultural activities are abundantly available in Lamahi and nearby locations.

Benefits from agriculture remain to increase compared with that of 1994 and 1988. But the overall contribution of agriculture to the annual gross income has substantially reduced in 2012 to only 18.36 percent. Off-farm income has dominated the overall income of the sample households in the project area. Main contributing sources of income include service, general and skilled labor works, foreign jobs, business and other related works. Among these sectors income from service, general and skilled labor contributes largely to the overall income. The average annual per capita income of the sample households is more than 2680 USD, much higher than the national per capita income of 735 USD.

Nearby market Lamahi, the rapidly growing economic hub of Dang District, is easily accessible to the project. Large government funded infrastructure development projects were implemented in the vicinity of Lamahi in addition to the rapid construction activities in the area providing ample job opportunities to the locals and nearby population.

A food deficit area prior to 1988, is revealed a food surplus area after completion of the project in 1994 and continues to remain food surplus area in 2012 also. Increasing expenditure trend because of increased income has been noticed and the expenditure is mainly on food followed by education, clothes, health, social ceremonies and travelling.

Irrigation system is functioning smoothly with almost no operation and management hassles. Water is adequately available for continuous supply for monsoon and winter crops. From Falgun to Jestha, a rotational water management is utilized. Despite rotational water distribution arrangement water remains inadequate. WUA

is functional and implements operation and maintenance activities. Strong internal resource mobilization mechanism exists in the project. The Water Users Group (WUG) of each village collect irrigation charges and allocate for maintenance of main canal and headwork in addition to maintaining the field courses and channels. The prevailing irrigation charges vary from NRS 180 to NRs 1050 per hectare depending on the location.

Farmers revealed excellent irrigation system performance: 81 percent of the farmers reported the project meeting their irrigation requirements. Mainly family members are involved in agricultural and livestock activities. Agricultural surplus labors are consumed in the local market for non-agricultural activities. No significant commercial farming observed in the project area except one or two innovative farmers going for small poultry farming schemes.

Substantial impact on energy consumption in cooking has been observed. By the end of 2012 there are substantial bio-gas and LPG gas users in the project area. The farmers were found to be highly motivated by the project initiative of 1988. In the project area, 34 percent of the sample household farmers use bio-gas plants for cooking and some 31 percent use both bio-gas and firewood for cooking. Remaining 35 percent of the households depend only on firewood as source of energy. Farmers' awareness has substantially increased to conserve forest and biodiversity in order to maintain clean and healthy environment.

The excellent road network inside the project has made transportation of agricultural products easier and cheaper in the project area. About 30 percent of the sample households possess motorbikes and 79 percent of the sample farm households have bicycles.

Modern electronic gadgets are becoming popular among the project locals. Cable television, land line and mobile phones are also common among the people.

The physical status of irrigation infrastructure are in satisfactory condition. Concrete and masonry structures remain intact and functioning smoothly and appropriately with no tempering or damaging by the unsatisfied users. However, the gabion protection works of canal structures have completely deteriorated and damaged. Head regulator and under sluice gate installations appear rusty and faded with discolored paints. Farmers have indicated that weir crest level to be significantly lower than the intake head regulator floor. In order to completely

divert the winter flow farmers have to raise the weir crest using locally available material mud and wood.

The water resource management of Arjun Khola Irrigation Project from a livelihood prospective revealed a strong link between irrigated agriculture and rural livelihood. The above outlined impacts of irrigated agriculture is remarkable in transforming rural livelihood. However, the declining irrigation intensities show a shift in livelihood activities from agriculture to non-farm sector. Notably, the 80% agriculture based household income in 1994 has slid startlingly to only 18.36% in 2012. In a nutshell, the project has stimulated initiatives to bring a clean environment, good sanitation, improved income due to increased agricultural production and overall improvement in living conditions gradually shifting from agriculture to other non-farm sectors for livelihood.

RECOMMENDATIONS

Arjun Khola Irrigation System improvement as before through integrated project approach is recommended. The project has completed more than 20 years of operation without any external resource mobilization for operation and maintenance activities. The rehabilitation should include infrastructures improvement and construction; agriculture extension, training and research; appropriate technology, institutional development programs, black topping of gravel road and automation in water management.

The study of alternative options to improve water availability in the Arjun Khola catchment basin should be initiated. There are two option to analyze, first the study of construction of Dam in the upstream stretch of Arjun Khola tapping the monsoon flow and utilizing the same for winter flow in Arjun Khola Irrigation Project and at the same time providing irrigation to Satbariya Village Development Committee. By this, rain fed land of Satbariya will also come under irrigation. The second option is extension of Praganna Irrigation Scheme canal along the Chure foot hill and dropping the water into the Arjun Khola which will be picked up by the headwork of Arjun Khola Irrigation Project.

Installation of water measurement devices or calibration of canal structures for volumetric assessment of water in the system. A stream gage to be installed in the upstream of headwork to measure the stream discharges. Farmers are paying

Irrigation Service Fee (ISF) to meet maintenance requirements of the system with no external assistance from other agencies is an exemplary deed. It's recommended that the project should be assisted in modernization. Successful projects such as this should be taken up as pilot project to inject recent irrigation and agricultural technology, and institutional strengthening.

Developing Lamahi as the gateway city of Dang, Salyan and Rukum creating more opportunities to the local and nearby people. The surplus agricultural production can be supplied to these places in addition to supply in other locations. Furthermore promotion of appropriate technology like bio-gas to reduce the pressure on forest and environment.

Irrigated agriculture is still the life line of farmers of the project and promotion of these activities in more commercial way is the present requirement to control the declining irrigated agriculture.

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GMIS for Sustainable Planning and Management of Irrigation Systems

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Abstract

Agriculture is the major economic sector of Nepal and irrigation is one of the major inputs for agriculture. There is about 2.64 million hectares of cultivable land out of which about 1.766 hectares is estimated to be irrigable, simply considering the available water sources and their potential command area. By the end of the Fiscal Year 2012/13, the total cumulative irrigable area provided with the irrigation infrastructure is estimated to be about 1.331 hectares. However, due to the scarcity of water in winter, the area with year round irrigation facility is estimated to be only about 36 %. In terms of the technologies, even the land, so far classified as non-irrigable, can be more or less irrigable by some means of technologies.

With the priority of the government to agriculture and irrigation being the basic input for it, the demands for irrigation from every corner of the country is increasing. However, the percentage of national resource allocation for irrigation sector is decreasing and the gap between the demand and the allocation is increasing. In order to cope with this situation, focus should be given to allocate more national resources to this sector and also to adopt priority based planning. Besides, due to the lack of adequate resources and proper management system, the irrigation systems are not efficiently delivering the water to the envisaged command area. These all urge that we should have an efficient system for proper planning and management of the irrigation systems.

GIS based Management Information System (GMIS), a modern computer based spatial information system that can manage, analyze and retrieve all the spatial and associated attribute information related to the irrigation system, whether to be planned or existing one, can be potentially applied for the efficient planning and management of the irrigation systems. This paper conceptually illustrates how the spatial information such as water sources, canal systems, command areas and other geo-physical settings and the associated agricultural, environmental and socio-economic information related to the irrigation systems can be integrated, managed and evaluated or analyzed for planning, monitoring and management of the irrigation systems in an efficient and sustainable way.

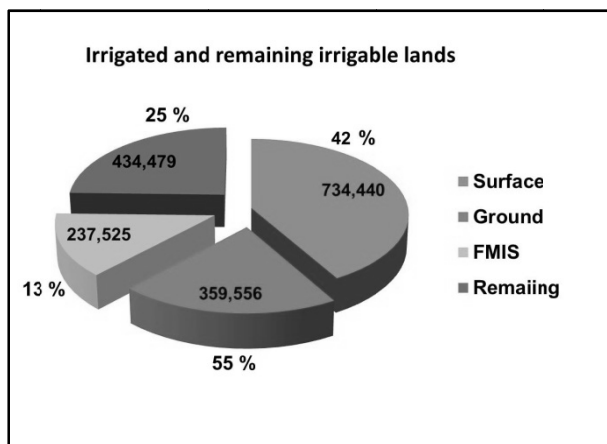
1. Introduction

Access to irrigation is key to increase agricultural intensity and food production in order to maintain food security. Irrigation has been established as the prime contributor to improving and stabilizing agricultural production in the country. Despite government efforts to promote irrigation and agriculture, the overall impact of irrigation is limited and agricultural production remains at subsistence levels. The National Water Resource

Strategy envisages that reliable irrigation service expanded on the basis of sustainability by 2017, and appropriate and efficient irrigation available for the optimal use of irrigable land in a sustainable manner by 2027. Accordingly it has set out a number of activities including integration of irrigation planning and management with agricultural development; improvement in the planning and implementation of new irrigation systems; and management of existing systems. It has been targeted that by 2017, 80% of all irrigable land served by irrigation and year-round irrigation increased to 66% of irrigated land. Similarly by 2027, 97 % of all irrigable land served by irrigation and year-round irrigation increased to 90% of irrigated land. It has focused to improve the planning of new irrigation schemes with the identification and ranking of potentially viable projects based on sustainability, cost-effectiveness and equitability. In the long term, activities are to be focused on ensuring the availability of efficient, reliable and sustainable irrigation to all irrigated areas.

2. Irrigation potential and present status of irrigation development

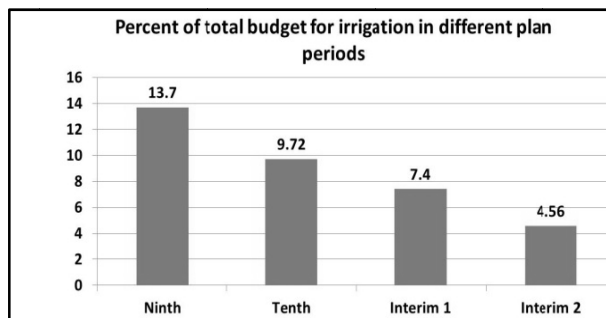
About 67% of the cultivated land (1,766 thousand ha out of 2,641 thousand ha) in Nepal is reported to be irrigable. There is ample opportunity for expanding and improving the irrigation facility not only to all irrigable land but also to all cultivable land to ensure better food security. The distribution pattern of irrigable land in different ecological regions indicates that out of the total cultivated land,



about 24% is in the mountains, about 34% is in the hills and almost all the cultivated land (1,356 thousand ha out of 1,359 thousand ha) in the terai are irrigable. The net irrigated area for which infrastructure was available is estimated to be 1.331 million ha as of 2013. Irrigation with ground water sources through shallow and deep tube wells covers about 0.36 million ha which is just about 30 % of its potential (0.91 million ha including 0.72 million ha with shallow tube wells and 0.19 million ha with deep tube wells) in the terai and inner terai. There is also good potential to utilize ground water irrigation in conjunction with surface irrigation system to ensure reliable service throughout the year. The coverage with government- intervened surface sources is about 0.734 ha and the rest 0.238 ha is from non-intervened traditional systems managed by the farmers. Out of the total irrigated area, only about 0.48 million ha (36 %) of land had round-the-year irrigation facilities and the irrigation efficiency is also assumed to be below 30%.

3. Major challenges and future direction

The major challenges of irrigation sector are to expand the service to the remaining irrigable land and even to all cultivable land exploring all the possible options and technology. Besides it is equally important to make the existing and future systems more reliable to have optimal irrigation service as required round the year for better productivity. The reliability of irrigation services can be improved by availing the required irrigation water round the year through the conjunctive use of ground water irrigation and development of storage and inter basin water transfer systems in one hand and at the same time it needs to improve the irrigation efficiency with proper maintenance and modernization or rehabilitation of the traditional and old systems.



Accordingly more demands are coming from the farmers for new expansion as well as for the rehabilitation of the medium type surface irrigation including the non-conventional systems and also for the ground water irrigation through shallow and deep tube wells. In order to address the demands of the farmers, the numbers of projects undertaken are increasing but the resource allocation not being on that pace, the resource gap has been increasing. With the present trend of resource allocation and number of projects undertaken, minimum 5-10 years is required to complete a project which not only delays in getting the benefit of the investment but also involves various complexities related to financial and contractual managements. Similarly, due the insufficient resource allocation for maintenance and rehabilitation, the efficiency of the system is decreasing and the systems will be more deteriorated and ultimately even collapsed. To cope with all of these challenges, it requires more investment and hence need to increase the annual allocation to the extent possible in one hand and also to prioritize the investment with proper planning for the development and management of the irrigation systems.

4. GMIS for planning and management of irrigation systems

Planning and management of irrigation systems deals with the collection, integration or analysis and visualization of various spatial information such as water sources, canal alignments, command areas and other geo-physical settings and the associated agricultural, environmental and socio-economic information. Geographic Information System (GIS) is designed basically to capture, store, manipulate, analyze, manage and present all types of geographical data whereas Management Information System (MIS) is an organized approach to manage the information related to the business of an

organization in making operational and strategic decisions. The basic objective of MIS is to design and implement procedure, processes and routines that provide suitably detailed reports in an accurate, consistent and timely manner.

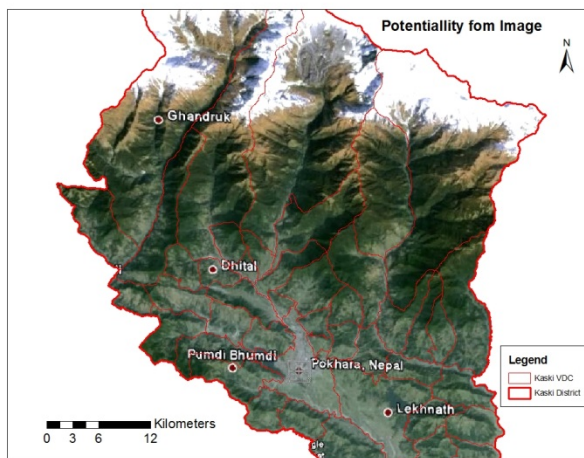
GIS based Management Information System (GMIS) is the well-structured combination of GIS and MIS designed to continuously gather relevant data both the spatial and non-spatial which is then processed, integrated and stored in a centralized database. The database is constantly updated and retrieved as support to make decisions. So, GMIS can be a good tool to integrate, manage and evaluate or analyze the relevant information for planning, monitoring and management of the irrigation systems in an efficient and sustainable way. It has already been initiated to use GMIS by DoI as facilitation to the implementation of CMIASP and IWRMP sub-projects. They are designed basically to manage sub-project level information and more project specific with limited functionality (sub-project preparation) for overall planning and management of irrigation systems. The basic modes of planning and management of irrigation systems and the potentiality of GMIS application are conceptually illustrated in the following sections.

4.1 Mapping of the agricultural development potential

Irrigation is required for agricultural production and hence the areas potential for agricultural

development/cultivation (soil type and fertility, topography, climatic conditions, crop suitability, access to agricultural inputs, etc.) are to be identified along with the spatial distribution of the cultivable lands, sources of water for irrigation, settlements/market facilities, road access and other socio-economic and environmental

information within the water basin. Some of the information which are more or less static like the drainage system, administrative boundaries, topography, etc. can be generated through the reliable secondary sources and those like land use, specifically the cultivated land, irrigated land including the source and alignment of irrigation systems can be generated primarily with the updated topographic maps, images like the Google images or more precisely with some high resolution satellite images.

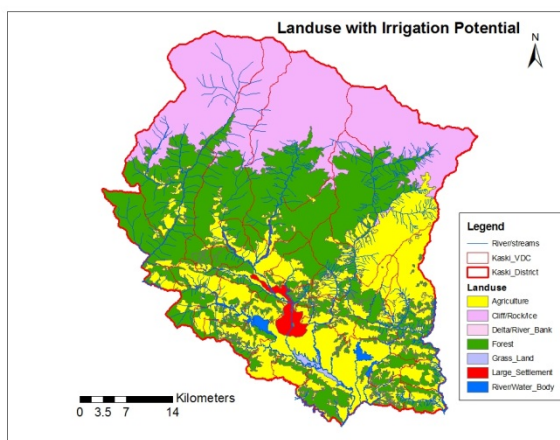


4.2 Spatial inventory of the irrigation systems

Once the agriculture development potential along with all cultivated and irrigated land in the basin is identified, the spatial inventory of the irrigation systems within the basin are prepared along with the most important attribute information of the systems (type, year of construction/rehabilitation, command area, design discharge, idle length, etc.). Information on the structural conditions and performance/efficiency along with the structural interventions required for maintenance or rehabilitation are also collected and maintained. The inventory of the irrigation systems needs to be updated, preferably every year and if it once established, can be updated and maintained efficiently with GMIS.

4.3 Perspective and periodic planning with prioritization for implementation

Integrating the information on agricultural and irrigation development potential, specifically the cultivated lands, irrigated lands and the potential sources of irrigation, the cultivated lands not provided with irrigation facility yet can be easily identified. Looking into the available sources of water for irrigation (river, stream, spring, rain water harvesting, ground water, etc.), the potential options to irrigate the uncovered sizeable cultivated



lands can be assessed. These all list out the potential irrigation systems to be developed within the basin. Then the identified systems are to be prioritized based on some of the important and objective criteria (cost per ha, productivity, cropping intensity, etc.) which are attributed to each of identified schemes. Looking into the trend of resource availability/implementation capability and the prioritization of the schemes, the periodic and annual planning with prioritization for implementation can be done in an efficient and more transparent way.

4.4 Maintenance management

Maintenance of existing irrigation system is equally important to keep up their performance in delivering the irrigation service smoothly. Maintenance planning can also be done more efficiently with GMIS by maintaining the inventory of the systems with information related to performance (irrigation efficiency, irrigation coverage against the

designed command area, overall condition of the system, etc.) and the maintenance requirements (minor/major maintenance, rehabilitation) with structural interventions. Then the systems can be prioritized for maintenance based on the importance factors of the system such as productivity, cropping intensity, farmers' contribution, degree of deterioration and the consequences if not maintained on time.

5. Conclusions

There is still need to expand the conventional irrigation services to about 25 % of the irrigable lands and further to all the cultivable lands exploring the suitable non-conventional techniques. Besides, the efficiency of the existing systems needs to be maintained or improved with proper maintenance and rehabilitation. The resource allocation in this sector seems far behind the real need resulting delays in project completion and getting benefit to the farmers. In this context, the annual resource allocation needs to be increased and also the projects, both the new construction, rehabilitation and maintenance, shall be implemented on priority basis with proper planning. GMIS, which is a well-structured information management system, has capability to integrate, analyze and visualize all the spatial and attribute information related to planning, management and prioritization and hence can be used as an efficient tool for the sustainable planning and management of irrigation systems.

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Improving Irrigation efficiency through alternate wet and dry irrigation method of Water management for paddy cultivation

Ramashraya Shah¹¹ and Indra Lal Kalu¹²

Abstract

Actual irrigated area is often less than the design area in most surface irrigation system, and the climate change has further reduced dry season water availability making farming more vulnerable. Hence improving irrigation efficiency has been set as the means to extend year round irrigation by National water plan (2005). Reduced irrigated area is also created due to wasteful irrigation practice with lower irrigation efficiency in distribution and field application which is less attended.

To cope with situation and to improve productivity, Alternate wetting and drying (AWD) method of water management has evolved is a promising option for paddy cultivation; It is practiced in SRI method as well. This has been demonstrated in some irrigation schemes in Nepal by reducing frequency of irrigation water delivery. This method, in which only about a quarter is water is applied compared to traditional practice, has produced spectacular result especially in spring paddy when water is scarce. This can be expanded to large area provided there are distribution networks to field level.

The paper presents brief synthesis of finding of the demonstration done compared to traditional practice in Nepal and estimates the possible saving of irrigation water.

1. Context

Water is essential for growing crops and so Irrigation schemes were developed. Irrigation infrastructures have been developed to create potential to irrigate nearly half of total arable land 2.64 M ha (DOI Handbook 2071). But in fact the actual irrigated land is lower than the stated potential. Even in summer (rainy season) when there is adequate flow in the stream, only around 70% of created potential gets irrigated. In winter stream flow also decrease and actual irrigated area decreases to less than 40% (Agrawal, 1996), and it falls under 16 % in spring. Low performance is more in large irrigation systems compared to small FMIS. It appears to be caused due to shortage of water at the source and also excessive wastage mainly in field distribution and application. Much is wasted as seepage, runoff and deep percolation. And another reason is lack of water distribution system (field channel network to plots) and the schedule of water delivery. This increases unreliability and as a result farmers resort to apply more water for storage for

¹¹ Farmer resource person for demonstration of AWD

¹² Irrigation management specialist for ADB TA 7967 -REG MFLW

later. There is wrong notion of applying cold freshwater continuously will improve yield, and as farmers need not pay for irrigation water used, so more water is used by head reach farmers at the cost of tail reach users.

Currently irrigation is utilizing around 80% of freshwater (WRS, 2002) and due to increased demand of water for other purpose water allocation for agriculture is going to be reduced and further due to effect of climate change water availability at stream is expected to be reduced. By 2025, the per capita available water resources in Asia are expected to decline by 15–54 percent compared with 1990 (*Guerra et al. 1998*). However the demand for food and fiber is going to increase and so there is pressure to grow more food with less water. National water Plan (2005) therefore has targeted to increase irrigated area by increasing current irrigation efficiency from 35% to 50%.

Nepal is a mountain country with little arable flat plains in the Terai. Soil in hill slopes and foot hills is mostly colluvium comprising thin layer of coarse textured soil. Even in valleys in Terai plains at the northern belt, the fine textured soil layer is generally thin over coarse textured sand or gravels. This belt is the recharge zone for groundwater. And as one proceeds south, fineness in soil increases. It can be seen in soil type of Bagmati Irrigation command area. Remarkable land is of coarse texture ranging from sandy loam soil. And the deep percolation loss in soils of BIP ranges from 10 mm/day to 900mm/day (*Nippon Koei et al, 1995*). Similarly high percolation loss was observed in Sikta Irrigation command area. So the estimate of taking water duty of about 1 lps/ha water duty assuming 2.5 mm/day percolation is not enough.

2. Water requirement for Paddy:

The water requirement consists of: (1) 150–250 mm for land preparation; (2) about 50 mm for growing rice seedlings in the nursery before transplanting; and (3) 500–1,200 mm (5–12 mm per day for 100 days) to meet the evapotranspiration (ET) demand and unavoidable seepage and percolation in maintaining a saturated root zone during the crop growth period (*Guerra et al. 1998*). The actual amount of water used by farmers for land preparation and during the crop growth period is much higher than the actual field requirement. Paddy farmers often store water in their fields as a back-up safety measure against unreliability in water supply. Also, there is often field-to-field irrigation. This leads to a high amount of surface runoff, seepage and percolation accounting for about 50–80 percent of the total water input to the field (*Sharma 1989*).

Alternate Wetting and Drying Irrigation (AWDI) is one method that can increase the productivity of water at the field level by reducing seepage and percolation during the crop-growth period. Controlled irrigation and drainage is in practice since long in developed countries like Japan, Korea, India etc.

3. AWDI Practice:

In AWDI method water is applied and then soil is puddled, then land is leveled using a local land leveler and a shallow depth of water (5 cm) is applied along with first dose of nitrogen, and full dose of phosphorous and potash fertilizers. Then 2-3 seedlings are transplanted at the spacing of about 20-25 cm. Following this, soil is maintained moist

with little standing water for about 5 days after which land is drained and kept dry for 15 days for clayey soil (for sandy soil it can be 10 days). During this period, land may get cracked and plant may show temporary wilting symptom. Then 5 cm water is applied and soil is kept moist for another 5 days. Plants absorb more water and then second dose of urea (fertilizer) is applied. Then again field is drained and kept dry for another 15 days. Then the same practice of keeping land wet for 5 days and left it to dry 15 days is maintained until about 3 weeks before the harvest time when field shall be drained to permit harvesting. This way by keeping land dry for a period of 2/3 rd time deep percolation loss is reduced and so water saving of 20-30% can be achieved.

Systematic rice intensification (SRI) method of rice cultivation also adopts alternate wet and dry practice, but here only one seedling of 8-15 days old seedling is transplanted at one hill at wide spacing 25 cm or more.

4. Results of field Demonstration

In Nepal field demonstration of AWD and SRI for spring paddy and also summer paddy in few irrigation systems were conducted since around 1996. Here a brief description of the practice, results and the benefits and requirement for adoption is listed below.

A comparative test was done between traditional practice (continuous wetting) and AWDI in Panchkanya Khageri and Kankai for spring rice and summer paddy. The results of the experiment is as follows:

Table 1 Comparison of paddy yield and water application between AWDI and traditional practice.

	Panchkanya		Khageri		Kankai	
	Traditional	AWDI	Traditional	AWDI	Traditional	AWDI
1996/97						
Yield Kg/ha					5184	5312
1997/98						
Yield Kg/ha	4736	4864	6272	6272	3712	4736
water applied	77 days	34 days	77 days	34 days	57 days	20 days
1998/99						
Yield Kg/ha	3968	4736	3904	4032		
water applied	81 cm	36 cm	81 cm	36 cm		

Source: Adhikary, S

Similarly in 2005 research demonstration of SRI and AWDI was conducted for summer paddy in Praganna Irrigation system. The result of experiment in Yadav,(2006) is as follows:

Table 2 Comparison of Paddy yield & tillers between AWDI and SRI practice.

Location	Seed variety	SRI		AWDI	
		No. of Tillers	Yield (Mt/ha)	No. of Tillers	Yield (Mt/ha)
Tikuligarh	Bindeswari	45	9.72	24	8.46
	Rampur Masuli	46	11.25	35	9.54
Arnahanpur	Bindeswari	30	9.74	23	8.25
	Rampur Masuli	34	10.86	32	9.11



Photo1. Number of Paddy Tillers in SRI method.



Photo 2. Farmers are using rotary weeded in paddy field adopting SRI method.

Likewise in Kailali District, SRI in few food deficit villages and the results of demonstrations in farmers field school is shown in Table 3.

Table 3 Comparative results of Paddy Yield across different farmers field school in Villages of Kailali district

S.N.	Field School Location	Variety	SRI Method		Conventional Method	
			No. of Tillers/hill	Yield (MT/ha)	No. of Tillers/hill	Yield (MT/ha)
1	Phalmanpur	Sunaulo Sugandha	35	7.5	5	3.5
2	Ramsikharjhala	Sunaulo Sugandha	45	7.8	6	4
3	Pawera	Radha -4	56	6.9	8	3.3
4	Phulbari	Jaya	50	8	7	3.7
5	Darakh	Radha-4	55	7.5	9	4
6	Khailad	Sabitri	58	8.2	9	4.5

Source: Khadka(2013)

5. Discussion

In general, both AWDI and SRI methods allows keeping field dry for about 10-15 days compared to traditional practice of continuous flooding, and permits irrigation water use is generally reduced by 25-50% as water is managed to maintain mostly aerobic soil conditions¹³. Similar results were observed in other studies too. AWDI using the proposed irrigation schedule of 10 wet days alternated with 10 dry days used less water (29%less water) without significant reduction in grain yield Chapagain & Riseman (2011). And yield is more compared to traditional practice. It is clear that farmers can continue to cultivate rice where water is becoming scarcer or rains unpredictable, and can mitigate losses from late monsoons or less rainfall. Less water used at the head of canals means more water is available for farmers at the end. Water can be freed up for other crops and people, and for the maintenance of natural ecosystems. There exists technology of efficient paddy cultivation technology requiring less water which can support to expand actual irrigation area at least in summer to designed area by increasing crop yields and farm income.

But to make farmers adopt this method, farmers need reliability of delivering water in time and quantity which is possible under well-developed water management system with channel networks to every plot, and field plot should be level. This can be done by supporting administration of reliable water distribution schedule and providing supports/incentive to develop field channels and also implement precision land leveling.

The main benefits of AWDI are:

1. Reduced water use to an order of one half & less depending on soil permeability.
2. Increased number of tillers
3. Less insects problem
4. Less lodging problem due to strong stem
5. More tillers and increased yield
6. Effective utilization of nutrients and so less leaching of applied nutrients.

Farmers do not adopt these methods outright for few constraints. Some of these are:

1. Farmers feel risk that yield will be reduced.
2. Weeding manually is costly and labor is not available
3. Skilled labor shortage for line transplanting

¹³ Africare, Oxfam America, WWF-ICRISAT Project (2010). More Rice for People, More Water for the Planet. WWF-ICRISAT Project, Hyderabad, India.

6. Conclusion

Farmers should be trained by demonstration to believe that maintaining standing water continuously is not only unnecessary but also reduces yield, or in other words, when paddy is grown as aerobic crop, it produces more yield. And to reduce added drudgery, rotary manual weeding machine which is being used to weed out or even improved machine should be promoted; and similarly simple line trans-planting tools should be made available. These methods not only reduces water application requirement but also increase food production and farm income.

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Spill energy From Micro hydropower Plants for Small Scale Lift irrigation in hill and Mountain region—An Untapped Synergy

- SURAJ BARAL¹⁴

Nepal is mountainous country with most of its land covered by hills and mountains and blessed with more than 6000 rivers & rivulets. Out of 2,642,000 ha of cultivable land in the country nearly 33% is categorized as non-irrigable. Till date, around 17 % of total cultivable land has all the year round irrigation. Most of the irrigation system uses conventional technologies such as canals, diverting river, small stream etc. There are few non- conventional Lift Irrigation (NC-LI) schemes in hilly and terai region of the country. Most of NC-LI do not primarily focus on high value crop production and effective market linkages which makes them unviable in many cases. Moreover, lack of regular operation and maintenance, implementing water levy etc has been seen as major problem in NC-LI. On the other hand, Micro hydropower plants (MHP), promoted by AEPC, have been able to electrify more than 168,000 households in rural villages of hill and mountain region through more than 700 such plants. Several studies have revealed that the utilization factor of MHP is only 30% as the consumption occurs mostly during morning and evening peak hours. This has resulted in low revenue which further raises concern on the long run operation of the MHP. The utilization of MHP can be increased to around 90% through effective demand management. LI powered from MHP in hilly and mountain region could revolutionize the agriculture production, uplift rural economy and increase long run operation of MHPs. The paper entails technical, business and socio-economic prospect of utilizing spill energy from micro hydropower plants for LI and uplifting rural indigenous community through enhanced utilization local resource potential based on the study conducted in Simalchaur -4, Burtibang VDC, Baglung.

BACKGROUND

Agriculture is the Nepal's principal economic activity as the sector still employs more than two third of the population contributing around one third to the GDP. The productivity of this sector is heavily hinged upon subsistence farming of largely cereal grains on fragmented landholdings highly depended on the monsoons. Growth of agriculture sector, which is directly linked with majority of common people livelihood and could widely impact poverty, inclusive growth, food security and employment in the country, has remained stagnant over the past two decades. Nevertheless, it has also not been able to produce sufficient food to meet domestic demand leading to food security

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issues in the country. Though several policy to grassroot level issues and challenges such as low labor productivity, low production yield, less attention to commercialization etc attributed to stagnant growth and food insecurity in the country, lack of irrigation is the fundamental cause.

The total land holding of the country is 2.6 million Ha (~16% of total land area of the country i.e 14 million Ha). Out of total land holdings area, around 94.1% is arable and 5.9 % is considered as non-agriculture land, and around 68% of total land holdings is considered irrigable. Terai (plain) belt hold major portion of 55% of the total arable land. Hill and Mountain region holds 37% and 8% of total arable land respectively. In terms of potential irrigable land areas, around 76% lies in terai region and rest lies in hill and mountain region. However, all the year round irrigation has reached up to 17% of total arable land until present times. Out of total irrigated land of 926,106 ha, 85% is in terai, 13% is in hill and less than 2% is in mountain region. In terms of total land holdings, only 13% of arable land holding in hill and mountain region is irrigated. Technology wise, 77% of irrigation system are surface irrigation, 22% are ground water irrigation and remaining 1% is non-conventional system. The data indicates that huge portion of arable land, mostly in hills and mountains still rely on monsoon and the technology suitable for hill and mountain i.e NC-LI is very limited. Number of rivers and streams pass through the hills, their utilization in most cases is impossible without pumping as land elevation is higher than a canal or stream sources. Often canal alignments have to pass through rocky or landslide-prone areas. Likewise, in the Terai zone (Bhabar), the groundwater table is usually deep and normal shallow tube-well drilling techniques are not feasible in all locations. NC-LI could be instrumental for such region.

On the other hand, Micro hydropower plants (MHP) remains prominent technology for isolated electricity supply in rural hilly and mountainous areas where extension of grid is not possible in near future. Till date, AEPC has installed more than 700 MHP with installed capacity of more than 1 MW in rural areas of Nepal and is planning to install such plant with cumulative capacity of 25 MW in five years through National Rural and Renewable Energy Programme. Several studies have revealed that only 30% of the total capacity of the micro hydropower plants (MHPs) has been utilized. The utilization is high primarily during morning and evening peak hours for lighting purpose, small household appliances and other various small commercial and productive end uses such as grocery shops, hotels, photo shops, schools for operating computers, agro-processing and other small village enterprises. Almost 70% of the electricity generated from MHPs is not being used in off peak hours (day time off peak hours: 8:00 am to 5:00 pm, night time off peak hours: 9:00 pm to 5:00 am). Hence, MHP remain idle during off peak hours. Low utilization means higher low revenue for MHP which raises serious questions on the financial sustainability of the MHP. However, establishment of enterprise / improvement of existing enterprise which create demand for spill electricity could provide win-win

situation for both MHP and community as it will increase the revenue for MHP, open new employment avenue for community, and promote green economy in rural areas.

Summing up, irrigation is one of the basic factors affecting the agriculture production and providing irrigation in hilly and mountainous is a daunting task without having access to electricity. MHP operating in hilly region has sufficient amount of spill energy which could power LI in rural hilly areas of the country. Such LI can uplift rural economy through increased agriculture production and increase effective utilization of water resource. The paper entails technical, business and socio-economic prospect of utilizing spill energy from micro hydropower plants for LI and uplifting rural indigenous community through enhanced utilization local resource potential based on the study conducted in Simalchour -4, Burtibang VDC, Baglung.

LIFT IRRIGATION IN NEPAL

LI scheme are those scheme in which an appropriate quantity of water would be raised by means of a lifting device from a dependable source to an appropriate height for irrigation of an area located at a level higher than that of the water source. In conventional LI scheme practice, water is released at an elevated location so that irrigation of the desired area is performed under gravity flow through open channels or buried pipelines but in non- conventional lift irrigation system, micro irrigation system such as sprinkler and drip irrigation systems are integrated. Non-Conventional - LI project that includes a range of technologies including trickle and sprinkler irrigation (often of vegetables), rainwater harvesting, dug well, piped water schemes (including multi-use schemes) and small-scale lift pump systems. The advantage of LI is that land at higher elevation can be irrigated and will ensure the efficient utilization of water. In Nepal, prospect of developing lift irrigation is at large as the scheme is suitable for all kind of landscape. More importantly, in hilly and mountain areas of Nepal where land elevation is higher than that of water source, fragile geology, and dominant traditional agriculture practices.

Such NCI -LI were commenced through the Agriculture Development Bank Nepal (ADBN, now ADBL) and a number of international/national NGOs since mid-1990s, particularly CARE Nepal, CEAPRED, IDE and SAPPROS. The institutionalization and main streaming of NCI- LI were concluded after the establishment of Non-conventional Irrigation Technology Project (NITP) under DOI in 2003. In recent year, NITP has demonstrated some good examples of partnership with NGOs and the private sector in water acquisition, and technical support for water application technologies. Likewise, the Department of Agriculture (DOA) under its small-scale irrigation program is involved in supporting development of cement or plastic lined pond irrigation, water lifting devices, such as diesel or kerosene pump sets, electric motors and treadle pumps. Various community-based organizations (CBOs) have also been introducing micro-irrigation

technologies in locations all over Nepal. Till date, around 13,011 ha of land in hill and mountain region of Nepal has been irrigated through around 21,000 NCI scheme. The contribution in total irrigation through NCI-LI is negligible.

METHODOLOGY

The paper constitute the finding from the first phase of the project entitled “Developing alternative sustainable income generating activity for kumal and other community by efficient use of spill energy from existing micro hydropower plant” supported by WISIONS, Wuppertal Institute for Climate, Environment and Energy, Germany. The first phase was focused on establish baseline parameter, technical design, business plan and feasibility study. Following are the methodology used for data collection for mention study.

- Market Survey from Baglung to Burtibang and Burtibang to Baglung
- Technical Survey for designing water lifting system
- Household survey
- Focus Group Discussion
- Key Informant Interview
- Discussion with relevant stakeholders and experts

CASE STUDY OF SIMALCHOUR LI PROJECT

The project area is located in Simalchour Village, Ward Number: 4, Burtibang VDC, Baglung District with fair access to institutions and infrastructures within 2-3 km distance including mid hill Highway passes through village. The village is 120 km from Butwal and 90 km from Baglung Bazaar. The project area is shown in [figure 1](#). The area constitute of cultivable land of 582 Ropani (29.62 ha) grouped in different cluster with Chhibekharka & Machhindra at 1060 msl, and Siranghar & Dhungeodar at 1332 msl.

Community and Livelihood:

A community of 98 HHs (80% Kumal and 16% others), primarily dominated by youth with mostly school level education, resides in the village. The average monthly household income is NRs 8,550 which is below the global poverty income line on USD 1.25 per capita per day. Remittance and daily wages contributes around 77% of total income of the households whereas agriculture based income is less than 2%. Female members, who mainly work as daily wage labour, are also directly contributing

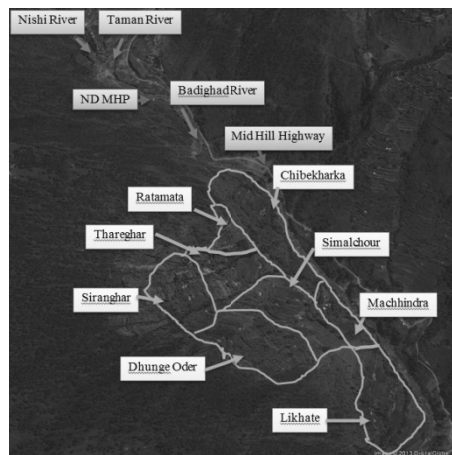


Figure 13: Different Clusters in Simalchour, Burtibang VDC, Ward no-4 from Google Earth

in income generation in 56.4% of the households in the community. Regarding the land related income, the community own 582 Ropani (29.62 Hectares) and 280 Ropani (14.26 Hectares) land for agriculture grazing respect ively. Maize and millet are the main crops. The annual average total agro-production per hectare is 2,511 kg which is heavily used for domestic consumption. 3.02% of agro production is sold resulting to NRs 3,157 annual income per hectare only. Use of land only for 8 months per year, primitive farming methods and knowledge, and lack of irrigation are the contributing factors for low productivity and income.

Operational status Nishi Dovan Microhydropower plant (ND MHP)

The 32 kW ND MHP, commissioned in April 2010, supplies electricity to 280 households covering 9 villages and 4 enterprises (includes 98 HHs in Simalchour). The figure below illustrates the daily consumption pattern- maximum and minimum loading of the plant. The MHP at minimum load of around 3.2 kW from midnight 12:00 to 4:00 AM and maximum load maximum load around 16 kW which at 19:00-20:00 PM. During morning time (7:00 – 8:00 AM), the loading is around 9 kW. Moreover, daily consumption pattern shows that out of total production potential of 768 kWh per day only 119 kWh is being used which indicates power spill is around 572 kWh resulting in daily plant factor around 16%.

The total annual electricity consumption is found to be 44,980 kWh. Out of this, 72% is contributed by household consumer and 28% is contributed by the enterprises. The electricity consumption in the enterprise is 2.6 times lower than that of household consumption. With this consumption status, the annual plant factor is found to be 16%. This indicates that still 84% of the energy (~238,000 kWh per year) is not being used on annual basis. Due to the low plant factor, the plant has low revenue from electricity sales i.e annual gross profit before interest charges and tax is around NRs 43,500. This gross profit is less than annuity payment of NRs 128,000 that has to be paid to cooperative for loan taken. ND MHP has not been able to pay the principle and interest of loan of NRs 800,000 at 16% interest rate. However, the community has paid NRs 300,000 from their pockets. B/C ratio of the plant was 0.83 and has negative NPV value at the discount rate of 8 % and the inflations of 5%.

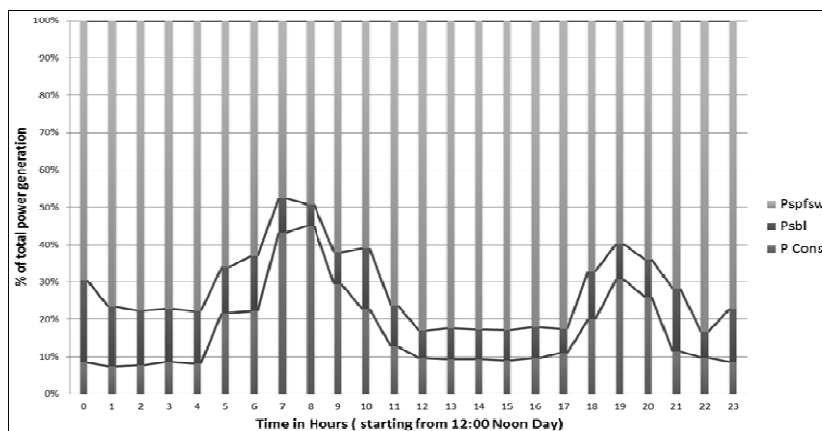


Figure 14: Daily electricity generation and consumption pattern of ND MHP (Pspbl: Power Spill to Ballast, P Cons: Power Supplied to consumer, Pspfs: Power spill in the form of water diverted via spill way)

Current vegetable business in the periphery of the project area

Burtibang Bazaar is the major commercial hub of the western Baglung region and is around 3 km from the farm site. The other significant market centers are Bhimgethe, Khara, Nwara, Kharbang, Wami and Bhuwachiti bazaars that are located along the mid hill highway, and Burtibang Butwal road and are within 30 km radius from the project site. Butwal Vegetables and Fruits Wholesale Market(BVFWM) supplies about 89% and local source supplies 11.00 % of vegetables consumed in Burtibang, Bhimgethe, Khara, Nwara, Kharbang, Wami and Bhuwachiti bazaars, whereas Hatiya bazaar mostly gets vegetables from Baglung bazaar. The total current weekly combined green vegetable consumption (excluding potato, onion and garlic) of the all the market centers, is about 51,750 Kg. Vegetables commonly available in market centers are seasonal type, stale with shipping damage marks. Marketing agents, middle persons are involved in supply through BVFWM, which has its well-established, wide, diverse, and low price supply sources. This indicates that BVFWM has a clear advantage in term of price flexibility during the time of tough competition over the local vegetable segment in the market centers. Marketing agents in BVFWM charge NRs.2.00 per kg over the price of BVFWM for their services along with NRs. 5.00 per kg as shipping charge to the market centers. With regard to local sources, individual local farmers directly sell vegetable to the retailers in the market centres and such supply is limited and sporadic in nature.

Potato, onion and garlic which are not considered as green vegetables by the consumers constitute about 40% of total vegetable consumption. All other vegetables which constitute about 60% of the total vegetable consumption are considered as green vegetables. With respect to seasonal factors, at the beginning of the winter season, mustard green, supply of tomato, cauliflower and potato could not meet the demand of market centers. During the summer season, green chili is mostly in short supply. During late summer season period, the scarce vegetable is Cauliflower. The combined consumption of tomato, cauliflower, cabbage, cucumber, bottle gourd, radish and chilly green in market amounts to about 80% of supply of total green vegetable. Broccoli, snake gourd, capsicum, broad leaf mustard, smooth gourd and carrot individually represent less than 2% of total supply. Average annual retail price point of green vegetables in demand in the market centers varies from NRs 23 for Radish to NRs 87 for Broccoli.

Design of Irrigation system

Size of pump:

The nearest source of water is Badigad River. The river is perennial in nature and constitutes ample discharge. The water requirement for 582 ropani of land is estimated to be 582,000 llitres per day as suggested by different expert if drip/sprinkle technology. The land elevation difference from the source to the highest point of project area is 320

m. Assuming, 12 hours of operation (based on daily consumption pattern of MHP), the size of the pump exceed the capacity of ND MHP, if designed for 100% cultivable land and 43% cultivable land (12.76 ha). However for the latter case, based on the constraints illustrated above, two pumps are anticipated where first pump will lift water up to 1151 m and second pump will lift water from 1151 m to 1332 m. The use of two pumps and stationing of second pump at 1151 m altitude is further justified as significant cultivable land area is situated below the altitude of 1151 m. The size of the pump is calculated to be 18.5 kW and 7.5 kW. However, the size of the pump is reduced to 15kW ad 5 kW considering the technical constraints of operating induction motor in very limited supply from MHP. Regarding the type of the pump, vertical multistage centrifugal pump is deemed suitable for the particular site as the flood level and sediment is very high in Badighad River. The point to be noted here is that, while designing the lift irrigation in supply constraint scenario such MHP, optimization of size of pump and even the area to be irrigated is essential.

Water conveyance, storage and distribution

A combination of Galvanized Iron Pipes and High Density Polythene pipes is used for water transmission up to RVT is envisaged and HDPE pipes are used for water distribution to each cluster.

Reservoir tank (RVT) is used to facilitate gravity flow and avoid possibility of soil erosion. Two Reservoir tank, a tank having reinforced concrete cement structure, with total capacity of 4 m³ is required to facilitate water distribution purpose for different cluster.

A low-cost and virtually seepage proof pond construction technology is adopted for water harvesting tank (WHT). The total of 9 WHT will be constructed at each cluster with low cost and locally available material. Excavation will be done depending upon the site conditions and the water requirement. The whole excavated terrace surface is pasted (mud plastering) with red clay and then covered by a plastic liner to nullify the seepage.

Application technology

Sprinkle Irrigation requires 8-9 m head whereas drip irrigation requires only 1-2 m head. Also, drip irrigation drops the water on the root of the plant but sprinkle scatters the water in open air. The utilization of water remains very effective in drip irrigation. Hence the project envisages deploying drip irrigation wherever appropriate because the drip pipe network needs to be laid out and remove during each vegetable crop season which could be tedious to some farmers.

Business plan and feasibility

The community had already Badighad Commercial Agriculture Development Cooperative Limited (BCADCL), a farmers' cooperative, in 2010 in Simalchaur, Burtibang-4 for diversifying their existing agriculture practices and commercializing vegetable farming business for the community. The cooperative, however, could not

come to operation, as the community lacked knowledge and experience bases related to modern vegetable farming practices, vegetable business, and operation and management of cooperative. BCADCL is envisaged as the central organization which will

- Encourage and provide technical knowhow support to its members in setting up their individual green house in orderly way for growing early seasonal and off seasonal vegetable in market
- Act as a sole marketing agent performing grading & sorting of vegetables , packaging, shipping to market, maintaining customer relation with the market clusters, collecting dues from the market. The cooperative will take up 10% of vegetable sale value as its marketing commission for the above services
- Act as an in-between in securing reliable supply chain of input services such seeds, insecticides and organic manure and agro vet etc. on bulk price basis for its farmers and this service rendered will be on cost basis, i.e. with no additional mark up.
- Act as a custodian of the pumping system, established under project's initiatives, will charge its members @ NRs. 250 per Ropani of land per month for supplying water for irrigation

The cost estimation, revenue projection and feasibility of the irrigation project is analyzed in integrated manner i.e considering vegetable production cost and sales revenue where BCADCL performs as central community based organization. Followings subsections entails business plan & feasibility aspects of the project:

Market strategy

The marketing plan for the cooperative is elaborated in the following points

- **Target Market:** The project is located alongside the mid hill highway and has access to numerous and sizable market within 30 km from the proposed farming site. Burtibang, the main market hub, along with other market in Bhimgethe, Khara, Nwara, Kharbang, Wami Taksaar of the western part of Baglung district and adjoining parts of Gulmi district. Among them, Burtibang Bazaar is the major commercial hub of the western Baglung region and is around 1 km from the farm site of BCADCL. The total population in the market centers is around 41,000. The population in market centers has increased significantly during the last one decade. The overall size of the targeted market is estimated to grow at the rate of around 2.22% per annum
- **Target vegetables:** Total 51,750 Kg of green vegetable per week comes in the target market. Butwal supplies about 89.37% green vegetable supply and the remaining 10.63% comes from local farmers, indicating overwhelming influence

of Butwal market in the target market area and Butwal defines quality of supply, pricing and marketing practices in the target market area. Tomato, cauliflower, cabbage, cucumber, bottle gourd, radish and chilly green amounts to about 80% of total green vegetable supply in the target market clusters. □ Broccoli, snake gourd, capsicum, broad leaf mustard, smooth gourd and carrot individually amounts to less than 2% supply. Tomato, Cauliflower, Chilly, Cabbage, Bitter gourd, Cucumber, Radish, French bean, Okra, Carrot and Bottle gourd are the selected vegetables from market and farming considerations.

- **Selling strategy:** These vegetables are planned to be grown on off seasonal and early seasonal basis with low pesticide usage to secure better price in the market. Consumer preferred cleaned, graded, and freshly picked green vegetable of hill areas of the region and are willing to pay premium price up to 20%. Selling prices proposed are derived mainly from historical vegetable price data of Butwal market. 15% premium on off seasonal and early seasonal vegetables is considered in pricing. Nine authorized vegetable distributors i.e. 3 in Burtibang, 1 each in Bhimgethe, Khara, Nwara, Wami Taksaar and 2 in Kharbang market centers are proposed, based on market center size and volume of business.

Organization and operation plan

The existing Badighat Commercial Agricultural Development Cooperative, which is community owned and managed cooperative at Simalchaur, Burtibang-4, is proposed to own and operate water pumping system and green vegetable business for the community on at following services charges

- Vegetable marking service : 10% of selling price
- Water Charge: NRs. 250 per month per ropani
- Other farming support services: at cost basis

A nucleus organization consisting of three-person on full time employment basis is planned under the existing vegetable business subcommittee the Cooperative to run the business.

Capacity utilization: The capacity utilization is assumed to be 50% in the first year which is expected to reach 100% by the end of 8 year.

Farming plan: In order to maximize the profit from vegetable farming, it is necessary to identify the vegetable based on the tradeoff between consumption and profit from each vegetable in the farm and consultation with expert. Also it is pertinent to determined land area for farming for each vegetable which is calculated on the basis of market share of

each vegetable, total vegetable demand and yield of each vegetable. The table below provides the list of vegetables for farming and land area allocated

Table 6: Selected vegetables and gross annual production

Vegetables	Land allocated (ropani)	Farm gate Selling Price	Cost of production (NRs/ kg)	Profit margin (NRs/ kg)
Tomato	29.51	33.40	11.17	22.22
Cauliflower	82.71	31.31	21.06	10.25
Cabbage	25.99	22.13	10.53	11.60
Radish	15.98	24.19	11.68	12.51
Cucumber	12.34	27.09	11.26	15.82
Bottle gourd	6.97	28.91	17.33	11.59
Bitter gourd	7.95	42.02	11.27	30.75
French bean	16.57	38.90	19.17	19.74
Okra	10.16	48.03	20.62	27.41
Chilly green	18.88	41.91	16.15	25.75
Carrot	18.88	40.68	18.04	22.65

Financial plan and feasibility

Cost Estimation: The total project cost is estimated to be around NRs. 5.089 million having initial investment of around NRs. 5.074 million and interest of around NRs. 11.5 thousands. The total fixed asset is around NRs. 3.83 million. Out of the total investment of NRs. 5.089 million, grant, debt and equity investment are NRs. 3.856 million, NRs. 108 thousands and NRs. 1.126 million respectively. It does not include debt of NRs. 2.64 million (@ 12 % annual interest with 4-year loan repayment period) through line of credit extended for procuring and installing irrigation equipment to each farmer member by the cooperative. They are responsible for repayment of loan and interest themselves.

Revenue projection

In order to estimate the revenue it is essential to predict the farm gate selling and profit margin for each vegetable. Two sets of price data namely local market price data based on interview from key vegetable vendors wholesale price at Butwal are analyzed and lower price set is selected for further processing. The table 1 presents the farm gate selling price for cooperatives. Vegetable business is the major contributor to the projected annual revenue. It generates around NRs. 24.18 million which is around 89% of total annual revenue. Service charge contributes around NRs. 3.12 million that is about 11% of the total annual revenue. Among vegetables, tomato, cauliflower, and cabbage are the three major revenue providers, contributing about 30%, 21% and 9% respectively.

From land allocation consideration, tomato, cauliflower and cabbage occupy around 12%, 34% and 11% respectively. Thus, revenue earning per Ropani from tomato is about 3 to 4 times more than that of cauliflower and of cabbage. In short, Tomato crop is the crucial. Among revenue through services, marketing service charge contributes to about 10% of total revenue, whereas water charge adds to 2% in total revenue.

Feasibility of the project

At the proposed capacity utilization mentioned above, Net cash flow is found to be positive from the first year. Moreover, discounted cash flow analysis shows that Internal Rate of Return is 33%, discounted payback period is 4.5 years and net present value is NRs 4,201,000. Results from the financial analysis, the lift irrigation project is feasible. However, there is likely situation that the price might fluctuate. Hence a sensitivity analysis is performed with change in the price point from +10% to -10%. The result of the sensitivity analysis shows that the IRR will reduce to 25% if the farm gate selling price is reduced by 10% below. Result indicates that even with the variation of -10%, the irrigation cum farming project is feasible.

Total Socio-Economic Impact

Within 10 years of operation, the sales revenue from the vegetable would be around NRs 260 million. Out of this amount, 30% will be the expense incurred in import input material for vegetable production. However, 80% of the revenue (182 m) will be retained in the local economy. The money that will be retained in the local economy will go to MHP, cooperative, labour, local material. The distribution is presented in figure 3

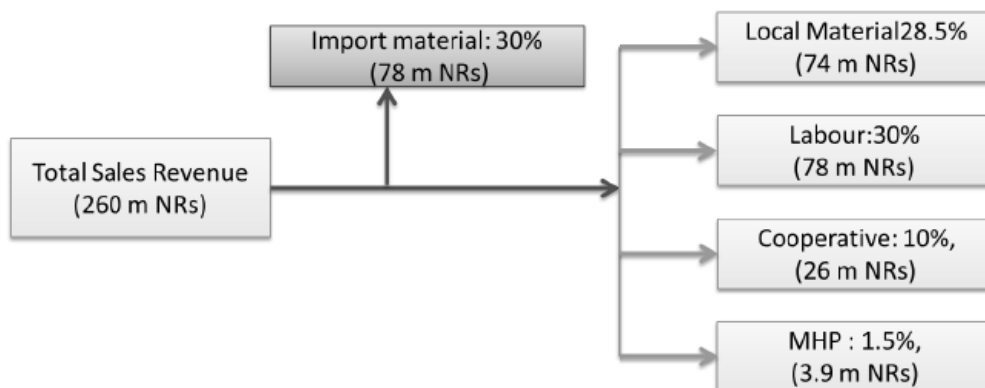


Figure 15: Distribution of the sales revenue in the local economy

Through the proposed interventions of the project, the targeted beneficiary, Kumal community and other marginalized group residing in Simlachaur, Burtibang area could improve their per Ropani land income by 448 folds, and per household income 3.16 times (using discounted cash flow method), as shown in table 2

Table 7: impact on land related income, household income and increased revenue for MHP

Particulars	Baseline	Projected	Remarks
Annual Income per Ropani of land NRs.	161	72,132	448 times increase
Annual Income per household NRs.	102600	185,482	• 1.8 times increase- (Simple method) • 3.16 times increase – (Discounted Cash flow @12%)
Average annual revenue MHP		NRs 396,900	• Consume additional up to 270 kWh per day • Increase the plant factor up to 55% • The cash flow becomes positive after two years as the ND MHP will be repaying its loan and interest during this period.

Foreseen issues and challenges

Despite being feasible, there are following challenges in foreseen during the project study period.

- The use of drip irrigation is a challenging task. Though there is the efficient utilization of water in drip irrigation, the farmers may find it a tedious task to use this irrigation system over and over a period of time.
- Farmers may find the cropping plan a suitable one but there are risks that many of them would stick to only one vegetable that gives them more profit. With many players producing the same vegetable would eventually decrease the price of the vegetable and thus less profit would be attained.
- The main income source of the community is remittance and wages. With vegetable farming in action in the local area, switching to vegetable farming instantly is not practical.
- The vegetable farming if undertaken by farmers in nearby areas located out of the specified region of the project, there may be the fear of competition among the farmers in vegetable production resulting in lower prices for the vegetables.
- The project is trying to propose specified number of retailers for distribution of vegetables in different market clusters as per the size of the population. Getting the regular price of Butwal wholesale market is challenge. As the community have access to mobile communication, they will get such vegetable price easily which could be the reference price which sometime get very low.

DISCUSSION AND CONCLUSION

Providing year round irrigation in hilly and mountain region, where people livelihood is hinged on agriculture and migration remains the critical challenge in rural society, is a daunting task despite having abundant water resource nearby the villages. MHP operating

in such hilly and mountain region clearly lack demand for electricity and are underutilized. Such underutilized MHP could be used to lift water much above the water source elevation level and is feasible. The Business plan and feasibility study of proposed lift irrigation integrated with vegetable farming business properly linked with market in Simalchaur, situated in Western Baglung, clearly indicates the project is feasible within +30% to -30% price variation in vegetable and water tariff. Moreover, the study shows there is a win-win situation for both community and the MHP from such initiatives. Kumal community and other marginalized groups residing in Simlachaur, Burtibang area could improve their land income in per Ropani by 448 folds and per household income by 3.16 times and MHP increase the utilization up to 60% and double the revenue through the NC-Li system integrated with vegetable farming. There is a clear synergy in utilizing spill energy from MHP for lift irrigation for vegetable farming and create employment and create demand for electricity generated. In Baglung District, there are 90 MHP with total installed capacity of 2500 kW. The utilization of these MHPs is around 40%. 60% of the spill energy could power lift irrigation that can lift 12,734 m³/day of water to a height of 150 m. This can irrigate 600 ha of land only. The prospect of utilizing MHP for NC-LI is huge but there are critical factor that need be consider for NC-LI projects which are as follow.

- **Induction motor operation:** Pump consists of induction motor which is the main driving equipment for pump. Induction motor needs 2 to 3 times the normal full load current during start up. Suitable star /delta starter or soft starter need to be employed to reduce the startup current. If any MHP has 10 kW of spill capacity, due to the startup current, more than 6 kW pump is not suitable but deploying soft starter could make possible of using 9 kW pump.
- **Water charge:** Water charge is very critical for lift irrigation. The charge should consist of depreciation of the pump so that community will have reserve fund for replacement in case catastrophe or accidental collapse. Also water levy could encourage community for effective utilization of water
- **Implementation of cropping plan and allocation of land:** Farmers may find the cropping plan a suitable one but there are risks that many of them would stick to only one vegetable that gives them more profit. With many players producing the same vegetable would eventually decrease the price of the vegetable and thus less profit would be attained
- **Copying and crowding, and market failure;** The vegetable farming if undertaken by farmers in nearby areas located out of the specified region of the project, there may be the fear of competition among the farmers in vegetable production resulting in lower prices for the vegetables. The project plans to overcome this through vegetable selection, and trading in new market centres.
- **Drip irrigation a tedious task:** The use of drip irrigation is a challenging task. Though there is the efficient utilization of water in drip irrigation, the farmers

may find it a tedious task to use this irrigation system over and over a period of time.

- **Switching from existing occupation to vegetable farming:** The main income source of the community is remittance and wages. With vegetable farming in action in the local area, switching to vegetable farming instantly is not practical. Hence, one minimum of person per household is advised to get involve in vegetable farming. Also, the proposed incubation support during the first year of operation from the project will facilitate such switching.

ANNEX -3

PARTICIPANT LIST

S.No	Name	Designation	Organization	Contact no	email	Signature
Ministry of Irrigation						
1	Narayan Prakash Saud	Minister	MOI	9841387912	Npsauda@gmail.com	
2	Madhav Prasad Regmi	Secretary	MOI			
3	Padma Raj Bhatta	JS	MOI	9841258281	Bhattapr@hotmail.com	
4	Bidya Sagar Mallik	JS	MOI	9855023306	bidyasmallik@yahoo.com	
5	Binod Kumar Jha	SE	MOI	9852022812	jaymanobinol@yahoo.com	
6	Madhukar Prasad Rajbhandari	SE	MOI	9841286717	madhukar_64@hotmail.com	
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Annex -4
Photographs of Workshop



Seminar Banner



Chief Guest with Participants



Chief Guest Hon. Minister Mr. N.P. Saud Arriving the Seminar



Chief/Guest in the Dash



Inaguration of the Seminar by Chief Guest



Activities in the Seminar Hall



Speech by Chief guest Hon Minister N.P. Saud



Speech by Special Guest Secretary Madhav P. Regmi



Speech by DG Mr. Shiv Kumar Sharma



Seminar Remark Speech by DDG Madhav Balbase



Welcome Speech by DDG Mr. Susheel Chandra Tiwari



Speech by IWMI country Chief Dr. Luna Bharati



WR Experts Present in the Seminar



Token of Love to Former Minister Uma Kant Jha









