Small Scale Irrigation Systems: Challenges to Sustainable Livelihood

Proceedings of the Sixth International Seminar
Held on 15-16 February, 2015, Kathmandu, Nepal

Edited by
Prachanda Pradhan | Upendra Gautam | Naveen Mangal Joshi

Farmer Managed Irrigation Systems Promotion Trust
Kathmandu, Nepal
November 2015
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EDITORS' NOTE

Sixth FMIST Seminar 2015:
Small Scale Irrigations are not small at All

The sixth Farmer Managed Irrigation Systems Promotion Trust's international seminar that took place in Kathmandu on 15-16 February 2015 was devoted to the theme of "Small Scale Irrigation Systems: Challenges to Sustainable Livelihood." In the understanding of the editors, who were active participant observers at the seminar, the key resounding message of the seminar was: the small irrigations are not small at all.

The seminar’s resounding message was eloquently supported by the key note addresses, several paper presentations and panel discussion organized at the seminar. As a matter of fact, FMIST’s Sixth International Seminar announcement on “Small Scale Irrigation Systems: Challenges to Sustainable Livelihood,” at the hindsight, turned out to be a meticulously prepared note that seems to have guided the seminar throughout. The announcement read: "The share of Small Scale Irrigation Systems (SSISs) including all types of technologies adopted has substantial coverage in the world providing livelihood support to a larger number of agriculture based population. The SSISs are found in all eco-geographic terrains in general and in hill and mountain regions in particular. These SSISs have made important contributions; they ensure and resiliently adapt, to a greater extent, to the needs of the food security, local rural livelihood, climate change and local ecological setting. They provide job opportunities and contribute to the overall rural poverty alleviation." It described the context of the seminar in the following lines: SSISs are usually defined by the size of its command area either by a national irrigation policy or by the decision of a public agency to provide support and services to such systems. It is also important to include in this category the non-conventional irrigation systems like sprinkle, drip, pond and water tank, shallow tube well, treadle pump, water harvesting pond or well, and other types of environmentally adapted technologies utilizing available quantity of local water resources. The SSISs reflect local knowledge, local organization, local skill and adaptive technology. They represent social relations, resource mobilization mechanism, and local institution and rules for local natural resource management. The share of SSISs including all types of technologies adopted has substantial coverage in the world providing livelihood support to a larger number of agriculture based population. .....These systems are either built by the community of users or by a local government unit, or a lineage of land owners/cultivators close to the water sources, or by individual households. Therefore, they are either:
public, private, lineage or community owned systems depending on who are the users and who provided the resources to establish the system. In countries which are more agricultural, the SSISs hold a significant share in irrigated agricultural area. Same thing could be said about their contribution to local food security and gainful employment. As such, small irrigations are not small at all in terms of their total impact on national economy, agrarian relations, and ecological adaptability and resilience."

In the seminar, N. S. Jodha, FMIST Icon of Honor 2015, in his key note speech stressed on the critical need of supporting the integrity of mountain communities in the context of challenges of mega changes introduced by Climate change, globalization, persistent poverty and vulnerability with emerging water and biophysical constraint. For Barbara Van Koppen, FMIST Icon of Honor 2015, on-going "Multiple Use Water Services" (MUS) practices and research could help the communities in facing the mega challenges. Prachanda Pradhan, FMIST Icon of Honor 2015, in his key note address pointed out the importance of recognizing small scale irrigations in terms of status in policy, institutional support and access to transparent funding.

In this seminar, the editors were particularly impressed by the institutional resilience and technological adaptability of the small irrigation systems as they were comprehensively expressed in the deliberations made. As Upendra Gautam has noted in his seminar remarks, more than 65 percent of the papers somehow or the other dealt with exploring and testing one or another strategy to develop and strengthen small irrigation systems. These strategies mainly related to adoption of adaptive alternative technology and associated institutional development. A futurist paper presented by George F. Taylor enlisting good lessons from Nepal FMIS stated, "What is labeled non-conventional by technocrats and bureaucrats today is already widespread in Nepal, and with the impact of two key drivers, climate change and out-migration, will be part of the mainstream tomorrow. As a part this expanded scope for FMIS, devote special attention to a third key driver: Nepal's high rate of urbanization and the associated explosion of peri-urban agriculture."

In the last 15 years of so, the trajectory of FMIS, as documented by a 2015 FMIST publication launched at the seminar by Dr. Kenichi Yokoyama, FMIST Icon of Honor 2010, has characterized more risk than rejuvenation in FMIS for the reason that irrigation communities disrupted for sectoral interest, lacked in essential support and financial assistance. The sixth FMIS seminar on small scale irrigation systems has gathered the body of evidences whereby the resilience and adaptability of farmer managed small irrigations systems in the face of challenges posed by governance, climate change and population mobility provide anything but practicing inspirational lessons. Let this trailblazing inspirational lessons be mainstreamed into sustainable, cooperative, enterprising multiple water use services and products. Indeed, small scale irrigations are not small.

Prachanda Pradhan Upendra Gautam
Naveen Mangal Joshi
PART I
INITIATION, BOOK LUNCHING AND HONOR CEREMONY
Welcome Address

SUSHIL SUBEDEE*

On behalf of the organizer- Farmers Managed Irrigation System Promotion Trust (FMIST), Co-organizer the Department of Irrigation, GON and our key co-sponsor the Asian Development Bank I stand here this morning to greet and welcome you all in our International Seminar on Small Scale Irrigation Systems: Challenges to Sustainable Livelihood. Further, I also remain here to accord you a warm welcome on behalf of our valued associated partner institutions like JalsrotVikasSanstha, Community Irrigation Project, Global Water Partnership, INPIM Nepal, Society of Irrigation Engineers Nepal, IIT Roorkee Alumni Association, Nepal, Society of Hydrology and Meteorology andIWM. This is our sixth international seminar since the institution of the Trust some 15 years ago.

As in the past, FMIS Trust continues with its mission-advocacy for self governing indigenous institutions, particularly irrigation institutions. In this regard the Trust strongly believes that small irrigation systems, which are not so small in their contribution to rural livelihood, have remained outside the purview of service delivery agencies because of their limited mandates. In present day of food insecure world with rapidly declining livelihood opportunities in rural areas, the role of SSIS does not need over emphasizing. In due consideration of this the Trust decided to draw attention of policy makers, professionals and practitioners to this contemporary issue and hence the present seminar is organized. This seminar is believed to offer an inventive stage wherein the primary and secondary stakeholders can have fruitful interface to attend to the core issue and the academia is expected to enrich the environment with the output of their grueling research.

Since its establishment, FMIS Trust has conducted 5 international seminars focusing on diverse issues. Distinguished scholars of global repute were felicitated for their exceptional contributions to the promotion of farmers managed irrigation systems. The honored names

* Member-secretary, FMIS Promotion Trust
include Prof. Lucas Horst, Prof. Linden Vincent, Nobel Laureate Elinor Ostrom, Prof. Norman Uphoff, Prof. Walter Coward, Dr. Robert Yoder, Mr. Charlse Lindsay Abernethy, Dr. Emmanuel Reynard, Prof. Nyoman Sutawan, Prof Nirmal Sen Gupta, Dr. Ujjwal Pradhan, Dr. Ganesh Shivakoti, Mr. Kenichi Yokoyama and Prof Wai Fung Lam and farmer leader Saligram Chaudhary of Bardiya district of Nepal. The culture continues and in this seminar also FMIS promotion Trust has decided to honor individual professionals for their steadfast support to and believe in FMIS.

Finally, we are once again assembled here to delve into the promises the future holds for small scale irrigation schemes managed by farmers themselves. The Trust hopes that the seminar will closely look into the dynamics of small scale irrigation in relation to sustained livelihood for rural poor and help guide the policy makers and practitioners to develop small farmer friendly modality of irrigation development.

Thank you, and a warm welcome again
This is a special morning for all of us who have gathered here to deliberate on the small scale-farmer managed irrigations systems. In this sixth FMIS seminar, we are trying to focus on the challenges they face in rendering sustainability to the livelihood in these systems.

As you are aware, the objective of the seminar is to provide a forum to share and disseminate the knowledge and experiences on the multi-dimensional contributions of SSISs. These SSISs bring intense impact on the sustainable livelihood of the people. They need serious deliberation for correct understanding so that intervention to deliver better services to the people dependent on these systems could be planned and implemented. The livelihood, water and food security impact of SSISs informs us that they are not small and insignificant in terms of their contribution to the national economy, social stability, local self-governance, agrarian relations, ecological adaptability and resilience.

We expect to accomplish the seminar objective to a significant extent. In this context, we are encouraged by the participation of the authors/researchers who have duly contributed papers to the seminar, and have traveled all the way to attend this seminar. All together, we have received about forty papers. Except for a few papers, 80 percent of them will be presented and deliberated in the seminar. The seminar will be conducted in two parallel sessions—one on **FMIS cases and contributions** and the second on **Strategizing FMIS**. Each parallel session is divided into several sub-sessions. By the end of the second day of the seminar, we will have a plenary session on the **FMIS agenda ahead**. We have also arranged a field visit for the interested foreign participants to have a personal feel and exposure to the SSIS impact and realities.

We have tried to categorize the papers on the basis of their approach, main thrust and outcome. FMIS cases and contributions deal more with benefit, access, livelihood, and

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* Founder Chair and Adviser, FMIS Promotion Trust
impact. On the other hand, under Strategizing FMIS category, papers deal more with institution development, technology alternative, knowledge-technology and management transfer, ecological adaptability etc.) Out of the papers, two papers have continental reference to Asian livelihood and low cost manual well-drilling in the African context respectively.

The papers represent 10 country/area studies namely: Nepal, Afghanistan, Thailand, Pakistan, Rwanda, Bangladesh, West African Sahel, India, Zambia and Ethiopia. The authors of the papers represent 9 countries namely: Nepal, France, Pakistan, Thailand, Bangladesh, USA, India, France, and Ireland, Switzerland.

We would like to sincerely recognize ADB, IDE, IWMI, Center for Rural Development, DOI, Switzerland (Swiss Irrigation Museum Curator) CNRS/ France, IFPRI (International Food Policy Research Institute), FAO Regional Office for Asia and Pacific, and Arizona State University Research Team. for institutionally taking initiative to contribute papers to the seminar.

We note more than 65 percent of the papers somehow or the other deal with exploring and testing one or another strategy to develop and strengthen FMIS. These strategies mainly relate to FMIS’s institutional development, technology alternative-adoption and use, adaptation to ecological changes and knowledge-technology and management transfer. These papers overwhelmingly support my conclusion contained in the book "Trajectory of FMIS", to be released right after a few moments, that is, FMISs—small or big, face more risk than rejuvenation of their glory in these decades of the 21st century. The risk can be significantly lowered if the governance mechanism supports FMIS on a level playing field; and individual "poor" farmers in the irrigation area (AMIS and FMIS) are recognized by the state into a localized productive cooperative enterprise so that they are collectively enriched ownership and share cost and benefit equally. As compared to an individual industrial labor, individual farmers in agricultural economy are poor. But if organized into a productive enterprise, the land owned and water used by the farmers together make them competitive and attractive for modern agricultural investment. Further, what we believe in our Trust is that larger the irrigated agricultural area under FMIS governance, the better will be water and food security situation.

To realize the goal and vision mentioned, applied social science has the greatest role to play. But now we are in a space and time where applied social science is most neglected; the academies and universities have social science just in their libraries and farmers' contributions are only recognized at low level—where farmers organizations like FMIS are never able to receive highest state honor. Now, in the name of “balancing trade,” foreign-induced export-oriented hydropower projects are given the highest priority against the country’s water resources law, the country’s ownership over water, farmers’ core interest and the people’s water security in general.

We hope the seminar will help us in rejuvenating FMIS, a local, a national and a global heritage.
Activities Of Fmis Promotion Trust

SUMAN SIJAPATI*

Since its inception, the FMIS Promotion Trust has been actively involved in the promotion of FMIS scattered throughout Nepal and even beyond. FMIST has been organizing relevant trainings for the FMISs. Moreover, in the name of Dialogue Series, FMIST has also been organizing various talk programs in topics related to the FMISs. FMIS Trust has also been engaged in different relevant research works. Another important work that the Trust has been doing is the rewarding the best performing FMISs. So far, the award has been given four times in different themes. Similarly, FMIST has also been providing revolving fund through Mr. Chandraswor Rauniyar’s cooperative to poor farmers in Janakpur area for installing irrigation facilities. FMIS Promotion Trust also has many publications to its credit.

By far the most outreaching and important activity of the FMIST has been its International Seminars. It brings together academics, practitioners, technocrats, bureaucrats, farmers and common people to share their knowledge and experiences for the benefit of each other. These seminars focus on the generic issues. So far, five seminars have been successfully conducted and for which proceedings have been published and widely circulated and extensively used by practitioners and academics for all five seminars. The seminars have also been utilized as an opportunity for honoring eminent scholars who have contributed to FMIS. So far, 15 eminent personalities who have contributed to the FMIS have been recognized. Apart from recognition as FMIS Icons of Honor, FMIST also separately honored the Nobel laureate Dr. Elinor Ostrom during her visit to Nepal after she received noble prize. As most of you are aware, this is the sixth seminar and three more eminent personalities will be honored today.

* Vice-chairman, FMIS Promotion Trust.
FMIST implements all its activities in partnership mode, not consulting mode. We have also made every effort to make all our activities as transparent as possible. Anyone seeking further information of the FMIST activities can easily access it through its webpage.

Finally, this international seminar is one of the most important activities that the Trust has organized after the formation of the current Executive Committee. We look ahead towards receiving full support from all of you in the days ahead in all the activities that we organize. We have recently executed a small contract with IFPRI and have many activities in the pipeline. Our publication entitled "Trajectory of FMIS" will be released today in a short while. The publication is an anthology of the keynote speeches by distinguished luminous scholars of the different seminars that capture the dynamism of irrigation systems from socio-institutional, technical as well as property perspective to behavioral aspects in the management and adaptation of the systems in the changing context brought by socio-economic changes and internal and external environmental factors. The Kamala-Medini award, instituted by Mr. Lava Raj Bhattarai in loving memory of his parents will also be activated and regularized. Just this morning I received information from Mr. Bhattarai that he would like to donate additional 25,000 to the award. FMIST is also planning to get engaged collaboratively with CDKN/DFID/MacDonald in study on Increasing Resilience of Climate Change on Small and Medium Irrigation systems in Nepal.
Book Launching:

“TRAJECTORY OF FARMER MANAGED IRRIGATION SYSTEMS”
Small Scale Irrigation Systems: Challenges to Sustainable Livelihood
The Book Review on "Trajectory of Farmer Managed Irrigation Systems"

BASU DEV LOHANI*

The book entitled "Trajectory of Farmer Managed Irrigation System" edited by Prachanda Pradhan, Upendra Gautam and Naveen Mangal Joshi of Farmer Managed Irrigation Systems Promotion Trust (FMIST) is well organized and informative book. This book has 17 sections starting from introduction to trajectory of FMIS. Each chapter is written by different authors based on their research experiences.

Introducing the book by Prachanda Pradhan, he attempts to characterize the Farmer Managed Irrigation Systems (FMIS) as a national heritage of Nepal. FMIS for him reflect the local knowledge, local skill and local technology. Keynote speeches by various irrigation experts/professionals in this anthology present their valuable views and experiences of different parts of the world. It adds the importance of this book by representing cross-boundary and cross-continental knowledge and experiences. This is another beauty of this book.

1. FMIS and Technology dealt by Lucas Horst mentioned about two types of technology for FMIS and Agency Managed Irrigation Systems (AMIS). Comparison of technology of FMIS and AMIS has been made with positive and negative aspect and recommended for further research in FMIS technology.

2. Contemporary Issues in FMIS: Challenges to Whom? By Linden Vincent pointed out the need to work together. Due to diversity of FMIS, it is very difficult to follow

* Deputy Director General, Department of Irrigation, Government of Nepal.
the specific design option in the development and modernization of FMIS. The internal problems and external dynamics need to be studied before intervention.

3. FMIS: A resource of governance by Ujjwal Pradhan rose about the lack of policy issues. Need of collective action and user-friendly and meaningful policies. Through the FMIS promotion trust, some of the FMIS challenges and linkages would be supported through strategic alliances and networking.

4. How Farmer Managed Irrigation Systems Build Social Capital to Outperform Agency Managed Systems That Rely Primarily on Physical Capital by Elinor Ostrom discussed about collaborative research and database with Nepal Irrigation Institutions and Systems (NIIS). From the analyses is that FMIS generally achieve higher levels of performance than AMIS.

5. Understanding and Utilizing the Softer Aspects of ‘Software’ for Improving Irrigation Management by Norman Uphoff realizes the importance of Participatory Irrigation Management (PIM) as software which is more successful than non-participatory alternatives. PIM is essential to make more effective and efficient hardware i.e. physical structure. Through the PIM in Sri Lanka, Management efficiency and irrigated area has been extended.

6. Farmer Managed Irrigation Systems and Subsistence Agriculture in Nepal by Robert Yoder emphasize on how the farmer realize themselves the importance of irrigation water a case of Chherlung of Palpa district. The right to use water for irrigation is carefully controlled by FMIS irrigators. Although the state views the water resources of the country as a common good, it does recognize that those who worked to develop an irrigation system have the first right to use the water. To protect prior rights, a new intake cannot be established above an existing one if doing so will decrease the amount of water being diverted into an earlier canal (Mulki Ain, 1936).

7. Property and FMIS Governance: Two Books that may be Unfamiliar, but that inform the Discussion by E. Walter Coward, Jr. defines about landscape and ecology of irrigation, Property and governance. Collective action in these systems is based on property relations.

8. Can Programmes of Irrigation Management Transfer be Completed Successfully? By Charles Lindsay Abernethy mentioned that Programmes of irrigation management transfer are initiated by governments. They are not, generally, the result of demands made by irrigators. Indeed, it usually seems doubtful that farmers like or want these programmes. It is the governments that decide to do it. To a significant degree, the adoption of management transfer policies in recent times has been “donor-driven.”

9. The Need for Sustaining Farmer Managed Irrigation Systems by Nyoman Sutawan concluded that Sustainability of FMIS should encompass: the technical, institutional,
economic, environmental and ecological, and socio-cultural sustainability. In this way, it would enable us to: (1) better understand the location specific nature of greatly diverse FMIS in a rather holistic perspective; and (2) formulate agricultural and irrigation policy best suited to specific conditions of a given country.

10. Governance of Farmer Managed Irrigation Corporations in The Swiss and Italian ALPS: Issues and Perspectives by Emmanuel Reynard demonstrated that the good functioning of irrigation systems is not only dependant on the physical structures but also (and may be more) on social structures. Integration and Interactions of Farmer Managed Irrigation Systems with other Natural and Economic Systems.

11. The Subsidy Swing: Growing Malady by Nirmal Sengupta has opinion that irrigation systems have to improve their efficiencies and curtail their subsidy needs. There is no second opinion about that and I will not elaborate the known arguments. For FMIS in particular, diversification is another recommended strategy which is a proven one.

12. Coping Policies, Institutions and Governance Challenges of Irrigation in Twenty-First Century by Ganesh Prasad shivakoti highlighted that Basin Committees as a necessary tool for managing competition of water at basin level. The issue of property rights and water right is drawing much attention at present. Linking policy with local context is necessary. Farmer to farmer peer training approach is necessary to share the experience and stimulate them to adopt.

13. Dynamics of Farmer Managed Irrigation Systems Towards Prosperity: Status, Lessons and Prospects by Kenichi Yokoyama wrote In pursuing irrigated agriculture productivity enhancement through PIM/IMT programs, establishment of requisite policy framework–policy, law, and implementation guidelines–has been pursued in many countries.

14. Understanding the Dynamics of Institutional Change and Irrigation Assistance by Wai Fung Lam indicates that Innovative Irrigation Assistance shall be implemented. Instead of simply spending large funds and imposing a top-down planning process, the WECS/IIMI project extensively involved farmers in deciding what should be done.

15. Budhi Kulo Irrigation System of Bardiya District:An Introduction by Shaligram Chaudhari explained about the farmers perspective for the management of irrigation system.

16. Trajectory of Farmer Managed Irrigation Systems : More Risk than Rejuvenation by Upendra Gautam shows the path of FMIS (Past, Present and Future). No IMT, in any form, can be successful and sustainable if all interventions are not localized. The bottom line perhaps is: no success will be greater for a country in irrigation sector if FMIS as a water and land corporate enterprise operate and self-govern larger chunk of irrigated area in the country in which public irrigation agency play
a supportive partnership role in the field; and planning and monitoring role at the water resource/country level.

FMIST conducted a series of international seminars and shared a lot of experiences of another part of the world. This publication consists of compilation of past research papers related to the trajectory of FMIS of Nepal including intervention. Next step is on-farm management (Technical and social) for the better productivity. I would like to thank all writers, editor for their contribution. Last but not least thanks to FMIST for providing me this platform.

Mr. Kenichi Yakoyama, Country Director of Asian Development Bank to Nepal was kind enough to launch this valuable book entitled “Trajectory of Farmer Managed Irrigation Systems” published by Farmer Managed Irrigation System Promotion Trust, Nepal. FMIST Board of Directors extends thanks to Mr. Yokoyama for his support to FMIST activities.

Mr. Kenichi Yokoyama launching the book on the occasion of FMIST Sixth International Seminar, Hotel Himalaya, Lalitpur, Nepal.
**INTRODUCTION OF THE "ICONS OF HONOR"**

**Dr. Luna Bharati, Nepal Country Head of IWMI** introduced the "Icons of Honor"

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**Dr. Barbara van Koppen:** Barbara van Koppen (PhD) at IWMI South Africa, is Principal Researcher Poverty, Gender, and Water in the International Water Management Institute (IWMI). She leads multi-country (action-) research in Africa and Asia on community-driven water service delivery and water laws and policies reform, also from a gender and human rights perspective. She is lead-author and -editor of five books and (co-) author of over 100 international peer-reviewed publications. She supervises post-docs, Ph.D. and M.Sc. students. She is actively engaged in national and international policy dialogue, among other as coordinator of the global Multiple Water Use Services (MUS) Group. She is Board member of the Water Research Commission, South Africa, and served in the Steering Committee of the Global Water Partnership. Before joining IWMI, she was assistant professor on gender and irrigation at Wageningen University and Research Centre, where she also obtained her Ph.D. and M.Sc. as rural sociologist, specializing in poverty, gender and water management.

**Dr. Narpat Singh Jodha:** Dr. Narpat Singh Jodha, born in a small desert village of Rajasthan (India) in 1937, had his post school education at University of Rajasthan (Jaipur), Delhi School of Economics (Delhi University– for MA in Economics) and Jodhpur University (Rajasthan– for Ph.D. in agriculture and resource economics).

Jodha has worked in over thirty five countries of Asia and Africa as well as Europe and Americas for different durations, for different agencies and on different subjects. His geographical focus had been on arid and semi arid tropical regions initially and later his attention shifted to mountain areas.. However, his research and advisory work often integrated the understanding on both types of landscapes and their problems and opportunities as most of his often quoted writings show.

He worked as employee of CGIAR Centers such as ICRISAT, IITA, and to a limited extent CYMMIT, IRRI, and other agencies such as the World Bank, FAO, UNESCO, WMO as employee of different CGIAR Centres as well as the other agencies like FAO and UNEP besides ICIMOD (International Centre for Integrated Mountain Development – covering 8 Himalayan countries), where he has worked for nearly two decades. Based on field level research and advisory work, he has published nearly a dozen books and over 90...
research cum advisory papers, some of which have been re-printed in Books of Readings by different publishers. Because of this, Jodha has been recognized as a FELLOW OF WORLD ACADEMY OF ART AND SCIENCE since the year 2000.

**Dr. Prachanda Pradhan:** Prachanda Pradhan, born in 1939, was Professor of Public Administration in Tribhuban University, Kathmandu, Nepal. In 1972-75, he was Dean of Institute of Business Administration, Commerce and Public Administration, Tribhuban University, Nepal. He earned his Ph.D in Government from Claremont Graduate School and University Center, Claremont, California in 1969. He was engaged in teaching and Research in Tribhuban University, Nepal until 1980. He was a Research Associate at the John Kennedy School of Government, Harvard, in 1972 and Fulbright Visiting Professor at the Center for International Studies, Cornell University, in 1979 and Visiting Scholar at Workshop in Political Theory and Political Analysis, Indiana University, USA in 2002. He has been working for last 35 years to promote the knowledge and understanding about farmer managed irrigation systems in Nepal and elsewhere. He has experiences working in Asian and African countries. He worked with IIMI, WB, ADB, GTZ, InWent-Germany, IFAD and FAO. He has several books and papers to his credit. He has published collaborative book with Lin Ostrom, Nobel Laureate titled “Improving Asian Irrigations” from UK and USA.

**BESTOWING THE HONOR AWARDS**

After the introduction, Mr. Naveen Mangal Joshi, Chairman, FMIS Promotion Trust, honored the "Icons of Honor" by presenting Dosallah (shawl), which is a traditional Nepali way of bestowing honors to the distinguished persons. Mr. Suman Sijapati, Vice-chairman, FMIS Promotion Trust, honored them by presenting commendation plaques, and Mr. Sushil Subedee, Member Secretary, FMIS Promotion Trust by offering bouquets. Mr. Bhubanesh Kumar Pradhan, Ex-Secretary of Ministry of Water Resources of Nepal read out the citations inscribed in the commendation plaques.

**Commendation plaque to Dr. Barbara van Koppen reads:** This Plaque of honor is presented to Dr. Barbara van Koppen in recognition to her outstanding, consistent and extensive contribution in promoting knowledge, discourse and action on community-driven water services; and the gender, poverty and water linkages in Asia and Africa.

**Commendation plaque to Dr. Narpat Singh Jodhareads:** This Plaque of honor is presented to Dr. Narpat Singh Jodha in recognition to his outstanding and considerable contribution in communicating and promoting micro level approaches on community group action, knowledge, livelihood options and adaptation in arid, semi arid and mountain eco-systems.

**Commendation plaque to Dr. Prachanda Pradhan reads:** This Plaque of honor is presented to Dr. Prachanda Pradhan in recognition to his outstanding contribution in exploring, establishing and promoting knowledge as well as heritage of self-governing farmer-managed irrigation organizations that significantly contribute to food security and local livelihoods.

The glorious moments of honor award ceremony, captured in the photographs, are shown in the following pages.
COMMUNITY-MANAGED WATER DEVELOPMENT: MULTIPLE USE WATER SERVICES

BARBARA VAN KOPPEN*

INTRODUCTION

For more than three decades, the Farmer Managed Irrigation Systems (FMIS) in Nepal has been a source of inspiration for farmers, practitioners, policy makers and academics across the world. Insights about Farmer Managed Irrigation Systems (FMIS) in Nepal figured in many global debates on participatory irrigation management. It was the cradle of the work of Nobel Prize laureate, late Elinor Ostrom. Authors of the studies on Nepal’s farmers’ wisdom in dealing with their physical and socio-economic environments became the heroes of generations of students, including myself.

The same lively debates inspire this paper. This paper starts with the observation already in 1983 by one of the heroes, Bob Yoder. Grounded in his crystal-clear insights in the dynamics of rural life, he noted that the storage tanks and reservoirs and the canals bringing water to fields were not only used for irrigation but for domestic uses, livestock watering and other purposes as well (Yoder 1983). In the course of the years more and more professionals observed the same and started exploring how to respond to this. This led to the new approach of ‘Multiple use water services’ (MUS). In the Smallholder Irrigation Marketing Initiative, Bob Yoder participated in one of first pilot MUS implementation projects in the world, which, again, took place in Nepal (Mikhail and Yoder 2008). This paper traces how these experiences with MUS were also gradually taken up by other water practitioners and researchers in Nepal and elsewhere. By now, MUS is being applied in 22 countries. A MUS Group has been formed to promote exchange and to maintain a repository of formal and grey literature on MUS (www.musgroup.net). This paper will draw on this repository.

* Principal Researcher International Water Management Institute, PBX813 Silverton Pretoria South Africa

Small Scale Irrigation Systems: Challenges to Sustainable Livelihood
We will not only show how Nepal is, again, a global front runner, but also the vital importance of FMIST’s commitment to put people first and to build on local wisdom, practices and priorities. ‘Putting people first’ entails more untapped opportunities for livelihood-enhancing water service delivery by governments and development agencies. The major challenge remains the one that FMIST has been addressing since long: how can external support agencies for water development and management build on communities’ wisdom and practices; identify and follow their priorities; and provide demand-driven support? How can the good intentions of decentralization and accountability to end-users, especially poor women and men be realized in practice? And once robust generic best practice has been identified, do they remain islands of success in oceans of misery or can they be replicated and upscaled and institutionalized at much larger scales?

Below, we will first discuss MUS as ‘best practice’, so as a model that has emerged from various innovative projects, in particular in Nepal. The claimed merits are based on evidence or on plausible conjecture. In the second part of the paper, we will discuss the potentials and obstacles for the upscaling of this best practice, again as pioneered in Nepal.
RURAL COMMUNITIES' WATER WISDOM

Multiple Sources, Multi-purpose Infrastructure and Multiple Uses

MUS puts people first and is anchored in people’s holistic and integrated water wisdom. The core of MUS is no rocket-science. Everyone can see it anywhere: people use multiple water sources for multiple uses and often through multi-purpose infrastructure. Even the urban middle-class uses both rainfall and piped supplies for diverse domestic uses, sanitation, washing, and for watering their gardens. This diversity is much wider and much more vital for people in rural and even peri-urban low- and middle-income countries. Here, a significant part of the population depends on water-dependent agriculture for a significant part of their fragile, diversified livelihoods. They need water for themselves (drinking, domestic uses), their plants (crops, vegetables, trees), their animals (livestock, fish) and a range of other purposes (including brick-making, crafts, enterprises and cultural uses). These different water uses lead to different dimensions of wellbeing of health and wealth. However, water is only one input; more conditions need to be met to turn water use into wellbeing, such as access to inputs and markets or hygiene education. The resulting dimensions of improved wellbeing mutually reinforce each other in virtuous cycles out of poverty. More health gives higher productivity and income, which, at its turn, allows payment for health services. Freedom from the drudgery of water fetching enables children to attend school and leaves more time for production.

In order to meet these multiple water needs, the rural and peri-urban poor combine multiple sources, depending on natural availability: rainfall, run-off, streams, natural storage, wetlands and groundwater. Combining multiple sources is environmentally appropriate and crucial for resilience. In order to better mitigate the vagaries of weather and climate, people take water from these multiple sources or protect against too much water through abstraction, storage and conveyance infrastructure. This infrastructure (or technologies) ensure reliable supplies of the right quantity, quality, at the right time and place. In Thailand, it was found that rural families use nine different water sources for their domestic and productive needs at their homesteads (Penning de Vries and Ruaysoongnern 2010). When communities design infrastructure, they design multi-purpose infrastructure as the rule. Obviously, multi-purpose infrastructure is more cost-effective than constructing two adjoining separate schemes, each for one single use. For communities, single use infrastructure is the exception, for example groundwater pumps at distant fields. The water sector does the opposite: single use infrastructure is the norm, and multi-purpose is the exception, at least at local level. More cost-effective multi-purpose design only becomes the norm again in the design of larger-scale storage, for example dams.

The Emergence of the MUS Approach

Why have intervening agencies largely ignored these straightforward characteristics of local water management? This is largely due to the compartmentalized and supply-driven
nature of the water sector. The WASH sub-sector is separated from the irrigation sub-sector, which is separated from the water resources management sub-sector, etceteras. Sub-sectors operate as administrative siloes, defined by the single uses of the sub-sector’s mandates and financing earmarks set at the centralized tops where public funds and resources are allocated. Accordingly, professionals tend to design schemes for one single use, so either domestic, or irrigation, or livestock.

Nevertheless, on the ground, all irrigation professionals know that people turn use such single-use designed infrastructure for many non-irrigation uses. Similarly, domestic supplies are also often used for other uses, for example livestock and gardening. In a research sample in rural Africa and Latin America 70 percent of the households were found to use water for productive uses, and 50 percent of the population uses the water facilities designed for domestic uses for these productive uses (Hall et al 2013). These non-planned uses represent considerable returns to investments. A banker would immediately calculate and welcome these ignored returns to these investments. However, the response by the respective water sub-sectors is very different. They sometimes even declare any other uses than their sub-sector’s mandate as illegal and they try to forbid, typically in vain. Or they turn a blind eye. Or, at best, they accommodate on an ad-hoc basis. The bottom-line in the fragmented water sub-sector is that other uses than those of the professional’s sub-sector remain being seen as ‘not my job’ (Renault 2008).

Since the early 2000s, professionals from both the WASH and irrigation sub-sectors decided to find a better response. Recognizing the benefits of multiple uses, they joined forces to plan for multiple uses from the outset. This approach became known as multiple use water services (MUS). MUS is a participatory approach to water services that takes people’s multiple water needs as starting point of planning and providing water services (Van Koppen et al 2009). In this definition, the ‘S’ of Services conveys that that the intervention is not just about infrastructure construction. The water should flow as agreed to meet people’s needs and render a service. The ‘S’ in MUS can also refer to a multiple use ‘System’ in the sense of the infrastructure, which remains a central element of multiple use services.

When MUS emerged, Nepal was one of the first countries in which planning and providing for multiple uses was pioneered.

**MUS PILOT PROJECTS IN NEPAL**

**The Merits of the MUS Model**

Winrock, IDE and other partners in the USAID supported Smallholder Irrigation Marketing Initiative (SIMI) were those pioneers. SIMI promoted profitable small-scale productive uses, also with unconventional technologies, such as drip irrigation. The project looked for water sources for vegetable growing at homesteads and nearby bari land. They
realized that water supplies near homesteads are bound to be used for domestic uses as well. From 2003 onwards they built multiple use systems, a total of 81 by 2008, to provide gravity-fed piped water supplies, with drip irrigation, for multiple uses. The pipes from the tanks and reservoirs were brought to homesteads and residential areas, and depending on the land use lay-out, to more distant irrigation fields as well. (Mikhail and Yoder 2008). Essentially, instead of only 45 liters per capita day (lpcd) as designed service level for domestic uses only, SIMI ‘climbed the water ladder’ by adding another 92 – 175 lpcd for productive uses (Van Koppen et al 2009).

These innovations were further supported and analysed as part of an 8-country comparative action-research project on MUS, led by IWMI, in collaboration with IDE (led by Bob Yoder), the International Water and Sanitation Centre IRC, and other partners, and supported by the Challenge Program on Water and Food (Mikhail and Yoder 2008). This first generation of new multi-purpose systems confirmed the merits of MUS. A ‘best practice’ or model emerged. The higher domestic and productive uses brought both health and wealth, and reduced the burdens of water fetching. Based on these and other global experiences, Winrock and partners did an in-depth financial quantification of these merits of MUS, supported by the Bill and Melinda Gates Foundation. This study calculated the incremental costs of the upgrading of a system designed for a single use, into a multiple use design, and compared that with the incremental benefits. It was found that the benefit cost ratio was very advantageous: the incremental investments could be repaid from the incremental income within a period of six months to three years. This calculation assumed that potential productive uses were taken up, and that there was a market for the sale of the products (Renwick 2007).

These innovations in Nepal and elsewhere revealed more. Analogous to the discovery of farmers’ wisdom in farmer-managed irrigation systems, these MUS experiments revealed communities’ water wisdom at ‘landscape’ scale. At this scale, people access different natural water bodies and invest in individual infrastructure and shared communal systems for their various sites of water use at homesteads, for cropping (bari and khet), livestock watering and other uses, upstream and downstream. Bob Yoder also observed how at least part of the community members has a clear vision and plans for next incremental steps to improve water management at community scale. Indeed, over time villagers smoothly integrate the contributions by the range of subsequent short-term projects, typically each with their own conditions, in their much more holistic views on steady incremental improvements. MUS at landscape-scale seeks to tap this wisdom by planning according to people’s priorities. This not only brings the cost-effectiveness of multi-purpose infrastructure to meet multiple needs and the environmental resilience of combining multiple water sources. It also brings at least four sets of other merits.

First, MUS saves costs by building on all five existing capitals, instead of ignoring them, or worse, eroding these existing assets: natural capital (water resources); physical capital
Small Scale Irrigation Systems: Challenges to Sustainable Livelihood

(existing infrastructure, whether self-initiated or through preceding projects or both); social-institutional capital (local arrangements to construct, operate and maintain infrastructure and to allocate and distribute water within and between schemes); and human capital (holistic knowledge of the locally specific ecological and socio-economic conditions, engineering skills).

Second, planning according to people’s priorities ensures more relevance or ‘ownership’, which is the single most important condition for any sustainability of external interventions. Third, people’s visions are holistic and locally appropriate. The landscape-level focus opens up new technical opportunities. Canals that are used for distant irrigation schemes can be diverted to feed into a multiple use system. In dry areas, storage jars can provide just enough water for irrigation in the dry season, while the cleanest source, even if just a trickle, can become the exclusive point to tap water for domestic uses (Mikhail and Yoder 2008).

Fourth, a MUS approach renders inevitable trade-offs, conflicts and negotiations over both public resources and water resources more transparent. This is especially important for women and other marginalized groups. As long as viable, MUS improves storage and promotes the diligent use and re-use the available multiple water resources as win-win for many. Yet, the equity question is: ‘Who, precisely, gets access to any new infrastructure and other public resources?’ Questions become more urgent when the limits of the naturally available water resources that can be cost-effectively exploited are being reached. This is increasingly the case in Nepal. The new question is: ‘With given infrastructure availability at landscape scale, which and whose water uses get the priority?’ Intervening agencies always have a strong influence, even if not fully aware, in either empowering some groups, but also disempowering certain groups in a relative and sometimes even absolute sense. The MUS approach raises two sets of more holistic equity questions that affect the job of any water professional. One equity issue regards the prioritization among uses and the second issue the prioritization among users.

New equity questions

MUS renders competition between uses more transparent, in particular between domestic water uses and productive uses. Productive uses require more water than domestic uses. The volumes for domestic water are relatively small; usually just a few percentages of all available water resources. Moreover, inequalities are stronger in productive uses. Not everybody uses water for production, while those with more land and more capital to invest in productive uses can use more water. Indeed, around the world cases have been reported in which upstream multiple uses, especially by a few relatively large-scale productive users, negatively affected downstream users, who even lacked water for domestic uses.

IDE has always been very careful that the new productive water uses still ensure a priority for domestic water uses for all. As a solution, IDE tried to hardwire such priority in the
technical design. For example, in systems with two distribution networks, one assumingly for domestic uses, and one for irrigation, a new upstream reservoir would first provide water for the domestic network, and only the overflow would feed the irrigation network. However, when villagers need water for multiple purposes at the same site, the intended single use and the name of the technology fail to impress them. When homesteads adjoin irrigable bari land, the availability of sufficient water tend to determine the uses more than the purpose given by the engineers.

The point is that IDE and other MUS implementers acknowledge the likely competition and seek to anticipate and solve already in the planning phase. In contrast, in a narrow sectoral perspective, irrigation professionals can simply claim an exclusive priority for irrigation. Within their silos, it is justified and even professional to ignore other uses and needs. As a Nepalese project coordinator expressed in a discussion on whether to also consider domestic uses or not: ‘irrigation is already so complicated; we cannot complicate even more’. Irrigation professionals can also chase people who use the water from ‘irrigation’ canals for domestic uses. Their professional argument is, that, if these people fall sick, these irrigation professionals can be held accountable. It is ‘not their job’ to find a better solution for people for whom the irrigation canal is, apparently, the preferred option for domestic uses as well (Van Koppen et al 2014a).

Yet, the human right to water for domestic uses and sanitation has been well recognized across the globe by now (Hall et al 2013). This right obliges the states as duty bearer both to deliver the water services through infrastructure and to ensure that there are always sufficient water resources available to meet basic domestic needs. It is difficult to defend that irrigation departments can ignore this human right, simply because of the mandate set by their senior managers. New questions are: how should irrigation professionals deal with domestic water uses, especially in areas where access to water for domestic uses is still lacking? Given women’s strong participation in domestic water use provision, this question has important gender dimensions as well.

The second equity issue regards the competition between users. MUS shows that the competition is not between abstract monolithic single-use ‘sub-sectors’, but between people, each with multiple water needs, but with different powers and at different locations. All tend to use water available at a certain site for any purpose on that site. There is a sharp contrast between the global WASH and irrigation sub-sectors. The WASH sub-sector well aligns with the human rights bodies and clearly seeks universal coverage, and keeps trying to also reach the unserved. Yet, the irrigation sub-sector has hardly any ambition in developing infrastructure to seek and reach everybody, or at least everybody interested in using water for irrigation or other productive uses. Quite some other countries than Nepal even favour medium- and larger-scale farming. There is a clear void in the public sector’s promotion of small-scale productive water uses in terms of factually delivering ‘wet water’. FMIST remains one of the few global players who keep putting public technical, financial
and institutional support to farmer-managed smallholder irrigation on the agenda.

Even worse, there is not only little public infrastructure support to deliver ‘wet water’ to smallholders for productive uses, but formal legal (‘paper’) protection for micro- and small-scale water users is completely lacking. Statutory water laws that allocate entitlements to water resources do prioritize domestic uses, but when it comes to productive uses, they just rank, at best, monolithic single-use sectors, so agriculture, environment, industry, hydropower, etc. These formal laws, and much of the discourse on water allocation worldwide, ignore the differences within sectors, and ignore that water is allocated between people, each with multiple water needs. Permit systems, in particular, favour the administrative proficient larger-scale users, who can easily get such permit. For small-scale users, it is much more difficult, not for their fault, but because the state lacks the administrative capacity to issue permits to large numbers. Small-scale and micro-scale users who are exempted from the obligation to apply for a permit are, by law, marginalized to second class entitlements. They include the poorest (Van Koppen et al 2014b).

As a first step to avoid such discrimination of micro- and small-scale productive water users, it is increasingly proposed to develop a ‘human right to water for livelihoods’ to meet the human rights to food, adequate standard of living, health and participation. This would, in any case, ensure that every productive water user is supported by the state in claiming access to a minimum quantity of water to meet basic productive needs, also if he or she still has to make the investments in infrastructure him- or herself. Again, the experiences of FMIST on how farmers set their rules in distributing water under scarcity are vital inputs in such debates. The common rule to ensure some water for all before some can take more water reflects such notions of justice.

Efforts to better promote and legally protect water for smallholder farming (cropping, livestock, fisheries, and other productive uses) has also important gender dimensions. Is the need for water for productive uses only the need of men, or the need of both genders? Should men represent their female kin, or should women and men join forces on an equal basis and represent the needs of every individual, so that both spouses contribute to the food and income of their families and dependents? With the strong outmigration and feminization of agriculture, they young men who migrate leave a gap in former male dominated land tenure and irrigation. There is an important challenge for women and youth, and for their supporting agencies, to fill this gap (Fraser et al 2014). A multiple-use perspective is especially relevant for women. For them, it is even more difficult than for men to separate their productive and domestic tasks, and water needed for both. Women’s less contested inclusion in water planning for domestic uses may appear a powerful entry point for women to obtain better access to productive resources as well for women’s higher labor productivity.
Conclusion on the merits of the MUS model

The insights generated by the MUS pilot projects of IDE, Winrock and others in Nepal and elsewhere corroborate the various merits of this new and holistic model of water service provision. This answers the question: ‘why MUS?’. The processes to put this model into practice (‘how to’ do MUS) has also crystallized: a participatory planning process that follows people’s priorities and adjusts to each specific location. MUS calls perhaps even stronger for the participatory processes that FMIST has always emphasized. Productive uses bring even more diversity and often more inequalities, in addition to the more universal need for certain volumes of water for domestic uses. In order to optimally tap local specificities, project designs critically depend on participatory planning. Funding and other support can only be defined for the outcome of a participatory process. Earmarking funding from the top down to blue-print single-use infrastructure goals may, ironically, seem to strengthen accountability of public resource spending. The price is high: support becomes less meaningful.

Later experiences elsewhere confirmed the findings in Nepal. The MUS Group has synthesized the ‘how to’ question into ‘Guidelines for planning and providing multiple use water services’ (Adank et al 2012). Winrock is compiling a web-based ‘Guide to SolutionMUS’ based on the institute’s many later experiences in both Africa and Asia.

Thus, the ‘why’ and the ‘how’ of the MUS model have crystallized by now. Over 15 international organizations have become interested in MUS and have applied (elements of) MUS. Their number keeps growing. The continued efforts to further upscale and institutionalize MUS have shown that there are four pathways along which MUS is spreading, each with own opportunities but also obstacles. In the remainder of this paper we will briefly discuss these pathways and lessons learnt.

FROM COMPARTMENTALIZED PROJECTS TO ITERATIVE HOLISTIC PLANNING

The two ‘+plus approaches’

In the past decade, MUS has been upscaled within the respective sub-sectors. These approaches are called the ‘+plus approaches’. These approaches keep tapping into the funding streams of the sub-sectors, and remain tied to the expertise that is needed to turn one particular water use into one dimension of wellbeing. However, in the +plus approaches, the mandates and funding earmarks for the priority single use are widened up to also enable other water uses.

Thus, in the ‘domestic+plus’ approach, WASH professionals, from the top-down, continue prioritizing water delivery to homesteads and residential areas, and ensuring that at least 5
litres per capita per day is safe for drinking. Hygiene and health education remain important accompanying measures. However, small-scale productive uses are also promoted, often just by providing more water and ensuring higher service levels. The affordable availability of more water triggers people to start using that water for non-domestic uses. Accompanying support, for example agricultural training or access to markets, can further increase the benefits.

In the ‘irrigation-plus’ approach, which is championed by FAO (Renault et al 2013), irrigation professionals prioritize water for crops, but they plan for other uses as well, especially water uses near an irrigation scheme. Designs can even be the same as for domestic-plus, as in piped gravity schemes. Cattle entry points and watering places, or washing steps can also be ‘added on’ to the irrigation design. Agronomic training, improving access to inputs and markets for the irrigated crops and other technical advice remain intrinsic part of the service provided. The widening up of mandates implies, for example, that even if certain pipes are paid by the department of irrigation, they stop being exclusively seen ‘irrigation pipes’ that can only be used for irrigation. Instead, they become neutral technologies that can serve various uses. Instead of rigid accountability of the local-level staff upward to their superiors on the proper use of narrowly earmarked funds, local staff gets more discretionary power to better meet their clients’ needs (Mikhail and Yoder 2008). The benefits of non-irrigation uses are recognized and counted as returns to (irrigation) departments’ performance.

MUS by design: the Rural Village Water Resources Management Project, Nepal

In the third pathway of upscaling of MUS, so-called ‘MUS by design’ at landscape scale, professionals set a frame of minimum conditions while enabling the community to set priorities for certain water uses, and not others. Minimum conditions would include the project’s vision on equity issues mentioned above, for example, aligning with the constitutional and human rights to water for domestic uses for all. Projects can also promote that everybody interested has access to minimum volumes of water for productive uses as a safety net.

In MUS by design at landscape scale, the processes of participatory planning are central. Funding should be available for the outcomes of this process. Moreover, the provision of technical expertise, so both engineering expertise and expertise on how to transform water use into wellbeing, becomes more demand-driven. MUS by design at landscape scale can be implemented as a specific project. However, upscaling warrants a much broader, if not nationwide replication and institutionalization of MUS by design. This is possible through local government as the main vehicle. The constitutional local government planning and financing processes need to be made to work for water. A project, again in Nepal, has pioneered this approach: the Rural Village Water Resource Management Project (RVWRMP). Funded by Finland since 2006, it operated in 94 Village Development Committees in the far and mid-west by 2014. A total of 944 schemes have been completed, directly serving over
500,000 people. The project takes a holistic area-wide approach by implementing the iterative planning processes of the Local Self Governance Act, 1999. In the absence of elected councilors, the project directly builds people’s capacities, preparing them for the future. Needs and opportunities are identified in a participatory manner at village level through five-year rolling Water Use Master Plans (WUMPs). This methodology was initially developed by Helvetas and Finnada. The decentralization of donor funds into a District Water Resources Development Funds under the local District Development Funds ensures that outcomes of the WUMPs can be financed. Other donors can also step in and support identified but still unmet needs. This structured needs identification and planning process mitigates ad-hoc lobbying by the elite to at least some extent.

For each scheme a Water User Committee is set up that follows a Step-by-Step approach for performance-based and publicly audited participatory construction and subsequent operation and maintenance. Preparatory meetings for women strengthen their voices, although the chairs of the Committees are still overwhelmingly male. With a clear recognition of a priority for water for domestic uses, RVWRMP increases both the numbers of schemes and service levels. Not surprisingly, infrastructure served multiple purposes. By 2013, 68 percent of a sample of 314 gravity piped systems was used for both domestic uses and vegetable growing. The 28 percent of systems that were only used for drinking were systems with very low flows. Various open canal schemes include micro-hydropower (Rautanen et al 2014).

This project shows how participatory planning by rural communities, without a priori single-use sectoral boundaries, organically taps into communities’ wisdom of developing multi-purpose infrastructure to meet multiple needs. This is not to say that all problems are solved. Problems like elite capture, the need for post-construction support, or an emphasis on new construction instead of rehabilitation, continue (Rautanen et al 2014).

In the three above-mentioned upscaling pathways, the intervening agencies set an important condition: interventions should be about water. But what happens if intervening agencies leave the choice even more open? Do communities prioritize water projects or not? And if so, what types of water projects are proposed? This leads to the fourth scaling pathway.

Implicit MUS in community-driven development

In the national and global development communities beyond the water sector, there has been a significant shift towards community-driven development in the past decade. Decentralization and accountability to the poor are widely recognized as necessary (but not sufficient) conditions to improved public services performance (World Bank 2004). Programs can aim at development or employment generation, and most do both.

India’s National Rural Employment Guarantee Scheme (NREGS) is undoubtedly the largest initiative. It started in 2005, operating from the central Department of Rural
Development and implemented through local government – an institution that is well developed in many parts of India. By 2010–2011, the program provided more than 2 billion person-days of employment to roughly 50 million persons, about half of them women. These workers implemented small, demand-driven and locally appropriate projects of asset creation. Two thirds of the assets that communities and local government prioritized are for water and drought proofing. This includes digging and excavation of wells and ponds, pit-latrine digging, irrigation canal rehabilitation, watershed management, groundwater recharge structures, river weirs, forestry, soil conservation, land erosion prevention, flood control, drainage of waterlogged areas, and gully treatment. With a total value of about USD 3 billion per annum for water, NREGS is arguably the world’s largest rural water program. Over two thirds of these water assets are for multiple uses, managing multiple conjunctive sources (Shah et al 2010; Verma et al 2011). Thus, NREGS is implicitly the world’s largest MUS program as well.

In other community-driven development initiatives, including the Nepal Poverty Alleviation Fund, there are also indications that MUS is implicitly emerging, but this has never been studied as yet. Thus, community-driven development is possibly an effective, but hitherto ignored pathway for upscaling both FMIS and MUS.

For all four pathways, technical support needs to become more demand-driven. Engineers need to design in a participatory manner for multiple uses, while experts who support the transformation of water use into wellbeing need to bring their much needed technical knowledge at a broader scale in a more demand-driven manner, instead of being supply-driven tied to specific projects only.

**CONCLUSIONS**

FMIS and MUS reinforce each other. They share core principles of people-driven water development and management; recognition of, and building on people’s wisdom and their vision, plans, and priorities; and transforming public sector service delivery into accountable, demand-driven provision of technical, financial and institutional support. The lessons learnt from best practice are relevant at national and global scales.

An emphasis in MUS that could further enrich FMIS regards domestic water uses and gender issues. MUS emphasizes water for domestic uses as a human right, in which the state is the duty bearer of the realization of this and other indivisible human rights among both state and non-state actors. Adding this angle to FMIS would not only support the implementation of this human right, but is also a potentially powerful entry point to better include women in infrastructure planning and design. Such participation would provide a platform to also empower women as farmers filling the gap in irrigation management and in water user associations that the young migrating men leave. Both women and men would
be recognized as needing water from the same sources for both domestic and productive uses. A negotiation of such prioritization already during the planning phase is the strongest guarantee possible that the priorities are observed later.

An emphasis of FMIS that fills a major gap in general global debates, regards the focus on small-scale irrigation (and other productive uses). The importance of this focus cannot be over-emphasized, also in the realization of MUS: there are only very few ‘public owners’ to promote, or even just protect productive water uses by the rural and peri-urban majority in low- and middle-income countries. Mainstream trends are the opposite towards widening gaps within the agricultural and other sectors. Learning from the WASH sub-sector, there is a need to develop a human right to water for livelihoods. Both women and men who strongly depend on water-related livelihoods need access to water to meet basic domestic and basic productive needs. FMIST’s focus fills this gap for an even broader global inspiration.

REFERENCES


THE BEGINNINGS

Prior to joining ICIMOD in 1987 I had never been to mountain areas even as a tourist, though I had opportunities to work with a number of CGIAR centres like ICRISAT, IITA and briefly for CIMMYT, IFPRI and IRRI as well as FAO, The World Bank etc. Covering half a dozen countries of East and West Africa, Malaysia, Philippines, South Korea, Myanmar and of course nearly ten states of India. An important research project linked to my joining ICIMOD in 1987 was a comprehensive four year – long study of rural common property resources (CPR) covering arid and semi-arid states of India. The very first publication of that research induced at least five renowned institutions including the World Bank, FAO and ICIMOD requesting me to consider the possibility of my joining them to do CPR research in their identified regions.

After long deliberations I opted for ICIMOD. They appointed me as Head of the newly created Mountain Farming Systems (MFS) Division, with a team of researchers including most persons who were either born and brought up or worked for several years in mountain areas. Leading or guiding such a team was both a challenge and source of hidden inferiority complex for me in several ways. Beside as a first formal facility I was also given volumes of literature on mountain regions to guide and plan my work.
ESSENCE OF MY PAST EXPERIENCES/LEARNING:

My choice of approach, however guided by my past learning and experience of diverse rural areas and situations from Africa and Asia, I opted for a low priority to learning from literature. The essence of my past learning can be summed up as follows:

i. There is a subtle difference between knowledge and understanding in my view and the latter should get higher priority in fresh enquires.

ii. Constructive dissent serves as an important source of innovative ideas and approaches for promoting work in dynamic contexts.

iii. There may be hidden useable links between different projects handled by the same individual irrespective of difference of location and type of project activity.

As a consequence of the above contexts approach with approval of ICIMOD Director General and supported by different donors particularly the Ford Foundation and a few others, who supported my research work on the mountain areas in the past I decided to spend around 2 years primarily on travelling through the rural areas of mountain regions of Nepal, India, China, Pakistan, Bhutan and to a limited extent Bangladesh.

Some members of MFS team and some local researchers from focused areas accompanied or guided us in choice of areas and logistics. Personally, I travelled to mountain areas with my eye glasses evolved through my experiences of diverse non-mountain areas during the past jobs for two decades.

MOUNTAIN SPECIFICITIES AND MOUNTAIN PERSPECTIVE FRAMEWORK

My quick and often sudden realization during the field visits to mountain areas was clear realization of the differences and diversities of mountain farming systems on the one hand and their general disregard by the formal policies and development interventions prompted by the higher level policy makers and development planners. They ranged from land use to water management, agro-forestry to bio-diversity and group action etc.

We attributed the above situations to the specific features of mountain areas and the policy makers’ limited active attention to the same. The features included (i) limited accessibilities, (ii) fragility (iii) marginality (iv) diversity and (v) niche or comparative advantage situations in mountain areas. As we learned and explored further, these features revealed their both bio-physical and socioeconomic dimensions and their multiple links. For mountain land areas, a conceptual framework based on the mountain specificities and their imperatives was developed. This analytical and operational framework is called Mountain Perspective Framework (MPF) was promoted and used by ICIMOD and its collaborators working on mountain areas.

MPF was initially used for mountain agriculture and natural resource management,
subsequently it was extended to emerging environmental and socio-economic changes faced by mountain regions/populations. To illustrate this included climate change, process of rapid globalization, persistent poverty and vulnerabilities faced by mountain communities, and emerging initiatives against the above by some states and donor communities. Different initiatives to address the emerging mega changes, ICIMOD in collaboration with its member countries and specific donors is actively participating in the above process. Personally, I was privileged to work in advisory and research capacity on these issues individually or as member of teams.

The self-perpetuating message and impacts of mountain perspective framework (MPF) has taken different forms and passed through different pathways including research and advisory work, teaching and collaborative research planning of different countries and institutions in which myself and different colleagues from ICIMOD and other organizations/donors were involved. Personally, I am grateful to various countries and national and international organization for involving me as their advisor on mountain specific initiatives. The same applies to different and book publishers who gave me opportunities for pre-publication reviews of the document published by them.

The key driving factors behind the descriptions presented above have been the combination of insights and approaches I learned through working in rural areas prior to and after joining ICIMOD. They include as mentioned in the beginning i.e. difference between knowledge and understanding positive role of constructive dissent in promoting innovation etc. links between successive learning opportunities despite vast visible change or differences in the thematic areas/context of work. I plan to illustrate this by referring to initial work at ICIMOD for first one to two years spent on visiting mountain rural areas in different countries.

Governed by the above areas of past experiences, at ICIMOD we began with field visits as a primary method of learning. Consequently, we spent days and weeks to observe, understand and verify the extent, role and impacts of different dimensions of various mountain specificities as well as how mountain farmers understood and responded to them in different landscapes and operational locations. After our observations, understanding etc. the above information/learning was broadly tentatively recorded we met the same farmers and the others, again to seek their judgment/assessment of our understanding. We were quite surprised and pleased to see that not only our observations were approved by the re-visited respondents and others but supplemented by additional information on the same aspects.

This approval was tried with different groups and villages as well as formal official workers such as school teachers, some revenue department workers and local NGOs. This offered sound and reliable information as a foundation of mountain perspective framework and became important part of methodology for field research in mountain areas. Though used in different years and contexts it was also very dynamic framework rather than a
static conceptual structure. As the mountain specificities changed due to shifts in the nature society interaction – dynamics, the negative and positive imperatives/implications mountain specificities also change. A review study entitled “Revisiting Mountain Perspective Framework” during 2013-14 by ICIMOD revealed significant changes in different mountain specificities which enhanced the potential capacities of mountain areas/communities to adapt to and harness the potential gains of national/global changes.

The first formal publication that contained the approach similar to that underlying MPF I happened to see was Robert Roads entitled “Thinking Like Mountain” in the popular journal on farming from Norway. That enhanced our confidence in the validity of our approach to understanding and ability of MPF. Subsequent literature review including different papers in Mountain Research and Development and collected articles.

MAJOR CHALLENGES

The Challenges of Mega Changes:
As mentioned earlier, the mega changer caused by Climate Change, Globalization, Persistent Poverty and Vulnerability of several mountain communities particularly with emerging water and bio-physical constraints are emerging challenges for Hindu Kush Himalayas (HKH). The proposed solutions due to market and self-interest are dividing mountain communities, leading to fragmentation of water, biodiversity and other mountain niche which need collective attention of positive thinking by mountain focusing groups.
WHY FOCUS ON SMALL SCALE IRRIGATION SYSTEMS:

PRACHANDA PRADHAN*

If I were to ask someone to show me an irrigation system in a country, the natural response would be to take me to a large irrigation project with a well-built intake, line canals and many concrete structures for water control and distribution. Many people would hardly notice the existence of numerous small irrigation systems. They are usually owned and managed by voiceless people. This segment of the people is either poor or comprised of marginalised farmers who do not have the capacity to lobby in the decision-making process.

While I was in Chitral of Pakistan in the late 1980’s, collecting information on small-scale irrigation systems, I told a district irrigation officer that Chitral had many interesting small scale irrigation systems. He responded that there were no irrigation systems, only kuls from dariyas. I was surprised and started thinking why this man could not see what I saw in Chitral. Those irrigation systems had been built by chiseling the vertical cliffs to convey water to the farm lands. The water distribution boxes were based on water right, and later on that became the basis for resource mobilisation for operation and maintenance.

Farmer Managed Irrigation Systems

For that Pakistani officer, his school taught him only about the large irrigation systems of Sindh and Punjab provinces, so they were the only irrigation systems he knew. Dr. Lucas Horst¹ saw deficiency in the engineering curriculum in not including the farmer managed irrigation systems of different sizes.

* Patron, FMIS promotion Trust
Small Scale Irrigation Systems (SSISs), including all types of technologies adopted, have substantial coverage in the world and provide livelihood support to a large number of farmers. In the South Asian region, they are contributing greatly in Nepal, Bhutan, Bangladesh, Sri Lanka, India, Chitral, Hunza area of Northern Pakistan, and Afghanistan.

In the Middle East, Yemen could be cited here. African countries like Tanzania, Kenya, Nigeria, Ghana, Niger, Burkina Faso and Ethiopia have substantial number of SSISs. In South America, the Andean mountain countries (Chili, Bolivia, Peru, Ecuador and others) have SSISs that contribute greatly to the livelihood of the local people.

In China’s south-western province of Sichuan, SSISs work as a means for conservation and use of water at the local level. Northern Thailand, Lao PDR and Northern Vietnam have substantial numbers of SSISs. These systems are either built by the community of users or by a local government unit, or a lineage of land owners/cultivators close to the water sources, or by individual households.

In countries like Nepal and Bangladesh, the SSISs hold a significant share of the irrigated agricultural area. The same thing could be said about their contribution to local food security and gainful employment. As such, small irrigation systems are not small at all in terms of their total impact on the national economy, agrarian relations, and ecological adaptability and resilience. There are thousands of SSISs ranging between 1 hectare and less than 25 hectares in the middle hills and mountains of Nepal, supporting the livelihoods of millions of people. So is the case in many other countries.

Looking at the scenario in Nepal, small irrigation systems less than 25 hectares, as identified by the Nepal Irrigation Policy, and small and micro-irrigation systems, as promoted by NGOs and government departments like DOLIDAR, DOA and DOI, exist. They are not recognised systems, yet they support the livelihoods of millions of farmers.

Reaching out to those places where the marginalised people live with sophisticated technology is a big challenge. Linking innovative technology affordable to these resourceless people with a credit organisation and supporting institutions for the implementation of these pro-marginal farmer programmes usually in those remote areas with difficult access to the market is a big challenge, yet we need to address their problem. There are so many technologies available in the market. But how can we make them easily accessible to them?

These questions seek an answer in the future policy toward small and micro-irrigation systems, adoption of new and sophisticated technologies, institutional support both at the

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2 There has been change in the size of SSIS from 25 ha to 10 ha. Irrigation systems less than 10 ha is categorized as small scale irrigation systems. (2015)
government and NGO level. What will be the subsidy policy resulting in self-supporting programmes?

There is a need to rethink about the small scale irrigation policy in Nepal. Institutional reforms in the irrigation development agencies should take in new values of socio-economic change such as inclusiveness, gender concern, self-governing local water institutions, promotion of self-supporting institutions and poverty alleviation.

Community engagement from project preparation to implementation, and operation and management has to be the prime concern in the implementation of small scale irrigation development programmes. Since many agencies have been providing assistance to the SSISs, there has not been uniform and consistent policy on intervention.

**Department**

Hence, it might be appropriate to think of establishing a Department of Small Scale Irrigation Development under the Ministry of Irrigation and take charge of overall policy formulation and implementation procedures and create the necessary manpower that understands the dynamics of the SSIS.

Investment in small scale irrigation development is a major issue. It might be appropriate to consider establishing a “Fund Board” where the users of the irrigation systems on the basis of need can request for a grant or loan for the construction, rehabilitation and improvement of small scale irrigation systems.
**Remarks By Chief Guest**

*MOHAN MAN SAINJU*

It is indeed a pleasure to be with you today as all of you are dedicated to review the past, learn from the experiences and look ahead for more evidence to strengthen our knowledge base and chart out the course of action. I would like to record my appreciation for the good work your organization has been doing.

Although we were not aware of what our ancestors had done at the community level, State led development process never recognized the strength of the community in the past in Nepal. Though, we have a tradition of social capital development for community activities in different walks of life. I come from Palpa district of Nepal where we have famous Rajkulo (Community irrigation systems) constructed during Mani Mukunda Sen. But now, there are examples in many sectors where community led process have shown successes. The potentials that lie ahead. Farmers managed irrigation system, community forest groups, community led poverty alleviation fund programs are a few good examples. The case studies undertaken in Nepal reviewing local level development activities clearly show that this process reflects the aspiration and need of the people and they are cost effective and most importantly they are sustainable in the long run.

In closing I would like to wish you all the successes in your deliberations. I thank you all.

* Dr Sainju was Vice Chairman of the National Planning Commission and Ambassador of Nepal to United States of America.
The conclusion of present event marks the successful completion of half a dozen of International Seminars on Farmer Managed Irrigation Systems, its dynamics, pertinent issues and the way forward. We at the FMIST feel proud to be closely associated with all the events over the years. In the mean time, the present discourse is expected to prove more meaningful as it tried to address the issue of national food security through the development of Small Irrigation Systems. And for the successful conduct of the event, credit goes to all our co-partners, co-organizers and the friends of FMIST without whose support, the program would not have been materialized. We sincerely acknowledge all and highly appreciate for all the support offered to us. In particular, first of all, I would like to thank Mr. Kenichi Yokoyama for sparing his precious time for the Pre-Seminar book launching event. The book titled “Trajectory of Farmer Managed Irrigation Systems” was made public by him despite his very busy schedule and also I would like to thank him for extending his full support to financially assist the Trust, through ADB, to hold this International Seminar. The support received from the staff members in ADB Manila as well as NRM were remarkable. Similarly, thanks go to the Director General of Department of Irrigation, Mr. Madhav Belbase as well as the Ex. Director General Mr. Shiv Kumar Sharma for kindly accepting our request to partake in the seminars Co-organizer. Further, thanks are also due to Dr. Luna Bharati for her support through International Water Management Institute (IWMI). Likewise we cannot forget the participation with big heart from GWP Nepal (Jalsrot Vikas Sasntha Nepal), Community Irrigation Project, Society of Irrigation Engineers Nepal (SIREN), IIT Roorkee Alumni Association (Nepal Chapter), International Network for Participatory Irrigation Management Nepal (INPIM), and

* Chairman, FMIS Promotion Trust
Society of Hydrology and Meteorology (SOHAM). Such participation from different organizations definitely shows the increasing importance given to the Farmer Managed Irrigation Systems in present context. We heartily extend our gratitude to all of these organizations.

FMIST Patron, Dr. Prachanda Pradhan, who showed his hesitation to accept the ICON honour, is definitely a key person whose efforts and contribution to the promotion of FMIS have been beyond boundaries. Locally his guidance to FMIST and his trans-boundary networking for Farmer Managed Irrigation Systems has been remarkable. So friends of FMIST strongly felt the need for acknowledging his contribution to this sector.

Furthermore, we express our sincere thanks to Dr. Narpat Singh Joda and Dr. Barbara Van Koppen for accepting our request and contributing the Key Note speeches. We once again congratulate our honorable new icons of 2015. I request all the friends of FMIS to give big hands to these honorable icons.

Papers on FMIS from different sectors and countries have been another milestone of this seminar in terms of its value and role. We highly appreciate the efforts of all the paper presenters and researchers.

Finally, we offer our thanks to Media, Hotel Management and Team of FMIST. Support from CMS (Nepal) and Nepal Engineering College have always been encouraging for FMIST. Ms. Anju Rana and all the team members involved in the Seminar have labored hard and I cannot leave space without thanking them. Lastly thanks to all the Friends of FMIST for the continued support to this organization and participation. Thank you and thank you all.
PART II
PARALLEL SESSIONS

CONTRIBUTION OF FARMER MANAGED IRRIGATION SYSTEMS: CASE STUDIES
INTRODUCTION

Overview of Irrigation Development in Nepal

Nepalese farmers with their own initiatives by using rudimentary material and local knowledge have created amazingly sustainable and efficiently operating systems since centuries to irrigate fields. Evidence of farmers managed irrigation system (FMIS) could be linked to an edict of King Ram Shah of 17th century BS (Hindu calendar), suggesting development of FMIS since historical ages. It is estimated that about 15,000 units of FMISs in hills and 1,800 in Terai covering 880,000 ha (66% of total irrigated area) exist in Nepal.1 FMISs display the power of self-governance- capable of crafting rules to sustainably manage their own systems. The continued survival of significantly larger number of FMIS since long owes much to their indispensible contribution to ensure food security in the subsistence agriculture ridden rural Nepal. Hence, it is considered beneficial to assess the success elements from a few successfully and sustainably operating FMIS since long and consider them for wider replication in future FMIS, which is the key objective of this Study.

A case study was carried out on the two successfully operating FMIS–Tanting Kali Khola (TKIS) in Jhapa in the eastern Nepal and Yampa Phant (YPIS) in Tanahu in the western Nepal. In addition, reference was also taken from Argali Raj Kulo Irrigation System (Argali) in Palpa district, which is considered to be one of the successfully operating FMISs for last four centuries (figure 1).

I. THE CASE STUDY

A. Introduction

**Tanting Kali Khola Irrigation System (TKIS)**

irrigating 200 hawas constructed in 1964

irrigating 200 ha, and was rehabilitated in 2011 by ADB/OFID funded Community-Managed Irrigated Agriculture Sector Project (CMIASP) which constructed a permanent intake for drawing sufficient water in the system. Water is sufficient in the source river- Kali Khola in monsoon, but the farmers have to supplement water in the winter from the adjacent Tanting River by excavating about 192m long link canal connecting the intake. Rotational system of water distribution in shifts is adopted during winter and spring. Water in all the 7 branch canals reaches the tail end, with some exceptions. The system benefits 1,230 farmers of mixed ethnicity with average land holding size of 0.72ha/HH. The command area is well connected with all-weather road, and is about 4 km north from the east-west highway. Sanishchare Bazar which is about 2 km is the nearest market centre for buying the inputs and selling the produces. Farming has suffered with the out-migration of youth to work abroad. Women groups are active in the area running saving and credit cooperative that also supplies agriculture inputs. A water-guard appointed by WUA distributes water to farmers as decided by the farmer’s general assembly (FGA).

**Yampa Phant Irrigation System (YPIS)**

irrigating 39.65 ha. is more than a century old and uses water from a perennial spring source- Adhikhola. The system is always in water right conflict during winter with the neighboring Satrasaya Phant irrigation system that draws water from the upstream of the same source. The farmers received agriculture extension technical support from UK funded Lumle Agricultural Research Centre (LARC) since 1980s. Hill Food Program facilitated in system rehabilitation in mid 1980s. The system
benefits about 675 farmers with the majority of Brahmin/Chetris. Average land holding size stands less than 0.2ha/HH. Majority farmers are owner cultivator, but are gradually moving towards share cropping and contract farming due to farm labor shortage. The area is pocket for commercial vegetable farming and milk production. The system is located beside Prithivi Highway and is well connected to surrounding markets with all-weather road.

Institutional Mechanism for System O&M

Tanting Kali Khola IS is represented by FGA with >80% membership of beneficiary farmers. The FGA meeting is held in the first week of January each year, and requires a minimum of 50% attendance. Decisions are made collectively and mostly in consensus by the FGA. The system has a formally registered water users association (WUA) with two levels of management— (i) system level responsible for operating the main canal, water allocation, irrigation service fee (ISF) collection, and farmers mobilization for seasonal construction of link canal; and (ii) block level responsible for maintaining canal and managing water in the blocks. The FGA elects an inclusive WUA executive committee with representation from head to tail ensuring women representation at 33%. Each block elects five member block committee including two female representatives. As the command area is inhabited by hill migrated people, mostly from Ilam district, cohesion in the community is visible. This has encouraging bearing on the farmers’ organization. The users in the past had selected the leaders based on their skills or social acceptability. This has not changed severely yet, although increasing socio-political fragmentation of community in recent years cannot be ignored. Farmers readily pay NPR300/ha for annual diversion of Tangting River water towards the intake in the winter. In addition, farmers also contribute 2 person-days per HH for canal cleaning, which required 7-10 person-days before system rehabilitation. A water-guard is appointed for managing water distribution in the command area. WUA were collecting irrigation service fee (ISF) at 65% of the target before the system rehabilitation, which has reduced to 8% due to sufficient water availability from permanent intake, good condition of recently constructed structures, and weak WUA leadership in pursuing farmers to pay the ISF. This suggests ISF collection should be linked with water allocation in agreement with the FGA. Also, the ISF rate should be reasonable without causing financial burden to the farmers.

Women representation is made mandatory by the WUA constitution at 33%. However, their participation is low in the WUA meetings, which is common case. Although women farmers claim their absence due to busy household work, this suggests that women representation in WUA by fixing percentage may not actually serve the purpose. Providing enabling environment, defined roles, respecting their voice, and incentive-based mechanisms may encourage their active participation.

2 Preceding chairman (Mr. Adhikari) was a social worker and skilled in accountancy.
Yampa Phant farmers have been forming unregistered and 11 members WUA of respected community leaders since 1985. Before this, they used to select a "Mukhiya"- a village leader each year before monsoon to mobilize farmers for canal O&M. WUA is formed by FGA held in the first week of June each year. Not only the land owners but also the contract farmers, who pay fees and water service charge, are accepted as the member of FGA. The FGA selects WUA, appoints contractor for water management, decide timing and resources for canal cleaning, decide penalty for water stealers and absentees. The collective decision making practiced by the farmers has promoted transparency and sustainability in the system operation. Women’s representation is limited in the WUA due to lack of free time from household errand and field work. Women actively take part in canal cleaning, and even manage water distribution under a contract with WUA.FGA which selects contractor for water distribution through open bidding. It is a unique and successful mode of operation in FMIS. Payment to contractors was made in kind (grain) in the past, which is now changed to cash collected as ISF from the farmers. Collection of ISF is fully complied with and penalty mechanism is strictly adhered to.

Water distribution practice is also interesting in the system. The farmers collect a water allocation receipt from WUA after clearing ISF and other dues. The contractor distributes water to the farmers land as mentioned in the receipt. Three types of rotational water distribution system is practiced: (i) Type A- The rotational distribution starts alternatively from head and tail supplying water to entire farm in turn by turn basis- locally called “Vijuwa Palo”; (ii) Type B- water distribution is managed through six outlets with three outlets opened for 20 hours in turn when water is insufficient for rotation through Type A; (iii) Type C- when water becomes further insufficient for type B rotation, time based rotation is applied alternatively from head and tail by dividing the area for 20 hours supply. Generally, a farmer having 0.05ha land is entitled to receive water for eight minutes. The well-established practice of farmer informing the next in queue after completing irrigation supports the notion that sustainability in a system can only be achieved through coordination and cooperation that is deeply rooted as a culture and social norms in the community.

B. Cropping Intensity and Yield

Tanting Kali Khola. Paddy is the main monsoon crop cultivated in 95% and vegetables in 5% of the command area. Winter maize occupies 37%, wheat/oilseed/vegetables occupy 60% and potato 3%. Early spring paddy occupies 35% of the command area. The cropping intensity increased by 20.3% reaching 235% after the system rehabilitation. This indicates that farmers are still continuing with the traditional farming of giving priority to water intensive cereal crops.

Figure- 2: Productivity of TKIS
The farmers have started to cultivate additional spring paddy replacing maize and winter crops (wheat, oilseed, pulse and maize) after having sufficient water from the system rehabilitation. The tail reach farmers however still face water shortage during late winter to entire spring, and as a result only 15% of the area along the canal can grow paddy. This practice is more of recognition of the select head-reach farmers who initiated the irrigation system with their own resources and hence have been entitled to prior water right, especially during lean supply at source. Such disparity suggests the FGA needs to establish a more equitable mechanism of water distribution protecting the welfare of tail end farmers.

The assessment of crop yield indicates significant increase in the major crops after system rehabilitation. Winter maize increased by 96.43% (5.5 from 2.8 t/ha), early spring paddy by 64.52% (5.1 from 3.1 t/ha), and monsoon paddy by 49%. Farmers were found using chemical fertilizers for their major crops. However, the average application of fertilizers falls short of the recommended dosage. Farmers use chemical fertilizer as suggested by the local agro vet suppliers and/or based on their own farming experiences. The increased productivity is also contributed by the use of high yielding variety (HYV) of seed. In particular, most of the farmers after having access to improved irrigation service have adopted HYV seed of winter maize and as a result increase in yield has been significant.

**Yampa Phant irrigation system** facilitated the farmers to cultivate three crops in a year. In the absence of irrigation water, they were able to cultivate only monsoon paddy in the past. But of late, the cropping pattern in YPIS is largely covered by vegetable farming. The major crops grown are monsoon paddy (90%) with vegetable; whereas vegetable dominates winter crop in 65% area and spring crop in 60% area. The district agriculture development office (DADO) reports that the irrigation system under LARC’s technical support has reached saturation in productivity with 300% cropping intensity. The reason behind the adoption of fairly advanced cropping practices is the outcome of extensive research and extension efforts carried out by Lumle Agricultural Research Centre (LARC). The Centre used the area as its laboratory for trials for a number of years (1987–1998). Research initiatives largely focused on agronomy and horticulture. Likewise extension focused field trials were conducted in farmers’ field which made farmers recognize the profitability of new crop varieties. Additionally, access to both input and output markets and the influence of the LARC encouraged farmers to try new technology. The cropping pattern is summarized in the following table.

<table>
<thead>
<tr>
<th>Before system improvement</th>
<th>After system improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Monsoon:</strong> Rainfed maize or paddy</td>
<td><strong>Monsoon:</strong> Paddy + Vegetable</td>
</tr>
<tr>
<td><strong>Winter:</strong> Drought resistant pulse or oilseed in small areas</td>
<td><strong>Winter:</strong> Vegetable + Wheat</td>
</tr>
<tr>
<td></td>
<td><strong>Spring:</strong> Vegetable + Maize</td>
</tr>
</tbody>
</table>

**Table- 1: Summary of cropping pattern before and after system improvement**
Irrigation increased 129% paddy productivity (5.5 from 2.4 t/ha). Cultivation of wheat and vegetables was possible only after system construction. Farmers use in average 100 kg of Urea, 90 kg DAP and 45 kg Potash per hectare for vegetable supplemented by 6 to 8 ton of compost manure/ha in each crop. Similarly almost all farmers use improved/hybrid seeds. This contributed to achieve production of all crops and vegetables higher than that of district and national averages.

The reason behind the adoption of fairly advanced cropping practice in YPIS is the result of the extensive research and extension services carried out by LARC (1987 - 1998). Farmers were motivated to grow new crop varieties, which were profitable. Access to inputs, market and the support by LARC encouraged farmers to go for commercial vegetable farming.

Farmers are gradually reducing the use of chemical fertilizer and pesticide since last 5 years after realizing reduction in soil fertility by the chemicals. One of the contributing factor is also the increased availability of organic manure due to increase in cattle farming in each HH. Farmers are also using animal urine instead of expensive pesticides for controlling pest in vegetables and as an alternative source of Nitrogen for paddy cultivation. The use of farm labor in daily wage for supporting in agricultural and animal husbandry is a unique feature of YPIS. Around 150 labors a day are hired in by the farmers from Chyangli village of neighboring Gorkha district.

C. Agriculture Extension and Marketing

**Tanting Kali Khola.** The farmers received agriculture extension support from DADO until CMIASP supported the program. Farmers largely benefitted by learning the improved farming practices through demonstration and farmers’ field school program. However, the agriculture extension support ceased and DADOs have rarely visited the command area after project completion. Although, some farmers continue commercial vegetable farming with their own efforts, this remains to wide-spread in the command area. Only a few farmers have taken up vegetable farming in small scale as spillover effect. Presently, there is no functional linkage and support between the lead farmers and WUA. However, WUA
is planning to form cooperative and introduce the collective farming in the command area. This suggests that technical agriculture development support to the farmers should be a regular program and not a project limited activity. Leader farmers should be trained to play a bridging role between DADO and farmers.

TKIS enjoys close proximity to two big markets—Sanischare Bazaar at 2km and Birtamod at 4km distance where farmers can purchase inputs and sell their products. The early paddy is generally sold in the farm gate to local merchants. Although, farmers have become discouraged in vegetable farming due to low selling price in the absence of an organized market. Women farmers are active and organized, and have established a cooperative since 1994 under the support of the Heifer International, an INGO. The cooperative supplies agriculture inputs as an authorized dealer of Agriculture Inputs Company and operates grocery shop and grinding mill in the area. Many other cooperatives are also serving the farmers. The women farmers could form cooperative and successfully engage in additional income generating activities because they had back-up support of the INGO. Hence, regular support is required to the farmers in order to build their capacity, make the system sustainable and self-sufficient, and steer their responsibilities towards multi-function.

Yampa Phant farmers under LARC support have become highly knowledgeable on improved farming and DADO confirms that they do not require agriculture extension support. They are in transition towards animal husbandry from vegetable farming, which requires less labor but brings higher profit due to access to bigger markets. The farmers have formed cooperative to mobilize saving & credit and supply fertilizer and other agro-inputs.

Farmers sell their product in the collection center located besides a Highway and owned by a local merchant who readily pays for the transactions of the day, which has gained farmers confidence. The merchant in turn sells fertilizer, seed and pesticide to the farmers. Vegetables are collected twice daily valued at NPR30,000 to 1,000,000 a day. Farmers receive reasonable price at a minimum spread rate of NPR 2 to 5. Farmers buy and sell commodities through their cooperative, which has increased their collective bargaining power for gaining higher benefits.

D. Economic Benefits

Tanting Kali Kholaa. The following figures 4 and 5 present the cost and return from the crops. The data show that winter maize has higher rate of return (213%) followed by early paddy (164%). The winter maize is an additional crop after the system rehabilitation, which has good market as livestock and poultry feed companies are coming up in the eastern hills. The early paddy is largely used for making bitten rice, which is purchased by mill owners from farm gate.
The following figure 6 shows the cost and benefit from the vegetables grown in Yampa Phant. Cucumber is the most profitable vegetable gaining a net profit of 303% followed by green peas and bitter guard (247%), cauliflower (242%), and cabbage (211%). The equity in water distribution and equal profit from head to tail has consolidated farmers’ collective endeavor for a sustainable O&M of the system. Figure 7 presents that paddy growers get 85% profit followed by maize (51%) and wheat (50%).

1. The indicators of farmer’s improved quality of life after system improvement are following:

- Farmers of neighbouring areas have migrated to the YPIS command area because of the benefits from the irrigation system;
- Farmers under LARC support have moved from vegetable to livestock gaining higher income;
- All the children of the area go to school;
- Farmers from head to tail have replaced their thatched roof by corrugated iron sheet;
- Almost all HHs have TV, electricity and water supply connection, and a motorcycle;
- Farmers have restricted haphazard construction on productive agriculture land;
- Number of shops in the area is increasing indicating increased consumer demand.
II. EXTERNAL SUPPORT IN FMIS

The FMIS started to receive meaningful support from the government and development partners (DP) since the last three decades. So far, the external support in FMIS rehabilitation has been roughly above $231 million, and FMIS covering 370,892 ha have received some form of support (see figure 8). Major FMIS support by the DPs initiated with the Asian Development Bank supporting through irrigation sector project in the eastern and central development regions; and the World Bank through the irrigation line of credit in the three western development regions. The projects supported in rehabilitation of traditionally operating old irrigation systems under ‘demand driven’ and ‘participatory approach’ along with institutional strengthening of WUAs and agriculture extension services. Farmers also shared about 3% of the rehabilitation cost in the projects demonstrating their ownership for a sustainable O&M of the system.

Table- 2. ADB and WB funded FMIS Projects

<table>
<thead>
<tr>
<th>Detail</th>
<th>ADB funded FMIS Projects</th>
<th>WB funded FMIS Projects</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ISP</td>
<td>SISP</td>
</tr>
<tr>
<td>Number of subprojects rehabilitated</td>
<td>283</td>
<td>283</td>
</tr>
<tr>
<td>Irrigation coverage in ha</td>
<td>46,371</td>
<td>41,147</td>
</tr>
</tbody>
</table>

Source: Department of Irrigation, 2015

The FMISs before the intervention by the DPs had temporary seasonal intake, high system losses, defunct or inefficient farmers organization, and conventional agriculture. The ADB and WB supported projects focused in providing a permanent intake, reduced system loss, and supported in strengthening of WUA and providing them training on better WUA management and practice improved and commercial agriculture.

Availability of water round the year has increased cultivation area and cropping intensity in the systems. Farmers have started to cultivate spring and winter crops, which were not possible before the system rehabilitation. However, it is learned from the past projects that yield can be improved only if the rehabilitation also improves the on-farm water management, proper use of fertilizer depending on the soil type, and mechanization in agriculture.

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ADB funded Irrigation Sector Project (ISP), Second Irrigation Sector Project (SISP), Community-Managed Irrigated Agriculture Project (CMIASP); and World Bank (WB) funded Irrigation Line of Credit (ILC), Nepal Irrigation Sector Project (NISP), and Irrigation and Water Resource Management Project (IWRMP). The CMIASP and IWRMP additional financing are on-going.
**Table- 3. Increase in System Efficiency after Project Intervention**

<table>
<thead>
<tr>
<th>Detail</th>
<th>ADB funded FMIS Projects</th>
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</thead>
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<tr>
<td></td>
<td>ISP</td>
<td>SISP</td>
</tr>
<tr>
<td>Cropping Intensity</td>
<td>-</td>
<td>40-45%</td>
</tr>
<tr>
<td>Yield</td>
<td>-</td>
<td>10-50%</td>
</tr>
</tbody>
</table>

*Based on project completion reports*

The lessons learned from system rehabilitation is that the intervention should not be partial for attaining maximum system efficiency and long term sustainability, and farmers’ must start raising irrigation service fee to address routine O&M.

The ADB and WB funded projects emphasized on institutionalization of WUA by keeping their formal registration as a pre-condition for receiving project support. Therefore, the farmers registered WUAs in the irrigation division offices with improved constitution, and elected executive committees. The farmers were mobilized through various mechanisms in the projects- such as NISP used water user association facilitators; SISP used farmers organizer and NGOs; CMIASP used NGOs and community organizers; and IWRMP used NGOs/CBOs. The WUA has become an important rural institution providing platform for social interaction and learning. 33% quota of women representation, equitable representation of farmers from head to tail, and dalit and vulnerable farmers’ representation.
in the WUAs have played a significantly decisive role in mainstreaming the weaker section of the community in the decision-making process. The DP supported projects provided capacity building training to WUAs in office management, account keeping, construction quality control, system O&M, water management, and commercial agriculture. Staff of EA and IA were provided capacity building training in participatory irrigation management.

The ADB and WB funded projects demonstrated the importance of improved agricultural extension support to the farmers and organized farmers training in crop production and water management, demonstration agriculture, on-farm crop water management, crop diversification and intensification, seed production, and organized marketing.

III. LESSONS LEARNED FROM THE CASE STUDY

The findings of the Study suggest that a FMIS can be sustainable with self-sufficiency in the long run only if all the farmers from head to tail receive equitable volume of water. This could be achieved through transparency and collective decision-making process implemented by a strong-team of farmer’s representatives- who are respected community leaders. The Case Study also validates that the systems governed with traditional practices have gained sustainability and should be followed with minimum changes while preparing WUA constitution under new projects. Also, “farmers” the key figure of FMIS should always be involved for a participatory decision-making while planning, rehabilitation, operation and maintenance of FMIS.

Following paragraphs present the lessons learned from the case study, which are important elements for future reference as the best practices for FMIS development.

**Optimization of water use.** Farmers have a false belief that the continuous flow of water in early paddy increases yield. Rather, crop water requirement should govern the extent of irrigation. Hence, WUA needs to be made aware to make proper water management after assessment of crop water requirements and irrigation scheduling, particularly for late winter and spring crops when there is shortage of water. The concerned irrigation offices and DADOs should regularly organize farmers awareness program and convince them on the benefits of using required amount of water depending upon the crop type. Also, contracting out the water distribution responsibility to a neutral contractor will help in avoiding any possible biased approach from WUA members- a lesson learned from YPIS.

**Equitable water distribution and farmers contribution.** The root cause of sustainable system operation is equitable water distribution from head to tail. The decisions for system operation are made transparently by the FGA, and punitive action is taken for those who do not contribute ISF or take unauthorized water. Hence, IDD and DADOs should assist
WUAs to prepare project-specific water management and O&M plan for equitable water distribution from head to tail.

**Water management.** Field water management is generally overlooked while rehabilitating only the main or branch canal, which causes improper use and wastage of scarce water available during winter. Hence, a system of developing field water management should be an essential component in the development of future FMIS projects.

**Water optimization and efficiency maximization.** Farmers should be capacitated in using innovative technologies in optimizing water use. They should be encouraged to improved water use efficiency and high productivity within customary water withdrawal practices by utilizing micro-irrigation application and water conservation technologies.

**WUA constitution.** Yampa PhantWUA has received farmer's full cooperation because the system O&M rules is formed transparently and collectively by their general assembly, which also follows the century long customary traditional practices built on cultural ground. Hence, due respect should be given to the local tradition and cultural practices while supporting and reorganizing new WUA constitution, and the management rules in the constitution should not be imposed on farmers, which sometime may not work.

**WUA institutional strengthening.** Stronger and active WUA is the key for successful operation of any FMIS. Distribution of membership certificates, transparent decision-making with proper record keeping, regular audit of financial transactions, clear division of responsibility between the system level committees and block committees, and WUA's intervention in case of complaint keeps farmers confidence on the WUA and ensures their cooperation. It will also be helpful to keep the WUA out of politics for achieving collective support of all the farmers.

**Make the farmers self-sufficient.** The farmers have a tendency to seek government support even for minor maintenance work. Hence, the government should establish a mechanism whereby the FMISs are made self-sufficient and discourage the dependency syndrome. This can be done by establishing a central “FMIS Fund” by the government or mobilize financial institutions for providing agriculture loan to the farmers for major repair and maintenance. Regular maintenance shall be done by using the ISF collected by the farmers themselves.

**Insurance of irrigation structure.** Government should facilitate in linking insurance companies with farmers to provide insurance of their irrigation infrastructure at a reasonable premium.
Table 4. Summary of the Best Practices

<table>
<thead>
<tr>
<th>Irrigation Practices</th>
<th>YampaPhant (Case Study)</th>
<th>Tanting Kali Khola (Case Study)</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Clear water allocation rules both for monsoon and winter with flexibility to change</td>
<td>- Clear water allocation rules that are changed in accordance with the availability of</td>
<td>- Water allocation decision are made in WUA with high level of flexibility (Relatively more</td>
</tr>
<tr>
<td>over time and requirement (recently, upland farmer engaged in vegetable cultivation</td>
<td>water in source</td>
<td>time allocation to tail reach to supplement the long distance and conveying losses)</td>
</tr>
<tr>
<td>also receive water during monsoon)</td>
<td>- Private-public partnership- provision of contractor for water distribution during</td>
<td>- Water distribution: Provision of water guard for the implementation of allocation decisions</td>
</tr>
<tr>
<td>- Supportive physical structures (i.e. Sanchos) for water distribution including</td>
<td>rice cultivation</td>
<td></td>
</tr>
<tr>
<td>effective water distribution mechanism, and institutional provision (Mukhiya,</td>
<td>- High level of equality in water distribution during lean supply period.</td>
<td></td>
</tr>
<tr>
<td>Bahidar, Panijanchaki etc.)</td>
<td></td>
<td></td>
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<tr>
<td>- A well-established system of regular maintenance twice a year.</td>
<td>- Existence of regular maintenance practices</td>
<td>- Fixed time for regular maintenance</td>
</tr>
<tr>
<td>- Clear division of responsibilities, who is responsible for what for canal</td>
<td>- Decentralization of responsibility to maintain canal beyond the idle length</td>
<td>- Maintenance responsibilities are divided between block and system level committees.</td>
</tr>
<tr>
<td>maintenance</td>
<td>- Provision of penalty for absentees in maintenance works with strict enforcement</td>
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</tr>
<tr>
<td>- A system with quick responsive mechanism in case of emergencies during monsoon</td>
<td></td>
<td></td>
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<tr>
<td>(regular patrolling of main canal and gauge reading).</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Provision of penalty for absentees in maintenance works with strict enforcement</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Clear correlation between the benefit and contribution (resources are generated</td>
<td>- Resource mobilization both in cash &amp;labour</td>
<td>- Financial sustainability through ISF, member ship and renewal fees</td>
</tr>
<tr>
<td>from users based on their share of water)</td>
<td>- Maintenance practices are changing over the time (i.e., provision of contract for</td>
<td>- Equity based resource mobilization for hefty resource mobilization (link canal excavation)</td>
</tr>
<tr>
<td>- Sound WUA for external resource mobilization, networks and linkage</td>
<td>canal maintenance to address the growing scarcity of labour</td>
<td>and HH basic for regular maintenance</td>
</tr>
<tr>
<td>- Internal resource generation mechanism (service charge @1000/ha from upland farmer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>who are not paddy cultivator but use water during monsoon including membership fee</td>
<td></td>
<td></td>
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<tr>
<td>and renewable charge)</td>
<td></td>
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<tr>
<td>Agriculture Practices</td>
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</tbody>
</table>

Challenges to Sustainable Livelihood:

Small Scale Irrigation Systems:
### Irrigation Practices

- Farmers proactive, open to new technology adaptation and cropping pattern gradually changing in winter
- Higher productivity of both cereal and cash crop through adoption of high yielding variety
- Organized marketing arrangement available through cooperative, agri-input supplier and "Paicho Pasal"
- Adoption of vegetable based cropping pattern with about 300% intensity
- High sense in choosing the crop that yields maximum benefit
- Wider use of hybrid and high yielding variety
- Advance agriculture clearly linked with marketing arrangement supportive to farmer through cooperative, agri-input supplier
- Vegetable and livestock farming are mutually reinforcing each other
- Adaptation of cropping pattern based on the availability of water (235% intensity)
- Selection of crops that yield maximum benefit like hybrid maize
- Cooperatives are effective in supplying agriculture inputs to farmer
- Profit based crop diversification (from cereal to vegetable and now fodder grass instead of vegetable for livestock)
- 60% area covered with winter maize instead of wheat and oil crop
- Each HH produces vegetable for self-consumption

### Social & Institutional Practices

- The diversification trends toward the high value crop is very forward moving (10% area in monsoon, 55% area in winter, 10% area covered high value crop instead of rice, wheat and maize)
- Cultivation of cauliflower, cucumber and cabbage is in commercial scale
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- Cultivation of cauliflower, cucumber and cabbage is in commercial scale

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<td>---------------------------------</td>
</tr>
<tr>
<td><strong>Irrigation Practices</strong></td>
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<td></td>
</tr>
<tr>
<td>• Registered WUA with regularly renewed and audited for external linkage</td>
<td>• Informal WUA with inclusive participation</td>
<td>• Formal WUA with the provision of ensured participation of entire system</td>
</tr>
<tr>
<td>• Clear division of responsibilities among the functionaries for irrigation management</td>
<td>• Office bearers are re-endorsed in each AGM democratically.</td>
<td>• Clear division of responsibility between the block and system level WUA</td>
</tr>
<tr>
<td>• Transparent decision making process where key rules/practices, function of office bearer are reviewed revised and endorsed in each annual general assembly meeting.</td>
<td>• Clear decision of responsibility among the member</td>
<td>• Flexibility in amending of rules and regulation</td>
</tr>
<tr>
<td>• High level of participation (above 98%) in GA meetings</td>
<td>• Transparent decision making process (decision are not written but high degree of awareness on rules and regulation among beneficiary farmer)</td>
<td>• Good administration system (e.g. using own letter pad, seal, membership certificate and irrigation fee collection pad)</td>
</tr>
<tr>
<td>• Integration of traditional institutions line &quot;Mukhya&amp;Baidar&quot; in formal WUA reinforced the irrigation management tasks safeguarding the existing level of social capital.</td>
<td>• Strong institutional commitment of WUA for maintaining fare decisions</td>
<td></td>
</tr>
<tr>
<td>• Inclusive participation (earlier women and Dalis were not allowed to work in canal with the belief that the physical contract of Dalit and women during their period impure water)</td>
<td>• High level of participation (above 95%) in GA meetings</td>
<td></td>
</tr>
<tr>
<td>• Provision of compensation for the time devoted by Mukhiya and Bahidar during winter</td>
<td></td>
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</tbody>
</table>
**ISF collection.** ISF collection is varying in different irrigation systems depending on how the ISF rate is decided and the quality of WUA leadership. Farmers comply in paying ISF only if the rate is transparently decided by FGA, the rate is within their capacity, formal record of payment is kept in farmers membership card, and if the payment is linked strictly to the water allocation.

**Irrigated agriculture development.** FMIS rehabilitation work generally focuses on system improvement, but the associated agriculture development support is ignored. Also, support to farmers generally stops after completion of projects. However, the first couple of years of support after system rehabilitation is critical for the sustainability of the system. Hence, irrigation and agriculture support should compliment each other and continue to engage themselves with the farmers in the first few critical years.

**Market for agriculture product.** An all-weather road connecting collection center and market are the essential requirements for encouraging farmers to move towards commercial agriculture and cultivating water-efficient cash crops. DADOs should facilitate to establish collection centers near the production area and support farmers by linking them with the contractors of bigger markets. WUA should support in collective buying of inputs and selling of agriculture products, which will benefit them from their stronger collective bargaining power.

**Mechanization of agriculture.** Farming in general is facing labor shortage due to low wage rate for farm laborers and outmigration of male family members for work. This has added the work load on women to manage both household chores and farm work. The government’s irrigation policy encourages for mechanization of agriculture to address the labor shortage and attain high productivity. Hence, the farmers should be mobilized to collectively procure some basic equipment that supports in labor-intensive work—such as power tiller and rice thrasher.

**Women participation.** Although women representation is made mandatory in WUA at 33%, their participation is low, although they argue that their absence is due to busy household work. This suggests that women representation in WUA by fixing percentage may not actually serve the purpose. Providing enabling environment, defined roles, respecting their voice, and incentive-based mechanisms may encourage their active participation—a lesson learned from TKIS.

**FMIS Division in DOI.** Department of Irrigation should consider establishing a division fully dedicated to FMIS development. Although, they will be trying to make all the FMIS self-sufficient, their continued technical support will be required by the farmers.
AN INTEGRATED EFFORT OF LEGAL, INFRASTRUCTURAL AND SOCIO-TECHNICAL INTERVENTIONS TO IMPROVE MINOR TANK IRRIGATION SYSTEMS SUSTAINABILITY AND PERFORMANCE

C. M. WIJAYARATNA* AND ARNAUD CAUCHOIS**

INTRODUCTION

The paper submits the strategy, process, and results of an integrated effort combining legal reforms in Participatory Irrigation Management (PIM); infrastructure improvement or rehabilitation and upgrading (R&U) and technological and organizational innovations focusing on managing kharif (wet season) irrigation demand for increasing rabi (dry season) cropping area through Collective Action managed by Water Users’ Associations (WUAs). In an area of 100,000 ha exploited by over 130,000 farm families (figure 1), WUAs have been organized to function as multi-functional organizations managing water and agriculture support services including input-output marketing.

* Consultant, functioned as the Team Leader of ADB-TA, Chhattisgarh Irrigation Development Project (CIDP), 2006-2013
** Senior Water Resources Specialist, Environment, Natural Resources and Agriculture Division, South Asia Department, Asian Development Bank
The overall goal of the CIDP is to improve rural livelihood and reduce rural poverty through improved irrigation service delivery, enhanced agricultural practices, and strengthened water resources management to increase the productivity of irrigated agriculture in the state. In addition to R&U, CIDP aimed at institutionalizing PIM and strengthening WUAs in Chhattisgarh, enhancing farm incomes through improved kharif production and rabid diversified cropping in CIDP systems and promoting WRD-WUA partnerships. The seven-year Project had four components:

a) Strengthening the Water Resources Department (WRD);
b) Participatory Irrigation Management;
c) Rehabilitation and upgrading of irrigation systems; and
d) Agricultural support services.

The total command area of 144 irrigation systems\(^1\) covered by CIDP’s infrastructure improvement or R&U was 173,984 ha benefitting over 200,000 farm families. CIDP also included a technical assistance (TA) programme financed by an ADB grant. This paper focuses

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\(^1\) Number of irrigation systems varied over crop seasons
on the following TA managed components: (i) legal reforms, (ii) WUA strengthening, and (iii) agriculture support.

The Project introduced legal reforms for promoting PIM; rehabilitated irrigation infrastructure; conducted basic PIM training for the 1324 WUAs state-wide; and organized about 100 WUAs under its IIP in about 75 irrigation systems covering 100,000 ha and over 130,000 families focusing on a novel strategy namely “Managing Kharif (wet season) for Rabi (dry season)” through WUA-managed "Collective Action". In the IIP area, farmers doubled kharif crop yield, enhanced rabi cash crop cultivation exceeding project targets before the end of the Project and more than doubled their incomes. The full cost, including infrastructure R&U has been recovered just in one crop season. In addition, the Project helped all the 1324 WUAs in Chhattisgarh to federate at district, regional and state levels. The following sections outline the intervention strategy, results, and sustainability issues of Chhattisgarh effort.

**INTERVENTION STRATEGY**

**PIM Legal Framework**

In 2006, ADB-TA assisted the state government in developing a new PIM Act, Rules, By-laws and Regulations through a participatory consultative process involving a cross section of stakeholders ranging from farmers, WUAs and local governance up to senior policy makers. The novel features of the Act included: a) management of minor irrigation systems and lower parts of medium and major systems by WUAs, b) water fee collection by WUAs and sharing with the government, c) nested and federated WUAs, d) extending WUA membership to spouse to ensure nearly 50% women representation in WUA, e) representation of head, middle and tail of irrigation systems, and f) reserved seats for women and underprivileged including scheduled castes. TA worked collaboratively with WRD’s PIM unit and assisted in capacity building of the unit in operationalizing the Act.

The first WUA election under the new Act was held on 6 February 2007. Utilizing a special grant provided by ADB, TA conducted a state-wide awareness campaign to educate farmers on the rights and responsibilities of WUAs and to motivate them to identify and elect good leaders.

“Managing Kharif (wet season) for Rabi (dry season)”

Most of the rain falls within the Kharif season from mid-June to October. Therefore, “Managing Kharif for Rabi” or matching rainfall with cropping pattern is the major challenge for enhancing year-round-water management efficiency and total annual productivity of Chhattisgarh irrigation systems. A fifty-year rainfall data shows that 4 to 4.5-month paddy varieties advantageously match with the rainfall pattern (Figure 2).
Figure 2: Kharif rainfall is matching advantageously with 4 to 4.5-month paddy varieties.

Staggered cultivation can be minimized and the utilization of rainfall can be maximized if (i) all the farmers in the irrigation system plant 4-4.5 HYVs by mid-June, or at least by the end of June except in poorly drained areas where 5-month variety would be more suitable, and (ii) WUA organizes inputs and manage water judiciously including On-Farm Water management (OFWM). Most of the irrigation systems are reservoir-based and water can be saved for rabi. This requires Collective Action in organizing the right kind of seeds and other input and output services in a timely manner, managing water at the source and throughout the distribution system.

In summary, main features of the Model were:

A. Shortening kharif to maximize the use of rain between mid-June and October (Figure 2);
B. Harvest early, ideally by the end of October and cultivate rabi cash crops by promoting diversified cropping using residual moisture and saved water in reservoirs. (Note: All the irrigation systems in the 100,000 ha intervention area were reservoir-based. Even in diversion systems, this strategy can save water and time and increase cropping intensity);
C. Promoting water, time and cost saving methods like SRI;
D. Organizing input-output marketing to match water with complementary inputs for improving water productivity and incomes: In both kharif and rabi, WUAs were assisted in organizing farmers in the adoption of improved package of practices (POP) through WUA-managed collective action (please see next).

This Model is beneficial to diversion systems as well. For example, "time" can be saved in the wet season and a follow-up (short-term) crop may be planted which would be supplemented with residual moisture. This would enhance cropping intensity.
WUA strengthening through “WUA-managed Collective Action” - Learning-by-doing

Collective Actions were focused mainly on “managing kharif for rabi”. This implies maximizing annual productivity of water, which refers to the total production throughout the whole year. This has been attempted by maximizing the use of rainfall by reducing staggered cultivation and advancing and shortening kharif to match with rainfall. Most important collective action related to this was the use of the same age HYV matching with soil and other conditions and as much as possible plant at the same time by all the farmers (group / advanced nurseries helped in this). The major collective actions organized / managed by WUAs are listed below:

A. WUA collectively developed an annual plan of crops, cropping pattern and water use to match demand with supply. Supply refers to reservoir, rainfall and other sources;
B. WUA-managed O&M and WUA-WRD shared management: By the end of the Project, 77% of WMOs have been managing minor irrigation systems and in all the medium systems, WUAs contributed to WUA-WRD shared management;
C. SRI: The team assisted WUAs and farmers to adopt SRI as a priority activity based on soil condition, water availability, labor availability, etc. The promise of SRI is not only higher yields but also a significant saving of irrigation water and time. It fits ideally to IIP strategy of “Managing Kharif for Rabi”. Knowing that the best way of promoting SRI is by showing results of fellow farmers, the team organized exposure visits for non-adopters and encouraged them to come to an agreement and arrange seeds, and prepare for the next season. When HYV seeds were distributed, preference was given to SRI farmers;
D. Input supply and output marketing: Seeds (see item iii below), seed treatment, fertilizer, pests/diseases/weed control chemicals as well as equipment such as seeders, weederers and tillers/ploughs and output marketing. After explaining the benefits and assisting in organizing agricultural practices (package) and input-output business, the Project assisted in strengthening WUAs’ capacity to handle such collective action profitably. As much as possible, WUAs organized collective action with profitable links with the service providers including government agencies and the private sector. WUA-Private Sector Partnerships have been developed;
E. Soil testing: All farmers were encouraged to apply fertilizer on-demand or as required by their own fields’ conditions and nutrient deficiencies. Unnecessary expenditure could be avoided and profits to individual farmer increased. Soil-testing was organized collectively by the WUA mainly through Agriculture Department and other organizations. The Project also provided soil-testing kits to WUAs and the facilitating team trained WUAs in this;
F. WUAs achieving self-suﬃciency in 4 to 4.5-month variety seeds: Use of short duration HYV seed is the most important factor in shortening kharif to match with rainfall (mid-June to October) so that rain can be utilized eﬀectively and reservoir water can be saved. The availability of quality seeds which is only 15-20%
is a major constraint in India. The fact that the Project facilitated achievement of WUA self-sufficiency in 4 to 4.5-month variety paddy seeds in over 100,000 ha within three years (Kharif 2010 - Kharif 2012) is a significant contribution. At the request of the Project, the government agreed for WUAs to register as seed producers. This contributed to WUAs achieving self-sufficiency in seeds. Testing and treating seeds were also organized through WUAs;

G. Integrated Pest management (IPM): WUAs and farmers were informed that their benefits to IPM would be more if all the farmers in a given locality were motivated to adopt IPM. The Project assisted the WUAs in this as an important collective action;

H. Integrated Nutrient Management (INM): Includes optimum economic levels of fertilizer application, technologically correct method of application (quantity, method and timing). In addition, it promotes organic fertilizer (long-term plan to improve organic fertilizer supply);

I. Command Area Development (mainly Field Channel construction) and OFWM: The Project prepared a manual for WUA-managed Command Area Development (CAD) and OFWM which was implemented with support from NGOs. However mainly due to procedural delays the progress of WUA-managed Field Channel construction was slow. The OFWM is weak and the Project could not contribute much in improving OFWM;

J. Farm records and M&E: Introduced and motivated farmers to keep simple farm records and evaluate input-output levels (crop budgets). This, however, needed further improvement. Self M&E by WUAs and Chak groups would need to be internalized;

K. Experiential group extension methods involving all the farmers in the Chak\(^3\): Farmers Field School was the major method of extension organized by the WUAs with the assistance from the Project, and the extension staffs of the Department of Agriculture (DA). The DA worked at Chak level with Chak groups without focusing just on few selected progressive farmers. The active participation of the DA, which focused on demonstrations in progressive farmers’ fields, was admirable; and

L. Assisted in the formation and strengthening of Sub Committees within WUAs to oversee finance, works, and social audit.

Past DA activities focused on managing water just for the crop season. Within the season, the focus was on the adoption of technology by the individual farmer rather than collective action by the WUA/Chak groups and higher level Farmers’ Organizations. CIDP’s social mobilizers spearheaded in educating, motivating and facilitating the WUAs and Chak groups to consider year-round demand and year-round utilization of tank water in WUA-managed irrigated agriculture production systems. The goal was to save as much water as possible in the reservoir while improving kharif rice production and productivity.

\(^3\) Chak is the lowest-level Group, based on hydrological boundaries. Several Chaks (5-25) forms the WUA
Method Adopted in Mobilizing Water Users for Collective Action

The mobilization methodology played a key role. Carefully selected and well-trained catalysts or change agents (social mobilizers) promoted association, interaction, and cooperation among WUA members; developed their perception of problems and needs as well as vision; and then motivated them to explore how these needs / goals could be met. In addition to the strength of the technological package, mentoring and participatory management (instead of control), participatory target setting and assessment, transparent reward and punishment (based on participatory performance assessment) were the major contributing factors to the success in changing the behaviour of farmers and in organizing WUA-managed Collective Action. Participatory reviews and target setting was the major tool for sharing experience and improving performance. This is a powerful tool because it can even exert peer pressure and remove those who did not perform.

Other Important Features of the Model

• **Irrigation system-wide improvements** through Participatory Methods and Experiential Capacity Building (“Learn-by-doing”) of WUAs: Interventions focus on all members and the total area of irrigation system with the aim of improving the total and average production and cropping intensity. WUA-managed Collective Action and the integrated approach were helpful in achieving irrigation system-wide improvements. Formal training was restricted (e.g. finance management, accounting and book keeping). Chak-based Farmers’ Field School (FF) was the major vehicle for agricultural extension.

• **Water management was not separated from agriculture** and, agriculture support was not confined to knowledge building through demonstrations and formal training of selected farmers. The ultimate goal was to develop multi-functional WUAs managing water and agriculture services including input supply and output marketing through collective action. Water management, including command area development (CAD) agricultural input-output interventions were integrated in many irrigation systems.

• **Multi-disciplinary approach**: One community mobilizer (CO) served about 1,000 farmers. There was a team of two senior community mobilizers (SCOs) for a cluster of 7-12 WUAs; one with coordinating and organising skills and the other one with agriculture and water management background and extension experience⁴.

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⁴ As the salary was low (about US$400) it was difficult to attract SCO agriculture extension candidates with good experience. In the case of COs too, it was difficult to attract organizers/social workers with the level of experience required for the Intervention. For most part of IIP, NGOs failed to provide the required number of Agriculture Specialists. The programme suffered due to delays in CO-SCO salaries. Many of the good SCOs and COs had left the programme.
• **Collaboration with Line Departments and their Programmes:** The WUAs activities were linked with the programmes of DA (e.g. seed production of wheat and black gram). The DA bought excess seeds produced under the seed production programs.

• **Organizing group / WUA-managed / advanced nurseries using tube wells:** With this strategy, group nurseries have been established in early June so that farmers could prepare lands with initial rains and plant early. Even if rains are delayed by 1-2 weeks, farmers cannot be affected as the seedlings are in the nurseries and irrigated by wells. Farmers proved to be difficult to be convinced and adoption rates were below expectation. This approach may need greater communication awareness to.

• **Package of Crop Practices:**

  A. Adoption of recommended package of practices through Collective Action, especially WUA-managed input services and modified FFSs contributed significantly to quick results. Soil testing and balance fertilizer applications yielde good results.

  B. Treatment of seeds with fungicides before sowing (adoption was very high and quick). Introduction of seedling treatment before transplanting to reduce pest attack.

  C. Use of mid duration Hybrids to increase yields and grain quality. Farmers’ Companies planned to take up seed production as a business (including Hybrids).

  D. Shallow irrigation to save water in Kharif for Rabi and to get more tillers especially with SRI farmers.

  E. Many farmers followed IPM.

  F. Transplanting: Transplanting has been promoted in the IIP. In addition to common benefits attributed to transplanting, this was required for promoting advanced and group nurseries.

**RESULTS**

CIDP has strengthened the roles, responsibilities and authority of WUAs for managing irrigation systems as profitable agriculture production systems.

The area covered by the CIDP-IIP reached 104,476 ha in Kharif 2011-2012. Rabi cropping intensity increased to 40% in 2011-2012 and over 50% in 2012-2013. Major outcomes of IIP are given below:

5 Interventions have been organized in 55 CIDP R&U systems in 2011-12 and 50 systems in 2012-13; the number of minor systems has been reduced to 41 and the medium systems increased to 14 in 2011-12 and in 2012-13, out of 20 CIDP Medium systems, 17 were included.

6 Exceeding the post-R&U target of 30% even before the completion of R&U
A. Doubling Kharif yield through WUA-managed Collective Action

Progressive increase in Kharif yield is illustrated in Figure-3 and outlined below:

i. Up to 2010: In the pilot irrigation systems, kharif cropping intensity reached 100% and kharif paddy yield increased steadily; by 29.3% over ‘pre-project yield level in 2007; 43.2% in 2008 and 78% in 2009.

ii. 2010: IIP extended to cover 100,000 ha in 2010. The pilot systems maintained 5.1 t/ha average but in the new systems (70,000 ha in Kharif 2011) average yield was 4.1 t/ha. Thus the average in the entire IIP was 4.32 t/ha.

iii. 2011 Kharif recorded an average of 5.6 t/ha. For the pilots, this was 100% increase over the base year yield level. In the new area (70,000 ha), the yield also increased over 60%. (Note: In Kharif 2011, as some field staffs left, the total area reduced to 90,835 ha). This means that the strategy and process tested in 25 pilot systems (25,000 ha) took only two crop seasons to achieve the target in 75,000 ha of new area. When compared to state average, the CIDP-IIP added extra 240,000 of tons to Chhattisgarh total production and recovered the full cost of CIDP just in this season.

iv. 2012 IIP exceeded 100,000 ha and average Kharif yield reached 5.91 t/ha.

Note: In 2006, the average yield of Kharif irrigated paddy was about 2.7 t/ha and 2.8t/ha in 2008.

Rabi: Diversified Cropping

The number of farmers cultivating diversified rabi cropping increased by several folds (Figure 4). The crop diversification program, which was expected after R&U, commenced ahead of schedule in 2007/2008 season. In the first few years, the average rabi cropping intensity remained low because the irrigated area was restricted due to R&U works. For the first time in Chhattisgarh, WUAs in pilot systems managed inputs and output marketing. WUAs were also involved in processing the rabi crops in the other four areas. Many WUAs were put in contact with government and private sector 'buyers’ for maximizing farmer profits.

Water saving in Kharif and Water Use efficiency

The strategy was to plan water use in a more efficient manner. “Managing Kharif for Rabi” was a novel concept. The target of saving the maximum possible amount of water in the tank at the end of kharif and maximizing crop yield, has proved to be a success as can be seen in Figure 5. Few other strategies adopted for improving water use efficiency are listed under “Other Interventions” below. Farmers were motivated to use residual moisture at the end of Kharif for a follow-up crop. Rabi planning and preparation (seed etc.) started before the end of Kharif season and this too helped increase rabi cropping intensity and production.
Figure 3: Average Paddy Yield in 100,000 ha Intensive Intervention Area: from 2006 (pre-intervention) to 2012, t/ha

Note: Yield dropped in 2010 mainly because 75,000 ha were added (IIP expanded from Pilot 25,000 ha to 100,000 ha). Average yield in newly added systems was 4.11 t/ha and in “old pilots” it was 5.01 t/ha

Figure 4. Cultivated Rabi area (as a percentage of total command area)

**WUAs achieving self-sufficiency in 4 to 4.5-month variety seeds**

Use of short duration HYV seed was the most important factor in shortening kharif to match with rainfall (mid-June to October) so that rain can be utilized effectively and reservoir water can be saved. Availability of quality seeds which was only 15-20% was a major constraint in India. Therefore, the IIP facilitated the achievement of WUA self-sufficiency in 4 to 4.5-month variety paddy seeds in over 100,000 ha within three years (Kharif 2010- Kharif 2012). At the request of the Project, the government agreed for the WUAs to register as seed producers. This contributed to WUAs achieving self-sufficiency in seeds.
Small Scale Irrigation Systems: Challenges to Sustainable Livelihood

System of Rice Intensification

SRI adoption was nearly “zero” in 2010, but in Kharif 2012, out of 133,717 farmers (101,312 ha), 5,378 farmers cultivated 4,285 ha under SRI (nearly 5% of the total area) (Figure 6). In 2011 and 2012 Kharif seasons, highest yield (over 11 t/ha) in Chhattisgarh had been reported by a CIDP-farmer having adopted System of Rice Intensification - Kharif 2010 to 2012

WUA-managed Fertilizer supply

Instead of individual farmers dealing with input services, collective action was promoted as a way to reduce transaction costs. A fertilizer group purchase was the most common initial intervention selected in the Project. At present, WUAs handle input-output marketing.
Farmers get inputs in time and at a reduced cost. This helps reduce staggered cultivation and save water. It is recommended that for new projects, the government should provide seed money/credit directly to WUAs and producers’ companies to expand input-output marketing.

**WUA Federations and Producers Companies to Extend CIDP Model State-wide**

CIDP’s exceptional achievements attracted visitors from other areas of Chhattisgarh and from other states. Farmers in non-CIDP area have shown interest in benefitting from the strategy. Experience sharing opportunities were organized by the Project to facilitate farmers-to-farmers interaction. In addition, the Project facilitated the formation of district WUA federations and a state federation. Later, regional federations were established. The irrigated area is about one third of the total cultivated area in Chhattisgarh and many farmers in irrigation systems are cultivating in rain-fed areas as well. Therefore, over half of the farmers in Chhattisgarh (or over half of population) formed into district level federated farmers’ organizations (27), regional and state-levels. However, district and state-level WUA federations are still at infant stage and need further support (see below).

**FURTHER IMPROVEMENT AND SUSTAINABILITY**

Sustainability of O&M and the sustainability of WUAs capacity and capability are inter-related. Handing over the O&M in minor irrigation systems and lower levels of mediums and majors as well as shared management at higher levels are required. Even in the IIP systems, the successful outcomes of the Project may not be sustained unless further assistance is provided to WUAs and their federations. For this to happen, the WRD-PIM unit that was created under the Project needs to be strengthened as the Institutional home for WUAs and provide the required support.

Further support from WRD to develop institutional capacity for PIM is critically required because:

A. WUA contribution to O&M and WRD-WUA sharing responsibility in O&M are necessary as the government finds it difficult to fully finance O&M and the heavy expenditure on infrastructure will not be cost-effective unless O&M sustained;

B. WRD-WUA collective responsibility is necessary for collecting and sharing water fees, financial auditing and accountability;

C. WRD-WUA partnership is necessary for: a) Joint/collaborative planning, setting objectives (quantity and quality of water, drainage, production activities and related services); and b) joint monitoring of performance and joint responses to system needs, as required;
D. Technology is changing. So, system management as well as WUA and WRD responsibilities need to be adjusted to achieve system efficiency. For this too, WRD needs an “in-house” capacity for PIM; and

E. When new issues emerge, new agreements need to be negotiated.

WRD-WUA partnerships need to be improved. WUA leaders / water management committees / Apex Body (Project committee) need to manage water allocation jointly with WRD. PIM unit needs a capable and committed multidisciplinary team of professionals and a core cadre of catalysts (for example, COs and SCOs). CIDP faced with considerable constraints mainly because Chhattisgarh’s WRD did not have prior experience in PIM CIDP type project and also lacked qualified non-engineering staff, or a multi-disciplinary team of professionals. Further improvements are required to complete the hand-over of O&M responsibility to WUAs in minors and for effective shared management in medium/major systems.

WRD needs to focus on agricultural water management. The strategy of adopting an integrated strategy including organizing WUA-managed collective action, and adjusting agricultural practices and services for irrigation system operation provided a good learning opportunity to irrigation system managers. There is a scope for further improvement including a) completing the WUA-managed CAD process to avoid farm-to-farm irrigation, b) facilitating WUAs to organize land-leveling, and c) advancing OFWM.

All the WUAs in the IPP area handled input services; many of them were also involved in output marketing and already developed business linkages / partnerships with the private sector. Few WUAs have marketed the produce outside Chhattisgarh. Assuming CIDP extension, four large farmers’ companies have been formed in different regions of Chhattisgarh, but CIDP ended. These companies as well as WUA federations are still at an infant stage and need further support.

Farmers’ companies, cooperatives or other forms of federated farmers’ organizations would be the most appropriate organizations for small farmers to reach economies of scale and enhance the bargaining power of member-producers. They can develop stronger partnerships with the private sector and may sustain as strong and viable production and marketing organizations which would be responsible, not only for irrigation management, but also for input-output marketing, collection, storage, quality control, value-added production and marketing.

WUA network (with Chak groups as informal organizations, WUAs as the formal base organizations, district and regional as well as state federations) needs to be further strengthened
and integrated horizontally and vertically. These WUAs would be utilized by line agencies including the DA and enable the expansion of government activities including extension and input services.

The organizational network of WUAs can play a key role in participatory planning and collective action in water management and infrastructure O&M, input supplies, output marketing as well as in value addition. For agriculture, WUAs can use collective methods (e.g. Farmers’ Field Schools). The WUA network is useful to undertake collective action at different levels (e.g. group, WUA, district, regional, etc.) and integrate to achieve: a) economies of scale (e.g. input-output services to farmers, and b) improve efficiency in O&M and the use of other resources.

The state-level WUA federation has demanded state-wide extension of the CIDP Model state-wide. As mentioned earlier, WRD has not yet developed the capacity to handle a multidisciplinary project of this nature. If the Model is properly extended state-wide it could be an eye-opener to the policy makers throughout India. State-wide WUA network could be strengthened further to extend collective action such as input-output services and value addition, to non-irrigated areas, and rural poverty could be eradicated.

REFERENCES

INTRODUCTION

Irrigation systems operate under the environment of pressure from several external and contextual factors. As a social-ecological system (SES), an irrigation system faces ever-increasing scale of influence of human activity. Specially, the indigenous irrigation systems are facing new threats because of openness to the new world, commercial interests of farmers, rise in cost of maintenance, increased competition of water and weakened social cohesion due to reasons including state interventions (Barker and Molle, 2005; Lam, 2001; Shivakoti et al. 2005). At the same time the climatic variations also pose threats to the small-scale irrigation systems.

It has been observed that irrigation systems are directly affected by a variety of disturbances like policy changes, market pressures and the changes in the biophysical context where it operates (Bastakoti et al., 2010). The social-ecological system, irrigation systems in our case, is a complex collection of human, physical and institutional entities that respond to internal and external disturbances through a diverse array of rules in different conditions (Shivakoti and Bastakoti, 2006; Bastakoti and Shivakoti, 2012). The nature of resource (mobile or stationary) responds differently to predictable and unpredictable disturbances (Janssen et al, 2003). The CPR theorists consider lack of storage and non-stationary character of a
resource, spate irrigation in our case, as major obstacle for collective action (Ostrom et al., 1994). The strong connections of SES with large-scale phenomenon pose challenges and opportunities for the stakeholders. Literature based on past performance of resource systems shows that many long endured SES have successfully adapted their institutions to these disturbance regimes (Ostrom, 1990; Agrawal, 1999; Shivakoti and Bastakoti, 2006), while others collapsed (Baker, 2005).

This paper focuses on irrigation systems from different physiographic regions of Nepal. The cases covered in this study have also endured to known shocks of regular climate variability such as droughts and floods with varying degree of success in different management regimes and resource uncertainty, and are now exposed to climate related shocks and disturbances at an increased pace. We assess how the external disturbances make the irrigation systems vulnerable and how they adapt to such external disturbances and develop long-term robustness of the system. We focused our analysis on major external disturbances and possible panaceas considering across four first level core components of an SES viz resource system; governance system; resource units; resource users individually and the interaction that affect each other and related ecosystems (Anderies et al., 2004; Ostrom, 2009).

ANALYTICAL FRAMEWORK

In our analysis we adopted the framework proposed by Anderies et al. (2004) that provides guideline to analyze core entities of the SES and understand interactions between them. The framework focuses on four entities that are mostly involved in CPRs harvested by people (Figure 1a). The two entities in the framework namely, ‘resource users’ and ‘public infrastructure providers’ involve humans. Other two entities namely ‘resource’ and ‘public infrastructure’ involve physical and institutional aspects.

![Diagram](image)

Figure 1: (a) A simple framework that highlights the main components of SES and their linkages (Anderies et al. 2004), (b) Modified framework for the irrigation systems
The public infrastructure consists human-made physical and institutional capital (Ostrom and Ahn, 2003). The ‘resource’ entity represents biophysical system used by ‘resource users’ through joint provision effort of the two human based entities in framework that is ‘public infrastructure’ and ‘public infrastructure providers’. The internal fluctuations can result from changes in relationships between resource users and infrastructure providers and can affect various components and linkages in the framework. The arrows 7 and 8 represent the external disturbances to the ecological and social components of the SES. Other numbered arrows show the linkages and interaction between different components.

In FMIS, the resource users and public infrastructure providers are the same (Fig 1b), and the factors that affect one entity also in turn affect the other (if provision of public infrastructure is affected by some factor, the users are also affected by it). While in case of AMIS/JMIS in our study, the human entities of the framework involve different actors, that is, the public infrastructure providers are mainly the state departments and officials thus affecting the infrastructure. The local communities have limited influence compared to the community-managed systems (Fig 1b).

In this paper we focus on how external disturbances differently impact the core entities of the framework and their interactions in irrigation systems under different management regimes, and variation in resource uncertainty.

**METHODS**

This paper is primarily based on information collected at the irrigation system level supported by necessary secondary information from various sources such as policy documents, official reports and published literature.

**Sampled irrigation systems**

For the field survey sample irrigation systems were selected from 8 districts in different physiographic regions of Nepal (Figure 2). The primary information was collected from the sampled irrigation systems.
Irrigation systems were selected based on ecological region, economic characteristics, and management structure. A sample of 30 irrigation systems was selected covering different physiographic regions of the country (Table 1). Out of the 30 sampled irrigation systems, 40% were from Siwalik/Terai, 43% from Mid-hills/valleys and 17% from Mid-mountains.

Table 1 Distribution of sampled irrigation systems in different agro-ecological regions of Nepal

<table>
<thead>
<tr>
<th>Physiographic region</th>
<th>District</th>
<th>Number of sampled Irrigation Systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Siwalik/Terai</td>
<td>Nawalparasi</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Chitwan</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Makwanpur</td>
<td>3</td>
</tr>
<tr>
<td>Hills/Valleys</td>
<td>Kaski</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Tanahu</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Syangja</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Palpa</td>
<td>3</td>
</tr>
<tr>
<td>Mid-Mountain</td>
<td>Sindhupalchok</td>
<td>5</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>30</strong></td>
</tr>
</tbody>
</table>
Likewise, out of 30 systems, currently, 29 irrigation systems are farmer-managed irrigation systems (FMIS) and one is under joint management (JMIS). Among the 29 FMIS, 24 were initiated and managed by farmers themselves, whereas, other 5 were initiated by government agency (Department of Irrigation) and later the management responsibility was transferred to the users (management transferred systems – MTIS).

**Collection techniques and variables**

The system level information was collected by conducting interviews with the officials of water user associations (WUA) in the selected irrigation systems. In each interview, 2-5 persons provided the response about their irrigation system and management aspects in detail. We used structured checklist for the interview. The checklist included the variables covering physical attributes of the system, social context of the users, local institutional arrangement, and existing rules besides others. After the interview with the officials from WUAs information was also cross-checked against official records of WUA wherever possible, for example the date of initiation, command area, number of user households and so on.

**RESULTS**

**Biophysical context: Irrigation infrastructure**

Traditional farmer-managed irrigation systems are predominant and mostly located in the hills/siwalik regions of the country. These systems feature infrastructure made-up of with the use of local construction materials. Such infrastructure often needed annual repair and maintenance. However, with changes in government policies, those traditional irrigation systems have also received support to improve their infrastructure. Nepal focused on expanding irrigation areas after initiation of planned development efforts during the 1950s (Shah and Singh, 2000). As a result many large-scale irrigation infrastructures were built. Most of the medium-large scale irrigation systems are built in Terai and valley areas and they are mostly of run-off-the-river types.

The size distribution across physiographic regions showed existence of large number of medium-large irrigation system in Siwalik/Terai. But, both Mid-hills/valley and Mid-mountains showed dominance of small-medium traditional irrigation system (Figure 3). All the studied irrigation systems were of run-off-the-river type. In Nepal, due to the existence of large number of local streams and topographic suitability, systems operated through gravity flow are common. These are cost effective as well. However, due to flood in monsoon and low water level during dry season, this kind of system has low reliability compared to storage type. In the context of growing competition for water, storage and pumping systems provide opportunity to control water supply depending on the need.
Many sampled irrigation systems still have temporary headwork. Especially in hilly areas, headwork is made from wood, stones and other local materials. The temporary headwork reduces reliability of the irrigation system. The irrigation systems in Mid-hills/valleys were older than irrigation systems in Siwalik/Terai and Mid-mountains.

**Community attributes and changing farming environment**

Corresponding to their size, irrigation systems in Siwalik/Terai region provided irrigation water to large number of households followed by the systems in Mid-hills/Valleys (Figure 4). The average land holding size was also higher in Siwalik/Terai region.

Crop cultivation is still dominated by cereal crops mainly targeted to meet the family food requirements. Irrigation systems in Siwalik/Terai showed higher food sufficiency situation
compared to other physiographic region where the need to meet the food requirements is still a challenge (Figure 5). However, in recent decades, there is also a growing trend of commercial farming in Nepal, especially vegetable production. But it is mostly concentrated around major road corridors and/or some pocket areas. Some authors noted the trend of crop intensification, multiple cropping and increased vegetable production during recent decades (Brown and Shrestha, 2000). Result showed that a large portion of command area is under market-oriented production in the irrigation systems of Mid-hills/valley followed by systems of Siwalik/Terai and Mid-mountains.

![Figure 5 Food sufficiency and market-oriented production](image)

In the recent decades, many farmers have diversified their livelihood portfolio. The notable shift has been the increasing involvement in overseas migration where majority of them work as non-skilled labor. But the contribution of such remittances is significant, as high as reported by about 39% of the households in Mid-hills/valley (Table 2).

<table>
<thead>
<tr>
<th>Occupation</th>
<th>% HH Agriculture</th>
<th>% HH Business</th>
<th>% HH Service</th>
<th>% HH Remittances</th>
<th>% HH Wage Labor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Siwalik/Terai</td>
<td>90</td>
<td>11</td>
<td>10</td>
<td>21</td>
<td>4</td>
</tr>
<tr>
<td>Mid-hills/valley</td>
<td>90</td>
<td>19</td>
<td>25</td>
<td>39</td>
<td>25</td>
</tr>
<tr>
<td>Mid-mountains</td>
<td>97</td>
<td>3</td>
<td>7</td>
<td>19</td>
<td>39</td>
</tr>
</tbody>
</table>

**Table 2 Diversification of livelihood options**

**External disturbances to the irrigation systems and increasing vulnerability**

The external disturbances can include biophysical distraction (Arrow 7 Figure 1), such as floods, droughts, erratic rainfall pattern, that impact the resource and the public
infrastructure, or policy and socio-economic changes (Arrow 8 Figure 1), such as population increases, migration, market forces, that have an impact on the resource users and the public infrastructure providers. Irrigation systems face several kinds of external disturbances, such as, natural events like floods and droughts, policy changes and market pressures. The external disturbances affect the entities, both resource and human part, of the social ecological systems in various ways. The major effects would be: affecting the infrastructure of irrigation systems and thereby water availability, expansion/contraction of irrigated command areas, increased competition for water use and resulting conflict, labor shortages and collective action, and shift in management regimes.

**Natural events as external disturbances**

Irrigation systems are adversely affected by climatic variability such as the erratic rainfall pattern causing recurring occurrence of droughts and floods. About half of the irrigation systems reported major losses from such natural events (Figure 6). Droughts, floods, landslides and resulting damage to infrastructure made irrigation systems vulnerable.

![Figure 6 Percentage of irrigation systems reporting major loss from natural events](image)

In the recent decades the delayed onset of monsoon has become common that affects the capacity of irrigation system to supply the water when there is need. The changing rainfall patterns due to the climate change significantly affect the irrigation systems dependent on non-perennial sources. The main effect was seen in varying water availability in different seasons (Figure 7).
The commonly observed situation is such that farmers cannot get sufficient water in their irrigation canals at the time when they need to start the cultivation practices for the priority crop. The climate change and the variability have adversely affected the capacity of the irrigation systems to maintain the steady supply of irrigation water. Such external disturbances have increased the vulnerability of the irrigation systems. Irrigation systems are sensitive to the changes in the infrastructure and the degree of sensitiveness significantly affects their capacity to maintain robustness.

**Policy changes**

Another major external disturbances that the irrigation systems face is the changes in related policies at different level. Such changes affect the entities of the SES in different ways especially on the public infrastructure and public infrastructure providers. The policy changes may result in the area expansion, system rehabilitation, management change and others.

In Nepal until the beginning of 20th century there was very little involvement of state in irrigation development and management. Few *raj kulos* were reported; otherwise the majority of the systems were constructed and managed by users themselves. Some public sector irrigation schemes were initiated around 1920s (Shukla and Sharma 1997; Shah and Singh 2000). Nepal focused on expanding irrigation areas after the initiation of planned development efforts during 1950s (Shah and Singh 2000). During 1970-1985 the focus shifted from the infrastructure development to production enhancement activities. It included completion of water distribution structures of already constructed irrigation systems, rehabilitation support to FMIS and other activities related to improved agricultural technology. Further, Nepal focused on improving the performance of the existing irrigation
systems that included renovation and expansion of FMIS command areas, and participation of users in development and management of irrigation infrastructures, among others.

Major policy shift was observed after the formulation of new irrigation policy 1992, giving the main emphasis on users’ participation. The government adopted the participatory irrigation management policy with two action plans: turn-over, or more commonly known as Irrigation Management Transfer [IMT], of AMIS to the user groups, and joint management of large irrigation systems where users and government agencies share the responsibilities.

The changes in government policies have, over the period, affected the various entities. The major effect was on the irrigation infrastructure, the public infrastructure, mostly the increase in overall capacity to supply the irrigation water. The changes were on improvement in the capacity of the existing irrigation infrastructure, such as rehabilitation of FMIS, and the expansion of irrigated areas with construction of new irrigation infrastructure. Similarly, the policy changes have affected the composition of public infrastructure providers and thereby the service delivery mechanism (water allocation). Many agency-initiated systems, where the irrigation officials used to play the role of public infrastructure providers, are now handed over to the user groups. In the changed situation the resource users and the public infrastructure providers have become more or less the same. The new policy has improved the water delivery, the resources condition, and resulted into better outcome, the increase in agricultural production. The adoption of IMT resulted into strengthened the capacity of the Water Users’ Association (WUA), the public infrastructure providers. The empowered WUAs became more capable in dealing with the external or internal disturbances to their system.

Overall, the policy changes seemed to have positive effects on the various entities of irrigation system and interactions among them. But in some cases it also resulted into conflict and lack of coordination between public infrastructure providers, the WUA and irrigation agencies. Similarly, the changes in policy meant that the resources users needed to cover the direct costs related to operation and management of their irrigation systems.

**Market pressure**

Changes in agricultural technology and markets have driven changes in water use in Nepal. Adapting to these influences is a significant challenge to individual irrigation systems. Market diversification and integration affect irrigation water management (FAO 2007). Various aspects such as, commercialization of the farming activities, seasonal migration, changing pattern of water use, contract farming, have direct effect to the water use dynamics and the characteristics of the water users.
Crop intensification, multiple cropping and increased vegetable cultivation was noted in case of many sampled irrigation systems in Nepal. The result showed that (Figure 8, part B), a large portion of command area has been allocated for market-oriented commercial production even though meeting the subsistence need is main objective of irrigation in majority areas. Especially the vegetable cultivation requires more water in dry season when there is water shortage in general. High comparative advantage, better market and price, however, has tempted farmers to grow the commercial crops but the water shortage means possible conflict among the users. The interdependencies between market trends, demand and price, and the farming decision also play important role in water use and thereby robustness of the irrigation system.

In the recent decades, the seasonal migration of the economically active population to the regional urban centers or the capital is on rise. The result showed higher level of outmigration from Mid-hills/valley followed by from Mid-mountains and Siwalik/Terai (Figure 8). This demographic transition in the farming areas has created labor shortage. Many irrigation systems we studied reported this situation. It has two implications. First it directly affects the labor availability of the household farming activities thereby forcing people to bring the hired labor. Second, farmers cannot allocate necessary time to contribute in repair and maintenance of the irrigation system. Such changes in the characteristics of the resource users due to the market associated factors ultimately result into less collective action to manage the resource and the public infrastructure. Many others have also reported the effect in resource management due to increasing market integration (Agrawal and Yadama 1997) that often results in decreasing collective action (Araral 2009).

![Seasonal outmigration of the people from different regions](image)

Overall, the expanding markets and trade have influenced the land-use decisions of farmers in Nepal. In many cases it has resulted in intensification of farming and introduction of new commercial crops thereby increasing per-unit return from the farmland. But at the same time the increasing demand in agriculture and other sectors has created competition for water, especially during dry season. The increased competition and shift in irrigation practices
have resulted in reduced collective action for irrigation management. This ultimately has made irrigation systems more vulnerable.

**DISCUSSION: ROBUSTNESS OF THE IRRIGATION SYSTEMS**

The analysis of external and internal disturbances, and the responses in the changes circumstances provided the interesting facts on changes in the characteristics of resource and public structure, changes in different aspects of resource users and the role of public infrastructure providers. In this section we analyze the linkages and interactions among various entities of the irrigation system, as a social-ecological system. The changed role of resource users and public infrastructure providers (human components of the Anderies et al, 2004 framework) resulted in the form of variation in operational-level rules and variation in interventions in the form of structural improvements of systems. The interactions among the entities of the core subsystems of SES (Table 3) provides the hints on difference in robustness due to variation in capacity to cope challenges associated with these systems. The inherent uncertainty in these systems has been a major threat and will be further aggravated due to climate change and preparedness of systems under two different management regimes with variation in resource uncertainty.

**Table 3**

Entities of irrigated social ecological system and linkages among entities

<table>
<thead>
<tr>
<th>Entities/linkages</th>
<th>Major threats to irrigation systems</th>
<th>Issues related to:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rainfall patterns; floods intensity and frequency</td>
<td>AMIS/JMIS/MTIS</td>
</tr>
<tr>
<td>Resource</td>
<td></td>
<td>Low reliability and uncertainty in availability of the water</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FMIS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Less reliable water availability in some situation but flexible rules to allocate</td>
</tr>
<tr>
<td>Resource users</td>
<td>Outside interference in rules</td>
<td>Users have limited role in rule formation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>High autonomy in forming rule based on the need</td>
</tr>
<tr>
<td>Public Infrastructure</td>
<td>Insufficient infrastructure to distribute water</td>
<td>Infrastructure do not match with traditional systems that were prevalent in the area; costly to replace when damage</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Simple and flexible structure using locally available materials, easy to re-build in case of damage</td>
</tr>
<tr>
<td>Public Infrastructure Providers</td>
<td>Insufficient capacity to operate the infrastructure in change situation</td>
<td>Agency officials lack clear understanding of local situation and local need</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Same people as resource users and so have better knowledge to operate the canal infrastructure</td>
</tr>
<tr>
<td>Entities/linkages</td>
<td>Major threats to irrigation systems</td>
<td>Issues related to:</td>
</tr>
<tr>
<td>-------------------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>Between resource and resource users</strong></td>
<td>Changing rainfall patterns, variation in available water and changing use pattern</td>
<td>Not enough attention and capacity to deal with the shocks and changing demand</td>
</tr>
<tr>
<td><strong>Between resource users and public infrastructure providers</strong></td>
<td>Declining deliberation process and weak monitoring</td>
<td>Low resource contribution for O&amp;M, poor condition, free-riding, poor monitoring</td>
</tr>
<tr>
<td><strong>Between public infrastructure providers and public infrastructure</strong></td>
<td>Fixation of rules, social capital and new infrastructural challenges</td>
<td>Infrastructure and allocation mechanism decided on top-down approach</td>
</tr>
<tr>
<td><strong>Between public infrastructure and resource</strong></td>
<td>High failure rates of structures and unpredictable resource availability</td>
<td>Infrastructure not fit to biophysical context, Ineffective due to lack of maintenance</td>
</tr>
<tr>
<td><strong>Between public infrastructure and resource dynamics</strong></td>
<td>Ground water pumping, head-tail end issues</td>
<td>Use of groundwater and in some cases overexploitation</td>
</tr>
<tr>
<td><strong>Between resource users and public infrastructure</strong></td>
<td>Conflicts, free riding issues</td>
<td>No-incentive to maintain the infrastructure, free-riding</td>
</tr>
<tr>
<td><strong>External forces on resource and infrastructure</strong></td>
<td>Flash floods, delayed monsoon</td>
<td>Increasing frequency of floods with uncertain strength damage infrastructure</td>
</tr>
<tr>
<td><strong>External forces on resource users</strong></td>
<td>Preference for non-farm jobs due to economic integration.</td>
<td>Outmigration, labor scarcity</td>
</tr>
</tbody>
</table>

External disturbances most often affected the public infrastructure and resource characteristics directly affecting the water availability. At the same time the interventions by public infrastructure providers’ in the form of changed rules at constitutional choice level have impacted operational level rules through changed role of actors at collective choice arenas mostly in AMIS. In such situation resource users in case of AMIS/JMIS, were
not willing to contribute in maintaining the resource systems mainly due to the inflexible rules. The lack of maintenance further aggravated the capacity of infrastructure to cope the damage by floods. The FMIS, on the other hand, also faced the external disturbances but the flexible rules and better monitoring mechanism help keep the functioning intact by providing fast collective response.

Similarly, as a result of market forces there was competing resource use and increased demand for the water resulting into conflict in many cases. It resulted into reduced collective action in case of FMIS also. But the FMIS has shown the robustness to adjust with the effects of external factors. The flexible rules, autonomous WUAs and local institutions provided the capacity to self-govern and maintain the robustness of their irrigation systems.

The repeated experience of the irrigation systems to deal with particular disturbances enhances their adaptive capacity in the long-run. The adaptive learning could ultimately help develop long-term robustness of the system.

CONCLUSIONS

Natural events as a result of climatic variability and change, policy changes and market pressure are the major external disturbances affecting core entities of the SES framework at varying degree. Among these disturbances, the natural events seem to have universally negative affects due to its uncertain nature. The vulnerability of the irrigation systems to those disturbances also depends on the sensitiveness to small changes in infrastructure and biophysical context.

The policy changes, on the other hand, have both positive and negative effects. The policy change brought realizing the experiences at community level and devised considering customary rights and local institutions have positive outcomes in the form of strengthened public infrastructure and the providers. The negative affects of policy changes are felt from rules violation, worsening resource condition including inefficient use and conflicts among users.

The market pressure have multidimensional effects in the form of tendency to use more water by some at the cost of others and also in the inter-sectoral competition causing shift in manpower from agriculture to other employment and investment opportunities. The internal disturbances in the form of management changes of WUAs affected the irrigation systems in different ways. External interference was always dominant in AMIS/JMIS and thereby affecting the public infrastructure providers. In some cases FMIS also fell into the trap of local selfish politicians and local elites who often wanted to use the CPR in their personal or group benefits. Seasonal outmigration of the people also affected the collective action.
Irrigation systems dealt with external disturbances in various ways. Governance structure and local institutions were found crucial in dealing with the disturbances. Mostly, highly autonomous FMIS were able to adjust with the changing situation. High autonomy provided them the opportunity to adjust their institutional conditions according as the changed context. It in turn enhanced their adaptive capacity making them capable of generating rapid response to the external shocks and maintain the robustness of their system. Existence of various forms of rule and better compliance by the users was another important aspect in FMIS. But in AMIS/JMIS rule formation was mainly done by the agencies being it ineffective in implementation. But in many FMIS the centuries old local rules prevailed and new rules were also formed based on the community needs. The irrigation systems showed their robustness in the form of diversity of rules to different situations, stronger institution of local leaders, and adoption of coping strategies to match with uncertainty in irrigation.

ACKNOWLEDGEMENTS

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ROLE OF WATER USER ASSOCIATION IN SUCCESSFUL OPERATION AND MANAGEMENT OF ANDHIKHOLA IRRIGATION SYSTEM, SYANGJA, NEPAL

SHARMA, K.R*, DONGOL, R**, KHANAL, A***

BACKGROUND

In addition to subsistence farming, erratic rain fall, limited access to gainful off-farm employment and a lack of income-generating alternative activities; political and economic instability, low agricultural production and population pressure have been commonly contributing factors to Nepal’s low level of economic development (World Bank, 2012).

Nepal brought out Water Resources Strategy (WRS) in 2002; Agricultural Perspective Plan 1995; to promote year round irrigation and to enhance institutional capacity of Water User Associations (WUAs) to cope with the growing challenges in the effective/efficient use of country’s water resources including irrigation. In support of WRS, National Water Plan, 2005 was formulated putting focus also on the effective and sustainable use of surface and ground water irrigation. Water Resources Act, 1992 considered WUA, a corporate body and set the guidelines for its by-laws listed the responsibilities.

Performance of irrigation systems along with sustainability has been an outstanding issue over the years. Some of the problems are: decreasing water carrying capacity of the scheme

* Faculty, M.Sc Interdisciplinary Water Resources Management, Nepal Engineering College
** Faculty, MSc. Interdisciplinary Water Resources Management, Nepal Engineering College
*** Faculty, MSc Interdisciplinary Water Resources Management, Nepal Engineering College
due to siltation and sedimentation, unequal distribution of irrigation water, inefficient water use, poor operation and maintenance activities, low participation of users in collective action, and conflicts among users (Pradhan, 2003). The WUA is the immediate responsible organization to manage jointly managed or self-managed irrigation schemes in a collective way. The organizational set up of the association, their participation in the management activities and institutional arrangements are some of the potential factors which affect their management quality (Pradhan, 2003). Moreover individual participation of users in collective activities has its own impact in achieving sustainable management.

STUDY AREA

The Andhikhola, a hill irrigation system constructed during 1989-1996 by Nepal Government and the United Mission to Nepal (UMN) with the financial support from the Norwegian Agency for Development Cooperation (NORAD) lies near Galyang bazzar in Syangja district of Nepal towards southwest of Pokhara. The study area receives average annual rainfall between 1300-1750 mm. About 86% of the population is farmers (BPC, 2010). Rice, wheat, maize, mustard and millet are the main crops. Over a large portion of the cultivated area, the farming system is dominated by traditional methods of rain fed crop production.

The irrigation system was constructed as a part of an integrated rural development program. The management responsibilities of the irrigation system were transferred over to a local beneficiary’s organization called Andhi Khola Water User Association (AKWUA) on June 27, 1997 (BPC, 2010).

The study area, a low ridge located between the Andhi Khola River in the North and the Kali Gandaki River lies in the southern part of the Syangja district. Population density is as high as 370persons/km². The total population consists of approximately 15,000 people, of which 75 percent are Hindus. Eighty-two percent of the households own less than half a hectare of land. The cultivation of the arable land is intense but risk-prone because of unsteady soils and landslides. Few farmers have access to irrigated land. Only less than 3 percent farmers own more than 1.5 hectares of irrigated land (BPC, 2010).

Adhikhola Irrigation System Scheme Layout

The Andhi Khola River, which is the main water source for the Andhi Khola Irrigation Scheme, is fed by snow melt water and rain. The discharge of the Andhi Khola river measured at the headwork of the irrigation system varies: from 1.8 to 362 cubic meters per
second (BPC, 2010). Water is scarcest in the spring months from February to April. The headwork is located at Tallo Galyang of Jagatradevi Village Development Committee. From the Andhi Khola River, water is diverted to the surge tank of a power plant of the Butwal Power Company (BPC) and to the irrigation system. The power plant requires a discharge of 2,700 lps to generate power on its full capacity. For irrigation, discharges up to 688 lps are required depending on the crop, the crop stage, and the rainfall pattern.

The altitude of the command area ranges from 380-625 m above sea level. 73 % of the irrigated lands are flatter than 8 degrees, but other parts include sloping lands up to 30 degrees. Immediately downstream of the head-intake, the canal splits into the eastern and western main canal. The eastern main canal is a contour canal of 5.1 km and has eight secondary off-takes (E1-E8). The western main canal is 1.5 km long with two lined branch canals, W1 and W2. Both the eastern and western main canals are lined with soil cement and pass through numerous drainage crossings. By doing so, the steep slopes remain stable. Distribution boxes constructed in the branches make it possible to distribute water proportionately.

**METHODOLOGY**

Primary and secondary sources were used to obtain qualitative and quantitative data of the system. Primary data were collected by using varied participatory tools such as field observation and system walk through, key informant interviews with Executive Director, General Manager, three AKWUA shareholder members and officials and two focus group discussions, one with branch committee members and another with women user group. Secondary data were collected through review of the journals, reports and national irrigation policy, legal frameworks about irrigation management and WUAs. Published reports on the projects and past case study reports on irrigation in Nepal were also reviewed.

**Data analysis**

To answer the questions about the physical, financial and equity performance of AKWUA, their organizational setup and institutional arrangement and their participation in irrigation activities qualitative analysis of observed and collected data was done. These data were analyzed by using Ubels organizational system analytical model (Ubels, 1997), and Uphoff cube matrix (Uphoff, 1987) as analytical framework. Moreover, descriptive analysis was used in order to support the findings from the qualitative analysis.
**RESULTS AND DISCUSSION**

**Andhikhola Water User Association (AKWUA) Structure**

With the prominent objectives of uplifting the poor and landless farmers in the command area through active participation in the development of the project, a representative body of the affected farmers was formed as early as in December 1984 and registered under the Association Registration Act, 2034 BS (1977). An organizational structure was established with the General Assembly as the highest decision-making body. All the water shareholders are the assembly members. General assembly selects the Executive Board of Directors, which is responsible for daily governance of the system. A General Manager (GM) is responsible for day-to-day management of the irrigation system; s/he is accountable to the Board of Directors. But, in completion of most of design works in the year 2000, the WUA structure was changed as per the need and continuation is given.

**AKWUA Executive Board**

This board is comprised of 13 members with at least 33% of women representation. This board is chosen through the direct election from the user shareholders. The election is held every year, however, each election replaces only 50% of the members that have completed 2 years tenure. This arrangement is made in order to make cohesion with the newly elected members and make sustainable governance. This executive body is not only responsible for the daily activities of the AKWUA office and its employees, it is the main body that looks after overall operation and maintenance, irrigation service fee collection, budget allocation, water distribution and resource mobilization within the system. This committee is mandated
to take all the decisions pertaining to the system management and is responsible to establish mechanism for cooperation and coordination with the major stakeholders and funding agencies, both the governmental and non-governmental. Regular monthly meeting is held of the executive body.

Two advisory bodies were established: the Evaluation Committee (to evaluate applications for land and advise the Board) and the Land Distribution Committee (to redistribute land). Shareholders were organized into Branch Committees to manage the respective branches. Maintenance and fee collection are some of their tasks. The major responsibilities and extent of works of organizational structure are described below:

**Evaluation and Monitoring Committee**

This committee is comprised of one chairperson and 10 members elected directly from the shareholders. The election for this committee is held every year for all 11 members. This committee is mandated to monitor and evaluate the activities carried out by the executive committee and make suggestions for further improvement. This committee submits the report of its evaluation and findings to the executive board every six months.

**Land purchasing and Redistribution Committee**

This committee was comprised of a chairperson and 6 members. All the 6 members and the chairperson were nominated by the executive body. This committee was mandated to keep the records of the land and water share of the individual. The trading of the water share can only take place after the recommendation of this committee to the executive body.

**Role of AKWUA**

The Andhi Khola Multi-Purpose Water User Association (AKWUA) was set up to coordinate between the United Mission to Nepal (UMN) and the water users (UMN, 1997 as cited in BPC, 2010). The aim of AKWUA is to co-implement the multifunction project and manage the funds. In the beginning the member of AKWUA was not limited i.e. everyone living within the command area covering eight Village Development Committees, for at least three months a year, had right to be a member by paying minimum charge of NRs. 11. Later in 1989, the ownership of shares was added as a condition for membership.

According to AKWUA’s constitution, a member has the right to i) earn up to four shares per household member, either through provision of labor, or through direct payment during the construction phase of the scheme. In 1989, this was amended to enable those farmers who were willing to contribute more labor to earn more shares. The maximum number of shares a person could obtain was increased from four to ten ii) distribute part of the water flowing out of the head gate at any given time, provided one had registered the required
shares before each season and paid the water fee. The amount of receivable flow depends on the number of shares a person has registered iii) lease out shares to other people. This should be done before the start of the new cropping season iv) allocate shares to any person who is not forbidden to purchase shares in AKWUA v) vote at General Meetings vi) have priority over non-members in receiving offers of any paid labor for extension or maintenance of the irrigation system.

Each member was obliged to:

- Offer a sale of 10 percent of surplus land to AKWUA.
- Contribute labor for construction of the scheme to earn water shares.
- Pay water fees and contribute to maintenance.
- Respond without fail to the General Manager's call for labor contribution in case of an emergency.

AKWUA has an agreement with the Butwal Power Company (BPC) which was signed in 1987, to share diverted water for their respective use. Under normal circumstances, AKWUA could obtain a maximum of 688 lps water at the headwork. However, when there is insufficient water for both the irrigation system and the power plant, priority is given to the power plant. But, there is a provision in the agreement to release water during one week in the dry season to make maize cultivation possible.

**Formation of Andhikhola Multipurpose Association (AMA)**

With the main objective of providing sustainable support to AKWUA a new organization registered in 2005 comprises of AKIP shareholders and representative from BPC that owns the hydropower. This organization has 250 general members. It also has an executive body comprised of 5 elected members out of water shareholders and 2 representative nominated by BPC. BPC has agreed to provide Rs. 250,000.00 on annual basis for institutional development of AKWUA through this organization. After formation of this organization, BPC has carried over the share of the cost (20%) that AKWUA used to pay to BPC towards the maintenance to head works and headrace tunnel. This organization is active in generating additional funds from donors. It releases the fund to AKWUA as and when requested. In April, 2013, BPC has agreed to increase the grant amount to Rs. 400,000 per annum. Also AKWUA has so far received Rs. 4 million for the repair and maintenance for the irrigation canals under the community support program of BPC, as it is under the process of upgrading the hydropower project.

**AKWUA Role in Implementation Modality**

In the initial stage, AKWUA had worked closely with Andhi Khola Project (AKP)/UMN Staffs in the implementation of the irrigation project. Later on, in the absence of UMN, AKP in the form of AKWUA now is helping in the technical and financial terms
of the irrigation system. It has been much instrumental specifically in mobilizing local human resources during construction, and executing necessary task of land purchasing and redistribution program of the project. Some of the prominent areas wherein the AKWUA has contributed are:

**Share Earnings**: Any person residing in project area could earn a share by contributing 5 days labor contribution (worth Rupees 165). A person was entitled to earn a maximum of 4 shares. There was a provision of 25,000 shares to be distributed to the beneficiaries. Possession of the single share would give the owner a water right of 1/25,000 part of the water flow available at the head. The total contribution made by the farmers was worth of Rs 4,125,000. However, by the end of the project i.e. hand over date the shares earned by the beneficiaries were only 17,739 worth rupees 2,926,935. Since the UMN had spent money in lieu of labors, for rest of the contribution the UMN kept rest of shares, 7,261 within itself. However, in year 2000 the share kept by UMN was handed over to the AKWUA. So far AKWUA has sold 1,056 shares out of 7261 and remaining 6205 shares are still in the possession of AKWUA. In order to sell the remaining share AKWUA is thinking of revising the quantity of water per share. Those of the share earned persons residing in the area but not as the water users i.e. beside irrigation command area or having land above the canal were not benefitted. They are thinking to sell the share earned even though the value of share has not increased over the years.

**Assessment of Water Need**: The AKWUA notifies to the user farmers register their shares within certain date before each cropping season. Share holders are required to mention the canal from where water is to be acquired. Based on such registration, the AKWUA calculates the discharge needed and it requests the hydro-power management to release water for irrigation from the surge tank. The AKWUA also determines the discharge required to each canal (main, branches and tertiary) based on the prior registration made.

**Land Re-distribution**: One of the major objectives of this project was to collect some lands from the relatively big (rich) holders and then distribute to the land less. The basis for determining the optimum land requirement for livelihood was based on the assumption that a family with 7 members would need a land area of 5 ropanis (0.25 hectares). This would mean that one person would need approximately 11.5 anna (0.036 hectares). As a result of this, the project made criteria that farmers having more than 0.036 hectares per person would require to sell 10% of their extra land to the AKWUA. Such purchased land pieces would then be distributed to the poor or landless farmers at the same pre-irrigation price.

To date, AKWUA has been successful to purchase 232 Ropani (11.6 hectares) of land and has already distributed this land to 83 poor/landless and marginal farmers. While the money was fully paid to the seller, the eligible buyers were allowed to pay in installment basis within five years without any interest. For this purpose of land pulling and subsequent
payment to the seller, UMN had provided a refundable fund to the AKWUA which later on was waived by the UMN for AKWUA’s institutional development.

**Irrigation Service Fee**: Each shareholder or beneficiary farmers has to pay NRs. 6.0/share/year for office expenditure of AKWUA. Besides this the shareholders are paying NRs. 4/share/year for maintenance and operation of the canal system. The shareholders were also shouldering a portion of maintenance expenditure of headwork and tunnel (20%) to the hydropower company. At present 15,000 shares are active and utilizing water for irrigation and paying the operation and maintenance as well as office expenditures of three staffs. Besides, the above the AKWUA also mobilizes some labor contribution from each shareholder for canal cleaning and reshaping. The canals are generally cleaned twice a year, before paddy transplantation and wheat sowing.

**Conflict Management**: The AKWUA board has been successful in resolving conflicts so far between water users and the association. This has been possible as there are clear rules and regulations related to water allocation and distribution. The AKWUA has rules whereby any person or shareholder who does not abide by the rule is normally penalized by depriving him/her of irrigation water or penalizing with certain fine.

**Water Allocation & Distribution**: In general, irrigation water is allocated according to the developed canal operation plan based on the discharge. Regular flow is measured taking fifteen days intervals at intake of the main canal just below the surge shaft. Most of the time, water flows at a constant rate over the 24 hour period in the main and branch canals. The irrigation water is distributed with plot soil characteristics at the flow rate of 2 l/s/ropani. But the flow may vary to 1 l/s/ropani for the farmers with less permeable soil characteristics area. Irrigation water distribution turns are normally made for 2 hours/ropani. During the period of insufficient water in the canal, mainly January to June turns are adjusted as per the situation. In general, as there is more flow in monsoon season, so intake gate is opened in full capacity. But in spring season usually flow becomes less, correspondingly rotational system is maintained.

**Decision Making**: General Assembly is the main body of the AKWUA where decisions concerning the whole irrigation system are discussed and decided upon. Representative member is from different hydraulic levels i.e. branch and tertiary canals. General Assembly elects a President, Board of Directors, and a council of representatives, appoints an auditor, approves remuneration for directors and council members, receives and approves reports from the Board of Directors, approves the annual accounts. The elected President is summoned and chairs the meetings in the council of representatives. Executive Board of Directors holds the authority to and is charged with the responsibility of protecting and directing the whole activities of AKWUA. General Manager is appointed by the Board of Directors to manage the daily official activities of AKWUA.
The General Manager has the role and responsibility in implementing decisions taken by the Board of Directors. The General Manager has to keep the records of irrigation turns, water allocation and distribution schedule, records of Irrigation Service Fee (ISF) collection, irrigation demand, cropping calendar and irrigated area as presented by each branch and tertiary member. These records are used to estimate water requirements at each branch and tertiary canal.

**Operation and Maintenance**: AKWUA officially communicates on a daily basis with BPC who will control the main headrace tunnel gates. An official understanding has been developed between the two parties as to how the best can be done. Operation of intake, main canal gates is done by the permission of General Manager. Operation of canal gate is made according to the agreed irrigation schedule. The chairman makes frequent inspection whether the farmers are following their turns or not. Normally farmers use spade and wooden planks with earthen embankments to divert the water towards adjoining fields.

Regular and periodic maintenance are carried out at main canal level, branch and sub-branch levels. In general as reported earlier, periodic maintenance is carried out at most twice a year. In general, maintenance is done prior to rice planting. If necessary, canals are cleaned prior to maize planting when irrigation is very critical. Maintenance activities include vegetation clearance, debris and sediments removal, abstract floating materials etc. Main, branch and tertiary committee assign water users to carry out these activities before and after completion of each cropping irrigation season.

**Rules and Regulations**: The GA has the authority to introduce constitutional amendments, make and approve rules and regulations as well as decisions. AKWUA has made many rules that water user has to follow i.e. payment for share, membership fee and maintenance fees. Water users were also responsible for weeding in the embankments of their plots. Executive committee members must be present in all the meetings and make dated records of activities. Also sanctions specified for i) late payment of fees, ii) water theft, iii) non contribution in cash or labor for O & M, iv) infringement of O & M responsibilities, v) violation of water distribution in branch and distribution canals, vi) encroachment of irrigation water source and vii) animal grazing and waste dump nearby the main canal.

In general, water theft was uncommon, and AKWUA has been trying to raise awareness rather than sanctioning water users.

**Accounting Records and Auditing**: Seminars and Trainings related to administration, financial management were carried out and recorded by the AKWUA. The financial records were handled by the General Manager and Chairman and kept in AKWUA office. The recording system began before construction and thereafter improved through seminars/ trainings. Financial records auditing was done every year.
**Mapping:** Detailed mapping for land ownership, records of land purchased and distributed to poor and marginal families, main canal, branch canals including plot distribution is carried out by the AKWUA. All plots are categorized by branch or distributions and a number is assigned. This number is kept in a file that specifies the plot size and plot holder. In this way the AKWUA could keep detailed records of cropping pattern and irrigated areas.

**CONCLUSION**

Water allocation and distribution schedule has been prepared and administered by AKWUA according to the prior filled water demand form from the water users. In the period of scarcity of irrigation water, it has maintained rotational arrangement among water users. For control structural activities, AKWUA has used the fixed rules and regulations that the water users have to follow.

Organizational activities like decision making, conflict management, resource mobilization was in hand of executive committee as general assembly has given the full authority and has been executed properly. With regard to the sustainability of the irrigation system, AKWUA was found in positive situation. For the sustainability of the irrigation system basic indicators like physical infrastructure development, financial capability, and collective participation in irrigation activities play the vital role. As Andhikhola irrigation system has properly maintained its physical infrastructure through collective participation of water users starting from the construction activities to operation and maintenance. For financial sustainability, AKWUA collects the service fee among its water share holders and also receives regular technical and financial support from BPC. Thus AKWUA is in the positive sound footing in self-sustaining the irrigation system.

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SMALL SCALE IRRIGATION TECHNOLOGY
INTRODUCTION

Improved seed and fertility technologies enabled the Green Revolution but expansion of reliable irrigation sustains it. Groundwater irrigation has been practiced for centuries but it is the ability to construct tube wells, together with low-cost pumps, that has made groundwater irrigation reliable and cost-effective for farmers. Pumping groundwater for irrigated agriculture, especially in South Asia, has expanded dramatically since the late 1960s, supporting a phenomenal rise in agriculture production.

In Bangladesh groundwater pumping is the primary irrigation water delivery mechanism. Pumping from groundwater now sustains nearly 55% of the area irrigated in India. In both Pakistan and India pumped groundwater bridges critical gaps in water delivery from the large reservoir or river-diversion irrigation systems of the Indo-Gangetic basin (Shah 2007). Since individual farmers control their own pumped irrigation water deliveries, the quantity and timing is flexible and reliable. This is essential for farmers growing high-value crops and also increases productivity of cereal crops where canal deliveries are unreliable. Currently the most common farmer-owned pumping systems in South Asia are small (4 to 7 horsepower) diesel engine pumpsets pumping from tube wells.

* Robert Yoder, independent consultant, Rutland, Vermont, USA robertyoder@gmail.com
** Deepak Adhikari, independent consultant, Kathmandu, Nepal deepaklochan@yahoo.com
The purpose of this paper is to report about an under-recognized development resource: the manual well drilling craftsmen (called *mistris* in much of South Asia) who make it possible for farmers and villagers to gain access to groundwater. Their expertise in constructing wells provides homestead water for countless millions. Initially their effort was primarily constructing wells for hand pumps and domestic needs but increasingly this has shifted to construction of irrigation “tube wells.” I became aware of the tremendous contribution *mistris* make in facilitating irrigation while working with iDE in Ethiopia. The first part of this paper describes the effort made to establish manual well drilling businesses in Ethiopia similar to that of village *mistris* in Asia. The second part of the paper provides a closer look at the manual well drilling enterprises owned and operated by *mistris* in the tarai of Nepal.

**International Development Enterprises (iDE)**

iDE was founded in the early 1980s as an organization dedicated to working with people now considered at the bottom of the economic pyramid. iDE’s focus soon migrated to what iDE termed dollar-a-day farmers, farmers trying to eke a living from a small plot of land with few resources. It became clear to the entrepreneurial founder of iDE, Paul Polak, that access to water for irrigation was a game changing solution for farmers (Polak 2008). Teaming with an organization that developed the low lift “rower pump” in Bangladesh and within a few years embracing the treadle pump, also developed in Bangladesh by a different group, iDE found its niche establishing supply chains for getting pumps to smallholder farmers. This included training and quality control for small workshops that manufactured and sold pumps, linking the workshops to a distribution system of dealers and retailers, developing promotional strategies to get the word out to the farmer community and ultimately a mechanism for pump installation and follow-on services.

From about mid 1985 through early 2000, millions of farmers in Bangladesh, India and Nepal purchased one of these pumps and added a dry season crop to their farming cycle.
Households using treadle pump irrigation, on average, increased their net income by $100 per year (Shah et al 2000). Streams and drainage ditches were important water sources for the pumps but shallow groundwater, water right under the farmer’s field, was often the best opportunity for a pumped irrigation supply. Fortunately, the green revolution was already generating demand to tap groundwater and as a result farmers could hire a local well drilling mistri to drill their well and install the pump. Mistris in Bangladesh already had experience drilling wells for hand pumps and small engine pumps and with a bit of training from iDE became experts at installing “bamboo” treadle pumps.

Having experienced overwhelming success in promoting low lift, smallplot irrigation in South Asia, iDE started programs in Africa in the mid 1990s to replicate this experience. But after nearly a decade of supply chain development in Zambia only 2-3000 farmers were purchasing treadle pumps each year. In 2006 as iDE began its program in Ethiopia, it was well aware that there were serious barriers for resource-poor farmers to access water for irrigation.

Lakes and streams offered some opportunity for irrigation but groundwater seemed the best option since few smallholders had access to land adjacent to a surface water source. In its effort to access groundwater iDE was able to find a few well “digging” craftsmen but well drilling as a village level craft was simply unknown in Ethiopia. Hand dug wells with manual pumps demonstrated the value of groundwater irrigation but well digging was time consuming and expensive.

Reflecting on iDE’s experience in the Ganges Basin where every village seemed to have a mistri ready to drill a well for a fee, iDE searched for such craftsmen in Ethiopia but found only a few examples where international NGO’s had sponsored manual drilling for drinking water wells. Their activities had not resulted in spontaneous establishment of well drilling enterprises. At that point it was not clear if the barriers to drilling shallow groundwater wells were technical problems, cost issues or simply lack of successful demonstration to spark a movement.

Much of Ethiopia has volcanic origin soils and limited areas where groundwater is shallow enough for suction lift pumps to work. Determining if low-cost, manual well drilling was technically possible in such an environment and if shallow tube wells could provide enough water for irrigation became the first step of the search for a way for farmers to tap groundwater for irrigation.

**Establishing a manual well drilling program in Ethiopia**

To quickly test low cost well drilling options iDE Ethiopia decided to engage an experienced mistri from South Asia. In early 2009 the iDE program in Nepal identified and recruited Gobardhan Tharu, who operates a successful well drilling business in Rupandehi.
district. Accompanied by iDE Nepal engineer, Deepak Adhikari, Mr. Tharu spend a month drilling 12 test wells in three selected locations in Ethiopia. One location did not have groundwater that was shallow enough to lift for irrigation with a treadle pump but both other locations demonstrated that with careful site selection successful treadle pump wells could be constructed at about half the cost of hand-dug wells and less than one-twentieth the cost of machine drilling.

Based on these results, iDE Ethiopia moved ahead with a pilot manual well drilling program in Ethiopia with three primary objectives:

1. To improve effectiveness and reduce the cost of manual well drilling by testing various techniques to find which work best in the range of geological conditions found in Ethiopia.
2. To identify and map areas feasible for manual drilling by test drilling in areas with shallow groundwater to confirm that some lens of the saturated unconsolidated soil profile contained a highly permeable sand/gravel layer providing sufficient flow of water into the well. Also to confirm that manual drilling tools could penetrate hard soil layers of the area with limited risk of being impeded by stone.
3. To create an industry of private well drillers by providing apprenticeship training to interested community member for constructing wells; to provide relevant hydro-geological training for advanced drillers and to encourage, train and assist those interested to establishing their own private well drilling business.

iDE Ethiopia secured financial support from the United States Agency for International Development (USAID) and the AgWater Solutions Project, funded by the Bill & Melinda Gates Foundation to run the well driller training program for 27 months. By the end of 2011 this program had trained 81 well drillers of which 15 were certified as master craftsmen having led a team in drilling at least 50 successful wells. In less than 3 years the program had drilled over 450 wells with 365 being successful, a success rate of just over 80%. Depending upon the depth of the well and type of pump installed farmers had paid between $75 and $130 for drilling, well construction and pump installation.

As the program in Ethiopia progressed, it became clear that providing training for technical drilling skills proceeded quickly and successfully. It identified many scatter locations where manual drilling can be highly successful, though finding them resulted in numerous failed wells. However, convincing drillers to establish their own enterprise was more difficult. Only a few have accepted that challenge and established drilling enterprises. Others are content to have government and NGO projects manage client arrangements and employ them as drillers either on a contract or employment basis.

Clearly not everyone wants the responsibility of running a business but the few who were qualified and expressed interest had many questions. As the training program began working on guidelines for drilling enterprises in Ethiopia, iDE realized that it did not
fully understand how *mistris* conducted their businesses in Asia. Even with Ethiopia’s very different social, political and economic setting it was decided that a good starting point for guidelines would be to review how village-based *mistris* in Asiamanage their businesses. This resulted in an extensive literature review and ultimately field interviews with *mistris* in Nepal.

**Literature review**

A literature search came up with surprisingly few references about the origin and spread of manual well drilling in South Asia. The groundwater irrigation literature often refers to tube wells being drilled by local *mistris* but only one article was found that discussed their hydrogeological knowledge (Sunderrajan, et al. nd). Nothing was found about how they gained their skills or run their businesses.

Village and household water supply and sanitation programs, funded by donor organizations and implemented by International NGOs have promoted low-cost well drilling in Africa for a number of decades. Research for developing low-cost drilling methods for Africa included the “Private Sector Participation in Low Cost Water Well Drilling” project carried out by Cranfield University (Silsoe, UK). Information in their final report (Carter 2001) and particularly the report by Ball and Danert (1999) about their visit and observation of *mistris* drilling in North West Bengal are among the few documents found that highlight the successful indigenous propagation of the manual drilling craft. However, the research focused primarily on the technology and gives little insight into the socio-economic institutions that have fostered rapid and sustained growth of village-based well drilling *mistris* enterprises.

We also turned to the iDE programs in South Asia to determine if their staff had information they could share with the Ethiopia program. iDE’s rower and treadle pump promotion in the Ganges Basin had exposed it to hundreds of village-based drilling *mistris*. *Mistris* are a wide spread resource of knowledge and skills that iDE could easily tap for pump promotion, installation and follow up servicing. However, discussion with iDE staff in Bangladesh, India and Nepal revealed that their interaction with *mistris* was largely to provide training for installing a new type of pump and to encourage them to promote pump-based irrigation. iDE staff had little information about the origin and spread of village *mistris* well drilling or information about the business models that sustain the craft. iDE South Asia staff did provide many contacts and facilitated meeting a large number of *mistris* as reported below.

**Interviews with well drillers in Nepal**

In 2012 the authors of this paper organized an eighteen-day journey through the terai districts of Nepal to interview well drillers who were managing their own enterprises.
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iDE’s program had already worked with many *mistris* like Gobardhan Tharu, so it was easy to establish contacts based on prior relationships. Hardware shops in small towns were a second source for identifying *mistris*. Hardware shops with pumps for sale all keep a list of local well driller names to give to their clients and were able to provide contact phone number.

A long list of questions was prepared to guide interviews. Questions were grouped under broad information categories and used to guide the conversation, not as a survey form to be filled out. Many conversations were recorded and later transcribed. The broad interview topics included:

1) **driller enterprise history**: how did the driller learn the trade, was there any formal driller training, where/how did the *mistri’s* guru learn the trade, how wide an area does the *mistri* serve and how rapidly did business grow?

2) **business development**: who are their customers, how do the customers find the driller, is there competition among driller groups, how do they determine the rate to charge clients, do they provide quotations or is there bidding, how many wells do others associated with or trained by the *mistri* drill each year?

3) **equipment, supplies and staff**: accessibility and cost of equipment, how do they engage helpers, how are helpers trained?

4) **local knowledge**: where is it easy or difficult to drill, are different tools or techniques required in different locations, can the *mistri* estimate how deep they will need to drill in particular locations, do all drillers they know use the same type of drilling tools and techniques, do other (all?) *mistris* follow the same business approach?

5) **driller business practice**: do they prepare a written agreement for their clients, is the price inclusive of materials and installation, do they require advance payment, how much do they charge if the well does not deliver water and if no charge how do they recover the cost of the failed well, does the *mistri* or the client hire and pay the helpers, do they charge extra if equipment is lost or broken, how much are helpers paid?

The *mistri* interviews took place in April during the height of the drilling season. Some of the meetings took place at the hardware shops that identified the *mistri(s)* for us, and several interviews included competing enterprises. Many of the interviews were carried out at a drilling site. Figure 1 gives an overview of interview locations. In total we met with 31 *mistri* enterprises. In most cases multiple helpers, often highly experienced drillers, working with a *mistri* joined in the interview so that the total number of drillers that participated in interviews was about 50. Table 1 shows the districts where interviews took place and presents the number and type of wells their enterprise drilled in the past year.

Overall the *mistris* interviewed were very proud to have an opportunity to share their stories. Almost all were from humble backgrounds. Some have clearly prospered but a few
were struggling to earn a living by drilling. Our short time with each individual or group could only capture a bit of the incredible depth of experience and knowledge they have collectively generated.

The origins of manual drilling in Nepal

One interviewee reported that a mistri who came to the Siraha district area in the early 1950s had trained many drillers in their region. Another reported that a mistri who came from what is now Bangladesh in the 1940s settled in the town of Rampur in Bara district where he trained many mistris. The nearby town of Kalaya became famous because a larger number of mistris that he trained live there.

Sixty-one year old mistri, Rajendra Rai, of Biratnagar related that his grandfather learned the drilling craft from his maternal uncle some time in the 1930s, during the period of rule by Judda Samser Rana. Rajendra learned the trade from his father so he is a third generation mistri. Many of the mistris who are now in their 50s and 60s learned the drilling craft from their father or a guru who was brought to Nepal by a sugar mill or other industry requiring a reliable water well. Seeing a business opportunity these mistris from India stayed on to drill privately. Helpers they employed launched out on their own, after gaining experience.

Table 1. Interview location and mistri estimate of total number of wells drilled in the year 2011/2012

Figure 1: Estimated number of wells drilled in 2011/12 in the Nepal terai
Devi Ram Sharma of Kapilvastu, 65 years old and retired, described running away from his home in Pythan district when he was in class 8 and making his way to Assam, India to live with his uncle. While working at an oil refinery he was assigned to help a Bengali mistri and learned the sludge drilling “wash tarika” drilling method. After some six years he returned to Nepal and with his savings bought land near Tawlihawa. His parents joined him there and started to build a homestead. Since the family needed water he drilled a well. Neighbors saw his successful well and requested he drill for them. As a result he established a drilling business in 1970. His son now continues the business and manages as many as eight teams of drillers. In his 40 plus years of drilling in Kapilvastu district, Mr. Sharma estimated their enterprise group has drilled more than 10,000 wells. Earlier most were for hand pumps used for household, animal and garden needs. In recent years an important part of their business has been 3” and 4” diameter tube wells with engine or electric pumps for irrigation.

Thage Tharu, Gobardhan Tharu’s father, was traveling to Gorakhpur, India, by train in the early 1960s when he saw drilling in progress in a field that caught his attention. He got off the train and walked back to see what they were doing and stayed at the site for several days watching until the well was complete. When he returned to his home near Bhairahawa in Ruphanda District he purchased pipe and tried to drill his own well. His first attempt failed but a second try was successful and soon neighbors asked him to drill wells for them. Gobardhan assisted his father and soon was given his own set of equipment and father and son drilled with two crews.

**Manual well drilling demand**

Manual well drilling was possibly first initiated in Nepal by industries like sugar mills to provide reliable processing water. Those were larger diameter wells powered by engine or electric motors. The method for making such wells was already used widely in India and Bangladesh for industrial wells and also for small diameter domestic water wells fitted with hand pumps. Manual drilling for irrigation started very slowly and became an important part of mistris’ businesses in India in the late 1950s.

As settlement in the terai increased so did the demand for household hand pumps. With electrification in the terai many households have installed electric pumps on their wells to lift water to a storage tank on the roof of their house to provide continuous access to water. These household wells do not require large quantities of water so often tap a shallow aquifer, making drilling a well relatively easy. One mistri reported that in favorable soil conditions a three-person team could drill a 40-foot deep hole, install a 1.5-inch casing and hand pump in as little as two hours. However, in more difficult conditions (hard soil, stones) it might take two days. An engine pump irrigation well with a 3-inch casing drilled to 60 or 70 foot depth generally requires a 4-person team 3 to 5 days. For a well with a 4-inch casing 6 days or more.
Most mistri’s had similar stories. Almost all had started as helpers, many working first with a family member or relative. Most indicated that the person who taught them had either worked with a drilling mistri in India or that the Indian mistri had come to Nepal for a specific assignment and stayed for some years hiring Nepali helpers. All mistri interviewed had learned on the job by trial and error, benefiting from the experience of their teacher. Most worked as helpers for a number of years and then were put in charge of a drilling team by their parent, older relative or employer. When they gained confidence and had an opportunity, they started taking their own jobs and became either a partner with their relative or former employer or became a completely independent enterprise. Only one interviewee indicated that he had started his own company with less than a year of work as a helper.

The earliest organized training for mistri that was reported took place in 1988/89 as part of the Agriculture Development Bank of Nepal’s Community Groundwater Project. The training course was taught four times in four different terai districts. Each training had a 45-day program. In the first 3 days they covered general principles that included everything from lithology to filter screen design. The remainder of the time was practical application in the field. The practical training was carried out by experienced mistri from both India and Nepal. About 30 mistri attended each of the 4 trainings. All of the trainees were experienced drillers but the training provided them opportunity to see and experience drilling methods used for specific hydrogeological conditions. The four most common drilling methods used in Nepal were demonstrated: sludge (locally called dhikuli and wash tarika); bailer (locally called bogi); hammer (locally called thokuwa) and manual rotary. See appendix 1 for a description of each method.

Since the 1990s the Ground Water Resource Development Board regional offices have contracted most of their shallow tube well construction work to mistri. As part of their program various types of driller training have been provided to mistri. CARE and other NGOs have also provided training and support for purchasing equipment. One mistri was able to purchase the “Cutter” (manual rotary) equipment used as part of his training and has developed his business around the unique ability this equipment has to penetrate gravel layers more easily than any of the other manual drilling methods.

The training programs were perhaps the first public or official recognition in Nepal of the valuable contribution mistri make to groundwater development. They encouraged mistri to embrace their work with pride as professionals. Of the 50 mistri we interviewed 5 had attended one of the courses. The three things mentioned about the training that were of most value to them were: meeting and sharing their experience with other mistri and the trainers; seeing first hand drilling methods they had heard about but did not fully understand, especially in which geological conditions they are most applicable; and for the
first time ever receiving and owning a drilling manual written specifically for the conditions they face in the terai using local terms they were familiar with. Though the manual is written in English and none of the mistri’s we interviewed read English proficiently, all mentioned that they consider the manual to be of great value.

**Mistri business practices**

The current most popular advertising that mistris do is providing their mobile number to hardware stores. The mistirs and hardware stores have a mutual business interest. Pump customers need information to find a reliable well driller and the mistri wants drilling business. The hardware store also wants the mistri to send their client to purchase well construction materials at their store. The hardware store also caters to the mistri’s need for pipe wrenches and other tools. In a number of cases mistris had arrangements with a shopkeeper to store their drilling tools in the shops warehouse. When a client purchases a pump the shopkeeper can check to see which mistri’s drilling equipment is in the warehouse and suggest a name to the client based on immediate availability. This arrangement also makes it easy for the client to transport the drilling equipment directly to his site since the mistri and helpers generally travel by bicycle.

Word of mouth and referrals by a satisfied customer are very important to the mistri. Successful well drillers become widely known and clients looking for a mistri actively solicit information from friends and neighbors about qualifications and reliability of mistri's they could engage.

The way a mistri runs his drilling enterprise depends primarily on the level of business they are doing. When demand is limited due to few wells being requested or extensive competition, the enterprise tends to be small, often a father and son doing the actual drilling and asking the client to provide unskilled labor to assist as the well becomes deeper. Drilling prices in most areas are considered by the mistris to be very competitive especially for 3” and 4”wells. One interviewee explained that when competition becomes too high someone ends up decreasing their price to gain business. However, undercutting prices is also risky since they must then find a means to reduce their cost to make a profit and the interviewee said he knows mistris who have gone out of business because they could not maintain high quality with reduced prices.

Where drilling demand is high the mistri/owner hires a lead mistri and experienced helpers to do the drilling. A number of mistris interviewed were managing two or three such teams, with one claiming he had as high as eight teams drilling at one time. In all cases the mistri/owner takes care of all price-related negotiations with clients: rate or lump sum payment; arrangements for hiring helpers and paying for their food as well as lodging if they need to live at the site; and collecting payment. The mistri/owner visits the drilling sites regularly to monitor progress and coordinate activities. When problems are faced the
lead *mistri* calls the *mistri* /owner to make critical decisions, especially decisions that impact profit such as abandoning a hole where they have hit a stone or situations where they reach the expected well depth without finding a suitable gravel/sand layer for the well filter.

At one drilling site a client looking for someone to drill her well approached the *mistri* and asked if he could drill her well. What would be the cost of the well including pump, was her first question? The *mistri* responded with two questions. Where is your house located and how deep are wells nearby your house? The *mistri* told her that he had drilled some wells in her neighborhood and that from his experience there is a shallow aquifer at perhaps 30-35 ft depth. It does not cost much to drill and install a pump in that aquifer but it tends to have low yield. A very reliable aquifer can be reached by drilling to about 80 or 90 ft. He asked her to go and ask her neighbors about their wells. Both how deep the wells are and do they have sufficient water all year. He advised her to operate the neighbors’ hand pumps and decide if their discharge is satisfactory. If the shallow aquifer is acceptable then he will quote a lump sum price and he would guarantee that the flow is the same as her neighbors are getting. If the well did not work for any reason like hitting a stone or not finding a gravel/sand layer, he would shift to a slightly different location and drill again at no extra cost. But if the shallow aquifer is not acceptable as witnessed at her neighbors, he could drill deeper but would charge per foot of depth drilled plus materials because it was less certain how deep the second aquifer is in that neighborhood.

Most *mistris* said that when they started their own business they always tried to negotiate a per-foot drilled rate for payment to avoid risk. Clients much preferred a lump sum rate for wells so that they would know the well cost before starting drilling and feel less likely to be cheated. In new drilling areas where the client had no examples from neighbors of how much they had paid they felt the *mistri* might drill deeper than necessary to increase his profit. In areas where the *mistri* has drilled many wells or can get information from other *mistris* they are willing to quote lump sum prices and guarantee satisfaction. Experienced *mistris* recognized they can slightly inflate their lump sum estimate, even including the known failure rate of the area in their calculations so that their income becomes slightly higher than from a per-foot drilling rate though there is more risk of losing income if their information is not correct.

In dealing with households and farmers, none of the *mistris* prepare a written agreement. None reported having had disputes over payment. However, government and NGO projects always required written agreements. Written agreements put non-literate *mistris* at a disadvantage and prompt them to bring a son or relative who was literate into the enterprise to manage agreements.

Advance payment usually depends upon arrangement of paying helpers. One *mistri* in an area where there are many experienced helpers prefers to have the client hire helpers directly and arrange for their food and lodging as necessary. This gives the client opportunity to negotiate a better rate and puts the burden of monitoring the helpers’ diligence on the client.
If the client also agrees to purchase the pump and casing, provide a continuous supply of water at the drilling site along with sufficient cow dung for the drilling fluid, etc., then the mistri/owner has only his personal time and perhaps the lead mistri’s expenses to cover and generally doesn’t request an advance payment. If the well fails the agreement usually is to retry up to two times in slightly different locations. If it is still not successful then the site is abandoned and the mistri/owner in most cases receives no payment for work completed. In locations where there are more frequent failures due to stone in the profile this is discussed prior to drilling and agreement reached on how much the client will pay for a failed hole and how many alternative sites will be drilled before abandoning the site.

If the mistri/owner hires the helpers, particularly in areas where there are frequent failures due to stone or well depth, there is generally agreement to pay some percentage, often 25-50%, of the negotiated drilling rate. The alternative arrangement in high-risk areas is to simply agree to a higher per-foot drilled rate to be paid only if it is successful. Then the owner/mistri takes all the risk that is calculated on past experience in the area. In determining the higher rate the mistri/owner considers the likelihood of additional drilling in the area as a way to recover costs from failed wells.

Well construction after the hole is drilled includes: washing out the drilling fluid, preparing the filter, installing the filter and casing, installing the gravel pack, installing the pump and then pumping the well until the water is clean. When the pump delivers clean water at an acceptable flow rate the well is considered complete and payment made. While government and NGO negotiated rates may require flow measurement as the determinant of a successful well, wells for households and even farmer-paid irrigation wells seldom if ever include a measured delivery rate condition for payment.

Well construction is usually included in the drilling lump sum or per foot drilled negotiated price if manually operated pumps are installed. However, if an electrical connection or concrete foundation is required the pump installation may negotiate those as a separate activity.

CONCLUSIONS

The most important factor driving the rapid development and spread of manual drilling mistri enterprises in South Asia is the relative ease with which manual drilling can tap shallow groundwater. The relatively low cost of a mistri’s tools and equipment and drilling labor makes the cost of waterwells affordable to many millions of households. As a mistri gains experience he also gains confidence that periodic failures can be managed, thus ensuring a profitable business.

A mistri requires helpers to power the drilling so in one way the very process of drilling develops the helper’s skill and provides a pathway to becoming a mistri. If drilling demand
is high and helpers have near continuous employment; they can gain the skill and experience necessary to launch their own business within a year or two. Where drilling demand is low there is often a time lag of a few days or weeks between completion of one well and starting the next. Since most helpers are paid as day laborers they lose interest when there are idle days and look for more steady employment.

Local hardware stores that are well stocked with pumps and well construction materials are very important for successfully accessing groundwater in several ways. The well owner can wait to purchase casing and other well construction materials until drilling the hole is nearly complete and the mistri confirms that drilling has penetrated a sand/gravel layer ensuring water flow will be adequate for a successful well. Then with an accurate measurement of the depth the client can purchase the exact amount of casing required along with filter material, pump and fittings. If materials in stock at the hardware store the owner can purchase and transport it while the mistri cleans the well in preparation for installing the casing.

There is considerable risk that the hole will cave and need to be re-drilled if there is a delay between cleaning the well and installing the casing. So reliable delivery is necessary or the mistri must halt work while waiting for casing to be purchased. Alternatively, either the mistri or well owner must pre-purchase extra casing to avoid a delay and then have the expense of returning the excess. This seemingly trivial issue was a major bottleneck in the fledgling drilling program in Ethiopia, causing both well failures and inventory costs that a start-up drilling enterprise cannot afford.

The field interviews confirm that the mistri-owned enterprises have been a spontaneous development that received no public funding or oversight. In recent years shallow groundwater development projects have added useful specifications for mistri constructed tube wells. These projects’ public funds have also facilitated useful and much appreciated training for well drilling mistris.

By our conservative estimate there are 800 to 900 mistri-owned well drilling enterprises spread over the Nepal terai. Extrapolated from interviews with 30 enterprises suggests that more than 50,000 domestic water wells and 18,000 irrigation tube wells were constructed in the 2012/13 drilling season. The valuable but unheralded resource of self-trained well drilling mistris has made drinking water both safer and convenient for tens of thousands of households over the past few decades. Groundwater access for irrigation enables one additional growing season each year and stabilizes irrigation deliveries in the other two seasons. Farmers across the terai have responded by paying for irrigation wells that are making a measurable impact on Nepal’s rural economy.

The fieldwork reported here is far from complete. We hope this report will stimulate further study and documentation of the well drilling mistri phenomena that has revolutionized
agriculture in South Asia. What problems and dangers do they face? What additional training would make their enterprises more effective? Is there danger that too many wells will deplete terai groundwater, requiring regulation? What are the limitations in replicating private driller enterprises in other parts of the world, like Ethiopia?

References:


Appendix 1
Manual well drilling Methods commonly used in Nepal

**Sludge drilling method** (locally called dhikuli and “wash *tarika*”)

This is the most widely practiced well drilling method in Nepal, India and Bangladesh and used to drill to depths of 40 to 50 m. A 1.5” galvanized iron pipe with an ordinary pipe socket on the bottom as the cutting tool is lifted and dropped in the drilling hole. The sludge circulates down the annular space between the hole and the pipe. It is pumped up through the pipe by the combined action of the driller holding his hand on top of the pipe while the helper lifts the pipe and then when the helper drops the pipe lifting his hand from the pipe. The action of the pipe dropping cuts the soil at the bottom of the hole and the sludge flow carries the loosened particles up the pipe where they are deposited with the sludge into the circulating pit where they settle and are periodically removed. The sludge continues to recirculate.

One pass with the 1.5” pipe socket results in a 60 mm diameter hole sufficient for a 35 or 50 mm casing for a hand pump or treadle pump. The hole can be enlarged by repeating the sludge drilling process multiple times with increasingly larger “reducing” sockets fitted to the bottom of the drilling pipe. A 1.5” to 4” reducing socket will result in a hole of about 130 mm to 140 mm diameter for fitting a 4” casing.

Sludge is the drilling fluid. It has high density, which together with a hydraulic head higher than the water table result in outward pressure on the hole wall preventing the hole from caving. When a highly permeable sand/gravel stratum is reached, fibrous cow dung is added to the sludge to better seal the hole and prevent rapid loss of the drilling fluid that could allow the wall to cave. After completing the drilling and installing the casing the drilling fluid is removed by pumping.

**Typical sludge drilling equipment list** (cost in 2012 estimated by mistri as Rs 50,000 ($641)
- 1.5” GI pipe: 4 pcs of 20’ each, 1 pcs 5’ and 1 pcs 10’ and about 10 1.5” sockets
- 1.5” to 2”, 1.5” to 3”, 1.5” to 4” reducing sockets
- 3 kg pointed tool for breaking stone
- 2 chain wrenches
- 1 20” pipe wrench
- 2 slide wrenches
- 1 spanner
- 1 pliers
- 1 1.5” pipe die
- rope and/or chain

![Sludge drilling tools and transport](image-url)
• wood pieces
• hammer
• hacksaw
• ½” wood chisel
• ½” wood auger
• cycle wrench
• screw driver

**Bailer drilling method** (locally called *bogi*)

The *bogi* drilling method forces a 150 mm pipe into the ground as a shield. It derives its name from the bailer used to cut and remove material from inside the pipe. Bailers are lifted and dropped repeatedly down the inside of the pipe shield and the cuttings are trapped by a flap valve inside and near the bottom of the bailer. The lifting and dropping is done by 3-4 persons pulling a cable through a pulley at the top of the tripod. A wooden beam is clamped to the pipe and weight added as necessary to push the shield downward.

This method is used in sandy soil conditions and can easily drill to depths of 60 m. When a permeable sand/gravel profile is reached the bailer is removed and a 4” casing with filter holes at the level of the permeable layer is placed inside the shield pipe and the shield pipe is removed.

**Hammer method** (locally called *thokuwa*)

The *thokuwa* method drives the casing and filter screen into the ground until it reaches a suitable permeable sand/gravel layer. 1.5” casing can usually be driven using a heavy hammer but larger casing requires a tripod and pulley cable arrangement to lift a 60 kg to 100 kg weight to...
drop onto the casing. The hammer is guided within a specially made pipe temporarily attached to the top of the casing.

When *bogi* method is used and progress restricted by stone, the *thokuro* casing can be installed inside the *bogi* shield and the well completed by hammering.

**Manual rotary method**

The manual rotary method derives its name from manpower used to turn the 2" drilling pipe to which the drilling bit is attached. A circulating (manual or engine) pump forces the drilling fluid down the drilling pipe from where it flows up the outside of the pipe carrying the cuttings. After reaching the surface the drilling fluid passes through a settling tank to allow the cuttings to drip out. A tripod is mounted over the hole to facilitate raising and lowering the drilling pipe. With this method a 125 – 150 mm diameter hole can be drilled in one pass until a permeable layer is found in the aquifer. Then the drilling pipe is removed to install the filter and casing. This method is easily capable of drilling to depths of 60 m and can penetrate gravel up to 50 mm diameter.
Benefits of Multiple-Use Water Systems (MUS) with Micro Irrigation for the Smallholder Farmers in the Rural Hills of Nepal

RAJ KUMAR G.C* AND LUKE COLAVITO**

INTRODUCTION

Over the last two and a half decades, International Development Enterprises (iDE) has been working in Nepal, focusing on market development and water resource development projects. iDE facilitates public-private partnerships that enable smallholder farmers to increase their income by utilizing efficient technologies such as drip irrigation, sprinklers and water storages and the use of community level Multiple Use Water Systems (MUS). These interventions allow for high-value and off-season crop production, and increase resilience to climate change and seasonal weather variability.

iDE has researched, developed and adapted technologies that are appropriate for the Nepali context. These technologies have been designed for scale-up that is simple, robust and affordable for smallholder farmers. iDE has facilitated the sales of over 250,000 micro irrigation technologies through the private sector’s supply chain networks throughout Nepal.

An uninterrupted drinking water supply for domestic use is the highest priority in rural

* Director, Water Resources and Engineering, iDE Nepal
** Country Director, iDE Nepal.
communities. Water carried from springs is the preferred drinking water source for households. For the past six decades the government of Nepal has been supporting many communities in developing piped water systems from spring sources to provide domestic water supply needs. By design these single-use systems are separate from commercial irrigation systems, which are typically treated as large-scale infrastructure projects. This has created a situation in which water intended for domestic use often gets diverted for commercial agriculture, introducing inefficiency and risking water shortage. iDE Nepal introduced micro-irrigation technologies in the hills to enable farmers to use their limited water supply to grow small plots of vegetables both for home consumption and for sale in local markets. This paper examines iDE Nepal’s experience in developing Multiple Use Systems, the benefits MUS delivers and the lessons learned from its successes in implementing MUS. iDE has consistently proven that these technologies have made possible dramatic reductions in poverty of rural households.

**MULTIPLE USE WATER SYSTEMS (MUS) APPROACH**

Multiple Use Water Systems are piped systems that provide sufficient water for both domestic use and high-value vegetable crops, primarily by using micro irrigation technologies and coordinating with local governance structures to establish community oversight. The vast majority of conventional water systems are single use systems designed to meet either agricultural or domestic needs. Most communities do not have access to both types of single use system, and those that do frequently lack any oversight mechanism. As a result, communities frequently end up using conventional systems in a manner other than intended, typically taking drinking water to serve agricultural needs. This introduces inefficiencies and increases the risk of water shortage. MUS satisfy household demand for domestic and commercial water supply through an integrated system, thereby eliminating redundancies and decreasing costs for these communities. Barbara *et al.* (2011) reported that MUS offer three main advantages compared to single-use water service delivery: 1) larger improvements in income, 2) greater environmental sustainability, and 3) strengthened integrated water resource management (IWRM).

Prior to the MUS program, farmers using micro irrigation technologies relied on domestic water supply for irrigation. These water systems were designed to provide drinking water for domestic needs only, and were generally not capable of satisfying the operational requirements for both uses. The idea was to come up with a design for a multiple use water system based on the model of gravity flow domestic water systems in the hilly regions of Nepal. These multiple use water systems were well-liked by the communities and collaborating partners, largely because they constitute an innovative solution driven by rigorous needs-based assessments. This success led to MUS being implemented through several of iDE Nepal’s projects. MUS focus on small-scale water resource development that results in multiple benefits and at the same time, provides a sustainable system (GC, 2013).
MUS Design

A typical MUS utilizes protected spring water sources above the village and uses gravity to move water to the village at a lower elevation. Different MUS models exist, depending on the landscape constraints, water demand, and users’ preference. In areas where the landscape is not conducive to using gravity to distribute the water and/or water sources are located below the settlements, a solar MUS technology is more appropriate as it is capable of lifting or pumping water. The standard gravity MUS design includes an above ground modified Thai Jar (MTJ) for domestic supply, which is filled directly from the source. In addition, there is an underground ferro-cement tank for the irrigation supply, which is filled from overflow of the domestic supply. The Modified Thai Jars are made with Ferro cement (a mixture of sand and cement which is applied as a thick plaster) and mesh-wire netting for reinforcement. The Ferro-cement lined tanks are pits dug in the ground with a soil and ferro-cement plaster lining. These designs were developed with emphasis on effectiveness and low cost. Dual distribution systems are utilized with tap stands close to houses, generally about 3-4 houses per tap stand, and low cost micro irrigation taps in the centre of the agricultural plots.

A core concept behind the MUS approach is the prioritization of the domestic water supply. MUS use low cost construction techniques including ferro-cement soil-cement technology. Water sources are usually within 1.5-2 kilometers of the village. Gravity MUS costs about $115 USD per household (about $3,000 USD per installation). The MUS are designed to serve about 15-60 households but can occasionally cover up to 80 households. MUS are generally designed according to the water demand, users’ preferences, budget, and the local needs. MUS provide adequate water in all seasons to meet both domestic and productive needs as specified by the 45 liter/person/day domestic and 400-600 liter/household productive use design criteria. This service level is categorized as a “high-level” MUS (Renwick, 2007 and Van Koppen et al., 2009). When appropriate (such as when water flow is low in the dry season), supply may be supplemented by rainwater harvesting as necessary.
MUS Status

Over the last 15 years, iDE and its partners have researched, developed, and refined the MUS approach in Nepal. iDE has been directly involved in developing 246 MUS installations benefiting over 50,000 people across 30 of Nepal’s 75 Districts. To date most MUS are gravity-fed systems. Gravity MUS are the most simple and economical configurations for contexts where the communities are at a lower elevation than the available water sources. iDE, working with Renewable World, has developed a Solar MUS design using Solar PV and Hydram technology for remote communities located at elevations above the available water sources. The USAID funded Smallholder Irrigation Market Initiative Project (SIMI, 2003-9) greatly expanded the MUS approach developing over 90 MUS and facilitating government recognition of the MUS approach in VDC block grant guidelines. The MUS approach has been recognized by and implemented in projects financed by USAID, UKAID, the European Union, WFP, ADB, the Gates Foundation, and the Government of Nepal (GON), among others. iDE is currently expanding and institutionalizing the MUS approach across several projects funded by USAID, DFID, EU and other donors, and is working in partnership with the International Water Management Institute (IWMI) to institutionalize the MUS approach with the Government of Nepal. MUS are developed as a partnership between the project, community, and local government. The Government of Nepal (including Village Development Committees (VDCs)/District development Committees (DDCs) and line agencies) has provided nearly 50% of the cash costs for MUS development, with communities providing all of the unskilled labor and local materials. As a result of these efforts, other organizations are now beginning to understand and implement the MUS approach in Nepal.

MUS – CLIMATE CHANGE LINKAGES

In Nepal, weather patterns have changed dramatically with less rain in the winter and heavier monsoon rains in the summer across the hills, leading to a consequent increase in floods and landslides, and increasing losses in agricultural production (Krishnamurthy, et. al, 2013). Clement et al. (2015) reported that water sources across communities in the western hills of Nepal are drying up as a result of climate change and other factors such as land use changes and road construction. A number of additional studies including Dhakal et al(2010) have confirmed that the shrinking of water sources is due to increasing climatic variability. Farmers have been complaining of decreasing crop yields for the past several years. Under these climate stresses, iDE has found that MUS strengthen climate change adaptation through facilitation of improved water resource planning and management, more efficient and reliable water access, and improved agricultural productivity and income.

iDE’s experiences have shown that: 1) MUS is an effective vehicle for improved water planning, increased water security and efficiency, and reduced conflicts in managing multiple
water demands, and 2) micro irrigation in combination with MUS provides an opportunity to increase smallholders’ agricultural income by enabling them to produce high-value crops during the off-season.

MUS offer smallholders the opportunity to reduce dependence on rain-fed agriculture and to increase the productive use of available water resources. A recent iDE financial analysis of MUS has shown an average increase of $300 USD in annual income per household. The improved water resources management from implementing MUS will substantially increase income while reducing susceptibility to climate change. As incomes increase, smallholders gain incentives to conserve and protect local water sources/watersheds. Where appropriate, recharge ponds are planned and constructed above the water sources in collaboration with the local community enhancing spring flow.

COMMERCIAL POCKETS FOR MUS BENEFITS

In Nepal, MUS are generally located in weak markets with poor infrastructure, and are remote from major population centers. Under these conditions, iDE has uniquely combined MUS with the “commercial pocket approach” to provide increased marketing opportunities and services for vegetable producers. Through the commercial pocket approach, farmer production groups are organised and over time, these groups are transformed into Marketing and Planning Committees (MPC). MPCs provide technical guidance to farmers through collection center facilities. The services provided include the sale of agricultural inputs, access to credit opportunities, provision of technical assistance, crop planning for market windows, and representation of farmers to government and development programs. The collection centers are developed to aggregate vegetables produced by farmers in the area. The MPCs manage collection centers in a variety of ways, including developing cooperatives or selecting traders to act as agents for the producers.

This market development approach is designed to support smallholders’ involvement in commercial production through the marketing process. Services from the MPC result in increased farm productivity for farmers. MUS are the key input system enabling increased productivity for these farmers. The introduction of MUS using micro irrigation technologies enables households to begin production of high-value vegetables at volumes necessary to establish local collection centers and a sufficient market for the establishment of local input and service providers. This ultimately allows farmers to increase their income and food security. The increased income will provide households incentives to maintain the MUS system. Therefore, MUS are the key interventions necessary to facilitate high-value commercial vegetable production and improved livelihoods in the commercial pocket areas.

MUS BENEFITS AND IMPACTS

Commercial MUS users focus on cultivation of vegetables and other high-value crops. Prior
to adopting the MUS approach they typically utilize rain-fed land that has very marginal crop yields and primarily grow low-value cereal crops. Most households were previously involved in cultivating small quantities of rain-fed vegetables for home consumption but were not producing for markets. iDE focuses on training and market linkages for off-season vegetables which command much higher prices.

A 2007 survey showed MUS enabled a 76% increase in girls attending school; 94% reduction in health costs; and 62% increase in latrine construction. The use of MUS has led to an increase in water use by about 50% for household use and 95% for irrigation (GC, 2011). An important indirect benefit is the development of skills associated with the design, construction, maintenance and use of improved agriculture techniques (GC, 2011). The time and labour savings also have significant benefits on women and girls’ health due to not having to carry heavy loads. Because MUS makes it possible to grow nourishing vegetables in larger quantities year round, the nutritional status of women and their families has improved.

Women are a prime focus group for MUS related project activities. Wherever MUS are installed, the roles of women begin to change and their decision-making both inside and outside the home increases. Women are involved in key leadership positions on the MUS user committees and are empowered to link with other agencies. The additional income they earn from vegetables sales provides them with financial independence and increases financial decision-making (Colavito et. al, 2012). Prior to participating in iDE Nepal projects, women are typically involved in agriculture by providing labor but have little input in the marketing, commercialization, and financial decisions. MUS also reduce women’s workload by decreasing the time needed to collect water, a task typically assigned to women (Clement et. al, 2015, Luke et. al, 2012). The time saved is used in productive activities such as vegetable growing and marketing, and livestock production. Gender equality in decision making also improved markedly (de Boer, 2007). de Boer (2007) and G.C (2011) also found in their research that household vegetable consumption is increased and provides better nutrition for women and children, saving on potential medical expenses. Increased incomes generated through MUS have a positive correlation with women’s decision-making, increasing joint household decision-making. This shift has been most evident for decisions involving crop selection, sales of crops and use of income (Clement et.al., 2014 and G.C., 2011). Experience has shown that as men migrate for wage labour, women are responsible for food production and marketing. Different studies have shown that families and communities are more open to involving women in new opportunities when there are concrete economic benefits. Increased knowledge of sanitation issues was another benefit as was a major increase in vegetable consumption over all seasons (de Boer, 2007). Similar findings are reported elsewhere (Mikhail and Yoder, 2008, Eco-Tech Consult, 2004 and Pant et.al, 2005).

The International Water Management Institute (IWMI) recently finalized a study of iDE-developed MUS that have been in place for 7-10 years to assess the sustainability of these
Small Scale Irrigation Systems: Challenges to Sustainable Livelihood

These MUS were installed under the Smallholder Irrigation Marketing Initiative (SIMI) project. The three major findings of the study are: 1) A large majority of systems are still delivering water for multiple uses and have active formal institutions. 87.5 % MUS are fully functional after 7-10 years. 2) MUS returns are very high, with a benefit-cost ratio of 11 to 1 in terms of return on investment through increased agricultural income. The average payback period is less than 1 year (8.5 months average). This analysis does not monetize the many other benefits of MUS including improved health and nutrition, and time saved from reduced water collection labour, and water availability for other enterprises such as livestock. 3) The economic returns generated by MUS contribute to protect the source and maintain the system. 4) MUS enhances the social and gender equity in communities, and there is strong equity in the management of MUS. Water users found the allocation of water equitable and fair in most of the MUS. The majority of MUS still have an active and inclusive water user committee who collects fees for maintenance and provides for a paid caretaker.

SUSTAINABILITY AND COMMUNITY OWNERSHIP

A research on the functionality status of water supply and sanitation in Nepal found that while the coverage for piped drinking water supply was high at 80%, only about 18% of the systems were functioning well (DWSS, 2011, in Rautanen et. al., 2014). Poor maintenance of existing water supply systems is one of the major causes of inadequate and unsafe drinking water (NEWAH, 2011 and G.C., 2011). Community ownership for maintenance and repair ensures the sustainability of the MUS while avoiding the pitfall of broken or unused technology due to lack of community engagement and responsibility (G.C. and Rautanen., 2012). Therefore, these piped drinking water supply systems have limitations to serve water users with quantity, quality and accessibility and continuity. When adopting a MUS approach, each community forms a MUS management committee that is responsible for management, repair, and maintenance. The communities elect a MUS user committee to be trained by the project to oversee construction and manage the MUS. Local masons and plumbers are identified and trained to build the system and for the repair and maintenance of the system. User committees prepare and adopt a constitution for management of the MUS, which includes provision of monthly fees sufficient to cover repairs and maintenance. System costs also include a paid manager to provide management and ensure repairs are completed as necessary. MUS users pay these fees out of their increased income.

MUS SCALE UP AND INSTITUTIONALIZATION

Despite all the benefits MUS is offering, it has not been scaled up widely in Nepal. There are strong institutional silos in government and major donors separating investments for drinking water and irrigation activities, resulting in higher costs and inefficient use of water. Lack of resources for mobilization of communities and agriculture value-chains presents yet another challenge for MUS scale up. To overcome it will take a sustained long-term
effort of rigorous analysis and policy advocacy, and stakeholder mobilization to advocate for multiple uses.

The proposed MUS scaling pathway for Nepal is further documentation, consolidation and advocacy of the ongoing domestic and community-based MUS innovations (Van Coppen et al., 2011). iDE will be developing over 400 MUS in the next four years, and working with IWMI and other stakeholders to institutionalize the approach. These efforts will seek to: 1) transfer skills to local government (DDCs and VDCs) for the technical feasibility and designs of MUS; 2) generate evidence that communities are capable of investing in MUS development themselves; 3) develop a model for the poorest communities with solutions that they can invest in, using affordable loan financing; 4) develop a model for integration of technical and financial services, and capacity building around collection centres and 5) mobilize stakeholders to advocate for the MUS approach at the national level, creating a learning alliance and series of MUS workshops.

CONCLUSION

The high sustainability and relatively rapid payback periods of MUS indicate the potential for these systems to self-finance and ultimately self-replicate if the MUS approach is institutionalized within the government. There are strong synergies between MUS and the commercial pocket approach; the commercial pockets provide access to markets and inputs which further increase MUS returns. MUS enable a volume of production (especially off-season production during dry months) that make rural collection centres sustainable. The MUS approach is an integrated package of interventions involving governance, low cost technologies, and strong linkages to markets that enhance the technical, financial, and institutional sustainability of rural water systems. Therefore, iDE Nepal’s MUS program has represented a practical and sustainable model for extending access to water services to poor rural communities. There is a growing national consensus that rural water supply systems should be designed for multiple uses. There is an important need in Nepal to expand the MUS approach, building local capacity, utilizing public private partnerships, and establishing policies for MUS scale-up.

REFERENCES


Department of Water Supply and Sewerage (DWSS, 2011). Nationwide coverage and


Pond Irrigation System from the Riverbed\textsuperscript{1} of Chekukhola and Tamaghatkhola for Vegetable Cultivation in Pachakhal, Kavre Palanchowk District\textsuperscript{2}

PRACHANDA PRADHAN\textsuperscript{*}

LOCATION:

The system of irrigating vegetable from riverbed pond is located along Cheku Khola and Tamaghat stream down from the bridge over highway at Panchkhala along Arniko Highway. Panchakhal is 50 km east of Kathmandu and about 20 km from Dhulikhel of Kavre. This place is famous for vegetable cultivation like cabbage, cauliflower and potatoes.

Certain section in this area has gravity irrigation. Where gravity irrigation does not exist, riverbed pond system is adopted for vegetable cultivation for last four years. As a matter of fact, flow of surface water in the river diminished recently. During dry season around the month of December to May-June, the river has lots of under-surface water flow. The farmer’s local knowledge helped them to utilize sub-surface river water for vegetable cultivation by

\textsuperscript{1} There are quite a few reports on pond irrigation or from river drawing water for irrigation. However, there are not much information and study on riverbed pond irrigation. This paper is only preliminary study on riverbed pond irrigation requiring more technical, economic, social and gender aspect analysis.

\textsuperscript{2} This paper presents only preliminary findings of the riverbed pond irrigation system for vegetable cultivation. This is an example of farmer’s innovativeness of better utilization of scarce water resources. Without riverbed pond irrigation, no crop can be cultivated in this area during winter. I acknowledge the assistance provided by Puskar Dhakal, Chairman of TersoKulo of Panchakhal, Kavre.

\textsuperscript{*} Patron, Farmer Managed Irrigation Systems Promotion Trust, Kathmandu
digging ponds in the riverbed. The farmers bring on the hourly basis rented excavator to excavate the pond in the riverbed.

Example of Pond at the Riverbed  
Extraction of Water from Pond

One would observe as reported by the local farmers that over 200 ponds were dug in the river bed in this area to collect seepage water over night to irrigate vegetable farms each year. During dry period, it takes 3 nights to fill water in the pond. Water is drawn from the kerosene pumps connected with plastic foldable two and half inches pipes. The flexibility of the plastic pipe helped the farmers to take water wherever the farmers want to cultivate the vegetable.

Pond Water Conveyed to the Farm

There are examples of ponds dug with the help of excavator. The cost is born either individually or collectively by two or three farmers willing to grow potato and other cash crops. Pond excavation is done around last week of December. The farms are located about 3-4 meters above the riverbed. With the help of 2 and half inch flexible and foldable plastic pipes, water is conveyed to the farm where irrigation is to take place. This technology has helped overcome the problem of right of way and undulated terrain.
Farmer Estimating the Need of Irrigation

Methods of irrigation

Irrigated Agriculture Land

Long Distance Conveying Water through Plastic Pipe
General Description of innovative riverbed pond irrigation

It is interesting to learn the way the farmers identify this method of irrigation. The river used to have knee deep water even during winter sometimes ago. Because of climate change and diversion of water upstream for irrigation, the river now dries up around December. About 4 years ago, a farmer tried riverbed pond irrigation for vegetable cultivation.

The local farmers took initiative to dig pond to trap sub-surface water from riverbed. Now, ponds are either individually or collectively owned for potato and cauliflower cultivation from riverbed pond water. This water is used for cash crop growing.

Components of Irrigation

The riverbed pond irrigation consists of
1. Pond Excavation,
2. Hiring of excavator,
3. Identification of the location of pond

Process of Riverbed Pond excavation

The farmers make decision whether they want to cultivate vegetable or not. Once they decide to cultivate vegetable like potato or cauliflower, the farmers make decision for pond digging at riverbed around December when water dries up in the river.

Excavator specially of JVC company is hired to dig pond. The size of the pond is about 30 x 30 feet, The excavator takes about 3 to 4 hours to dig the pond. The excavator rent cost is Nrs. 2,200 to 2,500/hour. The total cost for pond digging comes between Nrs. 8,000-10,000. If there is no flood in river, the pond will last for 6 months from the beginning of December.
The pond would be located in the riverbed close to the farmer’s field. The individual farmers or group of farmers who have dug the pond decide who will get water from the pond and who will not. In order to convey water from the pond to the farm, two and half inch pumps are necessary. The cost for such pump is Nrs. 12,000. They are usually China-made pumps. Such pumps are now available on rent. So it is not necessary that the pond digger should also own pump. The other accessory for irrigation is plastic foldable flexible pipes which are easily available in the local market.

**Equipment Cost**

The rent charge for pump is Nrs. 200/ hour plus the cost of kerosine or diesel. The fuel consumption is one liter/ hour costing about Nrs.100. It irrigates ¾ of a ropani (3900 sq. feet) per hour. The pump is connected by light flexible plastic pipes. The pump owner makes the plastic pipes available to convey water. With the introduction of riverbed pond system, water market has developed. Pond owner can sell water to irrigators. The water price is fixed at Nrs. 100/hour. Because of high demand of water for vegetable and availability of good market vegetables, water market and pump renting market came into existence.

**Cost for riverbed irrigation management**

It is pump driven water for irrigation. In the higher elevation, two stage pumps are used specially in the terrace fields. Topography is not considered hindering factor. It can irrigate farms even at higher elevations. This system does not present the problem of right of way. Renting arrangement for equipment is available in the local market.

**Estimated cost for irrigation**

Cost of one time irrigation of 1/20 ha.

- Pump rent: Nrs.200/ hour
- Fuel cost: Nrs.100/hour
- Water cost: Nrs.100/hour
- One hour can irrigate 3900 square feet (¾ ropani). The cost of one time irrigation is Nrs11000/ha
- Cauliflower needs 7 irrigation and potato needs 3-5 irrigations.

**Production cost and profit**

- The price of vegetables varies depending on the market price.
- It is estimated that 1/20 ha of land can grow up to 1000 kg of cauliflower. If it can be sold at 40/kg, the total income would be about Nrs. 40,000 (Nrs. 8,00,000/ ha)

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3 the exchange rate in USD 1= Nrs.100 in February 2015
and production cost including labor, seed, fertilizer and transportation will cost Nrs. 18,000/1/20ha.
(Nrs.3,60,000/ha)
• The net profit from Cauliflower pe 1/20 ha of land is Nrs. 22,000
(Nrs. 4,40,000/ha). Hence, compared to other crops, the return on investment in vegetable cultivation is quite high and quite attractive to the farmers.
• The farmers said that they grow three crops a year. The income from agriculture in Panchakhal is at the higher side.
• For potato cultivation, they need 3–5 irrigations (cost for one time irrigation for ¾ of ropani is given above. Irrigation depends on the type of soil and type of seed.
• In an average, the yield of potato per 1/20 is around 1500 kg (30 ton/ha). The market price varies ranging from 20–40 rupees/kg. The total income depending on the market price is Nrs. 6,00,000–1,200,000/ha. (It shows that they grow up to 30 ton/ha) According to the farmer of the area, out of the total production, the production cost is 40%. Sixty percent becomes profit so potato has been popular and profitable crop in the area. Hence, farmers are willing to invest on water and irrigation equipment.

Other social and economic factors

• Water marketing: water market has come to existence. The other complementary services like renting services of irrigation equipment and accessories are also available in the local market.
• Land ownership pattern. 70% farms are cultivated by owner-cultivators. 30% farms are cultivated on rent. Yearly rent of land per 1/20 ha is Nrs.8,000–12,000 (Nrs. 1,60,000–2,40,000/ha.)
• Market: The area has all season moterable road. The first market is Panchkhel itself (Tamaghatbazar). If price is not favourable, farmers go to Dhulikhel/ Banepa. Finally, they will go to Kalimati Vegetable Market at Kathmandu.

Conclusion

Farmers have adopted innovative measures to secure irrigation water from riverbed ponds for vegetable cultivation. With the popularity of riverbed pond irrigation, other supporting services like water market, renting facilities of excavators, pumps and pipes became available. The vegetable cultivation became profitable because of round the year moterable road and bigger market accessibility for products.
A CASE OF COMMUNITY PARTICIPATION IN IMPLEMENTING WATER LIFTING TECHNOLOGY PROJECT TO FACILITATE AGRICULTURE IN KAVRE DISTRICT OF NEPAL

NIRAJ SHRESTHA*

INTRODUCTION

Due to abundance of natural resources like hydro and existing topography, hydram is deemed to be an appropriate technology for communities in hills of Nepal. Centre for Rural Technology/Nepal (CRT/N) with an intention to diversify agro-practices and improve agriculture value chain, facilitated to install hydram at Nepane, Sanogaun-5, Balthali VDC in Kavrepalanchowk district under the project entitled "Livelihood enhancement through hydraulic ram pump in Kavrepalanchowk district" supported by UNDP (GEF-SGP). Ghatta Owners’ Association, Kavre (GOA) was the local partner organization (LPO) that assisted in bridging the communication gap between local government, community and CRT/N. The beneficiary Tamang community in absence of sufficient water and appropriate technology was reluctantly involved in cultivating low value crops like wheat, millet and mustard seeds. This situation escalated the trend of people abandoning agriculture for other occupations. Many people in the community preferred labor intensive work while few migrated to foreign countries to make living for themselves and their families. In such situations, intervention was necessary to enhance the livelihood of the people of the beneficiary community. CRT/N therefore intervened by introducing water lifting technology that can be integrated with micro-irrigation tools to improve agro-practices and thereby increases the income level of the households that inhabit Nepane, Sanogaun-5. This

* Center for Rural Technology, Nepal, Bhanimandal, Lalitipur, Nepal
case study is prepared with a view of advocating a new form of renewable technology that could prove to be farmer friendly technology for hamlets located in hill region of Nepal.

**METHODOLOGY TO DEVISE CASE STUDY**

The case study is prepared based on the experience and information collected from beneficiaries, frequent site visit, interview, focus group discussion, detailed feasibility report, baseline study report and feedback from CRT/N hydram team. The schematic diagram illustrating the methodology in formulating case study is shown below:

**HYDRAULIC RAM PUMP TECHNOLOGY**

Hydraulic ram pump technology was introduced in Nepal in early seventies. However, the technology has not been able to expand at desired pace. The hydraulic ram pump technology has high potential to reap economic benefits. The technology being promoted by CRT/N is an updated model from the Philippines. This model has won UK based Ashden Award in 2007. Hydram uses larger flow of water falling through a small head, to lift a small fraction of the water to a higher head in order to facilitate communities for micro-irrigation integrated agriculture practices. Hydram operates automatically using only the energy in the falling water itself. Hydram is therefore, inexpensive, robust and simple technology with very low operating cost that is also easy to maintain. The pump can deliver up to a head of around 150 meters for supplying drinking water and 80-90 meters for supplying...
water for irrigation practices. The pumps can operate continuously for 24 hours depending upon the water demand within the beneficiary community. However, the efficiency of the technology is low in a sense that only about 10 percent of water being drawn from the source will facilitate the end users. But, during the installation of the technology, arrangements are made to compensate the loss in energy in the form of water by diverting the water loss from the pump system to the source itself. A well designed and maintained hydram system can operate for more than 20 years.

In rural communities, other than using water for small scale irrigation, hydram can be used to deliver water for drinking and other household usage where the people would traditionally collect and carry water manually from downstream sources. Hydram is well suited to drip feed irrigation technology to maximize the use of the available water. A system can also support other livelihoods, such as cattle rearing, fish ponds and bio-fertilizer production. The system is generally benefiting to community rather than for a single household and thus the cost of the system can be shared by the whole community reducing the financial burden to individual. Since the ram pump requires no fuel input, it has zero greenhouse gas emissions during operation therefore mitigates carbon emission which otherwise would have been emitted from the conventional diesel generators used for pumping water.
PROJECT INCEPTION

Within the project, organization of district development committee (DDC) level initiation workshop was stepping stone for implementation of the project. In the initiation workshop, CRT/N team had presented about the technology, its working principle, its benefits and opportunities. The relevant stakeholders who participated in the workshop, upon being familiar with hydraulic ram pump technology suggested CRT/N team with potential sites for implementing the project. DDC level workshop provided the platform to link up with Village Development Committee (VDC) Secretary Welfare Council and VDC secretaries of Kavrepalanchowk district who assisted CRT/N in bridging the communication gap between potential beneficiary communities and CRT/N. Moreover, the VDC played major role in disseminating information about the hydram technology all over Kavrepalanchowk district. In due course of visiting potential sites as per the guidance of VDC Secretary Welfare Council and VDC secretaries, the representative from Nepane, Sanogaun-5, Balthali made contact with CRT/N technical team. They presented their need of water for irrigation to cultivate vegetables. They requested CRT/N to perform a detailed feasibility study of the potential site. The technical team from CRT/N after feasibility study concluded that Nepane, Sanogaun-5, Balthali is an appropriate and feasible site for implementing the project. So in this circumstance, the hydram project followed a bottom-up approach to implement the project. The need was felt in the community which led community to approach and coordinate with CRT/N in order to install hydraulic ram pump at Nepane, Sanohaun-5, Balthali VDC.

During the initial phase of the project cycle, Memorandum of Understanding (MoU) was signed between three parties; Center for Rural Technology, Nepal, Ghatta Owners’ Association, Kavre (GOA), and water user committee (WUC) from Nepane, Sanogaun-5 Balthali VDC. According to this agreement community was required to form hydram water user committee which has to be registered as per the Water Resource Act 2049 of Nepal. CRT/N facilitated the beneficiary community in activities leading to committee formation. The members of the committee were selected via mutual consensus of the beneficiary community. The executive board of the committee comprised of 9 members among which 5 were females and 4 were males. The responsibility of treasurer was assigned to a female member of the executive board. Involvement of women in the executive committee was commendable as women in the community had expressed their desire to be part of developmental activity in their community.

WORKING MODALITY AND ROLES OF PROJECT PARTNERS

In order to implement the project at Nepane, Sanogaun-5, Balthali VDC, a definite working modality was devised which is shown in Figure 3 and the roles and responsibilities of all the project partners are listed in Table 1.
Figure 3: Schematic diagram illustrating working modality for hydram project

Table 1: Roles and responsibilities of project partners

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<tr>
<th>S.N</th>
<th>Organization/Institution</th>
<th>Roles/Responsibility</th>
</tr>
</thead>
</table>
| 1   | Center for Rural Technology, Nepal (CRT/N)                                               | • To implement the project and coordinate field activities.  
• To provide the technical support for the hydram technology, devise socio-economic and technical assessment instruments, conducted orientation/trainings to develop capacity of beneficiary community.  
• Project monitoring and evaluation; publish information materials and advocacy of the technology. |
| 2   | Rural Energy and Technology Service Center (RESC)                                          | • Manufacturing hydram based on the detailed feasibility study performed by CRT/N.  
• To provide technical support while installing hydram in the project site. |
| 3   | Local Partner Organization, Ghatta Owners’ Association (GOA), Kavre                        | • LPO recruited a field mobilizer who was responsible to assist CRT/N field staff to bridge the communication between CRT/N and beneficiary community.  
• Supported CRT/N in advocating of hydram throughout the project district, facilitated communication between CRT/N and government institution and other line agencies. |
| 4   | Village Development Committee (VDC)                                                      | • VDC being political and development unit of the government at local level was instrumental to effectively implement the project as it provided continuous cooperation and support to accomplish the project objective. |
|   | Water User Committee (WUC) | • To manage the project and allocated project fund at local level.  
• A policy of consumers paying a reasonable and sufficient tariff was maintained by WUC in the community.  
• To collect the monthly tariff and depositing it in a community fund. |
|---|---------------------------|---|
| 6 | Beneficiary Community     | • They participated from the beginning in the project and also contributed to project construction activities in terms of cash, labour and kind contributions and supported the project partners whilst in the area.  
• The community had paid the skilled labour service charge for civil components of hydram system. |

### TECHNICAL FEATURE OF THE PROJECT

<table>
<thead>
<tr>
<th>Project Site:</th>
<th>Nepane, Sanogaun-5, Balthali VDC, Kavrepalanchowk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name of source:</td>
<td>LadkhuKhola</td>
</tr>
<tr>
<td>Source type:</td>
<td>Perennial Stream</td>
</tr>
<tr>
<td>Feed canal discharge:</td>
<td>700 lpm</td>
</tr>
<tr>
<td>Feed canal length:</td>
<td>130 meters</td>
</tr>
<tr>
<td>Drive head:</td>
<td>3 meters</td>
</tr>
<tr>
<td>Drive length:</td>
<td>25 meters</td>
</tr>
<tr>
<td>Delivery head:</td>
<td>43 meters</td>
</tr>
<tr>
<td>Pump size:</td>
<td>4&quot;</td>
</tr>
<tr>
<td>Delivery pipe size:</td>
<td>2&quot;</td>
</tr>
<tr>
<td>Delivery pipe length:</td>
<td>150 meters</td>
</tr>
<tr>
<td>Delivery discharge:</td>
<td>28 liters/minute</td>
</tr>
<tr>
<td>Reservoir tank:</td>
<td>24000 liters</td>
</tr>
<tr>
<td>Beneficiary household number:</td>
<td>25</td>
</tr>
<tr>
<td>Beneficiary population:</td>
<td>150 (M: 64 and F: 86)</td>
</tr>
<tr>
<td>Beneficiary land area:</td>
<td>65 Ropani (3.3 hectares)</td>
</tr>
</tbody>
</table>

### PROJECT COST AND FUND MOBILIZATION

The allotted budget for the project was mobilized through community account. As an innovative approach, in order to mobilize project fund through beneficiary community, CRT/N facilitated in establishing a community account in the bank so that the project fund would be mobilized through WUC rather than CRT/N. The allotted budget was used for installation of hydram as well as arrangements of main pipeline to facilitate micro-irrigation.
The total cost of micro-irrigation integrated hydram system was NPR 9,13,942 of which the share of the community including labor/kind and cash was NPR 2,25,000 and NPR 25,000. UNDP-GEF (SGP) contribution in the project accounts for NPR 6,63,942. The percentage share of cost contribution has been shown in Figure 4.

COMMUNITY MOBILIZATION

WUC was active in mobilizing community and increase community participation throughout the project cycle. Community had played active roles by participating in different stages and activities of the project. The ardent beneficiaries supported CRT/N with grit and guile in order to achieve the objective of the project. Beneficiaries always showed their enthusiasm in participating for community capacity building training. Community had provided contribution in the form of labor and kind as well as in cash. In relation to kind contribution, one member of each beneficiary household was required to contribute labor services for installation of hydram system. Among 35 households, only 25 households offered labor contribution for the project whereas remaining households did not have active, able person for labor contribution. For cash contribution, the beneficiary community had collected NPR 25,000 from entire beneficiary households. This sum of money was collected within the community on the basis of ownership of land. Community collected NPR 385 per ropani (0.05 ha). As per need, community had utilized the fund to pay the wages of skilled manpower that were used to construct civil infrastructure of the project and other internal activities associated with project. Community had also utilized this fund to fulfill the emergency need for cash while accomplishing the project. The WUC also appointed an operator with payment of NPR 1,000 per month and made the operator responsible to look after the operation and maintenance of the system. Soon after the completion of all the activities of the project, the project was handed over to water users committee on November 20, 2071. From this date the water users committee took over the responsibilities of operation and maintenance of hydram system.

The tariff was being collected at regular interval of time so that community can manage salary for the operator and cost for repair and maintenance. The WUC is responsible to collect and
manage the fund collected from tariff. CRT/N team participated in the community meeting regarding determination of tariff rate for water used for irrigation purpose. CRT/N team incorporated the suggestion from the community and devised a tariff collection mechanism for the community. In the project site, the beneficiary household owns the farmland ranging from 0.05-0.15 ha. A tariff rate of NPR 40 per ropani (0.05 ha) was considered to be appropriate rate for using water from hydram. Likewise, the beneficiary households are to pay a minimum charge of NPR 30 per ropani regardless of the using water for irrigation or not. This way, collecting tariff from approximately 3.3 ha would cover the operating cost of the hydram as well as community will be able to make savings from tariff collection which they can utilize within the community by providing soft loan to upgrade agricultural activities for the beneficiaries. Additionally, paying minimum water charge has motivated the beneficiaries to get involved in agro-practices. The beneficiary community believes that collection of tariff will aid in sustainability and prolonged use of hydram technology. Upon interaction with the beneficiaries, it was known that beneficiary households were willing to pay up to NPR 150 per month for using water from hydram in their farmland. Beneficiaries believe that with availability of water for their farmland, they would be able to pay the tariff by selling agro-products in the market. The estimated annual operation and maintenance cost and tariff amount has been shown in Table 2.

Table 2: Estimation of annual operation and maintenance cost of the hydram system

<table>
<thead>
<tr>
<th>Project Area</th>
<th>Annual R&amp;M Cost (NPR)</th>
<th>Annual Operator Salary (NPR)</th>
<th>Total annual O&amp;M cost</th>
<th>Tariff (NPR)</th>
<th>Annual Collection from Tariff (NPR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nepane, Sanogaun-5, Balthali VDC</td>
<td>10,600</td>
<td>12,000</td>
<td>22,600</td>
<td>40/Ropani</td>
<td>31,200</td>
</tr>
</tbody>
</table>

(Source: Shrestha, 2014)

COMMUNITY CAPACITY BUILDING

During the project duration, CRT/N has organized various capacity building trainings which were aimed at developing skill and knowledge to get maximum benefit from hydram project. The beneficiary community was provided with knowledge on bookkeeping for managing the project fund, maintaining the account at local level and buying construction material required for the project. Similarly beneficiaries were trained about new agro-practices (cultivation in plastic tunnel, biofertilizer production) and micro-irrigation practices. Furthermore, the project also shared knowledge on climate change, water resource conservation and management and hygiene.

Figure 7: Field based repair and maintenance training for hydram beneficiaries
and sanitation via capacity building training. The capacity building training was organized on the basis of "Training for Trainer" modality so that the beneficiaries who were part of this training program were made capable to disseminate the knowledge and experience gained in the training to other members of their community. The intellectual members from the community took over the responsibility of disseminating the lesson they learned via capacity building training to other members of the beneficiary community. 33 people representing the beneficiary households were trained on these different skills. CRT/N in order to facilitate capacity building training at community level had provided a booklet including all the modules of capacity building training and provided manpower to assist training at community level. To ensure sustainability of hydram system, 3 people with some level of technical knowledge about machineries were selected from among the community members and provided repair and maintenance training. This training was aimed to provide immediate service of repair in case of breakdown of the hydram system.

**CHALLENGES AND ROLE OF WOMEN IN THE PROJECT**

Accomplishing a community based project itself is a herculean task. In course of the project implementation, the beneficiary community faced several challenges. For the WUC, convincing the beneficiary community regarding credibility of the technology was difficult. As a result, during initial period of the project, the committee had faced difficulty in managing human resources within the beneficiary community as a part of community contribution. In due course of construction phase of the project, sudden strike from crusher industries in the country had significantly affected the progress of project. Due to lack of sand and stone, the project was lagging behind the planned schedule. In such circumstances, community managed to arrange stone from within the community. Beneficiary community members especially women put extra effort in finding big boulder and chipping them down to small aggregates which were essential for construction activities. The population composition of the beneficiary community shows the tilting towards female population as the female population is composed of 57% as against that of 43% of male population. The male members of community had either migrated to middle-east or Kathmandu in search of job, therefore women took over the responsibility of community contribution. Unsurprisingly, the female members contribution to the project accounted for 74% compared to 26% that of male members in the community. During the period of turmoil within the crusher industries of the country, community had hard time in managing sand which they brought from neighboring district, Sindhuplachowk. For bringing sand in the construction site, community members managed transportation vehicle by themselves which they operated either before dusk or by the end of dawn so that they could avoid any backlash from crusher industries. Such endeavor from the community justifies the fact that "where there is a will, there is a way". Additionally, the community had craved to have easy access to water in order to intensify agriculture activities, therefore community themselves took the responsibility to tackle any hindrances in course of installing hydraulic ram pump.
Table 3 shows the labor contribution by the beneficiary community from Nepane, Sanogaun-5, Balthali VDC. The number of labor requirement was significantly high because they have to engage in tiresome job of finding boulders, chipping boulders into aggregates and transport aggregates to the hydram installation site.

Table 3.

<table>
<thead>
<tr>
<th>Project Area</th>
<th>Labor contribution to project with respect to gender</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nepane, Sanogaun-5, Balthali VDC</td>
<td>Male Share (%)</td>
</tr>
<tr>
<td></td>
<td>102</td>
</tr>
</tbody>
</table>

(Source: Shrestha, 2014)

PROJECT BENEFITS

The hydraulic ram pump was installed to fulfill water need for irrigation. With harmonious coordination between WUC, LPO and CRT/N, installation and operation of hydraulic ram pump was accomplished on September 13, 2014. Soon after the completion of all the activities of the project including arrangement of pipelines to facilitate micro-irrigation, the project was handed over to water users committee on November 20, 2014. The pump lifted 28 liters water per minute into the reservoir tank of size 24 cubic meter which was constructed at an elevation of 43 meters. The WUC had decided to operate hydram system whenever there is need of water for irrigation purpose, however, if the pump is operated throughout the day (24 hours of operation), it can pump 40,320 liters of water in a day. The adjacent Figure shows the relation between volume of water lifted with respect to the operation hour of the hydram. The water lifted by hydram is stored in a reservoir tank from where the water has been channeled through a pipeline. To facilitate micro-irrigation, CRT/N supported the community by making required arrangements of main pipeline that would enable beneficiaries to divert water from reservoir tank to their respective fields. After the installation of main pipeline with saddle fittings, respective beneficiaries took the responsibility of buying required accessories like pipes and micro-irrigation tools (sprinkler unit) to facilitate irrigation procedures. The pipeline was provided with saddle pipe fittings along different points of the pipeline such that every beneficiary would have equal access to the water from hydram system. To avoid any conflict within the beneficiary households, provision of saddle fittings was considered in designing water distribution network. Installations of hydraulic ram pump
enabled pumping water from Ladkhu River to higher grounds closer to the settlement of beneficiary villagers. The project made an arrangement of irrigation facility via distribution pipe to beneficiary farmland. Approximately 3.3 ha land will now get facility of irrigation through this micro-irrigation hydram system. Farmers who previously were forced to stick to traditional cropping pattern and cultivate conventional crops like wheat, millet, barley and mustard oil seed are now attracted to new crop types basically coriander, cauliflower, cabbage, potato and tomato. Today, farmers can think of cultivating off-season vegetables in plastic tunnel because of availability of water. Through various capacity building training and other relevant information and advices, the beneficiaries now are able to efficiently and equitably distribute water for irrigation among beneficiaries, maintaining the system efficiently, solving conflicts regarding water use among the users, tariff determination and collection. Furthermore, the communication skill, leadership skill, decision making capacity and women empowerment within the beneficiary community were also improved after the completion of the project.

The availability of water has enabled beneficiaries to cultivate different crops. Table 4 demonstrates land area coverage by hydram when it is operated for 24 hours a day. For this calculation, assumption was made that if beneficiaries used drip irrigation in their respective farmland, they can reduce water consumption by 50 percent (Deshmukh, 2012). Furthermore, according to Department of Natural Resources and Environment in Food and Agriculture Organization (FAO), different crops require different amount of water (Heibloem et.al., 1986) which has been shown in Table 4.

Table 4: Capacity of hydram to irrigate land in a day on the basis of crop type

<table>
<thead>
<tr>
<th>Crop</th>
<th>Water requirement (mm)</th>
<th>Avg. Water requirement (mm)</th>
<th>Growing period (days)</th>
<th>Avg. growing period (days)</th>
<th>Irrigable land area (Ropani) at Balthali (40,320 L/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cabbage</td>
<td>350-500</td>
<td>425</td>
<td>120-140</td>
<td>130</td>
<td>36</td>
</tr>
<tr>
<td>Potato</td>
<td>500-700</td>
<td>600</td>
<td>105-145</td>
<td>125</td>
<td>25</td>
</tr>
<tr>
<td>Green onion</td>
<td>350-550</td>
<td>450</td>
<td>70-95</td>
<td>82.5</td>
<td>22</td>
</tr>
<tr>
<td>Tomato</td>
<td>400-800</td>
<td>600</td>
<td>135-180</td>
<td>157.5</td>
<td>31</td>
</tr>
</tbody>
</table>
LIMITATION
Prior to this hydram project when water scarcity was prevalent, the farmland was left virtually barren. The beneficiaries were not involved in cultivating high value crops. However, some farmers cultivated in small scale high value crops like onion, garlic and radish at domestic scale. The project supported capacity building training helped the beneficiaries to establish agriculture group. Beneficiaries are now lobbying at District Agriculture Development Office, Kavre (DADO) and resource person from DADO for bamboo and plastic at subsidized rate to construct plastic tunnel to cultivate tomato in large scale. The beneficiaries are yet to make maximum utilization of water from hydram project.

WINDOW OF OPPORTUNITY
Balthali VDC is progressing as top tourist destination of Kavrepalanchowk district. Availability of new trekking routes including Balthali VDC has been able to attract tourist to Balthali VDC. In recent times, two village resorts have been established in this VDC. Both Balthali village resort and Balthali eco-village resort are within the vicinity of hydram project site. It takes about 1 hour to reach Balthali Village Resort from project site and half an hour to reach Balthali Eco-Village Resort. Existences of these two resorts are additional opportunity for the farming community from Nepane, Sanogaun. The agricultural products have market within the community. Organic farming can prove to be another attraction for tourists. The co-owner of the Balthali Eco-Village Resort had participated in hydram WUC meeting and he promised to buy all the agro-products that will be produced from the project site. Some of the farmers have engaged in livestock keeping so that they can produce enough manure to grow organic vegetables.

LESSON LEARNED
In projects involving community participation, the project activities are to be planned keeping in mind the festive season and monsoon period in Nepal. Besides, during cultivation time (generally July and December) of paddy and wheat which are the main food crop in Nepal, it is practically impossible for community to participate in community based project. These periods are to be kept in mind in planning to enlist the community participation in project implementation. Therefore, development organizations, private and government institution involved in community based project must make sure that they plan the project activities in a way that allows community to be involved in both project activities as well as their day to day activities.
REFERENCE


ROLE AND PLACE OF IRRIGATION PONDS IN A CONTEXT OF CHANGE: A CASE STUDY IN SUNSARI AND SAPTARI DISTRICTS, THE EASTERN TARAI, NEPAL

CAROLINE SARRAZIN*

INTRODUCTION

Like most Asian countries, the lowland areas of Nepal called the Terai/Tarai region\(^1\) faces major problems caused by strong demographic growth resulting into high density areas\(^2\). This has impact on increase in demand for water resources and a shortage of available lands. The societal behavior changes towards individualization on resource appropriation in rural communities. This feature has become prominent. Many changes have occurred due to incertitude on local climate and frequent freak weather conditions such as the extension of the rainfall period and the increasing intensity of dry days (Pradhan \textit{et al.}, 2013)\(^3\).

The Nepalese actors involved in food production (mainly agriculture and aquaculture) in the eastern Terai have to cope with these changes by using local adaptation strategies including

\* PhD student (second-year), University of Paris Ouest Nanterre La Défense, Centre for Himalayan Studies, National French Research Center (CNRS)

1 In the context of this study, the Tarai region is the lowland area only, which ranges from Western to Eastern Nepal.

2 According to the last National population and Housing Census of 2011, the total density of population in Tarai was 392 inh./km\(^2\). However, the highest population densities are located in eastern part: 525 inh./km\(^2\) in 2011. The population densities of the districts of the following study were: 607 inh./km\(^2\) and 469 inh./km\(^2\) in Sunsari and Saptari respectively (2011).

3 These observations have been reported in ‘PAPRIKA’ project, one of the Research project from the French National research agency, as well as in the results of the 2013-2014 surveys completed on the fields.
small-scale irrigation systems (McCornick et al., 2013). Indeed, these water infrastructures are efficient solutions in order to respond to current issues concerning the inequalities of water availability as well as the access to it (Dixit et al., 2013). Among the small-scale irrigation systems, irrigation ponds are essential for local population uses (Dixit et al., 2013), especially for an economically active population mostly involved in agriculture activities. In addition, most of the eastern Tarai farmers are strongly dependent on monsoon rainfalls. They have limited access to water during the dry season. The eastern Nepal has a number of ‘Monsoon Rivers’ but they are dry for around 6 months. People have limited access to inefficient conventional irrigation systems.

Regarding the water supply status in Sunsari and Saptari districts, access of water to the people is facilitated by the existence of water bodies, called ponds, pokhari (in Nepali). Because of the diversity of these ponds in the eastern Tarai, any comparison of ponds located in hill areas is not meaningful exercise. The eastern Tarai has alluvial lowland and both study districts have many wetlands and swampy areas which facilitate the large numbers of ponds (Department of Geology, 2013). In 2014, we surveyed the number of ponds. The densities of the ponds are between 2.2 ponds/km² to 1.1 ponds/km² in Saptari and Sunsari respectively (Chart 1).

<table>
<thead>
<tr>
<th>District</th>
<th>Surface area (km²)</th>
<th>Number of ponds (2014)</th>
<th>Density of ponds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saptari</td>
<td>1,363</td>
<td>2,953</td>
<td>2.2 ponds/km²</td>
</tr>
<tr>
<td>Sunsari</td>
<td>1,257</td>
<td>1,590</td>
<td>1.1 ponds/km²</td>
</tr>
</tbody>
</table>

The ponds we find in both districts are natural or artificially made inland basins. We find rain-fed ponds as well as ponds that are filled up by diesel or electric pumps or bores, through a connection to irrigation systems. The diversity of these ponds in Sunsari and Saptari is also justified by the high range of sizes, starting from ‘pocket-size’ – less than 0.02 ha – to 5.5 ha. The size is considered due to the small size of landholdings that most eastern Tarai farmers hold (Yadav, 1993).

Sunsari–Saptari ponds are essential for the people in both these districts. They are used for multi-purposes. First, ponds are used to generate income and to facilitate social welfare in the communities. The main economic activities from the ponds are fish farming and the vegetable cultivation. In addition, there are multiple uses of ponds in villagers’ daily-life like for bathing, cleaning dishes and clothes, or for rounding up livestock. The ponds are used for religious purposes by the Hindus in the terai, either as a convenient infrastructure

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4 Proceedings of National Seminar on Small Scale Irrigation: Experiences, Challenges, Opportunities and Pathways, DoLIDAR, SDC, NFIWUAN and IWMI.
5 Data available on the National Report Census, 2011.
6 In 2014, only 25,000 ha (around 30%) of arable farmlands in Saptari had access to irrigation facilities (District Agriculture Development Office, DAO).
7 Spatial analysis of the density of ponds in Sunsari and Saptari through satellite images (July and August 2014).
for celebrations or because they are sacred. Many temples are built close to ponds. In the case of agricultural activities, ponds are also used in both districts for water storage. This same water is used for irrigation purposes mainly during the dry season. They are essential for securing water resources (McCornick et al., 2013), especially in the context of climatic change. The ponds are also used to regulate the excess water of flood during the monsoon.

The ponds located in the eastern Tarai are now encountering several demographic effects and climatic uncertainties. They have also to cope with rural society that is undergoing major economic and social changes due to globalization impacts and increased rural migration from this region (Aubriot and Bruslé, 2012). Indeed, the Sunsari and Saptari districts experience growing pressure on lands and competition over access to water, threatening not only food security but also the usefulness of ponds. The current role and place of the ponds in the eastern-Tarai rural communities have to be studied within this changing context.

This study entitled ‘Role and place of irrigation ponds in a context of change: a case study in Sunsari and Saptari districts, the eastern Tarai, Nepal’ is a part of a PhD work focused on the diversity of role and place, functions and uses of ponds along with social and climate changes located in eastern Tarai (Nepal). This study aims to understand, first of all, (a) whether these ponds are useful for irrigation? Whether these ponds ensure water supply and improve agricultural production? If yes, which area gets benefit in particular? (b) It is proposed to analyze the potential adaptation and the vulnerability of these ponds with respect to enormous changes in this part of Nepal. The question then would be: can we describe these ponds as guaranteeing factor for sustainable livelihood at present?

This the following section aims at describing the methodology used in this study. Attempt will be made to focus on the spatial distribution of the irrigation ponds in Sunsari and Saptari districts along with different management types used by farmers. It is also proposed to analyse different trends that have emerged in Sunsari and Saptari districts as to how the ponds in both districts have evolved over period of time and their maintenance, conservation and protection. In the meantime, it will also be studied as to how many of those ponds were rendered dysfunctional and disappeared from use.

**PART ONE: PLACE AND ROLE OF EASTERN-TARAI PONDS FOR IRRIGATION PURPOSES**

- Methodology for district-level ponds study.

In order to understand the place that the ponds hold in the eastern Tarai as major irrigation
infrastructures, the study undertook combined spatial analysis of these ponds – their spatial distribution at district level – and the results of a 3-months field survey during the dry season 2014-2015. The spatial context of the ponds with 10 criteria (Chart 2) based on initial typology of 51 criteria was prepared. These criteria are relevant to understand the spatial and socio-economic context for each pond, as well as their connection to the irrigation network (conventional and non-conventional) and their utilization for irrigation purposes.

Chart 2: 10 criteria used in the methodology

<table>
<thead>
<tr>
<th>Topic</th>
<th>Criteria</th>
<th>Constraints</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spatial background</td>
<td>Urbanisation</td>
<td>Rural area / Rural area with urban influences (periphery)</td>
</tr>
<tr>
<td></td>
<td>Density &amp; Evolution</td>
<td>Densities in Sunsari &amp; evolution trends 1962-2014</td>
</tr>
<tr>
<td></td>
<td>Population</td>
<td>Tharu / Madheshi / Pahari / Muslims</td>
</tr>
<tr>
<td>Socio-Economic background</td>
<td>Work Migration</td>
<td>Past and over / Old and ongoing / Current &amp; recent / No Emigration</td>
</tr>
<tr>
<td></td>
<td>Land tenure</td>
<td>Private (land owner or renting)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Public (community-pond; contract/tender)</td>
</tr>
<tr>
<td></td>
<td>Management of ponds</td>
<td>Old ponds, ancient management / Recent ponds &amp; management</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Collective / Community-pond or Individual / Familial</td>
</tr>
<tr>
<td>Water supply</td>
<td>Connection with CI or SSIS</td>
<td>Connection with conventional irrigation network or SSIS / Without connection</td>
</tr>
<tr>
<td></td>
<td>Water supply</td>
<td>Origin and type of process</td>
</tr>
<tr>
<td></td>
<td>Water extraction</td>
<td>Water extraction for irrigation / No extraction</td>
</tr>
<tr>
<td></td>
<td>Time Schedule irrigation facilities</td>
<td>Permanent irrigation (high level of water in ponds)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Occasional irrigation (other alternatives)</td>
</tr>
</tbody>
</table>

- Possible connection of ponds to irrigation facilities

One of the main goals of this study is to identify a possible connection of ponds to irrigation network. This is vital because the use of ponds for irrigation purposes depends partly on the existence of irrigation network as well as their efficient use. The type of irrigation whether conventional or non-conventional will be categorized. It will also be determined the level of access to water for farmers through irrigation facilities through alternative technology like that of ponds. Secondly, it is to identify the extent of these farmers confidence in irrigation systems. The alternative technologies of irrigation also depend on the efficiency of these systems. Where there are irrigation facilities, ponds for irrigation purposes are useless.

However, in the case of Sunsari and Saptari districts, where there are irrigation networks, ponds are proved to be useful for irrigation. This can be largely explained by the fact...
that they are inefficient irrigation networks to provide water supply. In Saptari, they are the pump canal and the Chandra canal, in Sunsari, the Chatara canal (Sunsari Morang Irrigation System).

The inefficient management of the irrigation network in both districts is attributed to maintenance problems at all levels of the irrigation systems, high dependency on electricity in Nepal for use of the pump canal in particular, and full control by India of certain main irrigation canals (mainly Western Koshi Canal), based on agreements between the Nepalese and Indian governments (Dhungel and Pun, 2009). Eastern-Tarai farmers face a water shortage depending on farmlands location along the main canals, and depending on the farmers' socio-economic status. It is, therefore, that ponds play an important role for irrigation purpose.

- Application of criteria: survey of 100 ponds

Bearing in mind all 10 criteria, the map (Fig.3) shows the 100 ponds of our survey. In the map, we have purposely shown few of the main criteria on the map. It is all the more important to understand how valuable these ponds are for irrigation. For each pond, we focus on all 10 criteria. Indeed, they are fundamental for explaining the situation of pond use in the context of change.

Fig.3.: Map of the 100 ponds of the survey
Thus, the first criterion is land tenure (circle for public / square for private). The second category is the possible connection of one pond to a conventional or non-conventional irrigation network (blue for connection / red for no connection); The third criterion focuses on the use of ponds for irrigation purposes (a dark colour indicates a permanent irrigation function / a lighter colour an occasional irrigation function / and the lightest colour, no irrigation function). The field observation justifies that it is fundamental to focus on the temporary use of ponds for irrigation. Their temporary use for irrigation purposes is no doubt an evidence that shows how farmers rather use alternative techniques instead.

• Findings: 6 main models in both districts

Given the main results and taking into account of other 7 criteria, 6 areas were selected for the main models based on the organization and the role of ponds in Sunsari and Saptari. The 6 spatial divisions focus mainly on the use of each pond in irrigation (Fig. 4.). It is worth noting that inequality in terms of the organization, place and role of ponds in Sunsari and Saptari districts reflects social and spatial injustices in these districts.

Fig. 4.: Map of the 6 areas, main models of pond organization

Northern part of Saptari district as referred to group A has witnessed a high rate of migration from the hill areas. There are a few urbanized areas along the high way. There are no irrigation networks in this part, so farmers use the ponds occasionally for irrigation.

In group A, most farmers are dependent on rainfall. This can be explained by the fact that all ponds have a smaller water storage capacity due to their small size. They are mostly private ponds and thus are used for individual purposes such as fish culture. The topographical constraints in this part of Saptari prevent the use of boring systems.
Group B covers the central part of Saptari. The rural areas in the western part and the urbanized areas in the eastern part are supplied by the Chandra canal or the pump canal. However, most of the farmers interviewed in our survey reported that they have systematically used ponds for irrigation. As explained earlier, the permanent use of ponds for irrigation has become necessary due to the ineffective management of both these canals. Hence, the farmers have more confidence in ponds.

Group C extends to southern part of Saptari. This area is settled by old generations of Madheshi and Tharus people in rural areas adjoining the Indian border. Farmers take advantage of the irrigation canals but this canal network falls under the authority of the Indian government which provides services to the farmers from Bihar region. For this reason, the ponds are used for irrigation purposes during the dry season.

The Sunsari district is also divided into 3 groups. However, the situation of Sunsari is quite different from Saptari. In the far north, ponds in group 1 are not connected to irrigation facilities because they are located upstream from Sunsari Morang Irrigation Project (SMIP) (Adhikari and Kumar, 1998), so the ponds do not serve for irrigation. In fact, farmers use ponds mostly for fish farming in this area and prefer to look for alternative techniques such as boring to extract ground water for irrigation purposes.

Group 2 is located in the central part of Sunsari district with both urban and rural areas. This area has also experienced internal migration from north to south as well as out migration mainly to the Gulf countries. The migrants upon return prefer to invest in building houses instead of farming. In many villages close to the main city of Itahari, it is observed a large number of ponds buried under the ground. In addition, most government and non-government projects to promote fish farming development using ponds are usually found in this part of Sunsari. Water facilities are thus used here as a priority for these intensive economic activities.

Group 3 is very different. Madheshi and Tharu people are settled in this area. They have generally low economic status. They own small parcels of land or they work for rich landlords. They have limited access to water due to the lack of irrigation facilities. Moreover, secondary canals connected to SMIP stop supplying water in this area during the dry season. The sub-canal Shankarpur stops providing water to Jalnapur VDC and VDCs of southern part during the dry season. Although there is limited access to water especially during the warmest months for irrigation, farmers prefer to use alternative techniques such as boring systems rather than ponds. Even though one of the uses for ponds was irrigation of farms until 3 generations ago. The farmers felt that the use of ground water provides unlimited water supply by using modern techniques like that of boring system. Groundwater uses are promoted by the Nepalese Government (Department of Irrigation, 1997). On the otherhand, ponds usually become without water during the dry season.
**PART TWO: TRENDS IN SUNSARI AND SAPTARI**

Part two of this paper is divided into two parts and focuses on how ponds have evolved in the context of change in the eastern Tarai. First, the main findings are divided for the period between 1992 and 2014 in the both districts. Secondly, attempt will be made to focus on the main factors that explain the changes before concluding this paper.

- Statistical analysis at district-level

At the beginning of this study, it was intended to analyze changes in ponds in both districts for over 60 year periods. However, it was very difficult to focus on this period of time due to the lack of data for this period in both districts. Hence, the approach is based on the 3 areas which are divided into groups like A B and C in Saptari, groups 1, 2 and 3 in Sunsari. It seemsthat it is more relevant to focus on the density of ponds and their changes in each area.

First, the number of ponds was almost the same between 1992 and 2014 in Saptari district as a whole, (Chart 5).

![Chart 5: Number of ponds in Saptari in 1992 and 2014](image)

However, two significant trends have merged for the 3 areas (Chart 6).

![Chart 6: Densities of ponds in Saptari divided into 3 areas](image)

The first trend is to be found in the area A, the northern part of Saptari that the density of
ponds has been declining for the last 20 years. It is found a drop of 20% in this area. As already explained, the use of ponds for irrigation is very limited in this part of Saptari.

On the other hand, if we focus on areas B and C in the centre of Saptari and in the southern Saptari respectively, the number of ponds in both areas has increased over the last 20 years. In area B, we note a 10% rise and in area C, a 12% rise. This increase can be attributed to the lack of proper access to water even though irrigation facilities exist.

For Sunsari district, old maps dating 1962 was found. According to these maps, the number of ponds is insignificant (Chart 7). This low number of ponds is due to a difference in interpretation by Indian engineers who may have focused on water tanks in this area which are defined as reservoirs for irrigation only. Most water storage basins that one finds in India are these water tanks, which are not used as much in Nepal.

**Chart 7: Densities of ponds in Sunsari divided into 3 areas**

<table>
<thead>
<tr>
<th>Total number of ponds : 1992</th>
<th>Total number of ponds: 2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>2961</td>
<td>2953</td>
</tr>
</tbody>
</table>

However, it is interesting to note that the majority of these irrigation water infrastructures are located in the centre of Sunsari, where nowadays only few ponds are used for irrigation purposes.

In addition, although the number of ponds is on the decline in the north and in the centre of Sunsari district. In area 3 which is located in the extreme south of Sunsari, the number of ponds is on the increase with +18% of ponds over the last 20 years. This rise in the number of ponds can be explained essentially by the development of fish-farming activities and several projects promoted by the Nepalese government.

- Factors of change: resilience or vulnerability?

In the last part of this presentation, it is proposed to summarize the main reasons why ponds in Sunsari and Saptari districts have undergone these different trends. In other words, how social, economic and climatic changes may affect the way ponds are used and managed, and their consequences.

Keeping this in view, it is proposed to present a comparison between Sunsari and Saptari districts. Although both districts are located close to each other and share the same context of change, the trends and the factors involved are quite distinct.

First of all, the rural communities living in Sunsari district have experienced a break with their common resource due to the process of individualization of the use of ponds. Three factors must be explained here.
The first issue is that local committees in charge of public ponds, mostly the oldest ponds, take the responsibility of renting of these infrastructures. Generally speaking, these committees grant one farmer (and his family) the right to use the ponds for a period of 5 years or more, and they offer various types of contract: auction, tender or random draw. In this case, the public property-tenure of these ponds is prevented. However, the access to water by communities is reduced by individual motivations.

The second main point is that government highlights importance of ponds regarding their economic value only. However, ponds are considered vital for developing fish farming but their usefulness for community purposes is underestimated. In this context, the government legitimizes the private appropriation of a natural resource though it is common property resource.

The last point concerns changes in the behavior of rural society in Sunsari regarding irrigation issues. Most farmers in Sunsari have to face climate uncertainties such as a drop in rainfall frequency. Ponds are not perceived as the most effective way of coping with water availability issues. Farmers feel safe by using groundwater.

Another point highlights the consequences of out migration, both inside and outside Nepal. When migrants come back to the Tarai areas, they prefer to invest in building houses as close as possible to cities. This situation has dramatic impact on pond conservation because most of these people, upon return, first bury their ponds to sell the lands or to build a new house on it.

The situation in Saptari is different despite its proximity to Sunsari. This district is facing an important large-scale process of ‘governmentalization’ of ponds and a loss of commons rights regarding natural resources. Although Saptari communities benefit from irrigation facilities by using old private ponds with no restrictions imposed by the owner (mostly from the landlord’s family), they have to face a lack of common-rights as well as injustices due to the ambiguity in Nepalese legislation. First, Saptari district is facing legal pluralism concerning pond infrastructure due to the fact that ponds are between a common resource (water) and private rights (private property). Secondly, for generations, most owners of private ponds have had to go to the Supreme Court of Nepal to try to cancel the decision of the Nepalese government to change the property rights for ponds. This situation is perceived as extremely unfair for owners and also communities, and even more so when they witness the lack of management of these government owned ponds.

**CONCLUSION**

To briefly conclude, the importance of ponds for irrigation purposes depends mainly on where these infrastructures are located within the same district. The different areas of case study justify the use of a geographical analysis to address water issues.
Local constraints differ greatly from one district to another, from Sunsari to Saptari. One can note an individualization trend of the way to use ponds in Sunsari, whereas in Saptari, communities face on ‘governmentalization’ of private ponds and a decrease of common-rights on natural resources.

In order to answer the main question: Can ponds support sustainable livelihoods?, Sunsari and Saptari districts are encountering a significant rise in the vulnerability of irrigation ponds despite the fact that ponds are perceived by communities as ensuring essential livelihoods.

REFERENCES


Cooperative Based Water Management Strategies for Securing Sustainable Livelihood- A Case of Gulmi District Nepal

CHIRANJIBI RIJAL* GANESH DHAKAL** HOM NATH GARTAULA*** AND DEEPAK LOCHAN ADHIKARI****

INTRODUCTION

Nepal is one of the richest country in water resources among Asian country, however, water crisis is a major issue in many urban and rural areas of Nepal. There are about 6000 rivers in Nepal having drainage area of 191000 sq. km, 74 percent of which lies in Nepal alone. On the other hand 65 percent of the population depending on agriculture for their livelihood does not have proper access to those resources. If this natural resource is properly harnessed, it could generate hydropower; provide water for irrigation, industrial uses and supply water for domestic purposes (WECS, 2011).

Agriculture is major source of economy where 18 percent (2,642,000 ha) of the total land in Nepal is under cultivation, of which two thirds (1,766,000 ha) is potentially irrigable (Poudel and Sharma, 2012). Out of cultivated area 42 percent of land has some sort of irrigation, but only 17 percent of cultivated area has year round irrigation. This finding shows that available water resources is not properly utilized for economic benefit of the people where less than 8 percent of the country’s water potential is used for irrigation (WECS, 2011).

* PhD student (second-year), University of Paris Ouest Nanterre La Défense, Centre for Himalayan Studies, National French Research Center (CNRS)
** Ministry of Agricultural Development, Agriculture Management Information System, Kathmandu Good Neighbors International Nepal, Jawalakhel, Lalipur, Nepal
*** IDRC/DFATD Sustainable Agriculture Project, International Development Studies Canadian Mennonite University, Winnipeg, Manitoba, Canada
**** Water Resources and Climate Change Adaptation Department, Development Inn Pvt. Ltd, Nepal
Rain fed subsistence farming is typical agriculture system of mountain and hill region of Nepal. Majority of farmers have to totally depend on rain for cultivation but rainfall pattern is not equally distributed throughout the year. Summer monsoon rainfall contributes almost 80-90 percent of the precipitation which is broadly similar across the country expect in the far west (55-70 percent) (Nayava, 1980). Due to unequal distribution of precipitation, the monsoon summer season makes the country flooded, while the dry winter season becomes extremely drier.

Water harvesting is one of the potential means of water supply in mountain and Hill of Nepal. There are two types of water harvesting system: Collective water harvesting system where the water collection and storage is centralized and then arranged to distribute to individual household. It needs a large catchments area, storage tank. The other type is at household level water harvesting system where an individual household collects and stores water separately in small tank or Water Jar. The individual practice is more common in Nepal due to low cost requirement and ease of management and distribution of the resource.

**WATER USE EFFICIENCY AND DISTRIBUTION**

The world will not achieve food security without significant increases in water use efficiency (FAO, 2006). Empirical evidence shows that water resources development has tended to favor relatively well-off people and has widened the gap between the rich and the poor. Much of the benefit of irrigation infrastructure, for example, has gone to the rich or large landholders who have the ownership of irrigable and fertile lowlands. The poor, who are often either landless, or have only a small patch of non-irrigated upland, are deprived of the benefits growing from the irrigation investments, which mostly come from the national capital or international grant/ loan assistances. (Hussain et. al., 2004). Government has invested substantial financial resources in the past on developing irrigation infrastructure, however their performance has been found unsatisfactory. Among the problems reported were - failure to provide an assured supply of irrigation water, failure to meet the water need of farmers in the tail-end and failure to achieve economies of scale in all spheres of construction, operation & maintenance (Poudel and Sharma, 2012)

Cooperative water supply is a potential way to develop small-scale irrigation facilities (Baker, 1998; Ostrom, 2000; He and Luo, 2006) because an individual typically cannot afford the expensive small-scale irrigation device, and a cooperative will help defray their costs and provide irrigation supplements. The impact of social capital and cooperatives has been shown to be especially important in irrigation projects (Tatlonghari and Sumalde, 2006). Empirical finding shows that cooperative based management significantly increase irrigation efficiency in Northwestern China. In a study of 48 irrigation systems in India, Bardhan (1999) finds that the quality of maintenance of irrigation canals is significantly lower on those systems where farmers perceive the rules to be made by a local elite. Ray and Williams (1999) finds that deadweight loss from upstream farmers stealing water on government-owned irrigation systems was one-fourth of the revenues that could be earned in an efficient water allocation by community.
This paper presents one of the successful case studies of Gumli district and illustrates how an effectively managed Cooperative based water management system can ensure an equitable and year round supply of water for its users. It also focuses on the linkages of water and poverty in a mountainous area in the Nepal Himalayas. The overall goal of the case study is to draw lessons and identify interventions that can help policy makers, planners and other stakeholders to develop actions that are effective in community based water resources management for the poor. This research was guided by two specific objectives. In the first it aims to examine management strategies adopted by community members for year-round water supply equitably, and to analyze the impact of rainwater harvesting in socio-economic status of rural poor.

**DESCRIPTION OF LOCATION AND COMMUNITIES**

The study was carried out in Rajha village of Gaudakot Village Development Committee (VDC) of Gulmi, one of the hill districts of Western Development Region of Nepal. The village is located at 1450 mean above sea level (amsl) and surrounded by mountains reaching highest points at 2900 amsl. The VDC is located 15 Kilometer away from district head quarter Tamghas. The region faces sub-tropical climate and has 9 months of relatively drier season and four month of summer monsoon with 90% (586 mm) of total rainfall (Figure 2). The average rainfall in the watershed is 651 mm. The region suffers from alternating cycles of excess and scarcity of water that are acute in the communities dwelling (CBS, 2011).

Unlike majority of settlements of mountains village, Rajha village is located at the top of the hill. Therefore, Monsoon rain drains to downstream which is vulnerable to erosion and flood where rest of the other period is dry with no water storage. The villages gets drinking water through a 16 kilometers long pipeline with scattered distribution outlets and regulated timetable due to limited availability of water at the source especially in the dry season, leave away the water for irrigation.

![Figure 9 Map of Gulmi District indicating study area in green color](image)

**Figure 9** Map of Gulmi District indicating study area in green color Sludge drilling tools and transport

![Figure 8 Twelve years (2000 to 2012) average Rainfall days and Precipitation of Tamghas](image)

**Figure 8** Twelve years (2000 to 2012) average Rainfall days and Precipitation of Tamghas (Source: Department of Hydro Metrology, 2014 & http://www.worldweatheronline.com)
STUDY DESIGN AND DATA COLLECTION

The study is based on qualitative research design conducted during December 2014. Primary data were collected from the field using the techniques of PRA, Transect walk, Focus Group Discussion (FGD), semi-structure interviews and Key Informant interview (KII). One event of FGD was conducted with water user associations which was focused on water management strategies and decision making process regarding water use in the community. Altogether 34 semi-structured interview were carried out with cooperative members, vegetable growers including women and local market actors. Key informant interviews were conducted to have a general overview of the area. The key informants were the community leaders, elderly people, Governmental and non-governmental organization official. Relevant secondary data was collected by reviewing previous studies, published and unpublished research reports, magazines, Newspapers and other relevant documents. Moreover, transect walk was carried out and field observation note was taken to see utilization of water resources and economic activates. All interviews and Group Discussion were audio taped and transcribed word by word.

Miles and Huberman (1994) framework’s to analyze the qualitative data was adapted to analysis data, which consists three major phases of data analysis i.e., Data reduction, data display, and conclusion drawing and verification. Various forms of primary data such as transcripts from the focus group discussions and semi-structure interview, field notes are documented under the format of a short report. Qualitative data analysis software called Nvivo 9 was utilized for systematic coding of raw data. Outputs from the data display i.e. a diagram, chart, or matrix or piece of text are integrated to have final conclusion.

RESULT AND DISCUSSION

Water use history of Rajha Village

The water scarcity problem in the research area was one of the common problems that the country’s hill region is facing. Rajha village settlement is located in top of the mountain hill with no additional source of water except rain. It was just 12 years ago, people used to rely on single source of spring water located at 1 hour walk from the village for drinking as well as household use. Resunga drinking water project, constructed in 2002, supplied drinking water through 16 kilometer long pipe line with scattered distribution outlet. Due to limited availability of drinking water at the source especially during dry season, water is supplied for limited hours in the morning and evening. The drinking water project provided safe drinking water to the community but it could not help for other domestic use, leave away the water for irrigation purpose. Therefore, rain fed subsistence agriculture was predominant farming system of the area. In order to cope with this situation, in 2007, a few community members started collecting rainwater from roof top and made it available for household use during
dry season. Even though, this was a good solution, the rainwater storage tanks made at household level were smaller and the stored water was not sufficient for irrigation purpose. The community members devised an idea of forming an Agriculture cooperative formed "Nava Durga Agriculture Cooperative ltd" with 35 share members. In the beginning, the cooperative served as saving and credit services to Agriculture Group. Few agriculture group started growing seasonal vegetable cultivation during monsoon period. Later on, in 2009, the cooperative formed a "Water management Committee" with nine members. The water user committee with some external support, constructed a plastic-lined water storage tank that could store 600 thousand liters of rainwater. The harvested water was made available Water User Group (WUG) of 34 household which was strictly used for income generating purpose such as growing off seasonal vegetable and raising improved breed of cattle. The demand of water was then increased since neighboring community showed interest using this water. To meet increased demand of water, the water user committee came up with an ambitious project called "PakhuKholaDharapani Lifting irrigation Project". Later in 2010, WUA was expanded to 63 member covering 70 percent household of the village and started lift irrigation project. The total cost of the project was NRs. 29 million of which community shared 91% expenditure (Community cash and Kind contribution NRs. 1598000.00 and NRs. 700000.00 loan from other cooperative) and rest was supported by District Agriculture Development office Gulmi (7.7%) and Gaudakot Village Development Committee (2.3%).

**Feature of water harvesting**

The community harvest rain water as well as lift spring water from downstream which is show in figure 3. Rain water is harvested during raining season in a plastic-lined water storage tank that could store 600 thousand liters of rainwater. The tank is located in center part of the village.

PakhuKholaDharapani Lift Irrigation pumps spring water situated at 190 meter downstream (1324 amsl) from the village and collected water at collections tanks constructed at top of the village (1514 amsl). At the source, a tank with 35000 lt. capacity collects water from two small springs i.e., PakhuKhola and DharaPani with a total discharge of 0.05lt. per second during dry season. The water from source is pumped by using 17.5 HP submersible motor which supplies water through 2.5 inch pipe to 1000 meter horizontal and 190 meter vertical distance. There are two distribution tank located at the center of the village which gets water supply from main collection tank located at the top of the village. The distribution tank has distribution pipe lines with gate valve at the bottoms from which water is supplied.

![Figure 10 Command area and water harvesting feature](image-url)
to individual household Jar with 2000 lit capacity. Household uses collected water from Jar to irrigate vegetable, for livestock and other domestic uses.

The water system is operated during dry season (December- May). There are two paid operators, one looks after a source and another is responsible for taking care of water distribution system at village. The motor operator at source operates motor twice a day, 3 hours in the morning and 3 hours in the evening. The operator at village distributes water from two distributing tank in alternative schedule i.e. morning and evening. The operator checks distribution pipe gate valve before and after water supply and reports to WUA if any misuses of water.

Management structure of Cooperative

The share members of Nava Durga Agriculture Cooperative ltd significantly increased to 835 (2014) from 35 in 2007. The cooperative has 62% women and 38% male shareholder from 95 (100%) households of Rajha village and 740 households from neighbor’s clusters. The increased in membership growth basically due to introduction of irrigation projects of the cooperative. There are 22 agriculture groups with 425 members affiliated in the cooperative of which only four groups are able to get water supply from the project. Cooperative management Board consists of 5 (55%) women and 4 (45%) male elected representatives. The Board is responsible for overall management of the cooperative and communicates and coordinates with Governments, non-government and privates sectors for agriculture developments. The board selects potential participants for capacity enhancements such as agriculture training, skill developments, exposure visits etc. and coordinate with external agencies (Governmental organizations, Non-governmental organizes and privates sectors) for financing, technology and input supply. There are four different subcommittee in the cooperative with specific function and responsibility. Figure 4 illustrate the management structure of Nava Durga Agriculture cooperative.

Figure 1 Management structure of Nava Durga Agriculture cooperative
Credit Mobilization Committee
The credit committee deals with credit applications by members. By the end of December 2014, the cooperative has total NRs. 4326000.00 share amount and NRs. 5598425.00 saving amount. The members voluntarily save in the cooperatives and get credit of maximum NRs. 40000.00 per person in one time. By the end of Dec 2014, the cooperative has mobilized NRs. 5,574,740.00 to 140 (85% Female) members. While looking sector wise investment, 83% investment was for vegetable cultivation Followed by 9% in irrigation and 5% in Goat keeping enterprise. Cooperative provides 8 % interest on saving amount and charges 12% interest on credit.

Water User Association (WUA)
Water User Association (WUA) is one of subcommittees of cooperative which is responsible for operation and maintenance of water supply project in the community. The WUA is made up of a president, a vice president, a secretary and a treasurer and five board members. Out of 9 members of WUA, there are five female and four male members. The president’s role is to make sure the water resource is managed well and properly utilized for productive purpose. The treasurer is responsible for finances and accounting of revenue and expense of water related expense in the cooperative. The cooperative has maintained separate ledger and bank account of water project. The secretary is responsible for administrative management of the committee, representatives of the technical commissions and other organizations. Other board members assist the team in daily operational and organizational managements. The WUA is representative of 63 water User Group (WUG) and guarantees the proper functioning of water supply project and ensures that the water source is managed and maintained well. WUA is also registered in District Water Resources Management Committee (DWRMC) and has bylaw and operational guidelines. Pakhu Khola and Dharapani spring have been registered in VDC. Since the water supply is more domestic and dominance of women member in management committee (55%), the water supply operation more effective and sustainable.

The membership of WUG is provided based on the interest of community people to take part in water supply project and their contribution on construction of project. Each members has contributed 85 man days labor force for construction of project and paid NRs. 10000.00 per membership fee.

Formulation of Rules and Regulation
The WUA draft rules and regulation in their meeting (often monthly with special meeting held when president feels it necessary). The secretary is in charge of keeping the minutes that summarize any decisions made during meetings. Operational decision such as operation and distribution schedule, maintenance of system, recruitment and mobilization of operator and other manpower etc. endorsed by WUA. Decision regarding on water tariff, distribution volume, expansion of project, membership fee are endorsed by General assembly of WUG which is held twice as in a Year.
Some of the effective regulation of WUA
1. Only the members of the Water User Group get water supply. Membership is open to all member to community.
2. Membership fee for a member is NRs. 10000.00 (who contributed labor force and other charges for project) and NRs. 50000.00 for completely new member
3. In case of household separation, separated household has to get new membership with NRs. 5000.00 membership fee.
4. Each members has to pay monthly NRs. 123.00 monthly operation cost (electricity and other running cost). The due amount is collected monthly.
5. Each member gets water supplied through separate water supply pipe from distribution Tank.
6. Water is supplied for limited hours (3 hours in a day)
7. The household is allowed to store water in household Jar with 2000 lt. capacity.
8. The water should be used for income generating activities
9. In case of violation of rules and regulation, water supply is cut off until the member pay for fine.

Insurance Committee
Year round access to water made possible to have improved breed of animal in the village. Currently there are 45 improved breed of cattle in the community. The price of cattle is NRs. 80000.00 per cattle which is significantly higher as compared to local breeds. To insure the cattle farmer from potential risk, the cooperative has endorsed cattle insurance policy and insurance committee is responsible for the endorsement of the policy. A cattle farmer pays NRs. 1000.00 per cattle as premium and gets up to 80% of loss in case of death of cattle. By the time of study, 22 cattle were insured and rest were in the process of getting insurance.

Market management committee
Market management committee is responsible for input and output marketing of the agriculture product. The committee coordinates with agro input suppliers such as fertilizer, seed, feed etc and collect and disseminate market information to its member. The cooperative has adopted collective marketing system of agriculture product, thus established vegetable and milk collection center. Vegetable collection center is operated by Mr. Dan BahadurBhusalwho display daily price list of vegetable. The market price is fix based on the current market price of Butwal and Tamghas, major market center of the location. There are three market price in the cooperative, one is Producer price, wholesaler price and retailer's price which is displayed daily in hording board. The price margin per kg of product is NRs. 5 for each commodity. For example, if producer price of tomato is NRs. 40 per kg, wholesaler and retailer price is NRs. 45 and NRs. 50 per kg respectively. Cooperative levies NRs. 1 services charge per kg of vegetable collected, NRs. 2 per kg has to pay for transportation and remaining NRs.2 is profit margin of Mr. Bhusal. Mr. LaxmiBhusal
Small Scale Irrigation Systems: Challenges to Sustainable Livelihood

operates milk collection center as private enterprise and collects milk from cattle farmer daily. This type of marketing arrangement has secured marketing of agriculture product and has increased market share of producer by reducing marketing actors and increasing bargaining power. It was found that the market of the agriculture product is secured and the farmers are getting fair price as a result of cooperative marketing approach.

**Socio economic Impact of water supply**

Access to irrigation water is viable and attractive option for poor farmers in developing countries (Burrow, 1987). The study found that water supply project has directly benefited to the communities and socio economic impacts which is shown in figure 7. The most direct outcomes of irrigation is changed in cropping diversity, cropping intensity, and crop yields. The farming system was typically subsistence and used to be two crop cycle in year i.e, Maize/Millet- Mustard/Beans/Lentils. With the increasing access to irrigation water and other input supply such as credit, agro input, technical skill and market information, the cropping pattern is changed to commercial farming. The farmer grow three crop cycle i.e., Cucurbits/Tomato-Cole crops/Tomato- Green pea/Okra which are completely marketing purpose. Currently 63 households are growing vegetable (cucurbits, Cole crops, Green pea) in 300 ropani (15) ha of land and tomato in 125 plastic tunnel houses. In spite of Green vegetable, people also grow spices crops (Ginger, turmeric and chillies). With the access of water people are benefited with increased yield of fruits crops such as Orange. The table below summarized total income generated by the community from agriculture product in during one year (2014).

Access to year round irrigation made possible to have improved breed of cattle for milk production as well as poultry and pig raising in the community. Currently there are 45 improved breed of cattle, two poultry farm and pig farm in Rajha village. Milk collection center records shows that during 2014, 42000 liter milk was collected from the village and sold in Tamghas which collected NRs. 1680000 in one year. Nearly NRs. 600000.00 revenue is earned by Poultry enterprise and almost same amount is collected by Pig enterprise. With increasing demand of agro inputs, there is forward and backward linkage with value chain actors. With availability of income generating opportunity in the village, out migration is reduced, remittance is utilize in productive sector. During the FGD, it is said that some of the people (about 30% household) who were out migrants in India and Middle East, returned in the village and engaged in commercial agriculture production.

Table 2 Revenue generate from the sale of agriculture product

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Production (Kg)</th>
<th>Revenue (NRs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tomato</td>
<td>18356</td>
<td>477,256.00</td>
</tr>
<tr>
<td>Cole crops</td>
<td>17865</td>
<td>321,570.00</td>
</tr>
<tr>
<td>Spice</td>
<td>8325</td>
<td>316,350.00</td>
</tr>
</tbody>
</table>
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Cucurbits 14885 327,470.00
Beans 6470 232,920.00
Orange 35600 1,068,000.00
Other (Veg) 4412 110,300.00
Total 105913 2,853,866.00

Source: Nava Durga Cooperative, 2014

Institutional development such as cooperative and WUA are the positive impact of water project which has developed linkage with Government agencies, for example, District Agriculture Office (DADO), District Livestock Services Centre (DLSO), District Development Committee (DDC), District Water Resources Management Committee (DWRMC) etc and Private sectors such as Agro Enterprise Development Centre (AEC) and other value chain actors. Community has managed water in efficient way through better water governance.

Figure 13 Socio economic impact of year round water supply in the community

Adopted from ADB. 2010. Data source: FGD, 2014

Women empowerment is one of the key impact of the project which was highlighted during FGD. With easy access of water and credit, women are involved in income generating activities. Out of total loan mobilization from cooperative, 85% of loan is issued for women.
Women are not only the beneficiaries of the project, they are key decision makers. Women’s representation is secured in all management committee, for example, 55% of WUA member are women. Out of 22 agriculture group, more than 50% group has women in decision making roles. Equitable distribution of water supply has benefited to all member of village including Disadvantage and marginalized people. Thus effective management of the scarce water resource has contributed sustainable community development by increasing household income and community assets and value, increased cooperation and water governance.

CONCLUSION

This study present a successful cooperative based water management strategies and its socio economic impact on rural livelihood. The case study reveals that if there is cooperation among community members, water scarcity problem can be solved through its efficient management. Navadurga Agriculture Cooperative of Gaudakot VDC of Gulmi district adopted integrated approach of community development which provides water, credit, agro inputs as inputs of agriculture development to its member and enhanced capacity development through skill development, exposure and sharing of market information. The cooperative harvests rain water as well as pumped water from downstream and stores larger tanks that could store 600 thousand liters of rainwater to secure year round irrigation. The harvested water is distributed among 63 member through distributing tank via separate distributing pipeline. Water User Association (WUA) is one of subcommittees of cooperative which is responsible for operation and maintenance of water supply in the community. Representative of women and disadvantaged people in the committee has increased ownership and distributed water to equitable amount to all member in the community. With the increased access of micro credit and availability of water resource, the community members are able to grow commercial vegetables and adopt micro enterprise to secure the livelihood. The direct and visible impacts observed are increased income through commercial vegetable production; reduced male out-migration; increased access to capital; and assured food security. Thus effective management of the scarce water resource has contributed sustainable community development by increasing household income and community assets and value, increased cooperation and water governance. The case study has drawn lessons and identify interventions that can help policy makers, planners and stakeholders to develop actions that are effective in community based water resources management for the poor.

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BENEFIT MULTIPLICATION THROUGH MULTIPLE WATER USE SYSTEM: COMPARISON OF SINGLE FUNCTIONAL AND MULTI FUNCTIONAL IRRIGATION SYSTEM IN THE MID HILLS OF NEPAL

ANAND GAUTAM*

INTRODUCTION

Multiple water use has drawn increasing attention of decision makers and water professionals around the world in order to increase the resultant impacts of investment in the water system development. Some of the most common forms of multiple water use systems being promoted are those involving integration of water uses in domestic, irrigation, power generation and also those producing and promoting recreation, tourism and environmental benefits. Many water systems although designed to serve only one use are also de-facto multiple services systems, serving many more uses even though multiple uses are not in the initial conception of design and development of the system (Renault, 2008).

Since early 2000s, multiple use water services have emerged as a new approach to development of water infrastructures and services in the rural and urban areas, especially in the low income communities. The concept of multiple use services (MUS) is based on the fact that people use water either from a single or multiple sources or for multiple uses. People’s demand for water is always multifaceted while the development of water services are often sub-sector based, involving water supply, sanitation, irrigation and fisheries, focused often to single use only. The structuring of the public water sector development approach with single use leads to conceiving projects that serve one or more groups of users at single or multiple locations. Contrarily, MUS go beyond the narrow sector boundaries

* Program officer, Co-Action for Community Development Nepal
and seeks to align water services with people’s multiple needs, thus integration of different uses in the water in the physical design and development of the system (Van Koppen et al., 2009). The implicit in the development of MUS is opportunity to increase the sustainability of water system management by creating opportunity of sharing the operational costs and benefits among several uses and users.

Integrated and multiple water use systems have been found to enhance production potential of available water supplies, leading to increasing the income and livelihood opportunities of the people. These are also known to produce host of intrinsic social benefits, such as, improved health and reduced workloads for women and children (IWMI, 2006). Systems that cater to multiple uses are also more likely to be sustainable, because of higher and multiple benefits to the users and therefore producing greater stake on part of the users in the development of such system and their willingness to pay for the cost of development and subsequent maintenance and upkeep (IWMI, 2006). Also, integrated and multiple use approach to water development and management creates opportunity to realize more than one Millennium Development Goals (MDGs), such as those relating to:i) eradication of extreme poverty and hunger, ii) promotion of gender equality and women empowerment, iii) reduction in the child mortality, iv) improvement in the maternal health, and v) promotion of environmental sustainability.

Also, multiple demand of water is alike both in the rural and urban areas. In Nepal, use of canals for irrigation as well as mechanical power harnessing for grinding of grains in water mills, locally called ghatta, has been the most common multiple water use system in the hills. People have been building and operating these ghatta for generation, using local materials and technology. In attempt to modernizing the traditional water mills, Alternative Energy Promotion Center (AEPC), the government agency responsible for promotion of appropriate renewable energy technology in the country, supported modernization of 465 water mills across the country during 1995-2000 (Rijal, 2004). Similarly, Center for Rural Technology (CRT) also helped improve traditional ghattas. The focus of the modernization program has been on converting the traditional water mills from the single purpose system to a multiple use system, involving integration of grain milling, hydropower generation and downstream irrigation and domestic uses.

There are also evidences of integration of more than one source of water and also water uses in the development of water systems. In Kathmandu Valley rich tradition of multiple water use system involving integration of water sources and uses of water existed until recently which essentially served multiple water uses of the communities. Such integrated water systems involved hydrological linked irrigation canals, ponds and stone spouts. Some of these traditional water systems built as early as in 550 A.D. are still in use in many parts
of Kathmandu valley (Shrestha, 2003). The importance of multiple water use system is still large in the rural areas where livelihood opportunities of the people are intricately linked to more than one uses of water. This study proposes to look into the value of multiple water use system in the production of multiple goods and services and thereby creating opportunity for improved livelihood and livelihood diversification and contributing to system sustainability in the mid hills of Nepal. In identifying the pathways of livelihood opportunities created with the multiple water use system, the study has compared the water systems with and without multiple uses.

The study used Palung Khola Irrigation System, a multiple water use system located in Chhisty VDC in Baglung District and Bhalke Pani Irrigation System in Khadgakot VDC in Gulmi District where irrigation has been the sole water service produced by the system. In identifying and comparing the pathways of livelihood opportunities in the two systems, the study hypothesized that multiple water use system create higher opportunity for incremental benefits and opportunity for livelihood diversification than those in the single use system and therefore the resultant social and economic gains to the users in the multiple water use system is higher.

OBJECTIVE OF THE STUDY

The overall objective of this study is to compare the benefit streams emerging in the single and multiple water use systems, the pathways of benefits created and thereby incremental gains in the livelihood opportunities and wellbeing of the people with the multiple water use system. The specific objectives of the study are as stated hereunder:

i. To compare the benefit streams and livelihood impacts and their pathways, produced in the single use and multiple use systems

ii. To analyze the contributions of the multiple use water system in enhancing livelihood opportunities and in promoting social and economic wellbeing of the people.

STUDY AREA

This study was undertaken in two irrigation systems- Palung Khola Irrigation System (PKIS) and Bhulke Pani Irrigation System (BPIS) in Baglung and Gulmi Districts, respectively. The two systems, though located in two different districts, are in the same proximity, share similar geographical and socio-economic context and infrastructure and services and development opportunities. PKIS involves integration of multiple uses of water in the existing irrigation infrastructure while irrigation is the only use in BPIS. Multiple uses of water integrated in PKIS included irrigation, operation of a water mill and a micro-hydropower system. The system therefore typically represents an Irrigation+ multiple use water system. The location of the two irrigation systems is provided in Figure 1.
PKIS is located at Dhusa in Chhisti VDC in Baglung district and BPIS in Lega Village in Khadagkot V.D.C in Gulmit district. The climate of the area ranges from sub-tropical to temperate type in both systems. The land use of the community comprises primarily of agricultural land, forest and settlements. The dominant castes and ethnic groups in the area are Magar followed by Brahmin, Chhetri and Dalits. The area is characterized by lack of road connectivity and access to market and services which limit the economic opportunities of the people in the area.

METHODOLOGY

The primary data were collected from households’ survey. Semi-structured interviews, key informant interview, focused group discussion and field observation were the tools of inquiries used in collecting relevant data. Household survey was conducted in total 60 households, 30 households each from the two systems selected randomly to collect information relating to economic gains of the households and in relation to single use and multifunctional use of water in the two systems. Focus group discussion were held in both the irrigation systems to get the information related to historical context of development of single functional and multifunctional water use system and socio-economic condition of the users in these systems, the benefits resulting to the local communities and the pathways and pattern of livelihood transformation of the people in the area. Focused group discussions were organized at four different locations in both systems. The data/information gathered from different methods were organized and managed and subjected to qualitative and quantitative analysis.
RESULTS AND DISCUSSION

History of Development of the Palung Khola Irrigation System

The farmers in Dhus and Tyan, the two villages in the present command area of PKIS, started initiative to develop an irrigation canal as early as in 1960 with Palung Khola as the source of water supply. This initiative of the farmers coincided with the construction of a suspension bridge in Palung Khola, however the efforts of the farmers in construction of the canal went into vain as the construction of the canal could not be started. In 1968, the District Administration Office provided Rs. 2,500 for the construction of the canal and the farmers from these two villages mobilized additional Rs. 50,000 in cash and in food grains and started fresh initiative of canal construction. The resources were mobilized by the users on the basis of landholding size as shown in Table 1 which was used in paying contract laborers employed in construction. The resources available at this stage were merely adequate to construct 1 km long canal in the head reach. Even though a small irrigation canal could be constructed, water could not be brought to the farmers’ field with this effort. This failure led to abandoning the canal construction for more than a decade due to frustration on part of the farmers resulting from initial failure and lack of resources to start fresh initiative of canal construction. The canal alignment in the head reach had to pass through a rocky terrain that made the construction almost impossible with the farmers’ efforts alone. In 1980, the District Water Resource Committee, Banglung, again allocated Rs. 40,000 for the construction of the canal on the request of the users. A construction committee was constituted under the leadership of a prominent farmer leader from the area- Mr. Hastaram Thapa. The digging of the canal through the difficult terrain was contracted out to a local contractor for Rs. 36,000 while the local farmers mobilized free labor to dig the canal in the easy terrain. After a year (in 1981) of the hard work of the farmers, the construction of the canal was completed and the irrigation water could be brought to the farmers’ field. Prior to this time the farmers in the area were growing rain fed crops, mainly maize, millet, groundnut and cotton in small patches. The availability of the irrigation water created confidence in the farmers for further development the system in the following years.

<table>
<thead>
<tr>
<th>Landholding Size</th>
<th>Resources Mobilized</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cash (Rs.)</td>
<td>Food Grains (Rice)</td>
</tr>
<tr>
<td>&lt; 5 ropani</td>
<td>500</td>
</tr>
<tr>
<td>5-10 ropani</td>
<td>600</td>
</tr>
<tr>
<td>&gt;10 ropani</td>
<td>700</td>
</tr>
</tbody>
</table>

1 pathi = 4 kg of raw rice grain; 1 muri = 20 pathi; 1 ropani = 0.05 ha
Source: FGD, 2012

Table 1Resources Mobilized by the Users in Palung Khola Irrigation System Initial Construction of the System
The farmers had foreseen the possibility of expanding the area under irrigation with the water available at the source however they lacked resources to undertake the system expansion. In 1989, the system was selected for rehabilitation and improvement through Dhaulagiri Irrigation Development Project (DIDP) under technical and financial support of ILO and DANIDA. The rehabilitation and improvement of physical infrastructure in the system was completed in 1992. The local farmers mobilized 10% equivalent of the cost in the form of labor contribution while the rest of the cost was supported under DIDP. Following this rehabilitation and improvement in the system, the area under irrigation expanded to 27 ha (540 ropani) with almost 5.5 km long lined canal with the design capacity of 200 liters per second. The farmers had constituted a construction committee at the time of physical infrastructure improvement under DIDP. The same committee was converted into executive committee of Water Users’ Association (WUA) upon completion of the construction works. This users’ organization was also registered with the District Administration Office in 1992 in the name of Palung Khola Water Users’ Association which provided legal identity to the WUA.

In the course of rehabilitation support under DIDP, the project had provided the farmers two options for possible supplemental support, either for the development of a water mill for grain grinding or for the development of a micro-hydropower system, to be developed based on the farmers’ preference for the either of the two options. The users decided to opt for the development of a water mill under the support made available by the project because grain milling and grinding involved excessive drudgery in the absence of milling facility in the nearby area. Also, majority of the houses in the two villages had thatched roof and the farmers feared that electrification in thatched houses could result to incidences of fire hazards. The women in the area were especially in favor of the development of water mill because they had to haul grains for long distances for milling and grinding. Based on the farmers’ preference, a water mill with equipments for milling and grinding for rice and maize and oil expelling was installed under the project support. Available head and flow of water in the irrigation canal was used in operating the water mill. Initially the operation and maintenance of the water mill was controlled by the executive committee of WUA with the charges (fee) set for milling and grinding for different kinds of grains. Later, the operation of the water mill was leased out to a local entrepreneur for annual rental of Rs. 6,000 payable by the entrepreneur in two installments.

With the dependable water supply at the source and the needed head in the canal, the users in the system had foreseen the possibility of electricity generation without the need of expanding the canal capacity or additional infrastructures though they did not opt for the installation of micro-hydropower plant when this option was given to them under DIDP support. In 2004, Dhaulagiri Community Research and Development Center (DCRDC) conducted a study to evaluate the feasibility of developing a micro-hydropower
plant with the available head in the irrigation canal on the request of the farmers from five villages- Wainakuna, Marnas, Rithawat, Dhusa and Tyan. The study assessed the possibility of generating 50-60 kW of electricity with the addition of some new infrastructures and equipments in the existing system, however the cooperation among the villagers could not be continued for long and the initiative was abandoned. The farmers in Dhusa and Tyan however decided to make a fresh initiative of micro-hydropower development on their own and they approached M/S Siemens Hydro Engineering and Energy Product P.Ltd., a micro-hydropower manufacturer and developer which has been working in the area for number of years in micro-hydropower development. They constituted a construction committee under a prominent local leader- Mr. Man Bahadur Sarbuja. The committee decided to add a turbine in the existing water mill and develop transmission lines to distribute electricity in the two villages. The idea was to use the existing infrastructures in the water mill to run the micro-hydro turbine alongside of running the water mill. The 34 households in Dhusa and Tyan mobilized Rs. 204,000 at the rate of Rs. 6,000 collected from among each household. While the construction work for transmission line was in progress, the cash mobilized from the users was found deficient by over Rs. 100,000 and the households in these two villages were not in a position to make further cash contribution to meet the deficit amount. They decided to include 48 households from adjoining Phoksing village of Parbat district as beneficiary of the hydroelectricity, who contributed the deficit amount. This amount was spent in the development and modernization of the transmission line. The construction of the scheme was completed in 2006 which succeeded generating 10 kW of electricity.

The small irrigation canal that was developed by the farmers in Dhusa and Tyan villages for irrigation as the single use went through changes over time to transform into a multiple water use system with three uses of water integrated into the system- irrigation in 27 ha of land, operation of a water mill and generation of 10 kw of electricity. Thus, Palung Khola Irrigation System typically represents Irrigation+ multiple use system. During the day time water is used exclusively for irrigation and for the operation of the grain mill and the micro-hydropower plant is operated from 5:00 p.m. to 11:00 p.m. in the evening and from 4:00 a.m. to 7 a.m. in the morning to generate electricity. Irrigation and operation of water mill run simultaneously during the day time. In order to distribute water equitably among the users, separate distribution canals have been developed to distribute water to different villages in PKIS (Figure 2). The first branch canal off-takes immediately after the hydropower plant to distribute water to Upper Dhusa village. There are two separate branch canals to distribute water to lower Dhusa and Tyan villages. The water available in the system is not sufficient to bring the entire area in irrigation at a time even during monsoon. Therefore, WUA has developed a timed irrigation distribution schedule. Irrigation is distributed on a rotational basis between the branch canals of upper and lower Dhusa, wherein the area under the two branch canals receive water for three days and three nights on turns. In the branch canal supplying water to Tyang, water flows continuously however water is distributed to the farmers by rotation from head to tail reach of the branch canal.
History and Development of Bhulke Pani Irrigation System

Bhulke Pani Irrigation System is a traditional Irrigation canal built by the farmers in the area with Marima Khola as the source of water supply. The people in the area estimate that the system to be in existence for more than three generations. It is estimated that the system must be at least 100 year old. The physical infrastructures in the system include a 2 km long canal, brushwood intake at the source and canal crossings made by the farmers using local materials available in the area and using their own traditional knowledge and skills.

Regular repair and maintenance of the system is carried out by the farmers in the beginning and at the end of the monsoon. Earlier, the farmers used to carry out repair and maintenance of the canal by themselves. With the increasing difficulty in mobilizing people to come to work on the days of annual repair and maintenance, the farmers in the area have started mobilizing cash contributed by the users for the annual repair and maintenance, collected at the rate of Rs. 80 per ropani (Rs.1,557 per ha) of land and the work is contracted out to contract laborers. Every year a water guard is appointed for the allocation of water among the users who also monitors the canal and infrastructures from the head to tail of the system.

Land Holding Size

The types of land in the possession of the farmers in PKIS and BPIS include non-irrigated upland, irrigated lowland and grasslands, which are typically referred as Bari land, khet land and khar bari respectively in the mid hills of Nepal. The distribution of each of these types of lands in the possession of the respondent households in the two systems is presented in Table 2. The distribution of types of land in the possession of the respondent households
shown in the table is indicative of the distribution of the land by potential for agricultural production in the two systems. The table clearly shows large proportion 81.78% of land in the possession of the households in PKIS to be irrigated land with higher inherent potential for agricultural production while only 29.35% of the land in the possession of the respondent households in BPIS was noted to be irrigated. This clearly shows that households in PKIS have relatively better access to potentially productive lands than those in BPIS.

Table 2 Land in Possession of Respondent Households by Land Quality

<table>
<thead>
<tr>
<th>Type of land</th>
<th>Land in the Possession of the Respondent Households in the Case Systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>PKIS, ha</td>
<td>BPIS, ha</td>
</tr>
<tr>
<td>Unirrigated Upland (Bari Land)</td>
<td>0.319 (2.04)</td>
</tr>
<tr>
<td>Irrigated Land (Khet Land)</td>
<td>12.43 (81.78)</td>
</tr>
<tr>
<td>Kharbari</td>
<td>2.46 (16.18)</td>
</tr>
<tr>
<td>Total</td>
<td>15.20 (100)</td>
</tr>
</tbody>
</table>

Values in the parenthesis indicate the percentage of land under each category

Source: Household Survey, 2012

The distribution of landholding of the households in the two systems is presented in Table-3. The table clearly reveals of average size of irrigated landholding to be larger in PKIS (0.43 ha per Hh) than in BPIS (0.38 ha per Hh). Contrarily, average size of non-irrigated landholding was noted to be larger in BPIS (0.58 ha per Hh) than in PKIS (0.17 ha per Hh). This clearly reveals access to productive land of the households being better in PKIS than BPIS. The distribution of the landholding size shown in Table 4.6 also reveals majority of households with landholding size large than 0.5 ha in BPIS while majority of households in PKIS were found with landholding size smaller than 0.5 ha.

Table 3 Distribution of Households by Landholding Size

<table>
<thead>
<tr>
<th>Landholding Size</th>
<th>Distribution by Category</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PKIS</td>
</tr>
<tr>
<td>Average Landholding Size (ha):</td>
<td></td>
</tr>
<tr>
<td>Irrigated Land</td>
<td>0.43</td>
</tr>
<tr>
<td>Non-Irrigated Land</td>
<td>0.17</td>
</tr>
<tr>
<td>Distribution of Landholding (No. of households):</td>
<td></td>
</tr>
<tr>
<td>&lt;0.25 ha</td>
<td>4 (13.33)</td>
</tr>
<tr>
<td>0.25-0.5 ha</td>
<td>13 (43.33)</td>
</tr>
<tr>
<td>0.5-1.0 ha</td>
<td>10 (33.33)</td>
</tr>
<tr>
<td>&gt;1.0 ha</td>
<td>3 (10)</td>
</tr>
<tr>
<td>Landless</td>
<td>NA</td>
</tr>
<tr>
<td>Total</td>
<td>30 (100)</td>
</tr>
</tbody>
</table>

Note: Figure in parenthesis indicate percentage
NA: Not available

Source: Household Survey, 2012
Changes in the Cropping System

The change in the cropping system has been the most noticeable changes with the availability of irrigation both in PKIS and BPIS. Entire area under PKIS was under maize and millet farming prior to the development of the irrigation system though the farmers in the area had also been producing cotton, ginger and groundnut in small patches. The cropping was limited to one cereal crop during monsoon and they were cultivating winter crops only occasionally. Since it was not possible to grow rice, the farmers used to exchange ginger and cotton for rice with other villages. After the development of the irrigation scheme, two noticeable changes in the cropping system in the command area had taken place. They are year round cultivation of crops in most parts of the command area and progressively increasing area under monsoon rice. The evolution in the cropping system in the two systems- PKIS and BPIS through different periods of time in the past is presented in Table- 4.

Table 4 Changes in the Area Under the Crops

<table>
<thead>
<tr>
<th>Area Under Crops</th>
<th>Area Under Crops by Season and Irrigation System (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PKIS</td>
</tr>
<tr>
<td></td>
<td>Before</td>
</tr>
<tr>
<td><strong>Monsoon Crops:</strong></td>
<td></td>
</tr>
<tr>
<td>Rice</td>
<td>0.15 (0.98)</td>
</tr>
<tr>
<td>Maize</td>
<td>5.72 (37.63)</td>
</tr>
<tr>
<td>Millet</td>
<td>-</td>
</tr>
<tr>
<td>Groundnut</td>
<td>5.56 (36.57)</td>
</tr>
<tr>
<td>Vegetable Crops</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Fallow</td>
<td>3.77 (24.80)</td>
</tr>
<tr>
<td><strong>Winter Crops:</strong></td>
<td></td>
</tr>
<tr>
<td>Wheat</td>
<td>3.39 (22.30)</td>
</tr>
<tr>
<td>Potato</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Mustard</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Vegetable Crops</td>
<td>0 (0)</td>
</tr>
</tbody>
</table>
As stated in Table 2, two types of lands under crop cultivation exist in the command areas of the two systems—irrigated low land (khet land) and non-irrigated upland (Bari land) and these two types of lands in the possession of the respondent households was estimated to be 15.20 ha in PKIS and 22.96 ha in BPIS. Rice and maize were the crops covering large area of cultivable land in both the systems. While millet is grown in large area by the farmers in BPIS this is not grown widely in PKIS. Maize and mustard are the important crops grown by the farmers in winter and spring seasons in PKIS while these crops have relatively small coverage in BPIS. The table also reveals progressively decreasing proportion of fallow land in PKIS resulting from intensification of crop cultivation while not much innovation in the cropping system could be noted in BPIS. Cultivation of potato during winter and spring and also inclusion of vegetable crops during monsoon and winter in PKIS reveal more innovative farming practices of the farmers and attention towards cultivation of high value crops in PKIS. The cropping intensity in PKIS was estimated to be much higher than that in BPIS.

### Changes in Crop Productivity

The changes in the productivity of different crops by season over time in the two systems—PKIS and BPIS is presented in Table 5. Significant increase in the yield of monsoon rice was noted with the availability of irrigation in PKIS and BPIS, however increment in the yield of monsoon rice in BPIS was noted to be lower than that achieved by the farmers in PKIS. The difference in the yield of monsoon rice in PKIS and BPIS can be accrued to more dependable irrigation supply in PKIS while the delivery of irrigation supply in BPIS was found less dependable due to unreliable nature of the physical infrastructures.
Table 5 Changes in the Yield of Major Crops by Over Time

<table>
<thead>
<tr>
<th>Area Under Crops</th>
<th>Changes in Crop Yield by Season and Irrigation System (tons/ha)*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PKIS Before -10 Yr.</td>
</tr>
<tr>
<td><strong>Monsoon Crops:</strong></td>
<td></td>
</tr>
<tr>
<td>Rice</td>
<td>0.95</td>
</tr>
<tr>
<td>Maize</td>
<td>1.23</td>
</tr>
<tr>
<td>Millet</td>
<td>-</td>
</tr>
<tr>
<td><strong>Winter Crops:</strong></td>
<td></td>
</tr>
<tr>
<td>Wheat</td>
<td>1.23</td>
</tr>
<tr>
<td>Potato</td>
<td>0</td>
</tr>
<tr>
<td>Mustard</td>
<td>0</td>
</tr>
<tr>
<td><strong>Spring Crops:</strong></td>
<td></td>
</tr>
<tr>
<td>Maize</td>
<td>1.23</td>
</tr>
<tr>
<td>Potato</td>
<td>5.82</td>
</tr>
<tr>
<td>Mustard</td>
<td>0</td>
</tr>
</tbody>
</table>

*Mean yield of crop obtained by respondent households in PKIS BPIS
Values in the parenthesis indicate the range in the crop yield.

Source: Household Survey 2012

Also, the farmers in PKIS were found more innovative in adopting high yielding crop varieties and use of chemical fertilizers while the farmers in BPIS were following the traditional cultivation practices for generations. Though the yield level of wheat was noted to be higher in PKIS than those obtained by the farmers in BPIS, the yield levels of wheat was noted to be stagnant over time probably because of traditional cultivation practices of the farmers. Simiarly, the yield level of monsoon maize was also found to be stagnant over time in PKIS while declining in BPIS. Monsoon maize is generally cultivated in the upland areas and year to year fluctuation in the crop yield is generally due to variation in the rainfall distribution in the crop growing season and occurrence of water stress at the time of flowering and grain filling of the crop. Increase in the yield of potato in winter and spring in PKIS has been the most noticeable change. In fact potato has emerged as important cash crop in this system with progressively increasing yield over time with the adoption of improved cultivation practices. Contrarily, the farmers in BPIS were found not growing potato due to deficiency of water in winter and spring.

**Changes in the Food Security Situation**

Changes in the food security situation has been another noticeable feature with the availability of irrigation. This has led to diversification of the cropping system and also increase in the productivity of crops with the availability of irrigation, thus improving the availability and distribution of food at the local level. The households included in survey in PKIS and BPIS were asked to indicate their perceived food security at different periods of time with the changes in the physical infrastructures and services in the two systems.
The perceived food security was asked to be indicated to three levels—food deficit, food sufficient and food surplus. A household was considered food deficit if production from own land was not sufficient to meet the year round food requirement and food sufficient if own production was sufficient to meet the year round food requirement without any marketable surplus. Similarly, a household producing marketable surplus was considered as food surplus household. The responses of the households to the perceived changes in the food security in the two systems over time is presented in Table- 6.

<table>
<thead>
<tr>
<th>Perceived Food Security Situation</th>
<th>PKIS</th>
<th>BPIS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Before</td>
<td>-10 Yr.</td>
</tr>
<tr>
<td>Food Deficit</td>
<td>30 (100)</td>
<td>17 (56.7)</td>
</tr>
<tr>
<td>Food Sufficient</td>
<td>0 (0)</td>
<td>13 (43.33)</td>
</tr>
<tr>
<td>Food Surplus</td>
<td>0 (0)</td>
<td>0 (0)</td>
</tr>
</tbody>
</table>

NA= Not Available
Values in the parenthesis indicate percentage of respondent households indicating stated level of perceived food security

Source: Household Survey, 2012

In PKIS, all the 30 households included in the survey perceived food deficiency prior to the development of the irrigation system. The food security situation was however perceived to have improved with the availability of irrigation in both the systems though the reduction in the food deficiency was noted to be higher in PKIS than in BPIS. The increase in the food sufficiency in the households can be accrued to increase in the yield of crops and diversification in the crop production that was found to have contributed to increase in the availability of food at the household level. Only small number of households revealed food surplus condition in both the systems. These are essentially large land holder whose production of the food crops was higher than the households' needs of food.

**Income of Households**

**Income from Farm and Off-Farm Sources**

Income from crop and livestock production and off-farm employment at the local level and within and outside the country were the important sources of income of the households in the command area of Palung Khola and Bhulke Pani Irrigation Systems. Income from crops and livestock production were accounted by estimating the gross income from the sale of crops and livestock on annual basis in each of the surveyed households in PKIS and BPIS. Similarly, the off-farm income coming to each household was accounted considering number of family members in off-farm employment within the country and outside, period of employment per annum and monthly wage/salary earned by them.
Distribution of average annual income from livestock in PKIS and BPIS is shown in Figure 3. The income from livestock is essentially from the sale of milk and live animals and sale of animal manure for use in the crop lands. The annual income from the livestock was found to range from Rs. 5,700 to Rs. 76,200 per annum in PKIS whereas income made from livestock was from Rs. 4,800 to Rs. 48,600 per annum in BPIS. The mean annual income of the households from livestock in PKIS was found to be Rs. 28,600 per annum while this was Rs. 22,190 in BPIS. Thus, the annual income from livestock was higher in PKIS than in BPIS.

The gross income made from crops and vegetable production was estimated from total value of crops produced upon deducting the cost involved in the production of different crops per unit of land area. The income made from all the crops grown by each household annually were added to find the annual income. The distribution of income from crop production among the households in PKIS and BPIS is shown in Figure 4. The annual income from crops and vegetable production across the surveyed households was found to range from Rs. 8,052 to Rs. 10,7440 in PKIS and Rs. 5,660 to Rs. 72,830 in BPIS. Average annual income from crops and vegetable production was estimated to be Rs. 39,620.66 in PKIS while this came out to be Rs. 24,434.66 in BPIS.
As stated earlier, jobs in the government offices and private organizations, foreign employment, pension, remittance and income made from small business/shops were major sources of off-farm income coming to the household in PKIS and BPIS. Income from all the off-farm sources in each household was added to arrive at the annual income of households from off-farm sources. The distribution of monthly income of the households from off-farm sources is presented in Figure 5. The annual off-farm income of the households was found ranging from Rs. 12,000 to 5,70,000 in PKIS and from 12,000 to Rs 6,36,000 in BPIS. The mean annual off-farm income of the household was estimated to be Rs.165,440 in PKIS and Rs.179,800 in BPIS.

On-farm and off-farm income in each household was added to arrive at the annual total income of households. The distribution of annual total income of the households is presented in Figure 6. The annual total income of the households was found ranging from Rs. 59,784 to Rs. 6,29,142 in PKIS and from Rs.70,349 to Rs.6,97,855 in BPIS.
The mean annual income of the household was estimated to be Rs.165,440 in PKIS and Rs.179,800 in BPIS. Considering mean households size of 5 persons in the rural areas of Nepal, this income would translate into per capita income of Rs. 33,088 in PKIS and Rs. 35,960 in BPIS. This income level in the two systems is comparable with the mean national household income of Rs. 1,71,950 and per capita income of Rs. 34,607 in the rural areas assessed by Nepal Living Standard Survey (CBS, 2011).

**Governance and Management of Practices**

**Palung Khola Irrigation System**

In PKIS, the access of the users to the use of irrigation, water mill and electricity was found to be decided by the contributions made by different groups of users in the development of the three services integrated into the system. The differential access of the user households to the multiple services in PKIS is provided in Table 6.

<table>
<thead>
<tr>
<th>Name(s) of the Village</th>
<th>No. of Households</th>
<th>Access</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dhusa and Tyan</td>
<td>34</td>
<td>Irrigation+ Electricity+ Water Mill</td>
<td>Prior appropriators</td>
</tr>
<tr>
<td>Wainakuna, Rithawat and Baralaba</td>
<td>36</td>
<td>Irrigation</td>
<td></td>
</tr>
<tr>
<td>Phoksing</td>
<td>48</td>
<td>Electricity</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>118</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: FGD, 2012

The 34 households from Dhusa and Tyan villages are prior appropriators of the irrigation system who also had invested in the development of hydropower and water mill, therefore the households from these two villages were found with the access to all of the three services. The 48 households from Phoksing have access to hydroelectricity only for their contribution in the development of micro-hydropower system. The decision to include electricity users from Phoksing, which is located on other side of Kaligandaki River in Parbat district, was made by the prior appropriators of Dhusa and Tyan villages only to a later date, after completion of construction of power generation unit, to be able to mobilize additional financial resource as their own financial resource was exhausted for the development and improvement of the transmission line. Similarly, 36 additional households from three other villages- Wainakuna, Rithawat and Baralaba, who have their land within the command area of the system but their houses are located away, have access to irrigation use only. These households though live outside the command boundary of the irrigation system, their lands are located within the command area of the system and they have been making cash and labor contribution in the maintenance and upkeep of the system. The existence of multiple water services and the differential access of the users to the services in the system makes the governance and management in PKIS complex.
The users in PKIS have created three independent but related organizations for the governance and operation and management of irrigation and hydropower system and distribution of electricity (Figure 7).

The WUA has employed a water guard on full time basis who is responsible to oversee the operation of the canal and other physical infrastructures on a day to day basis and distribute water to the users in different villages based on the schedule of water distribution. The users collect Rs. 3 per ropani of land per month to pay for the salary of the water guard. Earlier the farmers were mobilizing labor to carry out annual repair and maintenance by themselves but now the work of annual repair and maintenance is carried out by employing hired labors. The users mobilize Rs. 60 per ropani of land per annum which is used towards annual repair and maintenance of the system by hiring contract labors.

**Bhulke Pani Irrigation System**

There is no formal institutional arrangement in place for the governance and operation and management of the system in BPIS. Even though no formal governance arrangement in the system was found in place, the users of the system seem to have informal mechanism and arrangement for decision making relating to resource mobilization for regular and emergency repair and maintenance and water allocation among the users. The decision for annual canal maintenance was found to be made by the users collectively in a meeting convened at the beginning of monsoon season. The repair and maintenance of the system is carried out two times- at the beginning and end of monsoon. Repair and maintenance of the system carried out at the end of the monsoon keeps the system functional for irrigation in
the winter crops. Earlier all the user households used to mobilize compulsory labor to carry out regular and emergency repair and maintenance but due to increasing tendency among the user not to come at work on the scheduled date and difficulty in maintaining the records of the absentees at work, the users agreed to mobilize cash on the basis of landholding size and contract out the work of annual repair and maintenance. For allocation of water to the users a water guard is appointed in the system at the beginning of the monsoon season who is also responsible to monitor the canal from head to tail on a daily basis and to allocate water among the users on scheduled turn. The water guard also informs the users in the events of failure of the intake and canal breech and all the users mobilize labor in such emergency. For the services rendered, the water guard is paid 8 kg of raw paddy collected per ropani of land from among the users.

CONCLUSION

The findings of the study stated above lead to following conclusions:

i. The findings reveal that the MUS has incremental system productivity as has incremental system as supported by the fact that PKIS has on-farm (crops and livestock) average annual household income of Rs.68,220.66 more than that of BPIS Rs.46,624.66. Similarly, the average annual households expenditure is more in PKIS Rs.163369.8 as compared to BPIS Rs.1,48,769.8. Furthermore, annual resource mobilization to the system is also higher in PKIS Rs.1,16,840 than in BPIS Rs. 80,024.8.

ii. Inclusion of multiple water services in the irrigation system was found to have contributing effect on progressive intensification of cropping system and achieving higher level of crop productivity than in single use system. Intensification in the cropping system and increase in the crop yields in multiple use system was noted to be produced through more reliable irrigation services in the multiple use system. This conclusion is supported by noted increase in the cropping intensity to 257.83% in PKIS against only 134.13% in BPIS. Also, the yield levels of all major crops in PKIS were found higher than the yield levels of the crops obtained in BPIS. Similarly, the possibility of inclusion of high value crops like potato in the cropping system in PKIS was noted to have contributed significantly to increasing the on-farm income from production of crops. Opportunity of multiple cropping with the more reliable irrigation services in multiple water use system and increase in the productivity of the crops was found to have contributing effect on enhancing food security and decreasing the duration of food deficiency of the households at the local level.

iii. Installation of micro-hydro turbine in the existing irrigation canal in PKIS was noted to creating opportunity for electricity generation for distribution among the irrigation user households without significant investment needed towards development of physical infrastructures for electricity generation or harnessing of mechanical power for the operation of water mill. The diversification of water use in the multiple water use
was therefore noted to be possible with lower level of investment considering multiple services produced

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INTRODUCTION

Within canal irrigation systems, micro-irrigation will be feasible where the field application efficiency is very poor. Typical conditions of such systems are low discharge, porous soil and long length of field channel. Poor and marginal households are often bypassed by such irrigation development. Use of small upland water sources can contribute to improve water security in the upland hills. With the use of micro-irrigation technology, large areas of rainfed land can be made more productive. Crop intensification and diversification can be made possible. This, in turn, can improve livelihoods through increased food security, income and local employment. Micro-irrigation facilities are good solutions to equitable development of poor marginalized households. However, proper operation and management of the schemes are important. Viable community institutions with adequate capacity development through training programs are critical aspects for success and sustainability of micro-irrigation. In order to scale up of micro-irrigation systems, it is critical to develop smallholder commercial pockets. Other important conditions are to ensure sufficient volume of demand to establish local micro irrigation dealers/agents, input suppliers, and collection centers to link them to district and regional markets. It is also important to develop water governance and planning. They should include the multiple water use systems and encourage them to share and utilize water efficiently and profitably using micro-irrigation technologies.

* Deputy Director General, Department of Irrigation, Kathmandu, Nepal.
** Freelance Consultant
This paper attempts to present the methodology of Micro Irrigation (Drip Irrigation) Pilot Program implementation in Ripin Dhotar Irrigation System for cash crop cultivation in Sindhupalchowk district. With the introduction of this water conservation technology in the irrigation system, this will help livelihood enhancement of those marginal farmers. The preliminary result shows the increment of four fold income by adopting this technology as compared to the traditional rainfed agriculture system.

**Background**

Nepal is an agrarian country. More than 70% people are dependent on agriculture. It contributes 40% to the National Gross Domestic Product (GDP). Irrigation plays pivotal role in increasing agriculture production and productivity. Irrigation helps significantly reduce poverty as well.

Out of the total 2.64 million hectares of cultivated land in Nepal, only 1.76 million hectares are potentially irrigable, leaving almost 0.88 million hectares of land to rain-fed agriculture (Irrigation Master Plan, 1996). Much of these non-irrigable areas lie in the hills and mountains. Farmers in the hill and mountain regions are mostly poor with small landholdings farming marginal sloping terraces. Their land holdings are typically scattered patches without access of irrigation. The agriculture system of this region is predominantly rain-fed with high risk of erratic rainfall. On the one hand, there is abundant water in the large rivers but, on the other hand, it is not easily accessible for irrigation without pumping (Sharma, 1997) or by constructing a long but difficult to maintain gravity canals.

**Project Description**

**Location and Accessibility:**
The Department of Irrigation (DOI) has undertaken a pilot project with the objective to better utilize scarce irrigation water. The site, Ripin Dhotar Irrigation System, is located in the Ward no 3 of the Majhitar VDC, near Sipaghat of Sindhupalchowk district. From Sipaghat of Sindhupalchowk district, the site is connected by a seasonal earth road in the eastern bank of the Indrawati river.

**Irrigation System**

The headwork of the irrigation system is located at the border of Sipapokhar and Badegaun VDCs of Sindhupalchowk district. Water is diverted from RipeniKhola which is a perennial stream. This is a newly constructed irrigation system with a main canal length of 2.9km. Out of this, 1.4km has concrete lining. The irrigation system has the following physical components i) aqueduct-1, ii) crossings-6 iii) super-passage ~4, iv) syphon (90 m long)-1. The total irrigation command area is 40 ha. The command area is at Dhotar which consists of three clusters. There are 120 households owning land within the command area. The average elevation of the command area is 780 m from msl. The newly constructed surface irrigation can provide irrigation to only some parts of the command area.
The physical features of the command area:
Most part of the command area is a rolling slope facing towards south west direction. There are 6 small gullies across the command area. Farmers have cultivated rice in some parts near the gullies where there are small seasonal springs. The soil type is red soil. The farming system in the command area was rain-fed agriculture before the irrigation system. It is maize – millet cropping pattern.

Socio economic situations:
- **Food Sufficiency:** As mentioned above, there are 120 households in the command area of which 82 are majhi and the remaining 28 belong to other caste groups. Majhis, traditional fishermen, belong to a disadvantaged caste group from the socio-economic development aspect. Most of them are poor and marginal households having insufficient food availability for a year. Their land holdings are very small. The produce from their land is not sufficient for a year.

- **Occupation:** Many households depend on farming for livelihoods. For most households, the main income source is from wage labour in agriculture and construction works. Agriculture labour is a seasonal in nature. However, there is high demand of labourer in the nearby sand/ gravel mining throughout the year. About 20% households are involved in the fishing activities for income generation. Similarly, 30% households are out-migrated for employment in India and Gulf countries. Hence, remittance is also a major source of income for a number of households. Some households keep livestock. They sale the livestock and the milk for extra income at household level.

- **Education:** There is a Primary School within the Dhotar village where 120 students are enrolled. Nearest Secondary school is at Sipapokhar at about 1 hour walking distance from the village. The other nearest higher secondary school is at Phataksila VDC. The education level of the community is far below the national standard.

- **Health:** The nearest health post is located at Bhimtar at a distance of 3 km from the village. Many people in the village depend on the traditional healers like DhamiJhakri.

- **Water Supply**
The community has a reliable piped water supply system with 13 taps in the community. The supply is almost 24 hours except for dry season. The drinking water project was financed by Water Supply and Sanitation Fund Board, Nepal.

- **Local Institutions:** There are a number of community based institutions namely Indrawati Progressive Youth Club, Mothers Club, Community Forestry Users Group (CFUG) and RipeniDhotar Water Users Association. The Mothers Club is involved in small scale saving and credit activities.
where as the Youth Club conducts sports related activities. The CFUG is well functioning. It provides forest products to the users including 25 cft of timber for house construction upon the demand for Agriculture.

The irrigation system is newly constructed one. Before the irrigation system was constructed, agriculture system was largely traditional farming system which is totally dependent on the rainfall. In almost all part of the command area, maize is sown after rains in April/May. Before harvesting of maize, millet is intercropped along with maize in the month of July. At the same time blackgram is also sown in the same field. Maize is harvested in August / September and by January millet is also harvested. In this way two crops are grown between May till January. After harvesting millet, the land remains fallow till April when maize is sown. Some farmers also grow wheat and mustard in small piece of land. In the total command of 40 ha, two crops are grown in a year with a cropping intensity of 145%.

Although the land and climate is favourable for growing high value vegetable crops, irrigation has been the main constraint. Vegetable cultivation practice in the command area is of subsistence type. Some households have a small kitchen garden. They cultivate only rainy season vegetables for their home consumption. The common vegetables grown in the project area are Spinach, radish, beans, garlic etc. Often the beans are intercropped with maize. Fruit crops are very rare in the command area.

**Water Users Committee:**

Eleven member Water Users Association is formed for construction and management of Ripeni –Dhotar Irrigation system which is chaired by a woman member Champa Majhi. The Vice-Chairman and Treasurer are also from Majhi group. However, the secretary is from Brahmin group. The main committee has three sub-committees as i) construction monitoring sub-committees ii) agriculture sub-committee and iii) income generation sub-committee. They hold regular meetings on the 11th day of each Nepali Month.

It is found that the community had actively participated in the planning and construction of the irrigation system. On an average, every household contributed 40 days of labour during the construction of the project.

**After the Micro-irrigation project construction completion:**

The overall objectives of this project activities are to improve on-farm water management and agriculture practices. At this point, it is intended to establish water distribution network with use of pipes for developing a controlled irrigation system. Particularly, water from existing outlets of canal will be supplied in the water distribution tanks. A pipe network up to the field outlet is planned. There will be 7 inlet points at the existing canal from where water from the canal will be diverted into the distribution tanks. Valve chambers are
designed at strategic points to control and regulate the flow of water in the system. Water from the field outlet will be applied to the crops through the use of micro irrigation devices like – drip system, sprinkler, hose pipe or other methods to grow high value vegetables such as cabbage, bitter gourd, egg plant and others.

Cost Benefit Analysis of Cabbage at the market price (February, 2015) shows the net income of NRs 10860 per 1/20 of a hectare of land and Bitter guard shows the net income of NRs 17286 per 1/20 ha. in one season.

The farmers will also be encouraged to form Marketing Groups and Cooperatives. A small vegetable collection centre at the village will be supported from the project so that agriculture produces are collected and sold in the market. The project will also support to introduce small scale mechanized farm implements like mini power tiller. A strong social mobilization support will be provided to the farmers group to promote participation in all activities including training on collection of irrigation fee, and management of water distribution system. At the same time, intense technical support will be provided on production and marketing of high value vegetables along with the use of micro-irrigation systems.

The piped water distribution system is designed to deliver 1693440 litres of water per day at a total flow of 19.6 lps. This is approximately lean period discharge of the irrigation system. With the average water requirement of 1200 ltr per 1/20 ha per day for micro-irrigation which is about 288000 ltr will be required for the high value crops and the 1405440 litres will be used for other field crops and sufficient to irrigate more than 30 hectares.

Cost Benefit aspects of the project:

The total cost of the project is divided into two parts as Hardware and Software components. The Hardware component has also two sub-components as i) irrigation structures / equipment and ii) Agriculture structures / equipment. The software component includes training/capacity building of farmers and water users association and cost for consulting service to provide the essential services such as technical training, construction supervision, social development activities and proper management of the Water User Committee.

Costing of irrigation structures systems has been prepared on the basis of quantity calculations of standard drawings and rate analysis derived using the district approved basic rates. For the given case, rate of labours has been adopted from District approved rate of Sindhupalchowk district while rate of materials has been adopted from Kavre district approved rates for the current fiscal year. Appropriate transportation cost has been added from the market to the site. The details of cost estimate are presented in the separate section. Cost of the irrigation and agriculture equipment has been adopted from the market survey.

The overall cost of the project is estimated at Rs. 10529213.63 which includes VAT as well. For the demonstration phase, resource amounting Nrs.4580138.32. is allocated. As given
in the following table, the cost components include Irrigation, Agriculture, Training and service cost for consultant services as well.

Table: Cash Flow Analysis of the Project

A: Net Annual Benefit per 1/20 ha

<table>
<thead>
<tr>
<th>Present (Rs)</th>
<th>Future (Rs)</th>
<th>Difference (Rs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize &amp; Millet</td>
<td>Winter Veg</td>
<td>Spring Veg</td>
</tr>
<tr>
<td>3400</td>
<td>10860</td>
<td>17286</td>
</tr>
<tr>
<td>B: Net Annual Benefit during Demonstration phase</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crop</td>
<td>Area (1/20 ha)</td>
<td>Net Income /1/20 ha</td>
</tr>
<tr>
<td>Winter and Spring Vegetables</td>
<td>120</td>
<td>24746</td>
</tr>
<tr>
<td>B: Net Annual Benefit during Post-Demonstration phase</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crop</td>
<td>Area (1/20 ha.)</td>
<td>Net Income (1/20 ha)</td>
</tr>
<tr>
<td>Winter and Spring Vegetables</td>
<td>240</td>
<td>24746</td>
</tr>
</tbody>
</table>

Source: Field Survey, 2014

The Cash flow analysis for the first five years shows that the project has attractive return on investment with Benefit cost ratio of 1.84.

ENVIRONMENTAL CONSIDERATION:

The project does not have any negative environmental impact in the physical condition. WUA members will be provided training on the proper use of chemical pesticides. As the irrigation water will be supplied through pipes and micro-irrigation, chances of soil erosion will be negligible.

CONCLUSIONS:

The project is a new initiative for improving on farm water and crop productivity. It will significantly minimize the convenience losses in irrigation system thereby enabling to irrigate more area per unit of crop. It is easier to control water at different part of the command area due to pipe network and control system at different points of the field. The community is highly encouraged to participate in the project. They have provided their share of contribution. The households in the community are from disadvantaged groups (Majhi) and the project is intended to be social inclusive. Cultivation of the high value crop and its marketing will be fairly easy with some support for collection center management. As the water is supplied through pipes, there is no threat of soil erosion and water related environmental threats. Micro-irrigation systems are environment friendly technologies. Cost benefit analysis indicates that it has an attractive benefit cost ratio. The project investment cost can be recovered in less than 5 years. The project can be replicated in other part of the country in similar condition.
IMPACT OF CLIMATE CHANGE IN SMALL IRRIGATION SYSTEMS:
WATER MANAGEMENT STRATEGIES: A COMBAT AGAINST CLIMATE CHANGE ADVERSITIES

MD. ABDUL GHANI*

INTRODUCTION

Annual rainfall distribution pattern and surface water availability through 237 rivers of which 57 are from across the border, make a complex water environment in Bangladesh and affects life and properties of people. Excess water causes flooding almost every year sometime during June to September and damage standing crops and infrastructures. But due to water shortage, crop production during October to May is not possible without irrigation.

At present, Bangladesh has net cultivated area of about 8.3 million hectare and is to feed about 160 million people. Present population growth is about 1.5% and about 1% of agricultural land is going out of production due to other uses including infrastructure development. Population of the country is expected to rise to about 169 million by 2025 (Table 1). Therefore, sustainable increased agricultural production is essential for the country. About 90% of total food is rice and its bi-products, which provides about 55% of total protein intake. Rice production needs adequate supply and management of water for optimum production.

The National Water Policy acknowledges that Bangladesh, as the lower riparian, has limited control over the rivers entering its borders, thereby will have to depend mostly on

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* Irrigation and Water Management Specialist and Independent Consultant, House 8/A/3, Road 13, Dhanmondi, Dhaka 1209, Bangladesh. E-mail: ghani.abdul.m@gmail.com
groundwater for its agricultural production and household water supply. With ground and surface water irrigation systems, the country is irrigating about 5.4 million ha (Mha) against irrigation potential of 76% (Table 2) of which about 79% is irrigated with groundwater. Moreover, the country will have to provide adequate water for household uses during dry season also using groundwater. Water conservation especially in smaller rivers, canals, and low-lying areas (beels) can improve water availability in dry season.

The unfortunate scenario is that during the dry months, groundwater level goes down in many places beyond suction limit (>8m), arsenic contamination causes quality deterioration and crosses safe limit (>0.05 ppm), coastal salinity affects about 25% people of the country living in coastal area for their livelihood and safe drinking water and surface water sources especially smaller rivers, and low lying areas (beels) become dry. Therefore, conservation of excess water receives during monsoon and its efficient use during dry season is an option for the country for increasing irrigation area. Conservation of water in the rivers, haors, beels, low lying areas and ponds will assist in increasing irrigated crop production and will extend periods for groundwater recharge, which will further assist in reducing possibility of arsenic contamination and salinity problems.

Climate change may result to sea-level rise of 4.5 to 23 cm in 2025 and 6.5 to 44 cm by 2050 (Bangladesh Climate Change Strategy and Action Plan, 2008). It may also influence to increase in crop water requirement by 25% by 2025. Rainfall in peak monsoon may be about 28.6% higher by 2050. This may increase flood problem and drainage requirements. Extent of drought will also be higher. These issues will be affected more by climate change. Engineering community especially agricultural engineers should be equipped to face all the adverse situations and save the nation through appropriate adaptation to the changes and mitigation of anticipated problems.

**Impact of Climate Change**

The climate change is likely to increase sea level rise. Though the offshore islands will adjust to the rising sea level by sedimentation at higher level; but the inland estuarine area, which do not get sufficient sediment will suffer from submergence to greater depth covering larger area. The effects of climate change are depicted in the Figure given below.
Crop grown in any area mainly depends on the soil, water and climatic factors of that area. Climatic change situation may influence the land and crop productivity and resources use pattern.

**Measures against Climate Change:** Global climate change will certainly affect Bangladesh and the country is already facing its consequences. Though Bangladesh is a very insignificant contributor to the causes for global climate change, but is probably the worst sufferer due to its global position. The probable impacts based on some common indicators are given below:

- Increased temperature
- Increased evaporation
- Lower dry season rainfall
- Increased soil salinity
- Higher monsoon rainfall
- Increased intensity of storms including cyclones
- Increased sea level rise

The extent of changes (increase) in Bangladesh in 2025 and 2050 compared to 2000 respectively may be; rainfall 4.6% and 10.9%, ETo 2.1% and 5.7% and excess/deficit of rainfall – ETo 9.8% and 21.8%. Unit for all components are in mm (National Water...
Management Plan, OECD, Annex H, Page 29). Water logged area of the country will suffer most, therefore, Barisal and Sylhet Division will be among the victims and needs mechanism to face consequences of global climate change. Fortunately, the policy makers of the country are making this issue known to the international community and have been able to draw their attention to the causes of Bangladesh.

Management Alternatives

The country receives about 90% of the surface water resources during June to October through rainfall and river flows, most of which flows to the Bay of Bengal. With management alternatives, part of it can be retained in crop fields (especially rice), rivers, canals and low areas and can be effectively used for agricultural (crop and fish production) and non-agricultural purposes during the lean period. Through conjunctive use of ground and surface water, about 76% of the cultivable area can be irrigated (MPO 1991 and WARPO 2000), of which about 64% (Table 3) are presently under irrigation (MOA 2013).

Rainfall distribution pattern indicates that water requirement for most crops can be met from rainfall only during May to September, since monthly rainfall during these months on an average is more than 200 mm. Therefore, sustainable crop production can only be expected with rainfall only during these months and irrigation is essential during other seven months of the year. Conservation of rainfall will contribute to reduce irrigation requirement for Aman and dry season non-rice (Rabi) crops. Therefore, conjunctive use of water in Bangladesh context will be combined use if rain, surface and ground water. Conjunctive use of water resources and their improved management may be a strategy for mitigating adverse effects of climate change.

Climate and Climate Change in Bangladesh

The earth’s climate always varies naturally. In the past cooler cycles due to variations in the earth’s orbit round the sun, sunspot activity or volcanic eruptions altered the climate. However, large changes have been very gradual over longer time periods. What is new now is that due to pollution from industrial processes and wasteful lifestyles of inhabitants directly influencing the climate of the earth. Human influence is now believed to be changing the climate much faster than occurring in the past under natural processes. The phenomenon which is causing this faster climate change is identified as ‘Greenhouse Effect’.

The Greenhouse Effect is a natural process through which various gasses and water vapour in the atmosphere affects the earth’s climate. It is so named because it acts like a glass greenhouse for plants by preventing the incoming heat from the sun from leaving causing warming of the earth just as the inside of a greenhouse warms. The earth’s climate is driven by this continuous flow of energy from the sun, mainly in the form of visible light. About 30% is immediately scattered back into space, but most of the remaining 70% passes down
through the atmosphere to warm the earth’s surface. Being much cooler than the sun, the earth does not give out energy as visible light. Instead, it emits heat in the form of infrared or thermal radiation. Greenhouse gases (GHG) in the atmosphere block this infrared radiation from escaping directly from the surface to space that cause global warming and rapid climate change of present state (Williams, 2002).

The global emission of greenhouse gases during year 2000 is shown in Figure 1. It is evident that the majority of the global greenhouse gases are contributed through energy emissions, while the remainder is related to land use either for crop production or other activities.

![Figure 1: Greenhouse Gasses emitted in 2000, by source (Stern, 2006) -- Adapted from Alam and Ghani, 2013.](image)

Although global emissions of GHG from agriculture is comparatively small but it directly releases into the atmosphere a significant amount of carbon dioxide (CO₂), methane (CH₄) and nitrous oxide (N₂O), amounting to around 14% or 6.8 Gt CO₂-eq/yr of global anthropogenic greenhouse gas emissions annually (FAO, 2009). Total greenhouse gas emissions from agriculture are expected to increase, reaching 8.3 Gt of CO₂ eq/yr in 2030 (Smith et al., 2007).

The climate of Bangladesh is influenced by monsoon and characterized by high temperature, heavy rainfall, often-excessive humidity and marked seasonal variations. The Himalayan mountain chain is such as to make the climate more or less tropical throughout the year. The climate is controlled primarily by summer and winter winds, and partly by pre-monsoon (March to May) and post-monsoon (late October to November) circulation. The southwest monsoon originates over the Indian Ocean, and carries warm, moist and unstable air. The easterly Trade winds are also warm, but relatively drier. The northeast monsoon comes from the Siberian desert, retaining most of its pristine cold, and blows over the country, usually in gusts, during dry winter months.
Bangladesh is already vulnerable to many climate change related extreme events and natural disasters. It is expected that climate change will bring changes in characteristics of natural hazards and gradual changes phenomenon of the physical system. Studies and assessments of impacts, vulnerabilities and adaptation to climate change and sea level rise for Bangladesh clearly demonstrates that Bangladesh is one of the most climate vulnerable countries in the world and the intensity and frequency of occurrences of salinity, cyclones, drought, irregular rainfall, high temperature, floods and flash floods have been accelerated due to climate change.

Impact of Sea Level Rise on Crop Production

Sea level rise affects agriculture in three ways, i.e., by salinity intrusion, by flooding and increasing cyclone frequency and its depth of damage. Combine effects of these three factors decrease agriculture production in the coastal zone. Salinity intrusion due to sea level rise will decrease agricultural production by unavailability of fresh water and soil degradation.

The rise of sea level up to 1 meter, normal flood waves can be expected to increase from presently 7.4 meters to 9.1 meters, and about 15-17 million people will be displaced from 12-16% inundation land area of Bangladesh (World Bank, 2000). Another study predicted that for a sea level rise of 1.5 m about 22,000 sq. km area and 17 million people will be affected in the coastal region of Bangladesh (Fig. 3).

![Image of potential impact of sea level rise on Bangladesh]

Figure 3: Potential impact of sea level rise in Bangladesh -- Adapted from Alam and Ghani, 2013.

Mitigating Climate Change Affects

Mitigation of climate change refers to efforts to reduce greenhouse gas emissions. Mitigation may also refer to efforts to capture greenhouse gases through certain kinds of
land use and soil management. This will reduce global warming, as the greenhouse layer in the atmosphere will not be so thick and its warming, blanket-like effect will be lessened. Mitigation also includes measures to reduce affects of climate change through management practices.

Conservation tillage and other farmland practices including land management and vegetation that can reduce GHG emissions and sequester carbon may be adopted:

- **Land conversion and restoration**—conversion or restoration to grasslands, wetlands; and selected structural barriers, such as vegetative and riparian buffers, setbacks, windbreaks;
- **Cropland tillage practices**—reduced/medium-tillage, no-tillage or zero tillage, ridge or strip-tillage;
- **Soil management and conservation**—soil supplements or amendments, soil erosion controls; precision agriculture practices, recognized best management practices;
- **Cropping techniques**—crop rotations, cover cropping, efficient fertilizer and nutrient (including manure) and chemical application;
- **Manure and feed management**—improved manure storage (e.g., anaerobic digestion, methane recovery); and improved feed efficiency, dietary supplements;
- **Grazing management**—rotational grazing, improved forage practices;
- **Bio-energy and bio-fuels substitution**—on-farm use, replacing fossil fuels or deriving bio-energy from land-based feed-stocks, renewable energy; and
- **Energy efficiency and energy conservation**— More efficient use of energy means less consumption of fuel and oil, which will reduce emission of GHG and conservation of fuel and oil.

- **Plantation on embankment and canals slopes, riverbanks, railway tracks, roadsides and fallow lands.** This is very important for Bangladesh as the land resources can be effectively used for additional income generation and for mitigating adversities of climate change but without affecting primary objectives of the infrastructures built or developed. This will also assist in developing income generating activities for poor and landless people and contribute to livelihood improvement.

Conservation practices related to soil, water and environment are almost non-existence in Bangladesh. However, in recent time, climate change affects are becoming visible and significant shadows are engulfing agricultural production activities and yield attributes. Therefore, few conservation activities in agricultural crop production have been initiated and these are delineated.

Attempts should be made to emphasize on how water environment of the country can be managed to make positive influence on health, food availability and intake of nutrients and mitigate negative impact on these issues. It has been proved that “With altered rainfall patterns and extreme weather events causing agricultural productivity losses”. With irrigation and improved water management the extreme weather events can be minimized.
Climate change has further aggravated water environment of the country as Bangladesh is particularly vulnerable to climate change. Two-thirds of the country is less than 5 meters above sea level, making it one of the most flood prone countries in the world. Severe flooding during a monsoon causes significant damage to crops and property, with severe adverse impacts on rural livelihoods. Climate change seems likely to increase the destruction by monsoon floods, while the frequency of cyclones may increase. The poor are hit hardest because they live at greater density in the most poorly constructed housing in settlements on lands prone to hazards.

Two areas within Bangladesh stand out as being particularly at risk to climate change, which are coastal belt and Haor area. Although continued supplies of river sedimentation may limit land loss resulting from sea level rise, drainage problems will increase where protection schemes exist. Salinity levels are likely to rise in Delta Rivers in the dry season, mainly due to increased upstream abstraction of water. Upstream flow during rainy season aggravates flood problem in the Haor area.

Climate change may result to sea-level rise that will increase flood problem and drainage requirements. Extent of drought will also be higher. These are water management related issues to be affected more by climate change. Therefore, the community should be equipped to face all the adverse situations and save the nation through appropriate adaptation to the changes and mitigation of anticipated problems.

**Engineering Solutions to Water Management Problems resulting from Climate Change**

Conservation of excess water received during rainy season and effective use of rainwater and infrastructures developed so far can play important role in improving water availability in dry season if comprehensive use of the facilities are ensured. Improved management at local and national levels through government and social interventions can ensure water availability for irrigation and other uses. With management alternatives, part of rainfall and surface water can be retained in crop fields (especially rice), rivers, canals and low areas and can be effectively used for agricultural (crop and fish production) and non-agricultural purposes during the lean period.

Water sector of Bangladesh is highly criticized for poor maintenance of large scale FCDI facilities. Both FCDI projects and tubewells are operating at about 50% of efficiency level (Table 4). However, FCDI and minor irrigation projects are making significant contribution to keep space with increasing population and the country is almost self-sufficient in food grains. If efficiencies of existing irrigation systems are increased by 25% that can meet anticipated additional 25% of water requirement due to climate change.

Conjunctive use of rain, surface and ground water resources will assist to expand irrigation facilities for increasing green coverage during the year, which in return will minimize extent
of damages due to climate change. Water bodies will also minimize consequences of climate change by serving as a buffer.

Water availability conditions and volume of water that may be used for surface water irrigation may be estimated by water diversion and from rivers flowing through the area. Rivers especially smaller rivers varying in width of 25 to 100 meters can be compartmentalized to series of seasonal ponds during November to May through appropriate water conservation structures like weirs and rubber dams. Water conserved may be used for dry season irrigation. Community based fisheries management system can be introduced in the seasonal ponds following “Common Property Resource Management” procedure of the country. Fisheries experts confirmed that these seasonal ponds could be brought under profitable fish cultivation program through stakeholder participation and on an average 2.0 tons fish can be harvested per hectare of water body. Moreover, water stored in the seasonal ponds/riverbeds will be a continuous source for groundwater recharge, which subsequently can be used for irrigation using deep and shallow tubewells without severe lowering of groundwater table.

**Plantation on Embankment Slopes, Canal Banks and Public Lands**

For protecting lives and properties of the people, BWDB has created FCDI facilities for about 6.0 million-hectare (Mha) against potential requirement of 5.76 Mha. During infrastructure development for providing FCDI facilities, BWDB has constructed about 10500 km of embankments of which 4500 km are in the coastal area and 6000 km are in the non-coastal area. BWDB has also created water bodies through construction of about 5200 km irrigation canals, 4200 km drainage channels, barrages and river closures. These infrastructures are mostly used for saving lives and properties of people and creating favorable environment for increasing agricultural production. The embankment slopes and canal banks can support plantation of 40 million trees. Similarly river banks, roadsides and railway tracks can also support plantation programs which will help in mitigation of adverse affects of climate change (Peru Climate Change Conference 2014). Plantation along sea facing embankments will serve as barriers to adverse conditions including sea level rise and as wind barrier. Plantation programs can also contribute to income generating activities leading to increasing income of poor people and to their improved livelihood.

**Change Water Use Pattern Especially for Rice Cultivation**

In Bangladesh, irrigated agriculture means rice cultivation. Diversification of crops under irrigated conditions may make agriculture more profitable and may also reduce pressure on irrigation facilities. Wheat and other non-rice crops require much less irrigation water compared to rice irrigation and are becoming popular. But market variability of price for other crops still discourages cultivation of non-rice crops. Marketing system development
for non-rice crops will require administrative supports from the government for facilitating market chain development for domestic and export markets. Irrigation management for rice cultivation should be revisited as alternate wetting and drying that brings about 25% additional areas under cultivation without significant yield reduction with same amount of water delivery against traditional irrigation (continuous standing water). This will make irrigation systems cost effective. “Long years of research have shown that AWD could reduce methane emissions by 30–50%. It also presents other benefits, such as reduced water use and production cost and improved rice yields”.

Irrigation or water resources development of the country should be different for different agro-ecological regions. The national development plan should be to maximize utilization of rainfall, surface and ground water through conjunctive use of these resources. Comprehensive studies should be undertaken involving stakeholders, government and non-government organizations (NGOs) working with agriculture, soil and water based development programs for developing and implementing local level production plan. A comprehensive study on water management coordinated by Bangladesh Agricultural Research Council (BARC) indicate that improvements are possible for increasing annual crop production, increasing irrigation/water use efficiency and improving livelihood of farmers. It also identified techniques for mitigating consequences of climate change, which may be adopted country wide.

Low water demanding crops during dry season may be cultivated for minimizing irrigation cost during dry season in highly permeable areas. Low water demanding crops like wheat, pulses may be cultivated in place of high water demanding crops like Boro (rice) if the economic return and farmers demands permit. Research supports from national agricultural technology project (NATP) has proved this hypothesis effective through several research out puts.

**Renewable Energy Options for Reducing GHG**

Lifting of irrigation water requires substantial energy in rice crop production and cost of production is about 25% of the total production cost. Among all water lifting equipment only 13% is electrically operated and the rest is operated by engines using diesel. The power units are stationary in nature, therefore, can be operated by universal renewable energy sources like sunshine. Now a day, solar panels are used for powering up to 9 KW motors for lifting irrigation water in different locations of Bangladesh. Various private companies and Non-government Organizations (NGOs) are promoting solar powered irrigation pump system in the country. The system can be promoted to major irrigation systems to reduce the GHG emissions in agricultural production systems. Solar power system can also be promoted to other stationary agricultural activities.
Precision Agriculture Options for Reducing GHG

Precision agriculture or site-specific management refers to the differential application of inputs to cropping systems or tillage operations across a management unit (field). Input applications may vary either spatially or temporally within management units. The methods involved include application via predefined maps based on soil or crop condition or sensors that control application as machinery traverses the field (Jerry L. Hatfield, 2000). The system incorporates several technological tools including global positioning system (GPS), geographical information system (GIS), yield monitor, variable rate technology, and remote sensing. The technology based crop production activities ensure precise variable rate of application of inputs like irrigation, seed, fertilizer, insecticides and pesticides, thereby reduce the GHG emissions to the atmosphere. Future agricultural production activities must include the precision agriculture options for optimum application of inputs and reduce GHG emissions.

What is Required to Mitigate Affects of Climate Change

Mitigation measures suggested above will require coordinated efforts for improved water management, use of mechanical power in agriculture at different stages of crop production including intercultural operation, post harvest technology, processing and improved storage. This will also ensure favorable returns to the farmers. Cost of production of major crops is high in Bangladesh. Power use in agriculture is low compared to even neighbouring countries that also contributes to high cost of production. Therefore, efficient use of irrigation water and facilities, use of machine for agricultural operation and saving/minimizing post harvest losses are required to make agriculture cost effective in Bangladesh. Mitigation measures suggested in this paper to minimize affects of climate change will also require coordinated efforts.

Recommendations

The following programs for conservation and management practices are recommended for mitigation of climate change affects in Bangladesh:

<table>
<thead>
<tr>
<th>Conservation practices</th>
<th>General benefits</th>
<th>Benefits for climate change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conservation tillage and reduced field pas</td>
<td>Improves soil/water/air quality; Reduces soil erosion/fuel use</td>
<td>Sequestration, emission reduction</td>
</tr>
<tr>
<td>Effluent nutrient (nitrogen)</td>
<td>Improves water quality; Saves expenses, time, and labor</td>
<td>Sequestration, emission reduction</td>
</tr>
<tr>
<td>Improved soil management and soil erosion</td>
<td>Improves soil/water/air quality</td>
<td>Sequestration, emission reduction</td>
</tr>
</tbody>
</table>
Water conservation (e.g., rain water harvesting, water reservoir) | Improves water availability/water environment/irrigation coverage | Emission reduction
---|---|---
Manure management (e.g., storage/containment, anaerobic digestion and methane recovery) | Improves soil/water/air quality; On-farm fuel cost savings; Alternative income source; Nutrients for crops | Emission reduction
Energy efficiency/conservation | Improves soil/water/air quality; Cost-savings | Emission reduction
Bio-fuel substitution and renewable energy use | Improves soil/water/air quality; On-farm fuel cost savings; Alternative income source | Emission reduction
Precision agriculture practices | Reduce inputs/cost savings | Emission reduction
Energy and climate policy options | Improves soil/water/air quality; Cost-savings | Emission reduction
Enhance tree plantation on public lands and embankment, canal and river banks and slopes | Green belt will be developed which will absorb CO2 and create IGAs. | Absorb CO2, emission reduction and healthy green belt. In addition increase income of poor community.

### Tables

**Table 1: Projected Population and Availability of Net Cultivable Area for the Year 2000-2025.**

<table>
<thead>
<tr>
<th>Year</th>
<th>Population Growth Rate (%)</th>
<th>Population (Million)</th>
<th>Available Net Cultivated Area (Million Ha)</th>
<th>Per Capita Cultivated Area (Ha)</th>
<th>No. of People Per Ha of Net Cultivated Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>1.48</td>
<td>127.22</td>
<td>8.42</td>
<td>0.066</td>
<td>15</td>
</tr>
<tr>
<td>2001</td>
<td>1.33</td>
<td>129.25</td>
<td>8.29</td>
<td>0.066</td>
<td>15</td>
</tr>
<tr>
<td>2005</td>
<td>1.16</td>
<td>136.57</td>
<td>8.19</td>
<td>0.065</td>
<td>16</td>
</tr>
<tr>
<td>2010</td>
<td>1.07</td>
<td>145.08</td>
<td>8.09</td>
<td>0.061</td>
<td>18</td>
</tr>
<tr>
<td>2015</td>
<td>0.99</td>
<td>153.22</td>
<td>7.99</td>
<td>0.056</td>
<td>19</td>
</tr>
<tr>
<td>2020</td>
<td>0.90</td>
<td>161.25</td>
<td>7.99</td>
<td>0.053</td>
<td>20</td>
</tr>
<tr>
<td>2025</td>
<td>0.90</td>
<td>168.96</td>
<td>7.89</td>
<td>0.047</td>
<td>22</td>
</tr>
</tbody>
</table>


Population in 2001 is the actual population as per Census Data of 2001 (BBS, 2001)
Population growth rate is adjusted from estimated growth rate published by the World Bank.

### Table 2: Present and Projected Regional Distribution of Net Cultivated Area (NCA) and
Irrigated Area. In Million Hectares (Mha)

<table>
<thead>
<tr>
<th>Region</th>
<th>Total Area (Mha)</th>
<th>1994 NCA (Mha)</th>
<th>2025 NCA (Mha)</th>
<th>Irrigated Area*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2000</td>
</tr>
<tr>
<td></td>
<td>Area (Mha) %</td>
<td>Area %</td>
<td>Area %</td>
<td>Area %</td>
</tr>
<tr>
<td>NE</td>
<td>2.01</td>
<td>1.16</td>
<td>1.14</td>
<td>0.48 41</td>
</tr>
<tr>
<td>NC</td>
<td>1.60</td>
<td>1.06</td>
<td>0.99</td>
<td>0.55 52</td>
</tr>
<tr>
<td>NW</td>
<td>3.16</td>
<td>2.30</td>
<td>2.23</td>
<td>1.47 64</td>
</tr>
<tr>
<td>SW</td>
<td>2.43</td>
<td>1.28</td>
<td>1.24</td>
<td>0.59 46</td>
</tr>
<tr>
<td>SC</td>
<td>1.25</td>
<td>0.82</td>
<td>0.80</td>
<td>0.12 15</td>
</tr>
<tr>
<td>SE</td>
<td>1.01</td>
<td>0.68</td>
<td>0.65</td>
<td>0.32 48</td>
</tr>
<tr>
<td>RE</td>
<td>0.59</td>
<td>0.33</td>
<td>0.31</td>
<td>0.13 37</td>
</tr>
<tr>
<td>EH</td>
<td>1.93</td>
<td>0.34</td>
<td>0.33</td>
<td>0.11 33</td>
</tr>
<tr>
<td>TOTAL</td>
<td>13.98</td>
<td>7.97</td>
<td>7.69</td>
<td>3.77 47</td>
</tr>
</tbody>
</table>

**Note:** Total irrigated area as of 2012-2013 is 5.4 million ha (MOA), but distribution by Region is not elaborated.

* Irrigated area is estimated based on water availability during November to May period of the respective time.

NE=Northeast, NC=North Central, NW=Northwest, SW=Southwest, SC=South Central, SE=Southeast, RE=Rivers and Estuaries, EH=Eastern Hills.

**Source:** Water Resources Planning Organization (WARPO), June 2000. Technical Paper No. 7: Land and Water Resources, WARPO could not update it as there is no funding support for such work (personal communication with WARPO management).

**Suggestion:** DAE may be requested to generate such information for 15 Regions. Agricultural Engineers in DAE can do this.

Table 3: Trends in Irrigated Area in Bangladesh in Last Ten Years by Irrigation Technology in Thousand Hectares

<table>
<thead>
<tr>
<th>Season</th>
<th>STW</th>
<th>DTW</th>
<th>LLP</th>
<th>Traditional</th>
<th>Major Canal</th>
<th>Total</th>
<th>% Increase over last year</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001-02</td>
<td>2561</td>
<td>659</td>
<td>722</td>
<td>346</td>
<td>158</td>
<td>4446</td>
<td></td>
</tr>
<tr>
<td>2002-03</td>
<td>2355</td>
<td>530</td>
<td>629</td>
<td>302</td>
<td>700</td>
<td>4516</td>
<td>1.57</td>
</tr>
<tr>
<td>2003-04</td>
<td>2409</td>
<td>588</td>
<td>664</td>
<td>356</td>
<td>583</td>
<td>4600</td>
<td>1.86</td>
</tr>
<tr>
<td>2004-05</td>
<td>3160</td>
<td>654</td>
<td>838</td>
<td>26</td>
<td>109</td>
<td>4787</td>
<td>4.07</td>
</tr>
<tr>
<td>2005-06</td>
<td>3121</td>
<td>701</td>
<td>803</td>
<td>28</td>
<td>107</td>
<td>4760</td>
<td>-0.56</td>
</tr>
<tr>
<td>2006-07</td>
<td>3196</td>
<td>725</td>
<td>810</td>
<td>14</td>
<td>137</td>
<td>4882</td>
<td>2.56</td>
</tr>
</tbody>
</table>
Table 4: Status of Irrigation Coverage per unit of equipment during 1982-03 to 2012-13

<table>
<thead>
<tr>
<th>Reporting Period</th>
<th>Area Irrigated in Terminal Year (000 ha)</th>
<th>Average Coverage per Equipment (ha) for Reporting Period</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DTW</td>
<td>STW</td>
</tr>
<tr>
<td>1982-03 to 1989-90</td>
<td>384</td>
<td>1037</td>
</tr>
<tr>
<td>2000-01 to 2008-09</td>
<td>790</td>
<td>3245</td>
</tr>
<tr>
<td>2008-2009</td>
<td>790</td>
<td>3245</td>
</tr>
<tr>
<td>2009-10</td>
<td>773</td>
<td>3337</td>
</tr>
<tr>
<td>2010-11</td>
<td>719</td>
<td>3505</td>
</tr>
<tr>
<td>2011-12</td>
<td>759</td>
<td>3418</td>
</tr>
<tr>
<td>2012-13</td>
<td>934</td>
<td>3242</td>
</tr>
<tr>
<td>Expected Coverage</td>
<td>40</td>
<td>5</td>
</tr>
</tbody>
</table>

Note: Number of STW, DTW and LLPs operated during 2012-13 were 1523609, 35322 and 170569 respectively (MOA 2013).

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Impact of Climate Change to Farmers of Small Scale Irrigation Systems in Chiang Mai, Northern Thailand

Juthathip Chalermphol* Ganesh P. Shivakoti** Ram C Bastakoti***
And Nathitakarn Pinthukas****

Introduction

Thailand is the one country of Asia where the majority rural people is in agricultural occupation. Cultivation is main earning but the average income of farmers is nearly nine times lower than industry employees. However, agriculture has been generally accepted as the most economically important and made significant contributions in the country (Somsak, 2011). The small farms provide the majority of country’s agriculture products and a large proportion of these rely on irrigation system. Small-scale irrigation is playing a main role in adapting to climate change, achieving food security, and improving household incomes. Furthermore, agriculture is extremely exposed to climate change, as farming activities directly rely on climatic conditions.

Frequently unknown climate change increases the risk of agriculture, more attention has been paid to agricultural system itself in the research field, but few has been attached to the perspective of social dimension. Based on the research on Yangtze River Basin of China, the paper has adopted vulnerability theory including the exposure of agricultural

* Faculty of Agriculture, Chiang Mai University, Thailand
** Visiting Faculty, Arizona State University
*** Researcher, International Water Management Institute, Nepal
**** Asian Development Institute for Community Economy and Technology, Chiang Mai Rajabhat University, Thailand
ecosystem, farmers’ sensitivity to exposure and adaptive capacity to climate risk, to explain farmer’s adaptation to climate risk. It concludes that climate change has increased climate risk in agriculture and the uncertainty of agricultural production. Confronting climate risk in agriculture, different farming bodies have shown different farm and off-farm/non-farm adaptations in pre-risk, during risk and post-risk, which has reduced their short-term vulnerability. Household life cycle, pressure, institution, available resources and technologies are the key influential factors. From the adaptation in long term, it still requires external support and more investment including agricultural insurance system, village-level information and technology dissemination mechanism (Li and Rabina, 2010).

Climate change influences several environmental aspects, including specifically related to agricultural water resources. In different areas, changes in rainfall and hydrologic patterns due to climate change can increase the occurrences of reservoir water shortages and affect the future availability of agricultural water resources differently. Considering the impact of climate change on reservoirs in relation to the passage of time is an important component of water resource management and the maintenance of a stable water supply (Won-Ho Nam, Jin-Yong Choi and Eun-Mi Hong, 2015) More efficient and sustainable use of water is more and more becoming urgency. In particular, water supply is expected to become more uncertain because of climate change (Francisco Alcon et al., 2014). Study on impact of climate change to farmers of small scale irrigation systems have been an essential process for preparing farmer adaptation.

Research Objectives
In this research we will look on the small scale irrigation system maintain and various aspects of related to the impact of climate change to farmers of small scale irrigation systems in northern Thailand. The proposed research will try to address the following objectives:

• To study major source of water used for irrigation and analyze the changes in water reliability in the irrigation system
• To study irrigation infrastructure maintained of small scale irrigation system
• To investigate farmers’ opinions of the level of threat to their livelihood include some aspects related to the impact of climate change

Research Plan and Methods
This study focused on farmers of small scale irrigation systems in Chiang Mai, northern Thailand. It is based on 30 irrigation systems that were divided into two types of research site: adjoining district to the Chiang Mai city and high land area.
The information was collected from both primary and secondary sources. The secondary sources presented documents from province irrigation office and district agriculture offices. Secondary sources basically provided information on irrigation system, committee and members.

The primary information came from the head of 30 communities and committees of small scale irrigation systems of the selected areas. The primary information collected included water reliability, irrigation infrastructure maintained and level of threat to their livelihood. In addition, in each study areas some local agents were interviewed.

The methodology would be designed as per standard of qualitative and quantitative research that included the formulation of a structured questionnaire and interviewing the subjects by visiting the identified sites and also group participant discussion which the most key informants were questioned in the open participatory discussion.

In terms of climate change impact, the data were gathered from interview and analyzed by using five point rating scale method to classify level of threat to farmers’ livelihood from very low to very high level. This method was also used to consider the changes in water reliability in different seasons.

Results
From the study, the major source of water used for all 30 irrigation systems is surface water. This referred to both the head works of the systems and other sources from which water is made available for irrigation. When surface water is the primary source, most type of surface water is river. There were 2 irrigation systems that had the dam for other storage facilities at irrigation system level that can control the flow of units in the production, distribution and appropriation resources for the benefit of all users.

For clarifying water reliability in different seasons during last 10 years, the majority thought the reliability of water supply in the irrigation system was highly reliable in monsoon. It was unreliable in summer or hot season. At this stage, the situation of water availability at the tail end of most systems (94%) was scarce.

Interviewed farmers reported that they provided the maintenance and repair about two times in a year. They thought that 1-2 times dredging yearly was need for system. But, interestingly, the most labors (90%) used for maintenance and repair of irrigation systems were paid or contributed by voluntary farmers and members of irrigation systems.
In this study, all participants were asked to provide opinions on the level of threat to their livelihood on a scale of 1 to 5 which were meant very low, low, medium, high and very high. The topics of selected threat were changes in weather patterns, changes in government regulations and subsidies, big jumps up and down in the prices of inputs, strong changes in product prices, migration of rural people (labor) to cities for new economic opportunities, decay of irrigation infrastructure and natural disasters that could bring flooding. The study showed that, most of them stated that the important threats of their livelihood were big jumps up and down in the prices of inputs they have to buy for farming such as fertilizers, pesticides, seeds or fuels and strong changes in product prices. In addition, the low levels of threats were the migration of labor and changes in government regulations and subsidies.

**Discussion and conclusions**

All head of 30 communities and small scale irrigation systems expressed that there have been many changes in water reliability during last 10 years. The water supply in the irrigation system is fluctuating in different seasons. It is discovered that the critical period for water supply is during April and May through comparing the monthly irrigation water requirement with water availability. Though the annual water resources are much larger than the requirement, but there is severe physical water shortage during the critical water use period in April and May. The water resource supply is estimated to be facing more difficulties in near future (Yanjun Shen et al., 2013).

There is not much difference in involvement of irrigation infrastructure maintained. The study also illustrated that the labor used for maintenance and repair of the irrigation system should be contributed or paid more by a government agency. Similarly, the study about government supporting in North China showed that when faced with a more severe drought, farmers change their management practices to mitigate its effects by changing seeding or harvesting dates and enhancing irrigation intensity. The provisions of quick warning and prevention information and policy supports against drought facilitate farmers to make farm management adaptations (Jinxia Wang, 2015).

Another interesting point was the possible increased farmer adaptation due to impact of climate change has still got very less attention. Most of them stated that the important threats of their livelihood were big jumps up and down in the prices of inputs they have to buy for farming and strong changes in product prices, not climate change. It is a main concern for sustainable development in agricultural water resources management to evaluate the adaptive capability of a water supply under future climate conditions (Won-Ho Nam, Jin-Yong Choi and Eun-Mi Hong, 2015). In this case, agricultural extension agents may have to put more efforts into transferring research information to farmers so as to persuade them to realize agricultural adaptation to climate change especially for small
scale irrigation systems. As the analysis of perception of farmers to climate change revealed that age of the household head; wealth, information on climate change, social capital and agro ecological settings have significant impact on the perception of farmers to climate change (Temesgen, 2008). The government should pay certain attention to the farming communities, and farmers within a community who have a low level of social capital. Since, farmers’ ability of adaptation is also associated with the characteristics of their households and local communities (Huang Chen, Jinxia Wang and Jikun Huang, 2014).

REFERENCES


KNOWLEDGE TRANSFER: LEARNING FROM OTHER COUNTRIES EXPERIENCES
FROM FARMER MANAGED IRRIGATION SYSTEMS (FMIS) IN THE HIMALAYAS TO FARMER MANAGED NATURAL REGENERATION (FMNR) IN THE SAHEL: LINKS, LESSONS & IMPLICATIONS FOR AGRICULTURAL RESEARCH, CLIMATE-SMART RURAL DEVELOPMENT AND DEVELOPMENT COOPERATION.

GEORGE F. TAYLOR II*

LINKS BETWEEN THE TERMS FARMER MANAGED IRRIGATION SYSTEMS (FMIS) IN NEPAL AND FARMER MANAGED NATURAL REGENERATION (FMNR) IN NIGER

The links between Farmer Managed Irrigation Systems (FMIS) and Farmer Managed Natural Regeneration (FMNR) are connections between elements of rural development in two parts of the world that are not often connected: Nepal and Niger, South Asia and West Africa, the Himalayas and the Sahel. The connection was, in the first instance, one of language: the term Farmer Managed Irrigation Systems (FMIS) in Nepal served as inspiration for and gave birth to the term Farmer Managed Natural Regeneration (FMNR) in Niger. The more important connection, however, was one of substance and approach: of giving farmers the credit they so often have not been given in development discourse.

A. The Nepal-Niger Links
The term Farmer Managed Natural Regeneration (FMNR) was coined by the author and a colleague at USAID/Niger in Niamey in 1990/91 following a field visit to central Niger

* Director, International Programs, Philanthropy Support Services (PSS), Inc.P.O. Box 20601, Boulder, Colorado USA 80308
to see some very interesting and innovative rural development work being done north of the town of Maradi. This project involved working with farmers to protect and manage the natural regeneration of native species of shrubs and trees in their fields instead of “cleaning” their fields as they were told to do by Nigerien agricultural extension agents and foresters. The project supporting this new approach had been using the term “dirty fields”, contrasting it to the method of “clean fields” promoted by government extension agents. (Rinaudo 1999, 2008)

This exciting work deserved to be more widely known. An article was prepared and submitted to the 10th World Forestry Congress being held in Paris in June, 1991. (Taylor & Rands, 1991 & 1992) It was clear that talking about “dirty fields” would not capture the attention of the intended audience, the international forestry community. We decided to name what we had seen “farmer managed natural regeneration”. The name captured both the technique being used and the actor responsible for using it. The inspiration for the term came from the author’s earlier work in Nepal where work on Farmer-Managed Irrigation Systems (FMIS) was being championed by IIMI in Nepal and elsewhere in South Asia in the late 1980s.

B. Serendipitous Connection to a Nobel Prize

Professor Elinor Ostrom first visited Nepal in 1989 under the auspices of USAID’s Decentralization: Finance and Management (DFM) project (ARD 1994, Benjamin et.al. 1994). In 2009 she was awarded the Nobel Prize for Economics for “her analysis of economic governance, especially the commons”. In her acceptance speech Professor Ostrom spoke about her connection to Nepal and the importance of her early work there on irrigation. (Ostrom, 2009) These connections, including a trip back to Nepal in 2010, are celebrated and explained indetail on the Farmer Managed Irrigation Systems Trust (FMIST) website. (Pradhan 2010 & 2012) Ostrom’s work on irrigation led to her work on forestry. Although she did not visit Niger, the DFM project on which she was the leading intellectual light did important work in the West African Sahel building on a key regional meeting in Segou, Mali in 1989. (Shaikh, 1989) Following the Segou Roundtable on Local

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1 USAID/Niger NRM Advisor Barry Rands heard about this work led by Tony Rinaudo of SIM under the Maradi Integrated Development Project (MIDP) and organized the field visit along with USAID/Niger livestock specialist Hamadou Bourahima.

2 USAID/Nepal and others were funding IIMI’s work on FMIS in Nepal (IIMI, 1992). The key people involved in this work were Prachanda Pradhan, Bob Yoder and Ed Martin. USAID support was through the Irrigation Management Project (IMP) managed by Jon Breslar in the Natural Resources & Institutional Development (NRID) Division of USAID’s Office of Agriculture and Rural Development. Other USAID support for FMIS included the successful derailing of a large proposed ADB irrigation “improvement” project along the East Rapti River in an area where farmers were already producing 3 crops of rice per year. Taking on the ADB drew some of its inspiration from the Nepal Poplar Saga (Taylor, 2014b)

Level Natural Resources Management, the DFM project helped create the conditions and a policy environment on resource tenure, on decentralized management and on new roles for foresters under which FMNR could begin to take root.

C. FMNR in Nepal: On Not Planting Trees

At about the same time that Tony Rinaudo and the Maradi Integrated Development Project (MIDP) in central Niger started to promote “dirty fields”, some foresters in Nepal started questioning the dominant paradigm of addressing concerns about “deforestation” by promoting “reforestation” (i.e. raising tree seedlings in nurseries and planting trees).

Under the heading “On Not Planting Trees”, the editorial in the first issue of BankoJanakari, a new Journal of Forestry Information for Nepal launched in the Spring of 1987, captured the spirit of questioning and the search for a new paradigm for forestry in Nepal as follows:

"It is common ground that forestry is of great importance to the country, and that all is not well at the present time… The prime importance of community forestry is the new orthodoxy, and it is being realized that this means giving village communities real control of the forests that are important to them. ... As to what needs to be done, we find an almost universal, deep-seated belief that the answer is: plant more trees.... It is difficult to convince people that they ought to be suspicious of tree planting, but the truth is that it is all too often the "busy" solution, adopted by those who want to be seen to be doing something. In trying to pick out what is truly of most importance to Nepalese forestry, we think it is best encapsulated in the slogan: better management." (Jackson, 1987)

This point was strongly reinforced in 1988 with the completion of a seminal study on trees on private land carried out by the Nepal-Australia Forestry Project. (Carter and Gilmour, 1989) The study clearly showed that farmers were actively and successfully propagating, protecting and managing tree cover on private lands.

II. THE FMNR STORY

The material in this section is taken from Taylor, 1993. The author of the BankoJanakari editorial, Ken Jackson, was a very experienced tropical forester who had seen tree planting programs in many parts of the world with dismal seedling survival rates. Four years before writing the editorial, he had led a study for CILSS and the Club du Sahel on Management of Natural Forests in the Sahel Region. (Jackson et.al., 1983)

A. In the Beginning
Twenty five years ago, FMNR was something very small in an often forgotten corner of the world that seemed to have significant potential. The article prepared for the 10th World Forestry Congress in 1990 summarized the situation as follows:

“Farmer managed natural regeneration (FMNR), an agroforestry practice involving the managed natural regeneration of ligneous plant species by farmers in their fields, has been included in several projects in south-central Niger. ... A range of management options are noted and reasons for acceptance of FMNR outlined including: getting started in FMNR is simple, FMNR is cheap, it produces relatively short-term benefits, it requires only a minimum of community organization, and there has been effective extension and appropriate government support.

FMNR requires no nurseries, no vehicles and no special tools. The basic techniques are easily understood and are based on indigenous knowledge of agricultural and silvicultural practices. Information about FMNR is easily passed from farmer to farmer. Mastering FMNR does require intuitive and practical skills, but these can be learned by experience and through traditional channels of information exchange. Because costly inputs are not required, ease of replication is enhanced and sustainability virtually assured. FMNR must be supported by work to remove disincentives and to build the preconditions necessary for successful private initiative in local level natural resources management. The authors conclude that FMNR is a viable, local-level natural resources management technique with significant potential both in Niger and more broadly across the West African Sahel.” (Taylor & Rands, 1991)

Since 1990 FMNR has exploded across the West African Sahel. In 2004 Chris Reij returned to Niger after an absence of ten years. Building on his earlier work on farmer innovation (Reij & Waters-Bayer, 2011) he came across FMNR, understood its importance, and has been working hard with a committed group of colleagues for the past ten years to both document and promote FMNR and related farmer-led land management techniques across West Africa and beyond. From his base in Australia, Tony Rinaudo has been a very proactive member of this group. Word about the spread of FMNR has gradually made its way into the media and some segments of the development literature. (USAID 2002b, Polgreen 2007, WRI 2008, Heertsgaard 2011, Bilger 2011, USAID 2013) The results, along with the four other land management techniques described below, have been described as a Sahelian “green revolution”. (Reij, Tappan and Smale 2009) In recent years the Africa Regreening Initiative, World Vision Australia and related efforts have extended FMNR to East and Southern Africa, gotten it incorporated into the African Union’s plan for Climate-Smart Agriculture in Africa6 and conducted several training workshops in Asia, including India. (Africa Regreening Initiative & FMNR website updates, Garrity 2012)
B. FMNR: Some Visuals

1. Niger, the birthplace of FMNR 1975 vs 2005

Aerial photographs of southern Zinder, Niger, showing the increase in on-farm trees. (Tappan, 2011)

2. A Niger-Nigeria cross-border comparison

Extent and density of tree cover in southern Niger/northern Nigeria (Tappan, 2011)

C. Four Other Threads in the “Re-greening” Story
FMNR was one piece of a broader “re-greening” story. Four other threads are described below.

1. A traditional technique: Farmed Parkland
Sahelian farmers have been cultivating farmed parkland for generations. Three species are favored (Gao/Faidherbia (or Acacia) albida, Karite/Vitellariaparadoxa and Nere/ParkiaBiglobosa) and a fourth, Baobab/Adansoniadigitata, is cultivated on appropriate sites. There is an important literature on farmed parkland that has all too often been ignored by agriculture and rural development programs over the past thirty five years. (Pelissier 1966 & 1980, Pullan 1974, Taylor & Bonkoungou 1986, Bonkoungou et al. 1997, Boffa 1998) Farmed parkland and FMNR differ in several important respects: farmed parkland is generally found on more fertile soils, often close to villages, and involves a small number of species each with very important products and qualities. At the time when FMNR was being promoted, a World Bank-funded energy project in Niger was working with farmers to promote the natural regeneration of one farmed parkland species, Gao. (Montagne, 1992) This echoed earlier work, including a program in Chad in the 1970s. (McGahuey & Kirmse, 1977)

2. Land rehabilitation: “modern” soil and water conservation techniques
A variety of simple, farmer-friendly soil and water conservation techniques were introduced into the Sahel in the late 1970s and early 1980s. (Weber & Hoskins 1983) With the exception of the CARE-supported windbreaks in the Majjia Valley of Niger, most of the work with these techniques focused initially on the Yatenga Plateau northern Upper Volta, now Burkina Faso. The techniques used included zai (planting holes with manure)\(^7\), demi-lunes/half-moons (planting holes with micro water catchments) and stone bunds (rocks

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\(^7\) Zai – The Hole Idea http://www.1080films.co.uk/Yacoumbamovie/zai.htm
lined up along the contour) to slow overland rainwater flow. All of these simple techniques aim to increase the retention of moisture in order to promote the growth of crops and/or trees and grasses. The 2010 film *The Man Who Stopped the Desert* provides an excellent introduction to this work and its impacts. (Dodd, 2010 see also Winterbottom et.al. 2013)

3. The management of “Useless Brush”
The USAID-funded Forestry and Land Use Planning Project (FLUP) in Niger went completely against the grain of other forestry projects across the Sahel in the 1980s by focusing its attention on the management of so-called “useless brush”. (Weber & Hoskins 1983, Gallegos et.al. 1987, Christopherson 1988) Designed by Fred Weber, FLUP understood the futility of most tree-planting programs and the potential power of harnessing the natural regeneration of native species. It echoed the approach advocated by Ken Jackson half way around the world in Nepal with his motto: “on not planting trees” (Jackson, 1987). FLUP experimented with the management of “useless brush”, including the cutting of fuelwood and poles and the development of rural wood markets. FLUP was a precursor of FMNR in the species it worked with (e.g. *Bauhinia, Combretum, Guiera* etc). A key difference was that FLUP worked with foresters on forest management at a larger scale rather than with farmers in their own fields.

4. The neem and the mango: paradigms for farmer-led tree planting
Although most tree planting efforts in the Sahel have been dismal failures, two important successes have been observed with neem/ *Azadirachtaindica*, used extensively in both urban and rural areas, and a variety of grafted mango reported to have been introduced from South Africa. Neem was introduced into Senegal in 1944 and into Mali in 1953. It presumably arrived in Niger from Nigeria, brought there from India by the British, perhaps via Sudan where it had been introduced in 1925. Demand for seedlings of both neem and grafted mango continues to be high, with small private nurseries a going concern in urban areas. A lesson drawn from these examples of “contagious replication” in 1984 continues to be true: if the species being offered meet a “felt need”, they will be produced, planted and cared for. (Taylor & Soumare, 1984)

D. FMNR: Results and Key Elements Contributing to its Rapid Spread
There is a fairly large and growing literature on FMNR. The most solid synthesis piece to date was solicited by the International Food Policy Research Institute (IFPRI) and included as one of 20 case studies in its 2009 volume *Millions Fed-Proven Success in Agricultural Development*. (IFPRI, 2009)8

8 Another of the case studies was community forestry in Nepal. The only water-related case study was of shallow tube well development in Bangladesh. The FMNR case study covers key topics including technical information, the innovator, scale of adoption, inputs, sustainability and lessons for policy & practice. It also includes two useful Annexes: one describing the discovery of the geographic extent of FMNR, the other describing sources and methods of remote sensing used to calculate the scale of adoption.
FMNR results in Niger can be summarized as follows:

![Farmer-Managed Natural Regeneration in Niger](http://fmnrhub.com.au)

The economic, social and environmental benefits of FMNR have been summarized in a very useful table prepared by Tony Rinaudo and his colleagues and widely available through Wikipedia.

![Table of FMNR benefits](http://en.wikipedia.org/wiki/Farmer-managed_natural_regeneration)


The positive impact of FMNR on women deserves to be highlighted. Women may be the biggest winners from FMNR in Niger. They are excluded by traditional custom from many resource management decisions. FMNR favors women because it requires their year-round tending while many men migrate to find work and cash during the dry season. Using their own wood eliminates the cost of purchasing fuelwood with scarce cash, while selling wood and baobab leaves is highly remunerative. Women also invest their income in goats and sheep, which they feed with the pods of gao and at the end of the dry season with the leaves of Guierasenegalensis. (Reij et al. 2009, p.20)

Current spread of FMNR and related practices in Africa:

Source: Garrity 2012

Key elements contributing to the remarkable spread of FMNR have been summarized as follows:

“The success of FMNR is… a result of investing in study tours, exchange visits, participatory approaches linked to social mobilization, communication, networking and capacity building - in tandem with reducing the barriers to local participation and investment by getting the enabling conditions right for more secure tree and land tenure, farmer led innovation, empowerment, NR-based enterprise development, and local investment and implementation of integrated NRM … a key provision was the increased ability of farmers to harvest, market and benefit economically from the restored agroforestry systems without undue interference, or payment of permits and fines.” (Anon)

III. IMPLICATIONS OF FMIS & FMNR FOR PATTERNS, PREJUDICES AND PREDILECTIONS OF AGRICULTURAL RESEARCH, CLIMATE-SMART RURAL DEVELOPMENT, AND DEVELOPMENT COOPERATION.
FMIS and FMNR have three very important characteristics in common:

1. Both FMIS and FMNR put the farmer at the center of the stage as the key “actor”, the “expert”, the one whose “agency” and “voice” deserve to be given priority.
2. In putting farmers center stage, both FMIS and FMNR stand in contrast to the predominant international development paradigm, a paradigm that even in 2015 tends towards top-down, “expert”-led and the-State-knows-best.
3. Both FMIS and FMNR have had to struggle against the patterns, prejudices and predilections embedded in agricultural research, rural development programming and development cooperation.

That said, FMIS and FMNR have several important differences:

1. FMIS is defined through a distinction with AMIS (Agency Managed Irrigation Systems) – farmer managed vs Agency (ie government) managed. There is no such distinction in FMNR. Under different circumstances in Niger there might have been this distinction, but the Forest Service (*Eaux et Forêts*) both in the French colonial period and in independent Niger was spending most of its time and effort trying to “educate” farmers and “control” their use of forest resources (including the trees in their farm fields) rather than promote natural regeneration in the “Classified” and “Protection” forests that were nominally under their control.
2. FMIS involves collective action and a common property resource. FMNR is based on individual action, farmers deciding to protect natural regeneration and to have “dirty fields”. Although the trees that regenerated were, in theory, subject to State regulation and control in the 1980s, Nigerien and broader Sahelian ideas about the role of foresters and the Forest Service were evolving from policing in a para-military mode to promoting the management of trees in an extension service mode (be they in farmers’ fields, in well-established farmed parkland, in natural forests, or in the small percentage of tree plantations that had managed to survive).
3. Work promoting FMIS was started, for the most part, by researchers. Work promoting FMNR was started by development practitioners. These very different starting points have led to very different trajectories. There have been strengths and weaknesses on both sides.
4. FMIS started by working with existing agricultural production systems. FMNR started by introducing a simple innovation into an existing production system.

These similarities and differences will be explored in the sections that follow.

**A. Agricultural Research**

**Farmer-driven or researcher-driven**

Agricultural research for far too long has been researcher-driven rather than farmer-driven. There are plenty of individual scientists and some programs within the international agricultural research establishment that understand this. Getting this concept into the domains of agricultural research policy and agriculture sector strategic planning has proven
to be difficult and is an ongoing concern. Looking back in 2009 to the path-breaking Farmer First conference in 1987, Robert Chambers noted:

“Many of the challenges are still those of 20 years ago. The paradigm of pipeline research and transfer of technology, of top-down packages of practices passed on to farmers…of big and quick fixes, is embedded in mindsets and bureaucratic imperatives. It is resilient and keeps reasserting itself.”(Scoones & Thompson, 2009, p. xxii & xxiv)

**The technofix fixation**

One of the reasons that the researcher-driven paradigm continues to predominate is a technofix fixation. Too much research is based on the premise that “technical solutions” will “solve” development challenges without adequate understanding of or attention to the biophysical challenges and the economic and socio-political context in which these solutions must operate. This was a major issue in both Nepal and Niger in the 1980s. In Niger agricultural researchers assumed they could breed “improved” varieties of millet and sorghum that would solve the food shortage, livestock experts assumed that “improved” methods of pasture management imported from the West would “rationalize” the pastoral economy, and foresters assumed that carefully chosen varieties of fast-growing eucalyptus from Australia would “solve” the fuelwood/energy crisis. None of these technical “solutions” worked.

The technofix fixation continues to be a major issue today. Jeffrey Sach’s Millennium Villages is one recent example. Gates Foundation investments ranging from agricultural research to improved toilet design is another. To be fair, FMNR is also a technofix. But it is a technofix developed not in a high-tech, airconditioned lab by PhD researchers, but in farmers’ hot and dusty fields in what many would consider “the middle of nowhere”. Far from being high-tech, FMNR has been characterized by one recent observer as “baffling simplicity”. (Mesiku, 2012) One of the most proactive champions of FMNR, Chris Reij, enjoys noting: Yacouba Sawadogo (star of the film *The Man Who Stopped the Desert*) “single-handedly has had more impact on…conservation than all the national and international researchers put together.”

FMIS stands as an important exception to this general pattern of researcher-driven research. Work on FMIS was born at the International Irrigation Management Institute (IIMI) and nurtured by its successor, IWMI. As far back as 1986 there was an international conference hosted by IIMI on FMIS. (IIMI, 1987) IWMI’s work on FMIS over the years since then has produced a solid corpus of knowledge coupled with field programs that always included a substantial research component. In the seventeen years since its establishment in 1998, the Farmer Managed Irrigation Systems Promotion Trust has built on IWMI’s work, convening five international seminars prior to the one we are participating in and producing

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9 http://www.1080films.co.uk/project-mwsd.htm
five volumes of very solid work in a period of ten years. FMNR has had very little support like this until recently. One result is the paucity of peer-reviewed literature.

B. Climate-Smart Rural Development
Climate change is widely recognized as the most important environmental challenge of our time. Where do FMNR and FMIS fit into programs designed to address climate change?

FMNR has developed a strong link to climate change programming through The United Nations Convention to Combat Desertification (UNCCD). In 2013 both Yacouba Sawadogo and Chris Reij were honored with the UNCCD's “Global Dryland Champions Award” which recognizes the individuals who have made significant contributions to the field of sustainable land management. At the same time, World Vision Australia was honored with a “Land for Life Award” for the work of FMNR champion Tony Rinaudo and colleagues. And what of FMIS? At the Fifth International Seminar in 2012 Som Nath Poudel and Upendra Gautam presented an important paper on "FMIS in Twenty-first Century: Coping with the Climate Change". Beyond this, and a recent, tangentially-related IWMI study, the literature on FMIS and climate change appears to be sparse.

Nepal has been a leader among the Group of 77 in the international negotiations on climate change. This proactive engagement has resulted both in high-level attention to climate change, for example a Climate Change Council formed in 2009 under the Chairmanship of the Prime Minister which evolved in 2012 into a Multi-Stakeholder Climate Change Initiatives Coordination Committee (MCCICC) and a range of policy pronouncements and program plans including a National Adaptation Plan of Action (NAPA), a variety of Local Adaptation Plans (LAPAs) and a large Pilot Program for Climate Resilience (PPCR). Has the FMIS community had a voice in any of this?

New strategies in old bottles?
Nepal recently prepared a new Agricultural Development Strategy (ADS) with emphases on improved governance, higher productivity, profitable commercialization and increased competitiveness. There are a few references to FMIS sprinkled through the ADS preparation document. Most of them relate to assisting FMIS to construct permanent headworks and improve main canals. Climate change is not mentioned in the twenty-page Summary. It is highlighted as one of thirteen “Key Issues for the ADS” in a table that frankly discusses key challenges, but then it does not appear on the action/implementation side of the strategy. (ADB, 2013, Table 17, p.41-43). There are a few references to climate-smart agriculture, the first of them not until page 59. The document recommends the construction of seven

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11 Climate Change, Out-Migration and Agrarian Stress: The Potential for Upscaling Small-Scale Water Storage (Sugden et.al., 2014)
12 http://moste.gov.np/स्थायीर/ mccicc
inter-basin transfer schemes “with full EIA and safeguards”, but it is silent on the potential impacts of hydropower development on irrigation, particularly the systems with storage dams where, in some cases, water will need to be released at night in order to capture the higher electricity tariffs for exports to the Indian grid. One interesting innovation in the new strategy is the emphasis on farmers’ rights. Another is the emphasis on inclusion, with the target for percent of farm land owned by women or joint ownership projected to grow from a rate of 10% in 2010 to 50% in twenty years.

**An opportunity to broaden the scope of FMIS?**

In addition to FMIS and AMIS, there is a new category in the Agricultural Development Strategy documentation: Non-Conventional Irrigation (NCI). NCI includes systems such as “sprinkle, drip, pond and water tank, shallow tube well, treadle pump, water harvesting pond or well, and other types of technologies utilizing small quantity of local water resources”. The ADS background paper on irrigation notes that NCI is “the optimal method for expanding irrigation coverage in the hills and some parts of the Terai”. (Cook et al. 2012)

**Linking into and working with current drivers of change**

Development in many parts of rural Nepal has been undergoing profound changes. There are many drivers of this change: the exodus of working-age men to South West Asia (i.e. the Gulf), the communications revolution and an expanded and improved road network to name just three. ISET/Nepal and others have been following these developments. (Desakota 2008, ISET 2014) Among the changes: the feminization of agriculture in areas of exodus and the transformation of farming systems in areas with access to roads and markets in rapidly growing urban areas and/or India. Transformations have included switching from rice and other grain crops to higher value vegetables on *kheta* land and switching to even higher value niche crops such as organic coffee on *bari* land in areas where drip irrigation systems can be installed. These developments all have direct links to water resource use. In many cases they involve irrigation, not FMIS in its classic sense, but farmer managed irrigation in the broader “non-conventional” sense discussed above.

**Three frameworks to consider when linking FMIS and FMNR into broader, climate-smart rural development strategies and programs**

Three frameworks to consider when linking FMIS and FMNR into broader climate-smart rural development strategies and frameworks are the Climate Resilience Framework; the Nature, Wealth & Power (NWP) framework; and the SEED-SCALE framework for understanding social change.

**The Climate Resilience Framework (CRF):** CRF is both an analytical framework and an iterative planning process in which shared learning builds understanding and promotes resilience.
The Nature, Wealth and Power (NWP) Framework: NWP is designed to help leverage both natural and social capital for resilient development.

Source: USAID 2013 adapted from USAID 2002a, p.35

The SEED-SCALE Framework: The SEED-SCALE framework for understanding social change posits the need for catalyzing action from three directions with three different sets of actors: bottom-up (i.e. grassroots development), top-down (i.e. government leadership, policy reform) and outside-in (i.e. technical assistance, training, farmer-to-farmer visits etc.). (Taylor-Ide & Taylor 2002, D. Taylor et.al. 2011)

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13 For a graphic with additional details see USAID 2013 p.vii
C. Development Cooperation
What do the FMIS and FMNR stories on two continents half a world apart tell us about the patterns, prejudices and predilections of development cooperation?

As discussed earlier, the voices of farmers are still all-too-often marginalized and development planning continues to be both top-down and from the outside-in (i.e. primarily by outsiders determining priorities, be they donors or national governments). What can be done about this?

Looking back
Writing in 1984, Harka Gurung suggested that some aspects of Nepalese development experience were “pregnant for reflection” and demanded “a new perspective”. Among the aspects he identified: a cavalcade of concepts (i.e. the high degree of external influence on development priorities and programs), the euphemism of rural development (i.e. integrated rural development as a “reverential concept” based on the “pretension of [the] integrated approach”) and the penumbra of the political economy (i.e. the often overlooked central role of the political economy on development performance). (Gurung, 1984, p.246–256)

Devendra Raj Panday’s important insights on development cooperation, starting with Nepal’s Failed Development: Reflections on the Mission and the Maladies (1999/2009) and continuing with Looking at Development and Donors: Essays from Nepal (2011), deserve to be read and carefully pondered by all who are involved in this arena. Also the introductory essay in the 2011 volume by Seira Tamang on “The Imperative of Learning from the Past”.

In the water resources sector, retrospective reflections by Gil Levine, Robert Chambers and Dipak Gyawali in a Special Issue of the online journal Water Alternatives on Voices of Water Professionals: Shedding Light on Hidden Dimensions in the Water Sector also deserve a careful reading (Levine, 2013 Chambers, 2013 Gyawali, 2013).

On the broader international stage Robert Chambers, the long-time champion of the farmer first approach, noted in his most recent book Provocations for Development that there are two development paradigms. One, the neo-Newtonian, has elements that are linear, ordered, uniform, controlling and predictable. The other, which he calls adaptive pluralism, has elements that are non-linear, diverse, complex, empowering and unpredictable. “Development practice tends repeatedly towards neo-Newtonian practice, locked in by rules, conventions and conformist commonsense.” (Chambers, 2012, p.147, 190–194)

Looking back over three decades of forestry development, Jack Westoby, an early proponent of industrial forestry who later became one of its strongest critics and an early and prominent supporter of the new community forestry paradigm, noted:

Yes, development fashions have changed over the last three decades, and that is why gradually the

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14 The Special Issue was prepared with support from GIZ, an excellent use of donor resources for a particularly important type of “knowledge management”.

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files, the archives, the case-books of the development establishment . . . have come to resemble the private cemetery of a fantastic zoo, a cemetery stuffed with the corpses of wild geese, lame ducks, red herrings, white elephants and dead horses.” (Westoby, 1987, p.242)

What would Westoby say more than twenty five years later? Chances are he would agree with many of the critiques of development cooperation and assistance that have been penned over the past decade. The title of longtime World Bank staffer William Easterly’s most recent broadside captures the tone well: *The Tyranny of Experts: Economists, Dictators and the Forgotten Rights of the Poor.* (Easterly, 2013)

**Knowledge management: a panacea?**

Knowledge management (KM) has been promoted as a key element of new, improved development cooperation for well over a decade. The goals of KM are to use the power of the computer and the internet to rapidly disseminate knowledge (i.e. development experience including both successes and failures) and prevent wasteful duplication of effort. Are we learning more from the past and from related efforts in the present? Is information about FMIS and FMNR getting out to the wider world? The answer is, of course, mixed. Two sobering examples follow where KM has not done as much as it could and should have.

1. The Global Donor Platform on Rural Development

The Global Donor Platform is an impressive Network of 38 bilateral and multilateral donors, international financing institutions, intergovernmental organizations and development agencies established in 2003 to increase and improve the quality of assistance in agriculture, rural development and food security. The Platform’s website has an impressive list of publications, policy papers and much more.\(^{15}\)Search results on the website for FMIS = 0. Search results for FMNR = 0.

2. FAO Guidelines on Sustainable Forest Management in Drylands of Sub-Saharan Africa.\(^ {16}\)

FAO published these guidelines in 2010, twenty years after the initial paper on FMNR at the FAO-sponsored 10\(^{th}\) World Forestry Congress and in the middle of the rapid farmer-led spread of FMNR across the West African Sahel. The Guidelines make no mention of FMNR. Part of the problem is that the document, which reportedly was developed “with enormous contributions from international, regional and national forestry experts and partners active in the region”, was based in part on “outcomes and recommendations of the technical validation workshop organized in Dakar in collaboration with the *Agence Nationale de la Grande Muraille Verte* (Senegal), which gathered more than 70 participants representing forestry and environment-related departments and ministries from 12 countries, regional and international organizations, non-governmental organizations (NGOs), United Nations

\(^{15}\) [http://www.donorplatform.org/publications/platform-publications](http://www.donorplatform.org/publications/platform-publications)

\(^{16}\) [http://www.fao.org/docrep/012/i1628e/i1628e00.pdf](http://www.fao.org/docrep/012/i1628e/i1628e00.pdf)
La Grande Muraille Verte (the Great Green Wall) was Senegalese President Wade’s pet project: a delusional idea that the Sahara Desert was going to be pushed back by a wall of trees stretching from Senegal across to Ethiopia. (see Bilger, 2011)\[17\]

**Looking forward**
Looking forward, there are some hopeful signs. One is that technology, when used creatively, can give voice to those who for far too long have been shut out of development discourse. It can also start to hold development “experts”, government planners and politicians more accountable for their decisions. Another is that moving outside of traditional development paradigms and embracing entrepreneurship, including “development entrepreneurship”, opens new horizons and the potential for using both market and non-market incentives and mechanisms to take innovations to scale. A few quick examples:

1. **What do farmers want? Ask them in “real time”**.
With the telecommunications revolution, “smart phones” have now reached every corner of the planet. Surveys using smart phones are becoming more common. On the global stage, the selection of the Millennium Development Goals (MDGs) in 2000 was a top-down process run by “experts” and finalized through the arcane political processes of the United Nations System. For the development of the Sustainable Development Goals (SDG) that will replace the MDGs, the group MyWorld2015.org has compiled input from seven million people around the world to the UN’s My World Survey\[18\]. It is too early to assess what impact this remarkable data set will have on the final formulation of the SDGs. What is clear, however, is that if “the powers that be” want to know what a much broader group of people think, the technology is available for this to happen, and to happen quickly.

2. **The power of open source mapping**
Hydropower development is exploding across the mountains and valleys of Nepal. Decisions are being taken in Kathmandu by a small number of engineers and other technocrats and politicians that will have major impacts, some positive and others negative, some temporary and others irreversible, on a large number of communities across the country. These communities have had very little voice in the decision making process. Using Open Street Map software, Kathmandu Living Labs and its collaborators have developed a series of prototype maps that locate every active and proposed hydropower site. For the active sites, both photographs and local narratives are included. (Lord, 2014 Lord et.al., 2015) Similar work is being done at a broader scale across the Ganges-Brahmaputra-Meghna Basin on the theme of “visualizing hydropower across the Himalayas” with particular attention to the use of participatory GIS and mapping designed to improve governance “in a time of regulatory

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decline”.(Alley et.al.,2014)

Open Street Map has also been used to develop a realtime map of Kathmandu city. NamaBudhathoki, one of the first people in the world to do a PhD on Open Street Map, organized a group of volunteers and with World Bank support, mapped all of Kathmandu in three months. They labeled all the schools and hospitals and assembled data on how these places will dowhen a big earthquake hits. Since then he has started an NGO and taken this work to the next level, including a smartphone app where the GPS determines current location, maps a route to any desired location, calculates what the taxi charge should be, and gives spoken instructions on how to get to the destination. (Budhathoki, 2015) The potential uses of these technologies for FMIS, for mapping systems, monitoring water quantity and quality, linking and organizing farmers, tracking market prices, doing virtual farmer-to-farmer visits is limited only by our imaginations.

3. Development entrepreneurship

A move by FMIS to embrace “non-conventional irrigation” opens the door to working with individual farmers which, in turn, opens the door to the world of entrepreneurship. As the title of international development entrepreneur and founder of iDE Paul Polak’s recent best-selling book puts it, *The Business Solution to Poverty: Designing Products and Services for Three Billion New Customers.* (Polak and Warwick, 2013) While Polak and his co-author Mal Warwick focus on the private sector, a recent paper published by The Asia Foundation and ODI takes the ideas of business and social entrepreneurship and puts an interesting spin on them in *Development Entrepreneurship: How Donors and Leaders Can Foster Institutional Change.* (Faustino & Booth, 2014) This could have interesting echoes and implications in the worlds of both FMIS and FMNR.

IV. TAKING FMIS TO THE NEXT LEVEL: A FEW SUGGESTIONS

As someone who has recently returned to study and learn about water resources in Nepal after an absence of twenty-five years I have little standing to make suggestions about what the FMIS community might do next. That said, at times an outsider can see things that insiders may not notice, or make suggestions based on experience elsewhere that may prove useful.

Suggestions on taking FMIS to the next level:

- Embrace both small-scale irrigation and non-conventional irrigation as FMIS. What is labeled non-conventional by technocrats and bureaucrats today is already widespread in Nepal and, with the impacts of two key drivers, climate change and out-migration, will be part of the mainstream tomorrow.

- As part of this expanded scope for FMIS, devote special attention to a third key driver: Nepal’s high rate of urbanization and the associated explosion of peri-urban agriculture.

19 There is also work being done in the Tibet Autonomous Region using Google Earth (Eye in the Sky) to monitor hydropower development and a range of other resource issues. (Buckley, 2014)
Embrace and promote the use of interactive, open-source mapping to develop a geo-referenced inventory of all farmer-managed systems and use this powerful new tool to explore connections between FMIS, broader water resources management (WRM) issues and programs, and the wider dynamics of the rural and peri-urban development landscape.

Devote additional attention to gender, particularly to female irrigators in the context of the “feminization of agriculture” linked to high levels of out-migration in the hills of Nepal.

Define and promote FMIS links to broader climate-smart, rural development frameworks, strategies and programs.

Taking a page from FMNR, embrace the social media revolution starting with a Wikipedia page on FMIS and YouTube videos of FMIS best practices.

Ponder the question: What lessons can experience working with one common property resource (water) learn from working with another common property resource (forests)? More specifically, what lessons can be learned from the Federation of Community Forest Users, Nepal (FECOFUN) that can be applied to FMIS-related organizations?

Consider supporting an independent analysis of all externally funded FMIS programs, both to add to the historical record and from which to learn lessons for moving forward. One possible model: *Aid Under Stress: Water, Forests and Finnish Support in Nepal*. (Sharma et.al. 2004)

Nurture “development entrepreneurship” starting with the “new FMIS”: small-scale and non-conventional irrigation.

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Small Scale Irrigation Systems: Challenges to Sustainable Livelihood


Small Scale Irrigation Systems: Challenges to Sustainable Livelihood


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KAREZ IRRIGATION IN AFGHANISTAN: DYING LEGACY OF INDIGENOUS KNOWLEDGE

UMESH PARAJULI*

KAREZ IRRIGATION SYSTEM: AN OVERVIEW

A karez is an ancient irrigation system that draws water from an aquifer located at the base of a mountainous area or close to natural washes. Technologically, it is a gently sloping horizontal tunnel with a series of well-like vertical shafts (karez shafts). At their upstream ends, many of these shafts are located substantially below the groundwater table to allow water to flow through the tunnel. The karez then transports the water by gravity to an open land surface. Figure 1 and 2 present a schematic and an aerial view of a karez irrigation system, and photo 1 gives its pictorial presentation.

Figure 1: Schematic diagram of a typical karez irrigation system
Source: Mustafa and Usman (2007)
Existence of Karezes has been documented from Western China to as far west as North Africa and Spain (Wilkinson, T.J. et al. 2012, Hussain et.al 2008, Mustafa D and Usman, M 2007). It is known by several names in different countries. In Afghanistan and Pakistan, it is known by the name of karez, while in Iran it is known by the name of qanat¹.

Varying opinions exist with regard to the invention period of Karez. Fouache, E. et al. (2010) note that it was invented at around 500 BC during Achaemenid period, while Lightfoot (1996) and Wilkinson (1977) cited by Wessels, J. (2005) believed that it was invented during 3000 BC. Similarly, some others note its invention period at around 1000 BC (Wilkinson, T.J. et.al 2012, Hussain et al 2008).

¹ Likewise karez is known by the name of kahn in Baloch, ain in Saudi Arabia, falaj (or aflaj) in United Arab Emirates and Oman, kanerjing in China, qanatromani in Jordan and Syria, khettarain Morocco, galleria in Spain, foggara/fughara in North Africa (Hussain et al 2008, Mustafa, D. and Usman, M 2007)).
Regarding the invention process, Wilkinson, T.J. et.al (2012) note that it was invented in the arid region of central Asia, where agriculture depended on episodic run-off and local springs. At around 1000 BC, the area suffered from declining precipitation, which in turn resulted in the reduction of spring discharge. As a result, the villagers extended a horizontal tunnel to 'follow the spring', which in turn invented karezes. This hypothesis suggested that karezes were invented sometime around 1000 BC.

It is generally believed that Karez was first invented in Iran (Wessels, J., 2005; Wilkinson, T.J. et.al 2012; Mostafaeipour, A. 2010; Fouache, E. At.al 2010). However, after examining ecology of karez irrigation in Pakistan in terms of its nature, origin, and diffusion, Rahman, M (1981) argues that it was first invented in Afghanistan and not in Iran.

Whatsoever may be the period and country of invention, Karez is certainly a millennium old irrigation system, many of which were developed by the people of Persian Empire using their local knowledge and skill.

**Earlier studies**

There exist quite some literatures on Kareze irrigation in the region. Many of which examine them from the archaeological perspective dealing with their origin, historical trends, technology developed and so on (Wilkinson, T.J and Rayne, L. 2010, Wilkinson, T.J. et.al 2012, Röttcher, K. 2013, Rotolo, A. 2013, Rahman, M. 1981, Mostafaeipour, A. 2010, Fouache, E. et.al. 2010). The second group of literature focuses more on drought and ever increasing trend of groundwater extractions and their impact on karezes (Wessels, J. 2005, Zehtabian, G.et.al ???, Ahmad, S. Et.al (2004). These papers summarize that with the increasing extraction of groundwater through deep tube wells, groundwater table is declining leading to negative water balance, destruction of karezes, desertification, and soil salinity.

Groundwater recharge is the theme of the third group of papers. Endreny, T. A. and Gökçekuş, H. (2009) demonstrated the means of delineating potential recharge areas of a karez using the satellite collected data and subsequently estimated annual recharges through a limestone dominated mountainous and then water yield of a karez in Cyprus.

Most of the papers on artificial groundwater recharge are drawn from the case studies conducted on the impact of several delay action dams built in the Balochistan, Pakistan. These studies suggest that initially delay action dams, which allow deep percolation through the reservoirs’ beds, helped in increasing groundwater recharge in the area. As a result, discharges through nearby karezes were increased substantially (Ahmad, S.et.al. 2004, Mandokhail, K. Z, 2003). However, these studies further concluded that high content of fine

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2 Southern regions of Iran, neighbouring parts of Pakistan and Arabia
clay brought by runoff gets deposited and rapidly seals the beds. Consequently, the dams act as mere evaporation ponds with little to no recharge through the beds (Qureshi, J. U. 2007, Ahmad, S. et al. 2004, and IUCN, 2005. This suggests that artificial recharge of groundwater through a pond or reservoir in the watershed has a mixed result. However, external intervention in building delay action dams in the Balochistan, Pakistan in continuing with specific attention on sediment management.

Management of ground waters is the theme of the paper by Taher, T. et al. (2012). The authors describe a system of local groundwater governance in Yemen for managing karezes therein. The paper concludes that community-based groundwater management is an essential building block for efficient, sustainable and equitable use of groundwater.

Though it has been widely accepted that many of these karezes are drying, experiences of reviving these karezes through external intervention are limited. In this context, Wessels, J. (2005) and Rahman, M (1981) described a couple of cases of external interventions in reviving Karezes in Syria and Pakistan respectively. Their activities focused mainly on cleaning and strengthening karezes through concrete lining and placing concrete pipes, and provision of artificial recharge. It was noted that the technical impact of the karez cleaning was significant with increase in karez discharge by two folds (Wessels, J. 2005). Despite the availability of quite some literatures on karez irrigation in the region, literatures on karez irrigation in Afghanistan are limited. Those available provide some numeric data on karezes (Rout, B. 2008; Qureshi, A.S, 2002; and Hussain, et al. 2008), and describe their physical and managerial aspects supported by their case studies. Many of these papers suggest that besides drying groundwater aquifer and weakening social capital, the three decades of social unrest in Afghanistan have adversely affected performances of karezes and ability of communities to sustain them.

While a significant amount of literatures provided analysis of karez irrigation in the region mainly from the perspective of archeology, GW recharge, GW management, and external intervention, detailed socio-technical assessment of karez irrigation in the Afghanistan is rare. In this paper, we examine the technological and managerial aspects of karez irrigation and propose some interventions with a view to revitalizing the dying legacy of this Afghan accent technology.

**Helmand Basin and karez irrigation**

The Helmand basin, meaning ‘abundant water’ in old Persian, is the largest basin in Afghanistan as it covers almost half of the national territory. It covers an area of approximately 400,000 sq km with elevations ranging from about 490m in extreme south to over 4400 m in the north. The head waters of this basin drain from the ranges of mountains which start from the Sia Koh Mountains in Herat province in the West to the Parwan Mountains in

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3 About 11 and 4 percentages of this area in south are extended to Iran and Pakistan respectively.
North-West of Kabul in the east. Its main rivers drain into Sistan Depression in desert and it is a close basis.

People have deployed several technologies for utilizing waters of this basin for several uses. Karez is one such oldest water technologies that provided irrigation to crops for maintaining livelihood of the local community. Besides irrigation, karez waters are also used for meeting domestic needs including drinking. Many of these karezes are still providing such services. Though karezes are very popular in the basin, they are not found everywhere. Their availability is shaped by Hydro-geological feature of an area. This is outlined below.

Based on the hydro-geological feature, the Helmand basin can be broadly grouped into three categories. The upper or northern parts of the basin are more mountainous with distinct geological and hydro-geological characteristics compared to the middle parts of the basin that constitute of intra-mountainous and river valleys. Geology in the upper parts of the basin is mostly limestone and crystalline rocks that are not so productive in terms of groundwater. Thus, karezes are rarely found in the mountainous zones. Though some groundwater may be found in their fissure zones and cracks, it is difficult to predict their availability.

Several pockets or ecological areas of the middle stretch of the basin that consists of widespread quaternary deposits of unconsolidated sediments including alluvial sands and gravels, local glacial deposits, and alluvial and colluvium fills are more productive in terms of groundwater yield. Such pocket (or ecological area) is termed here as a ‘karez zone’. Most karezes are found in such pockets of the middle stretch.

The lower (or southern) parts of the basin mostly constitutes of undulating flood plains and desert. There are hints that deep freshwater aquifers may be present in this part of the basin which may even receive recharge from the middle and upstream stretches of basin where the precipitation is much higher (MEW, 2013b)

Precise data on karez irrigated areas in the basin are not available. The 1980 Statistical Yearbook published by the Government of Afghanistan estimated an existence of over 80,000 ha of karez irrigated land in the basin. This data was based on the 1960 survey of irrigated area. Likewise, Qureshi (2002) estimates that about 2,877 karezes exist in the six main provinces of the Helmand Basin that approximately irrigate about 69,000 ha of cultivated land. Similarly, Favre and Kamal (2004) presented an estimate of about 93,300 ha

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4 22 numbers of such karez zones were identified in the 6 districts (Kajaki, Sangin, Baghran, Musaquala, Washer and NawZad) of the Helmand Province  
5 Cited by Rout, B (2008)  
6 Six main provinces include Farah, Ghazni, Helmand, Kandahar, Uruzgan, and Nimroz.  
7 Considering an average irrigated area of a karez as 24.18 ha. This is based on the national data of total karez irrigated areas of 163,000 ha with 6741 karezes.
of land under karez irrigation in the Helmand Basin\textsuperscript{8}. In the same way, the recent Helmand River Basin Master Plan study following FAO 2012 land cover map identified about 57,400 ha of land under karez irrigation in the basin (MEW, 2013c). Figure 3 presents their locations.

![Figure 3: Location of karezes irrigated in the Helmand Basin](image)

Source: MEW, (2013b), See Appendix 1 GI maps

Figure 3 confirms that most of the karezes in the basin are located in its middle stretches (light yellow patches) that constitutes of the intra-mountainous zones and river valleys. The field studies on karez irrigation conducted during 2011-2013 was concentrated in this area. The studies included 17 focus group discussions (FGD) with karez farmers and officials of MEW and MAIL at both the provinces and district levels. Table 1 presents the list of districts where FGDs were conducted.

<table>
<thead>
<tr>
<th>Province</th>
<th>Districts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Helmand</td>
<td>Musa Qala, Baghran, Sangin, Now Zad, Kajaki, and Washir</td>
</tr>
<tr>
<td>Farah</td>
<td>Farah, Farah Centre, Bala Bolak, Pusht Rod</td>
</tr>
<tr>
<td>Uruzgan</td>
<td>Chora, Tarin Kot</td>
</tr>
<tr>
<td>Nimroz</td>
<td>Khash Rod</td>
</tr>
<tr>
<td>Kandahar</td>
<td>Kandahar</td>
</tr>
</tbody>
</table>

\textsuperscript{8} Cited by Mott. This includes 6 provinces namely Kandahar, Helmand, Zabul, Ghazni, Nimroz, Uruzgan
Table 2 summarizes some of the key outcomes of the FGDs, especially in terms of physical and functional aspects of karezes. Parts of their functional aspects are also reflected through Figure 1.

Table 2: Key outcomes of the FGDs

<table>
<thead>
<tr>
<th>SN</th>
<th>Key outcome (physical and functional)</th>
<th>Helmand</th>
<th>Uruzgan</th>
<th>Kandahar</th>
<th>Farah</th>
<th>Nimroz</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Estimated number of karezes in the province</td>
<td>8000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Total number of karezes in the study districts</td>
<td>928</td>
<td>84</td>
<td>32</td>
<td>36</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Presently functioning karezes</td>
<td>143</td>
<td>64</td>
<td>300</td>
<td>18</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>Dysfunctional Karezes</td>
<td>785</td>
<td>20</td>
<td>14</td>
<td>36</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Percentage defunct karezes</td>
<td>85</td>
<td>25</td>
<td>96</td>
<td>43</td>
<td>100</td>
</tr>
<tr>
<td>6</td>
<td>Physical details</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.1</td>
<td>Karez length (km)</td>
<td>1.5-4</td>
<td></td>
<td></td>
<td></td>
<td>5.5</td>
</tr>
<tr>
<td>6.2</td>
<td>Average depth of mother well (m)</td>
<td>25-50</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.3</td>
<td>Average distance between two wells (m)</td>
<td>20-40</td>
<td></td>
<td></td>
<td></td>
<td>11.2</td>
</tr>
<tr>
<td>6.4</td>
<td>Average wet season command areas (ha)</td>
<td>80-400</td>
<td>10-30</td>
<td></td>
<td>27</td>
<td></td>
</tr>
<tr>
<td>6.5</td>
<td>Average dry season command areas (ha)</td>
<td>30-300</td>
<td></td>
<td></td>
<td></td>
<td>6.5</td>
</tr>
</tbody>
</table>

Of the several FGDs conducted in above provinces, FGDs conducted in the Helmand Province also examined present water availabilities in karezes and that were compared with the waters that used to be available in the past. Here, the term “past” is roughly defined as over a decade ago. Figure 4 presents the said comparison.

![Figure 4: Comparison of average water availability in karezes between past and present in studied districts in the Helmand province](image)

Figure 4 indicates that the average availability of water in karezes in Musaqala District has reduced from 13 to 10 polah in winter and 5 to 2 polah in summer. Such reductions

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9 'Polah' is a local term used in Helmand Province for assessing rate of water flow. One polah of water is that flow which is required to irrigate a strip of land of average size 2 m x 50 m within one irrigation turn (roughly 20 minutes). One polah roughly amounts to an average flow of 15 l/s. With this flow...
in flows are more prominent in the Washer and Now Zad districts. A similar reduction of flows in karezes has been reported in other provinces as well.

Management of a karez mainly includes its cleaning, water allocation / distribution, and resources mobilization. Cleaning is done once in every two or three years. It requires special skills, and involves working in a difficult physical environment. Average cleaning costs of these karezes vary between US$ 1,260 and 3,600 per km. Compared to area irrigated, this cleaning cost is quite high. As a result, differed maintenance (cleaning) is increasing in managing these karezes.

In some cases, karezes are managed by their respective local water manager known as mirabs, while in others village elders manage them. Irrespective of management type, karez waters are distributed in turn. Size of land holding is the basis for water allocation, distribution and resources mobilization.

**Principal issues and discussion**

Though farmers of the Helmand Basin have built karezes for centuries using indigenous knowledge and skills, this technology is being lost as 85% of karez irrigation in Helmand, 96% in Kandahar, 75% in Uruzgan, 43% in Farah, and 100% in Nimroz provinces have already gone dry. Furthermore, flows in operating karezes have also declined drastically. It has been reported that over extraction of waters by tube well and poor maintenance of karezes are part of the reason for this. These are discussed below.

**Influence of tube wells on karezes flows**

It has been reported that a sharp decline in the groundwater table caused by huge extraction of groundwater using gasoline driven pumps is one of the primary reasons for drying out of karezes. However, authentic quantitative data are not available to support this argument. Further, to what extent tube wells of various nature influence flows in karezes in different hydro-geological situation is also not known. Paragraphs below discuss some of these aspects.

Groundwater aquifer is water bearing permeable formation (soil, rock, gravel, sand etc) that may exists at various depths from which waters can be extracted using several technologies like tube wells, karezes, dug wells etc. Based on the depth, an aquifer is usually defined as shallow or deep, and each of this aquifer has several characteristics.

As noted above, Karezes draw waters from shallow aquifer, which is closer to the surface. By virtue of its location, waters from shallow aquifer are also more likely to be extracted by tube wells, though they extract waters also from deep aquifer. It is quite natural to expect interference in karezes flows by tube wells if both of them extract waters from the same

(15 l/s), one can irrigate one jerib (0.2 ha) in about 4 to 5 hours.
aquifer, and their extraction points are close to one another. However, if they extract waters from different aquifer, such interference may not be that prominent. Some of the relevant characteristics of ground water aquifer outlined below help explain these phenomenon:

- In quite some cases, shallow aquifers are “perched”, meaning patchy ground water accumulating above low-permeable strata such as clay (Figure 6 and 7).
- In some cases, shallow aquifers are regionally extensive
- Shallow aquifers are usually unconfined
- Shallow aquifers are more likely to be recharged by local rainfall. Unlike this, recharge areas of deep aquifer may be far enough.

Figure 6 and 7 present sketches of ground water aquifers.

![Figure 6: Influence of tube wells on karez flow](image1)

![Figure 7: Influence of tube wells on karez flow](image2)

Above figures – though self explanatory – suggest that excessive extraction of waters through tube wells may influence flows in karezes if both of them draw waters from an extensive shallow aquifer close to one another (Figure 6). In contrast, if they draw waters from different shallow aquifers which are disconnected to one another (example perched aquifer), interferences of tube wells on karezes flows are not likely (Figure 7). Likewise, tube wells drawing waters from deep confined aquifer would not influence flows in karezes (Figure 7).

This suggests that understanding of geo-hydrological phenomenon of an aquifer, and accounting its water balance is essential to predict likely influence of tube wells on flows through karezes.

**Impact of maintenance on karezes flows**

Poor maintenance of karezes caused by changing socioeconomic conditions of local community is another reason for decreasing flows through karezes and ultimately drying out. This is explained below.
Common maintenance activities of a karez include cleaning of its bed (or sediment removal), and protection of karez cave and vertical shafts. Quite some times karez cave fallout. If it is not properly cleaned, water would not flow. But, cleaning of karezes is not an easy task as it needs to be done in a difficult physical environment. This activity thus requires special labor forces that have experiences of working inside karezes, and such labor forces were available in Afghanistan. Locally, they are known by the name of Karez-Kesh\textsuperscript{10} meaning karez diggers. Karez-Kesh in Afghanistan did not confine their activities within the country, but they provided services in digging karezes also in Pakistan (Rahman, M 1981).

In the past, several groups of Karez-Kesh were available in Afghanistan, and farmers used to contract out karez cleaning jobs to them. But, in recent past due to changing socio economic conditions of local community caused by decade of civil unrest and flurry of external interventions that created new opportunities to rural communities, such special labor force are not that easily available. This phenomenon has hampered Karez cleaning activities.

Further, cleaning of karezes is becoming expensive due to labor shortage. As noted above, average cleaning costs of karezes vary between US$ 1,260 and 3,600 per km. Compared to the average irrigated area served by a karez, this cleaning cost is quite high. As a result, differed maintenance of karez is increasing demanding external interventions for their rehabilitation.

Above noted phenomenon have not only influenced the functioning of karezes, but they also damaged local institutions that were active in managing community cohesion and participation for managing water flow from the sources to their farmlands and households. With the introduction of gasoline driven tube well, people became more individualistic, as community approaches were no longer required. This has ultimately weakened social capital of the area.

**Sustainability of tube wells over karez irrigation**

Though tubewell irrigation has several advantages over karez irrigation\textsuperscript{11}, the ecological and societal sustainability of tubewell irrigation against karez irrigation under the present farming system is yet to be studied. Furthermore, there is general recognition that tube wells (especially deep) help only the well-off groups in the society, and not the poor and disadvantaged groups. As karezes are part of the national heritage of Afghanistan, they promote social cohesion and they are, in the long term, more sustainable than using wells with ever increasing depths.

\textsuperscript{10} Locally, this group of people is known by several names. Rahman, M.(1981) named them as Karez-Kesh, while Rout, B. (2008) reported their local name as KarezKan

\textsuperscript{11} Some of the advantages are: tubewells can be managed by individuals, they provide water instantaneously, there are fewer limitations due to land slope and soil types / geology.
Way forward for re-vitalization of karezes

Primarily, two strategies are to be adopted in revitalizing karezes in the Helmand basin. These are: maintaining groundwater table in the karez zones and minimizing maintenance costs of karezes.

As noted above, need of maintaining groundwater table arises when its level goes down through excessive extraction of waters by tube wells making the nearby karezes dry. This situation can be avoided either by rationing the installation of tube wells in such areas or by increasing groundwater recharge for maintaining water balance of the aquifer and thereafter groundwater table.

This strategy calls for two interventions. The first intervention should focus on institutionalizing key IWRM principles in the karez zone (or area). This requires mapping the geo-hydrological situation of the areas, defining aquifer boundaries and recharge zones, forming water user associations (WUAs) for implementing IWRM principles at the local level, and establishing guidelines for monitoring, licensing and restricting groundwater exploitation through pumping. The second intervention should focus on increasing groundwater recharge either by building delayed action dams as in the case of Pakistan, or through watershed treatment for increasing rate of infiltration. There are several successful cases of such intervention.

The second strategy is to minimizing maintenance cost of karezes. This can be achieved by physically strengthening vulnerable zones of karezes that are prone to cave in, and would demand more labours for cleaning. Collapse of karez cave and vertical shaft is one of the key maintenance problems. This can be minimized by introducing pre-fabricated elliptical concrete rings or concrete pipes in such vulnerable zones. There are several successful cases of such intervention.

Conclusions

Karez irrigation is part of Afghanistan’s national heritage. Farmers all over the country have built karezes for centuries using indigenous knowledge and skills. Unfortunately, this indigenous technology of karez irrigation is dying. A reported sharp decline in the

12 With regard to licensing groundwater extraction, the Water Law states that shallow wells are exempted from a permit/license when the water is used for meeting drinking and/or livelihood needs. The Water Law is less clear on the need of a license for shallow groundwater wells for commercial irrigation. Some argue that no license is needed for this unless the tube well would influence flows in nearby karezes. Irrespective of these provisions made by national legal system, community can still develop mechanisms for regulating installation of tube wells, if the approach is participatory.
groundwater table caused by a huge increase in the extraction of groundwater using gasoline driven pumps is the primary reasons. However, to what extent a gasoline driven pump influences flows in a karez under different geo-hydrological scenarios is not yet documents. Changing socio-economic condition of the local community leading to poor maintenance of karezes is the second reason for drying out of the karezes.

Even though tube well irrigation would become economically viable, their ecological and societal sustainability is yet to be studied. Furthermore, there is general recognition that tube wells would help only the well-off groups in society, but not poor and disadvantaged groups. In such a situation, it would not be wise to overlook technology of kares irrigation.

Karez irrigation is not just a technological artifact, but it also represents a strong social capital for managing the water, the watershed and the karez itself. Damage to a karez thus not only affects the delivery of water to a community, but it will also ruin the social capital of an area and may lead to an unsustainable agro-ecological system.

Thus, karez irrigation needs to be maintained to the extent possible. People of the study areas also have similar opinions.

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Zehtabian, G., Khosravi, H., and G. Marzieh (???) High Demand in a Land of Water Scarcity: Iran (Book chapter)
**INTRODUCTION**

Zambia is a landlocked country with a large land resource base of 42 million hectares of which only 1.5 million hectares is cultivated every year (Zambia Development Agency, 2011). It has abundant water resources for irrigation and country has 40 percent of the water in central and southern Africa. Technically irrigation potential of Zambia is 2.75 millions ha out of which 523,000 hectares can be economically developed. However, at present about 155,000 ha of land are irrigated, out of which 32,000 ha is under surface irrigation, 17,000 by sprinklers and 5600 ha is under drip irrigation. About 1,00,000 hectares of dambos or inland valley bottoms (wetlands) are utilized for crop production by small-scale farmers (FAO 2005). Eighty percent of the population is dependent on agriculture, which provides employment for about 70 percent of the labor force. Farmers can be categorized into four groups viz. small farmers owning 0.5-10 ha, followed by emergent farmers (10-20 ha), medium-scale (20-60 ha) and large-scale or commercial own more than 60 ha. Small scale farmers are food-crop oriented whereas large-scale farmers primarily produce cash crops. The emergent farmers produce a mix of food and cash crops. There are 0.6 million small-scale farmers of which 17 percent are emergent farmers followed by 14.2 percent medium-scale farmers, only 1500 (0.02) farmers are large scale commercial farmers. Large number of people depend on agriculture. Mining activities have sharply declined and some mines have been closed so agriculture of Zambia is the top priority. Agriculture export potential of Zambia is enormous. It’s export to COMESA amounts 125-140 million US$ per annum while the exports to the SADC region is between 140-170 million US$ per annum (Zambia Development Agency, 2011). Main commodities for export are Tobacco, sugar, cut flower and ornamental plants, wheat, other cereals, cotton, root and tuber crops, coffee, tea and spices.

* Senior Agriculture Development Officer, District Agriculture Development Office, Biratnagar, Morang, Nepal
WATER RESOURCES

Zambia lies entirely within two large river basins of Zambezi and Congo river. Total renewable water resources of Zambia is about 105 cubic kilometer/year of which about 80 cubic kilometers/year are produced internally (FAO 2005). There are about 1700 dams and its capacity is about 106 cubic kilometers. Lake Kariba alone accounts for 94 cubic kilometers which is shared between Zambia and Zimbabwe. Wetlands, including dambos which cover about 3.6 million hectares or 4.8 percent of total land areas, are the source of livelihood for the majority of small-scale farmers in Zambia. Dambos are used to irrigate surrounding farm and also used as drinking water for people and grazing animals.

Photos: Kalomo and Choma dams

Photos: Namwala and Kariba lake

Zambia has abundant cultivated land, possibility of irrigation water. Of total water usage, groundwater accounts for 9% of total and groundwater provides 28 percent of domestic water supply. Rainy season in Zambia falls between the month of November to April. Mean annual rainfall is 1200 mm, it is lowest (750 mm) in the south while central parts get between 900-1200 mm and northern Zambia gets highest (1400 mm) rainfall. Total rainfall and intra-seasonal rainfall distribution vary greatly from year to year, particularly in the south (FAO 2012). This makes rainfed agriculture more vulnerable.
Existing farming situation and irrigation system in Zambia

Southern Zambia receives less rainfall and has less water sources so this region falls under zone III which is water deficit areas of the country. However, the situation is not very bad and it can be changed by changing water harvesting and management situation. Traditionally smallholder farmers grow local maize, groundnut and cotton tend to have low inputs costs but also relatively low returns (Siegel 2008). Low-input low-return strategy adopted by many smallholder was an economically rational strategy especially in remote areas where labor and credit constraints dominate land constraints. Recently several organizations (GOs/NGOs) are working to change the situation. They are trying to organize irrigated high-value crop production link with market.

There are well organized agro-input suppliers (seed, seedling, fertilizers, plant-protection and machines under same roof) in Zambia. Crop productivity of irrigated land is higher and market price of quality agro-products is also good but farmers are very scattered and less-organized. Majority of them are cultivating their crop under rainfed situation and labor shortage is a problem everywhere. Therefore, oxen technology increase (net-return per person per day) more than three times compare to traditional hand-hoe technology with traditional crop (Siegel and Alwang 2005). In other ways commercially grown large-scale farmers get higher return but initial investments and the operating costs are very high and such farming is labor demanding. Sugarcane, tobacco, wheat are some commercially growing large-scale crops in Zambia. But vegetables like tomato, cabbage, egg-plant, okra, mustard-leaf, onion are cultivated by small farmers for local market. Most of the vegetable crops need assured irrigation facility so such crop are grown by small farmers around dams and along the stream. They irrigate such vegetable gardens by the use of buckets and water can. Very few farmers use treadle-pumps, power sprinklers and diesel/patrol pumps. Majority of the large farmers has big rain-harvesting dams or used ground-water through central pivot system of irrigation.

Photos: Bucket, treadle pump and central pivot system of irrigation
Smallholder farmers and their livelihood situation

Small-scale farmers are utilizing about 100,000 ha irrigated areas for vegetable cultivation. Such farmers used water harvesting dams, small drains, shallow wells for irrigation. Majority of the vegetables growers use buckets, watering cans, and hosepipes for irrigation to grow vegetables along streams, rivers and dams. Usually those farmers' garden size is 100-200 square meters. Slightly more than 500 ha land is irrigated by use of treadle pumps and they are able to irrigate 1000-2500 square meters area by one treadle pump.

Photos: Smallholder vegetable garden in southern Zambia

Treadle pumps and other low-cost water lifting devices (electric-motor, diesel/petrol pump, motorize sprinklers) increase irrigated areas and water use efficiency but initial cost of such devices is very expensive in Zambia. Money-maker treadle pump cost 1000-1200 Kwacha (200-240 US$) and 5-6 HP diesel/patrol water lifting pump's cost is about 5000-6000 Kwacha (1000-1200 US$) which is very expensive in comparison to south-Asian countries and most of the time it is less affordable for most of the small farmers in Zambia. UNDP livelihood support project conducted demonstrations of low-cost water lifting devices in southern Zambia. Following is the list of number of participants and their demanded water-lifting devices:

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<th>Demonstration of low-cost water lifting device participants</th>
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There was very good response of those demonstrations from farmers side and big crowds were attracted in most of those demonstrations. However, majority of the farmers demanded water-lifting devices (costly motorize machines and sprinklers) which was not matching with their need. Their cultivated area for vegetable gardening was small (200-500 square meters) and simple low-cost treadle pump is sufficient to fulfill their need.

**Marketing of high-value vegetable crops**

Marketing of smallholder farmers high-value vegetable crops is less organized and face cut-throat competition. There is very high competition to sells their products, they display their product at road-side or running behind vehicles to sell their product. There is intense bargaining and producers sells their product at low price compare to organized super-market outlets near urban centers. In one way, farmers yield and production volume is low and they need to sell their product at lower price. So, their profit and earning from vegetable garden is not enough to support their livelihood.

In other way some bigger farmers production was bigger and buyers come to their farm to buy their product at higher price. This reality is that if farmers either increase their production volume or bring products in one collecting center (one village one sell), then they can get buyer at their farm place and get higher price. In one way, they don’t need to run behind vehicle. They can concentrate more on their production and they also get higher return. During my work in Zambia, I found that personal creditability is one major hurdle behind such common marketing system.

Better irrigation management by using low-cost water lifting devices can help to increase volume of production. By using treadle pump, farmers can easily increase their farm size 4-5 times (like 2000-2500 square meter). By using diesel pump and sprinklers, farmer can easily cultivate more than one hectare land. Bigger land size give bigger volume and
get buyer closer to production farm. iDE (International Development Enterprise) is promoting high-value crop business model among small farmers with the help of low-cost water lifting devices and market connection. It gives some hope but scale-up of this model is very slow especially in southern province of Zambia. Investment on water lifting devices was one of the main problems especially for small farmers who don’t have sufficient saving because of low earning.

**Successful small farmer in Kalomo district.**
Mr. Obvious is small farmer farming at Kalomo dam side of Kalomo district. He was cultivating on 1000 square meter area and tomato was main crop of his garden. In 2013 he has planted 1000 tomato seedling of a indeterminate hybrid variety and another 1000 plants of semi-determinate hybrid tomato variety. From tall indeterminate variety he was expecting 10,000 kg tomatoes and from medium semi-determinate he was targeting 5000 kg. When I visited his farm last time he had already harvested more than half and his plants were heavily fruiting. So, he was expecting to achieve his target easily. His buyers come from Livingstone (150 Km from his garden) and pays him at an average rate of 2.5 Kwacha/kg tomato (average retail price at supermarket is 5 Kwacha/kg). In every harvesting he sells more than 200 kg tomatoes. From his small farm, he was expecting more than 37 000 Kwacha (about 7400 US$) from one crop. Obvious has two wives and 5 kids, wives and husband work on garden and kids go to school. He is an example of several innovative and hard-working farmer in Zambia.

Photos: Obvious (second from left) with local extension officer and author and his tomato garden
CONCLUSION AND RECOMMENDATION

About 70 percent of all Zambians were living below poverty line. Agriculture is the main source of livelihood especially in southern Zambia where other non-agriculture job opportunity is less. There are possibilities of change in rural poverty of Zambia through high-value crop production. It can be improved by the use of efficient irrigation management practices and low cost water lifting devices. At the same time, it is necessary to organize small farmers to improve marketing opportunities of their production. For this, development organizations (GOs/NGOs/Private sector) need to work together to facilitate change. Farmers organization, better access of low-cost water lifting devices for irrigation can increase production areas and increase volume of production which are first necessary condition for better marketing of their product. Marketable volume of the product and its regularity improve marketing situation and give higher return. Efficient farming and better earning contribute for better livelihood of African farmers. For these all, improvement of irrigation situation is most important. The effort of organizations development need to focus on farmers organization, irrigation facility and marketing system.

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Bisses, Irrigation Canals in the Valais Area of Switzerland

ARMAND DUSSEX*

1 *Bisse* is the local name in the French-speaking part of Switzerland for a low-gradient canal, often an open canal that carries water from streams and rivers to farmland (mostly hay meadows and vineyards in the Alps) in order to irrigate it and to enrich it with fertile sediments.

Irrigation canals of this type exist elsewhere in the world, but the Valais network of irrigation canals is particularly vast and represents a remarkable heritage. Today, I hope to show you how important these irrigation canals are, and I will present their specificities.

2 Valais is a Swiss canton or administrative region in the Alps. It is formed by the upper Rhone Valley between two mountains that are oriented east-west and that culminate at over 4,000 metres. The Rhone plain is flat and extends over a distance of 75 km at an altitude of between 400 and 800 metres above sea level. It is only 2 to 3 kilometres wide. The relatively steep mountain sides have been carved out of deep valleys most of which were originally glacial valleys. The current population amounts to just over 300,000 and is concentrated mainly in the plain and at the foothills, below 1,200 metres.

3 Valais is an inner Alpine valley and it is protected from the maritime airflow. Its climate is very dry. In the lower part of the central Valais hill sides, annual rainfall does not exceed 600 mm. It increases significantly with altitude. The skies are often clear and the average temperatures are among the highest in Switzerland. It is often said that Mediterranean types of plants grow here. It is a paradoxical situation in that the slopes are dry and even arid, while the rivers that flow from glaciers have an abundant supply of water throughout the year.

4 Today, the Valais region lives mainly off industry and tourism, though it was once a predominantly agricultural region. Grapes were grown on the lower slopes while

* .....
livestock farming was common in the middle mountains. Today, fruit trees are grown in the Rhone Valley. Vines still occupy the lower slopes on the right bank of the river.

5 The average mountain, which ranges between 800 and 1,500 metres high, was for the most part covered in cereal crops and hay fields. Crop farming has practically disappeared and there has been a sharp decline in the number of hay fields. New crops have been planted, such as medicinal plants, strawberries, raspberries and apricots. Because of the hot dry climate all these cultures, and even vines, need to be irrigated. Here you can see medicinal plants growing.

6 Irrigation used to rely on a traditional gravity system. Starting from the main bisse, a small canal carried water to the top of the fields. (Slide 6) By means of a metal plate or stone, the water was made to overflow into fields that needed to be irrigated. (Slide 7) This technique has almost died out and has been replaced by sprinkler irrigation.

7 As far as the old distribution network is concerned, not much remains of it: pipes installed on the surface of the soil now carry water to sprinklers. Some villages have built their own underground water networks.

8 Irrigation has existed in Valais since the beginning of the Christian era, but it only became widespread from the 13th century onwards. More than 250 irrigation canals have been identified and their length varies from 1 to 26 kilometres for the longest. Their capacity ranges from a few litres to 400 litres per second for the biggest.

9 The Valais has very rugged terrain, with its high mountains, rock faces and deep gorges. So irrigation canals had to be built on very difficult terrain and often along sheer cliffs. The biggest challenge was to build water intakes in deep river gorges and to channel water from there.

10 Special techniques were developed from the 12th century onwards. Here you have a bisse that was dug out of a tree trunk and was suspended from a vertical cliff. The oldest remains of this installation date from the 13th century. The capacity of these irrigation canals is rather low and barely exceeds 60 litres per second.

11 Building techniques were always adapted to local conditions. It was often very difficult to bring in materials from outside, so building was done with the materials available. There was often no choice but to dig the canal directly into the rock.

12 In the 15th century, there was a significant increase in the number of irrigation canals built. New bisse were built but, most of all, modifications were made to existing irrigation canals and these were enlarged. What was the reason for this frenetic building? The population had decreased by half after being struck down by various plague epidemics. At that time a lot of land was on offer and this led to a change in lifestyle. Whereas in the past cereals made up the staple diet, in the 15th century cattle breeding was developed, leading to both agricultural diversification and a commercialisation of products. Indeed meat and cheese sold easily. Cattle breeding required a large amount of hay to feed livestock during
the winter. And in turn, hay production required irrigation.

More efficient techniques were therefore invented. And in particular wooden canals with a capacity of up to 400 litres per second were built. These techniques were used on sheer cliffs but also on unstable terrain.

In the space of a few decades, from 1420 to 1480 about a hundred bigger and better irrigation canals were built which are among the largest and the most spectacular. At the time *bisses* were also built in vineyards, along dry stone walls, neatly tucked away between them.

There was very little activity during the Little Ice Age (1600 - 1850); however, by the end of it new structures had again started to be built. Some irrigation canals were built at an altitude of over 2,500 metres.

Then new technologies emerged at the end of the 19th century. Digging tunnels helped avoid places that were dangerous and difficult to maintain. The invention of dynamite was to play a considerable role.

Suspended irrigation canals have gradually been abandoned and are slowly disappearing from the landscape.

Now, concrete and metal are used more and more. These are not always aesthetically pleasing, but they are very practical.

There has been a marked decline in mountain agriculture since 1950. Many irrigation canals have been abandoned, though around a hundred *bisses* are used nonetheless. Even though they are still used for irrigation, they have taken on extra value. They are wonderful places for walking and they play an important role in tourism.

A remarkable heritage has been preserved. The fact that these irrigation canals have been restored and refilled with water has made them even more valuable.

Regardless of the use of irrigation canals for the sake of tourism, we should not forget their value in terms of our heritage.

We are fully aware of the ethnological value of *bisses*. The social organization of these irrigation canals is an important intangible, immaterial heritage. It is organized according to a community-based management system where users take matters into their own hands. This type of management is of great ethnological interest. Some community-based management systems that saw the day in the Middle Ages still exist today. They have survived several political regimes and are an example of sustainability. *(Slide 23)* Before writing became widespread, water rights were carved into wood. Here you can see a few records of water rights that date back to the 18th century.

*(Slide 24)* Today the Swiss *bisses* in the Valais area have their own museum and have become known for the wonderful walks they offer, whilst making a significant contribution to “soft tourism”. The following photographs are an invitation to come and travel the length of these irrigation canals. *(Note: photographs could not be included here)*
IMPROVING IRRIGATION SYSTEMS
TOWARDS BETTER PERFORMANCE
Small Scale Irrigation Systems: Challenges to Sustainable Livelihood
BACKGROUND
It is assumed that there are more than 15000 farmer managed irrigation system (FMIS) in the hills of Nepal. Being an agrarian economy especially dependent on irrigated paddy, these systems have played significant role for food security in the country for a long time. After introducing periodic plans, Government of Nepal has given high priority to agricultural sector in order to meet the increasing food demand for soaring population. Hence during late 80’s many programs and projects were executed in FMISs by various agencies such as CARE/Nepal, International Irrigation Management Institute (IIMI), Agricultural Development Bank Nepal, Hill Food Production Project, SINKALAMA Irrigation Program, the World Bank (WB) and Asian Development Bank (ADB) to improve the performance of FMISs. These agencies either rehabilitated existing systems or constructed a new one. Out of these agencies, two agencies the World Bank (WB) and the Asian Development Bank (ADB) have been continuing its support in irrigation sector even after completion of Irrigation Line of Credit (ILC) on July 1997 and Irrigation Sector Project (ISP) on August 1996 respectively. Nepal Irrigation Sector Project (NISP) and Irrigation Water Resources Management Project (IWRMP) were implemented after ILC in western, mid-western and far western regions with the support from the WB whereas Second Irrigation Sector Project (SISP) and Community Managed Irrigated Agriculture Project (CMIASP) were implemented in Central and Eastern regions with the support from ADB.

ILC
Irrigation line of Credit (ILC) was launched on a pilot basis with technical assistance from UNDP and investment fund was made available from International Development Agency (IDA)/WB in Nepali fiscal year 2045/46 (1988/89). A total credit of US$18million has been allocated for the implementation of this pilot Project in three western regions. It has
three categories of programs.

- Program to support the FMISs in private sector;
- Program to turn over a government managed irrigation system to the organized group of beneficiaries in the private sector;
- Program for joint or participatory (both by government and organized beneficiaries) management of large irrigation system.

Physical achievement

The ILC improved 299 small and medium surface irrigation systems covering nearly 39,000 ha. Twenty-five of the 299 subprojects previously managed by DoI were turned over to registered Water Users’ Associations (WUA) for operation and maintenance. In addition, the ILC completed 217 medium and deep tubewells in 18 clusters covering about 4,120 ha.

Impact on Agriculture

During 1993, evaluation study was carried out in 22 ILC completion project by Research and Technical Branch of DoI. According to that study, it was found that out of 22, 16 systems had a clear positive impact on agriculture production and cropping intensity. The average increase in cropping intensity is 35%. In one system the cropping intensity was decreased by 10% and in other 5 systems, minor impact of irrigation was experienced in cropping intensity.

ISP

The ISP is financed by the loan of ADB. The project was launched in March 1989 with a target of commanding a total area of 31,000 ha. The total cost of the project was US$ 47.41million of which ADB provided a loan of US$ 36.3 million, Nepal government contributed US$4.4 million and UNDP supported a grant of US$ 2.01 million.

Objectives of ISP

- Rehabilitating and upgrading of FMISs commanding a total area of 25300 ha;
- Construction of new and medium scale gravity irrigation schemes commanding a total area of about 7700 ha;
- Strengthening two regional offices and and district irrigation offices of the subproject area;
- Financing of additional cost to be incurred by DOI in connection with the implementation of the project.

Physical achievement

Under this project 277 farmers’ irrigation systems were rehabilitated by providing irrigation facility to 46,371 ha. 99 new irrigation systems with total command area 11,211 ha were built. Overall 376 subprojects were accomplished by developing 57,582 ha.

Impact on Agriculture

In March 1995, Research and Technical Branch of DoI conducted the evaluation study of 34 ISP assisted irrigation systems. As per the findings of evaluation, out of 34 systems, the
project helped to alleviate food deficit at 14 systems. In 16 systems there was no change in the food deficit condition. In 18 systems, significant impact was observed regarding the increase in production. In 11 systems, either the production remained constant or increased very slightly but not significantly. In 2 systems, production decreased. In the case of paddy production, it increased highly in 8 systems, slightly in 12 systems and remained constant in 10 systems. In 8 systems cropping intensity increased by 25%. In 18 systems, it remained unchanged. In five systems, it was found to be decreased. It is stated that reason for decrease in cropping intensity is due to increase in paddy area rather than no other crop area.

**NISP**

NISP was supported by a Development Credit Agreement between the Kingdom of Nepal and the World Bank/IDA (Credit Number 3009 NEP) dated December 18, 1997 for total of SDR 58,700,000 (equivalent to about US$ 80 million). The credit became effective on 17 September 1998.

The NISP was conceived to develop the 'Water Sector' of Nepal with a comprehensive National Plan incorporating various components related to Water Resources in Nepal. Its components consisted of (i) Water Resources Strategy Formulation, Phase-II Study, (ii) Irrigation infrastructure development, and (iii) Institutional Strengthening of Department of Irrigation, Department of Hydrology and Meteorology, and Department of Agriculture. The primary goal of the project was to improve the productivity and sustainability of Nepal's Water Resources development and to increase agriculture production and income of the subsistence farming community. Poverty Alleviation has been the key mandate behind its goal through the improvement of the agriculture sector by promoting efficient irrigation, thereby increasing production in irrigated agriculture.

Especially, component two was envisaged to improve productivity and sustainability on viable private and public irrigation schemes of 59,600 ha including carryover schemes from ILC, as a first stand alone project and to allow Water User's Associations to be involved in the design and construction of irrigation facilities and, thereafter, to take over full or joint O&M upon completion.

This component consisted three main subcomponents

- Rehabilitation, improvement and development of small and medium scale farmer managed irrigation systems (FMIS);
- System improvement and farmer turnover in public irrigation schemes; and
- Infrastructure support development.

**Physical achievement**

Within the period of six years NISP is able to complete 373 sub projects providing irrigation facilities to 46,264 ha. Under participatory joint management and turnover schemes, altogether 17 schemes were undertaken in NISP. These schemes cover 4,731 ha in the Western Region and 800 ha in the Far-Western Region for improvement and turnover fully or partially. 11 out of 12 subprojects in the Western Region are completed and all the
five turnover schemes of the Far-Western Region are completed. In aggregate, 16 schemes covering 5,131 ha have completed rehabilitation and improvement works. Although all five schemes in the Far-Western Region have been formally turned over to the farmers, it is unfortunate to notice that no such schemes have been declared to be formally turned over to the user farmers in the Western Region.

Impact on Agriculture

**Crop Yields**
The MOAC survey in 2003 found that after the implementation of the project there was change in crop yields in all three regions. Production of Paddy, Wheat and Maize was increased by 43, 47 and 35 percentage in average of three regions respectively. The crop yield of paddy in the Far-Western Region has improved by 57%, and the increase of wheat and maize crop yields has been at the rate of 45% and 37% respectively. The data shows that there has been substantial improvement in crop yields of paddy and wheat in all the project areas under NISP. The availability of water during winter for the wheat crop and adoption of high yielding varieties in irrigated areas are the factors leading to significant improvement in yield of wheat and paddy crops.

**Cropping Intensity**
The cropping intensity (obtained by dividing the cropped area by the cultivated area) has increased from 162% to 221% in the Western Region, from 164% to 206% in the Mid-Western Region and from 132% to 190% in the Far Western Region after the completion of projects.

**SISP**
The SISP came as normal extension of ISP and was designed on the basis of results and achievements of the first ISP (Loan No. 923 NEP (SF)) and lessons learnt from the implementation of similar other projects. It was signed between Nepal government and ADB on 13 August 1996. The amount of loan was SDR 17.109 M ($ 25 Million equivalent) from Bank Special Funds.

Main objectives of the Project were to increase agricultural productivity and to improve farm income of the farming community on a sustainable basis. These objectives were meant to contribute towards the Government's goals of raising the socio-economic status of small farmers, reducing poverty, and generating employment opportunities in rural areas. This Project was implemented in the Central and Eastern Development Regions covering 35 districts of Nepal.

**Physical achievement**
In total 283 (41,148 ha) irrigation sub projects was constructed under this scheme including 14 defunct projects of ISP in Ilam due to unprecedented rainfall in 1996.
Impact on Agriculture

Crop yields
The main benefit assessed at appraisal was from increase in agricultural productivity and improvement in net farm incomes of marginal and small farmers of the sub-project area. The modest increase in crops yield was assumed to be on average of 25%. From the assessment of agricultural benefits due to increase in yields and productivity in the subprojects completed results were satisfactory. The yields were increased considerably but the net farm income per hectare did not go up much due to sharp drop in price of paddy at that time.

Cropping Intensity
Cropping intensity was raised to 30% in Terai and 25% in the hill sub-project's culturable command areas. However, in case of construction of new schemes the whole irrigated area was increased over rainfed conditions resulting in net increase in irrigated area. In the central region, the irrigated cropping intensities in the hill on the average have gone up from 145% to 192% and that for Terai from 104% to 194% in other words 47% and 90% respectively. Similarly in eastern region, it has gone up from 44% to 124% in hills and 107% to 203% in Terai. Thus increase of 80% & 96% respectively is observed.

1. IWRMP
The IWRMP was initiated in 2008 with the aim of supporting the national goal of poverty reduction and to develop Nepalese irrigated agriculture through irrigation development and management. The project was implemented with the grant assistance of the World Bank (WB), along with direct contribution of Water Users Associations (WUAs) and the Government of Nepal (GoN). The total cost of the project was US$65 million, out of which $50 million is grant assistance from the World Bank and the remaining $10 and $5 million is contributed by GoN and WUAs respectively.

The project comprised of four components: (a) Irrigation Infrastructure Development and Improvement; (b) Irrigation Management Transfer Reform; (c) Institutional and Policy Support for Improved Water Management; and (d) Integrated Crop and Water Management. The objective of the Irrigation Infrastructure Development and Improvement (Component-A) is to improve irrigation water service delivery in selected schemes in the Mountain, Hill and Terai including improvement and expansion of groundwater irrigation in the Terai.

Physical Achievement
Out of 134 subprojects, 85 subprojects were completed in physical Infrastructure Improvement and Development (IID) works on May 2014. The completed subprojects are providing irrigation services to 10,950 ha of irrigable land.

Impact on Agriculture

Crop yields
While assessing 85 completed subprojects which cover 78 surface and 7 groundwater
Irrigation schemes of different districts the effect of irrigation on incremental average production has been observed 63% in paddy (cereal crop) and 73.9% in potato. The average productivity under post project conditions in study area is found highest in vegetables (14.3 t/ha) than that of the productivity of pre-conditions (8.4 t/ha) followed by the productivity of potato increased from 7.8 t/ha of pre-project situation to 13.7 t/ha of post-project situation. Likewise in cereal crops, the average productivity is found highest in paddy (3.7 t/ha), followed by 2.8 t/ha and 2.6 t/ha for maize and wheat, respectively.

**Cropping Intensity**

The overall cropping intensity of 85 subprojects under assessment was found 247.68% with an increment of around 57.9%. The positive trends visible on productivity of different crops are as the result of intensive extension program with better irrigation facilities.

**CMIASP**

The CMIASP was supported by a Loan Agreement between the Government of Nepal and the Asian Development Bank (Loan Number 2102-NEP(SF)) dated 23 December 2005 for a total of SDR 13,615,000 (equivalent to about US$ 20,000,000). The loan became effective in January 2006. In addition, CMIASP was supported by a Loan Agreement between the Government of Nepal and the OPEC Fund for International Development (Loan Number 1060P) dated 21 December 2005 for a total of US$ 7,000,000.

The overall goal of the CMIASP was to promote inclusive economic growth while reducing poverty in the rural areas of the Central and Eastern Development regions of Nepal. Its specific objective was to improve agriculture productivity and sustainability of existing small and medium-size farmer-managed irrigation systems (FMIS) suffering from low productivity and high poverty incidence, and thus enhance the livelihood of poor men and women including ethnic minorities and Dalits. To achieve the objective, the Project would (i) provide improved means for WUA empowerment, irrigation facilities, agriculture extension, and targeted livelihood enhancement to build the human capital of the poor including women and traditionally neglected disadvantaged groups; and (ii) strengthen policies, plans, and institutions for more responsive service delivery and sustained impacts.

The Project's expected outcome as defined at appraisal for enhanced productivity and sustainability of FMIS by (i) providing improved measures for WUA mobilization, rehabilitation and expansion of irrigation infrastructure, agricultural development, and targeted livelihood enhancement for 270,000 households covering 34,000 ha (including 8500 ha of expanded command area); and (ii) strengthening policies, plans, institutions, and operational mechanisms for more responsive service delivery and sustained aspects. By 2015, the expected policy and institutional reforms were to be achieved, and the following targets achieved through 210 subprojects: (i) cropping intensity increased by 40%; (ii) annual crop production increased by at least 51,000 tons; (iii) gross margin per farm family
increases by 70%; (iv) permanent employment increases by 3.3 million days; and (v) annual farm income of landless farm laborers increases by over NRs2,000.

Physical achievement
No new schemes were included, although expansion of existing schemes was allowed for and has been implemented. It was said that because of a substantial increase in construction cost the expected outcome of the project had to be revised downward during the Mid Term Review. The total number of subprojects was reduced from 210 to 101 which in turn reduced the irrigation coverage from 34,000 ha. to 15,677 ha. By reducing the number of subprojects and the irrigation coverage the beneficiary population also reduced from 270,000 to 115,600. While the expected increase in cropping intensity, the gross margin per family and the annual farm income of landless farm laborers remained unchanged, the related targets for increase in the annual crop production had to be deceased to 32,100 tons, as well as the permanent employment increase which was reduced to 1.3 million days.

Impact on agriculture
Crop yields
The revised target for the increase in annual crop production of 32,100 tons would require an average annual increase in production of 2.05 t/ha, which with an estimated post project cropping intensity of 207% would amount to an increase in production of about 0.99 t/ha per crop. This amounts to an average increase in crop yield over the pre-subproject condition of approximately 30%. In the sample subprojects an increase of 20 to 100% in crop yields was observed with an average increase of more than 40%, which indicated that the project is likely achieve and most probably exceed the agreed production target.

Cropping Intensity
The increase in cropping intensity is slightly below the target of 40% set by the project. In the preparation of the subprojects it was estimated that an average increase in the cropping intensity of 34.5% could be achieved; however in a detailed survey by the Institutional Strengthening Project Management of batch 1, 2 and 3 sample subprojects, it was found that the average increase in cropping intensity was only 28%. This is mainly because of a lower than expected performance of many of the Terai ISPs.

DISCUSSION
Physical Achievement
At present market value around NRs 58 billion has been invested in these six projects equivalent to build around 300 MW hydropower project. Altogether 1517 irrigation sub projects were completed by irrigating 210,621 ha command area. The figure 1 and 2 has depicted comparison of command area and number of completed projects under all sector projects.
Impact on Agriculture
The prime objective of each irrigation project is to increase agricultural productivity by making the irrigation system sustainable, no matter whether it is donor-assisted or government-funded. Result in crop yield and cropping intensity reflects whether investment in irrigation is worth or not. According to DoI evaluation report in ILC and ISP, there was variation in crop yield and cropping intensity in different sub-projects. The result was not encouraging. The result of the crop yields in rest projects also varies a lot. In NISP, Production of Paddy, Wheat and Maize was increased by 43, 47 and 35 percentage in average. In SISP, the modest increase in crops yield was assumed to be on average of 25%. Similarly in IWRMP, it was increased by 63% in paddy (cereal crop) and 73.9% in potato and in CMIASP crop yield was increased by 40% in sample sub-projects. National Water Plan (NWP) has clear target to increase average cereal yield over 2001 by 28% and 44% in 2017 and 2027 respectively. None of the report calculated the average cereal yield over 2001 as envisaged by NWP.

While assessing cropping intensity, it is assumed that in a country where one crop is largely covered by monsoon, cropping intensity after irrigation has to go up to over 170%. Even NWP has envisaged increasing cropping intensities to 164% and 193% in 2017 and 2027 respectively. Water Resources Strategy (WRS) 2002, Nepal states that “155% cropping intensity on average is said to have year round irrigation.” However, in fig 3, IWRMP and CMIASP cropping intensity before project is at the level of 170% which is quite high than NWP targets and more than year round irrigation as stated in WRS. It indicates that either farmers cultivate two season crop prior to irrigation facility or there must be major information gap while collecting data. Cropping intensity more than 200% is also sceptical since most of the systems built in these sector projects are supplementary to rainfall. Despite the profit in spring rice farmers can not cultivate it due to less availability of water in source.
In average spring cultivation is fraction of the total CCA compared to monsoon paddy. Cropping intensity in NISP and SISP are reasonable before project and after project.

The irony is that despite such huge investment in irrigation, three and half million people (13% of the population) are still considered to be moderately or severely food insecure. 42 out of 75 districts are classified as food insecure with respect to food grains. As per the key indicators given in table 1, agricultural import is much higher than agricultural export. Employment in agriculture is in decreasing trend.

<table>
<thead>
<tr>
<th>SNo</th>
<th>Indicator</th>
<th>1995/96</th>
<th>2010/11</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Agricultural GDP</td>
<td>$3.4 billion</td>
<td>$5.2 billion</td>
</tr>
<tr>
<td>2</td>
<td>Agricultural land HH/ha</td>
<td>1.1</td>
<td>0.7</td>
</tr>
<tr>
<td>3</td>
<td>Less than 0.5 ha</td>
<td>40.1%</td>
<td>51.6%</td>
</tr>
<tr>
<td>4</td>
<td>Employment in agriculture</td>
<td>66%</td>
<td>60%</td>
</tr>
<tr>
<td>5</td>
<td>Agricultural export</td>
<td>$32 million</td>
<td>$242 million</td>
</tr>
<tr>
<td>6</td>
<td>Agricultural import</td>
<td>$157 million</td>
<td>$621 million</td>
</tr>
</tbody>
</table>

Even a layman can raise a question about the rationale of investment in irrigation if the result is not satisfactory. In Nepal, 46% of agricultural productivity comes from 40% irrigated land whereas 40% of agricultural productivity comes from 17% of irrigated land globally. Agricultural GDP of Nepal during 1995/2010 is only 3%, minimum in South Asia. Therefore it can be said that agricultural practice in irrigated land in Nepal still has some gaps.

Where does the gap lie? Is it due to non-availability of water or is it due to lack of other agricultural inputs such as seeds, fertilizer. As per project completion reports of sector projects, cropping intensity has gone up, yield has increased, EIRR is more than required, but the existence of many food insecure districts show contradictory result.
Nepal is disaster prone country. Operation and maintenance of irrigation systems in hilly area are sometimes very costly due to natural disaster. Despite water availability the poor maintenance results less irrigation efficiency. Increase in irrigation efficiency is another major indicator of success of project. However it was not mentioned in any project completion reports. Therefore NWP irrigation efficiency target of 45% in 2017 could not be compared with any of these projects.

As mentioned earlier that 1517 irrigation projects were completed by sector projects but the status of these projects needs to be updated every year in order to know there operating condition. For example it was found that after completion of ISP, 14 projects were destroyed immediately in next rainy season and they were again taken up in SISP for rehabilitation. The same incident might have happened in other sector projects too. Third party study and research are necessary in order to find out its status, impact and outcome.

CONCLUSION AND RECOMMENDATION:
Since time immemorial, Nepali farmers have been developing and managing irrigation systems by local techniques and local resources in order to store staple food year round. Still it is assumed that Nepal has more than 15000 FMISs and so far only around 10% of these systems have been intervened by government with the assistance from ADB and WB. Apparently, either remaining FMISs are self-managed without any problems or because of other technical reason these systems are deprived from state’s resources. As government has been investing a huge amount of money in order to foster WUA’s capacity, major portion of farmers have missed such opportunity to be the part of participatory irrigation management. In order to tackle it, government needs to conduct survey to identify FMIS in each district so that databank can be kept for future plan.

Cropping intensity and agricultural production measure the success or failure of irrigation project. It is found that the data taken prior to the project seems to be quite irrelevant in some of the sector projects so while preparing project completion report irrelevant data needs to be verified.

Nepal has prepared National Water Plan with the help from Canadian International Development Agency and the WB, however the development agencies working under GoN have not owned this document for the planning and implementation of water sector projects. So it is difficult to compare the envisaged target in irrigation sector of NWP to present status. Therefore it is recommended to prepare the project completion report in such a format that the data in the report can be compared with NWP target.

It has been realized that many systems rehabilitated under sector program are abruptly abandoned by government once handed over to WUAs. The linkage of WUAs and government needs to be continued for post irrigation impact and sustainability of the
systems. Lacking information of the past rehabilitated projects under these sector programs make it difficult for future planning of similar type of intervention. The status of rehabilitated projects needs to be updated every year by government in order to know the functionability and performance of developed irrigation systems.

Despite huge investment in irrigation the increasing trend of agricultural import is serious threat to country’s economy. The major agricultural product that have been importing needs to be identified and government needs to create conducive environment to attract younger generation to produce same imported agriculture product in their land so that their priority will be switched to agriculture at home than foreign employment.

REFERENCE


DoI, 2014. Project Completion Report, Community Managed Irrigated Agriculture Sector Project, Ministry of Irrigation, Department of Irrigation, Lalitpur, Nepal.


INTRODUCTION AND OBJECTIVES

Background

For many years, irrigation development in Nepal remained in the hands of the farmers, who have been constructing irrigation systems at their own initiatives. This tradition gave birth to FMIS throughout Nepal. These systems developed their own rules, norms and procedures of operation and management and are either built individually by the concerned farmer or by a group of farmers. Therefore, they are either individual or community owned, but most are community owned (Pradhan et al., 2013). According to the irrigation policy (2013), irrigation systems with a command area less than 25 hectares in hill and mountain regions and less than 200 hectares in terai region, has been referred to as small-scale.¹

Economically and socially, small-scale Farmer Managed Irrigated Systems (FMIS) are of huge significance for Nepal. Nepal Living Standard Survey (CBS, 2011) found that 76% of the population makes their living mainly from the agricultural sector which contributes 33% of Nepal’s GDP. Pradhan (2000) claims that 40% of food production in Nepal is generated from irrigated agriculture of which 70% is comprised of FMIS. Pradhan (1989 and Gautam et al. (1992) estimated there are about 16,700 FMIS in Nepal, which account for 70% of the irrigated land; approximately 15,000 FMIS lie in the Hill region. The FMIS in the hill region are small in size and cover 89% of the irrigated area of the region (Parajuli et al., 2001). These systems have ensured, to a greater extent, the food security and local

¹ The size of the systems has been reclassified from 25 to 10 ha as small in the hills and less than 100 ha in terai as small.
rural livelihoods in Nepal (Brabben et al. 2004). Improving the performance of FMIS is a key factor for increasing food production in Nepal (Ostrom et al., 2011).

The hill region of Nepal is in a food deficit condition and irrigated agriculture has not achieved the expected performance in terms of productivity and sustainability (NPC, 2010). Since the 1980s, a number of interventions have been undertaken in Nepal to improve the performance of irrigation systems by government and donor agencies. Often physical infrastructure gets higher priority than other aspects (Ostrom et al., 2011). To understand irrigation systems better, the physical as well as socio-ecological aspects of the systems should be considered (Pradhan, 2012).

**Research Objectives and Questions**

The objectives of this applied research are to assess policy and institutional; social and organizational; environmental and economic aspects of small FMIS and provide recommendations on practical improvements to small FMIS in the mid-hills of Nepal. The specific objectives are to provide recommendations on:

- Maximising agricultural production and incomes with minimal impact on the environment.
- Ensuring equity of water distribution and benefits among the users.
- Optimising efficiency in water conveyance and use.
- Having plans, policies and institutions in place to enable the above objectives to be achieved.

In order to provide the above recommendations, the specific research questions are:

1. What studies have already been undertaken aimed at improving small FMIS in Nepal?
2. What are the similarities and differences between different kinds of intervention approach of FMIS?
3. What inefficiencies exist with small FMIS in terms of production, equity, water conveyance and use?
4. What are the governance issues that affect small FMIS, and how can an Integrated Water Management (IWM) approach be used to improve the problems identified?

**Research Methodology**

This research was aimed at expanding on the literature review by making direct observations and talking with key stakeholders, to better understand the complexities and issues of small FMIS in the mid-hills of Nepal, and to make potentially feasible recommendations based on the literature and data collected.
For collecting the views of the FMIS users, qualitative research methods were used. Along with qualitative data, some quantitative data were collected (crops productions, market rates) to interpret and better understand the complexity of collected qualitative information. The three qualitative research methods used were:

1. Participant observation for collecting information on naturally occurring behavior in FMIS.
2. Semi-structured interviews for collecting information on individuals’ perspectives and experiences on agricultural, economic, environmental and social aspects of FMIS.
3. Focus Group Discussions (FGD) for generating broad overviews on issues of FMIS.

Field visits were carried out in three small FMIS scheme areas in Dailekh district, one of the mid-hill districts in Nepal for physical observations and discussions with representatives of FMIS users (individuals, user committees). To cross-check and consolidate observations and findings from the FMIS schemes, interviews were conducted with the representatives of District Development Committee (DDC), District Technical Office (DTO), District Agriculture Development Office (DADO), Helvetas and Local Service Providers. Representatives from the Department of Irrigation (Mid-Western Regional Office and Divisional Office Surkhet), River Training and other Infrastructure Development Section of DOLIDAR, Community Irrigation Project/DOLIDAR, and FMIS Promotion Trust were also interviewed and secondary information was also obtained from these organisations.

The three small-scale FMIS selected for the study in Dailekh district were:

1. Khagitada FMIS: Scheme-1, supported by DDC
2. Chaur Tarpanela FMIS: Scheme-2, supported by Helvetas
3. Hadekhola FMIS: Scheme 3, has not received any external support

Consultations were held with DDC, Helvetas and local service providers, to identify the most appropriate FMIS to include in the study. The main reasons for selecting these three kinds of FMIS were:
- They represented the most common types of FMIS found in the mid-hills of Nepal.
- Due to time and financial constraints, it was not possible to cover a large number of FMIS in various regions of Nepal, so a case study of three types of FMIS was undertaken to cover the range of FMIS, to obtain a deeper understanding of representative FMIS and thereby allow a comparison of the differences between them, and identify some of the key elements that are limiting the performance of all three types of FMIS.

All the schemes are located in similar geo-physical and agro-ecological settings, with the users having similar socio-economic conditions. The three schemes had some common
features of FMIS in the mid-hills of Nepal, these features being:

- All the schemes were originally built by the users themselves, about one hundred years ago.
- The schemes draw water from perennial streams which have higher flows during monsoon (June-August) and low flows during summer (March-May), with average flows during other months.
- The number of users, size of command area, length of canal, available water in the stream varies from one scheme to another. However the average command area per user is usually less than 0.5 hectares.

Dailekh district was selected for the study because many government organizations, such as DDC, DADO and Department of Irrigation, and non-government organisations such as Helvetas, Practical Action UK, Oxfam, IDE\(^2\), are involved in extending support to small FMIS through different projects and programs. As I was engaged in improving small FMIS of the district being associated with Helvetas for more than three years, I had a keen interest on further exploring the issues and status of FMIS in the district.

**Limitations**

A logical set of guiding checklist questions was developed, based on the objective of the study, and sufficient care was taken to select the most appropriate FMIS samples and representative farmers. However since a single person was dedicated to the study, this can potentially lead to unintentional bias in data collection. Given the limitations of time and broad catalogue of issues, most of the recommendations are based on examples rather than on statistical evidence. However, as much as possible, the data collected was triangulated through comparisons between sites, with information sourced from different stakeholders being compared.

**ISSUES AND PROBLEMS**

Farmers are currently experiencing several challenges, including competing demands for water, climate variability impacts on soil erosion and crop productivity, and low investment support in the agricultural sector (Slater et al., 2007). The challenges are also associated with issues of policy, institutional arrangements and technology in irrigation management (Shiferaw et al., 2009). Due to a lack of permanent structures, most FMIS in Nepal are prone to damage during floods and to silt problems. In consequence, the running of these systems is labour intensive. Often, there is high water seepage along the earthen canals, which not only results in frequent landslides, but also results in either insufficient or untimely water to the intended command area. This adversely affects crop yields and can also become a source of conflict among users (Helvetas, 2006).

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\(^2\) IDE: International Development Enterprises
Policy and Institutional Issues and Problems
In 1995, the National Planning Commission of Nepal devised a twenty-year Agriculture Perspective Plan (APP). The APP has emphasized on improving existing FMIS and constructing new irrigation systems, to provide round-the-year irrigation. Irrigation Policy of Nepal (2013) and Local Infrastructure Development Policy (2004) identify FMIS as a major contributor to poverty reduction and food security\(^3\) in Nepal, with both policies placing an emphasis on financing FMIS activities.

Although national policies and plans give high priority for FMIS, there is lack of a coordinated effort to promote FMIS both at the central and district level. Three ministries, Ministry of Federal Affairs and Local Development (MOFALD), Ministry of Irrigation (MOI), Ministry of Agriculture Development (MOAD), are funding and supporting small FMIS. There is current confusion regarding the roles and responsibilities of the different ministries. Although the related policies clearly mandates MOFALD, its department DOLIDAR and its local bodies DDCs and VDCs, to coordinate and implement small-scale FMIS related programmes, projects and activities, there are differences in opinions among representatives of different government organisations regarding who should take the lead role in supporting and coordinating small FMIS.

In Dailekh district, DOLIDAR is implementing the Small Irrigation Programme through DDC/DTO. The Department of Irrigation (DOI) has continued to support small and medium sized FMIS through a project titled Irrigation and Water Resource Management Project (IWRMP) which is funded by the World Bank. The DOI also supports command areas of less than 25 hectares through a Non-conventional Irrigation Technology Programme (NITP). The Ministry of Agricultural Development through its District Agriculture Development Office supports small-scale FMIS improvement, mainly for repairing and improving existing canals within FMIS Similarly, Helvetas was supporting small-scale FMIS through a project titled Local Infrastructure for Livelihood Improvement (LILI), coordinated by MOFALD and DOLIDAR at the central level, and DDC/DTO at the district level. Other INGOs such as Practical Action UK, OXFAM, and International Development Enterprises (IDE), also supported small-scale FMIS through local service providers (Notes from interviews, Dailekh March 2014).

All the above organisations, programs and projects aim at improving FMIS and increasing agricultural productivity and incomes. However, there is lack of consistency in the funding contribution policies (cost-sharing between supporting agency and communities), planning processes, scheme selection processes and criteria and implementation modalities, which show there is lack of harmonised policy and coordination among different agencies supporting FMIS. Therefore, the response to genuine community demands can be ineffective and insufficient, due to a lack of coordination and consistent policy for supporting FMIS.

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\(^3\) Food security: Availability and access to adequate amount of food for the healthy and active life
Irrigation systems are composed of a resource (water), physical infrastructure (storage and canals), actors who manage (farmers and irrigation managers) and a governance structure that regulates the action and interaction of the actors (irrigation institutions). Currently, the dominant approach has been on physical infrastructure improvement. This approach has undermined the significance of other components, resulting in low performance of irrigation systems (Ostrom et al., 2011). Revitalising irrigation systems to meet current and future needs requires an integrated development approach consisting of infrastructure rehabilitation, investment to increase yields, and promotion of appropriate institutions and innovative management modes (IWMI & FAO 2009).

Recently, DOLIDAR started developing a District Small Irrigation Master Plan (DSIMP) which aims at planning and development of small-scale FMIS through taking into account the existing situation of all small-scale FMIS in the district, prioritising them according to objective criteria with wider participation of beneficiary communities. Discourses are continuing as to whether by developing only a sectoral plan without having plans for other water sectors, can address FMIS issues in the long term.

Key stakeholders of FMIS have been arguing that, although the allocation of funds for the development of FMIS is increasing, there is a shortage of financial resources for FMIS development, and the available resources are not able to address the present needs of FMIS. However, it was observed that, as the funds are being channeled by different organisations in their own ways; there is a high probability of duplication or misuse of funds. Even for small repair work, FMIS users of many schemes expect external support to come sooner or later. This has caused an increased dependency of FMIS users on external support for work which, in the past, they would have managed to address themselves.

Social and Organisational Issues and Problems
For the past eight years, Nepal has been running with an interim constitution, and there has been no elected body at the local level for the last 16 years. This has resulted in low levels of enforcement of the rule of law, and has promoted corruption and sluggish growth in many sectors (Helvetas 2012). Tropp (2006) argues that 'corruption can play a decisive role in determining who gets how much of what type of water, when, where and how'.

According to the Local Self Governance Act (1999), a Water User Group (WUG) of 7-11 members should be formed in order to be eligible to receive support from government agencies. The WUGs are then responsible for the construction, operation and maintenance of the FMIS; however, most WUGs fail to continue after the completion of an intervention. The key positions in WUGs are often captured by elite men with large areas of land in the proposed command area, with women, disadvantaged groups and those with less land being less well represented. Traditionally, the operation and maintenance costs are shared equally by all users, irrespective of the size of the irrigated land while often water sharing is in favour of the head-end users and users having more land (Notes from field interviews, 2014).
The armed conflict between the Communist Party of Nepal (Maoist) and government forces between 1996 and 2006 resulted in thousands of rural population moving to the cities and abroad (Lokshin and Glinskaya 2009). CBS (2011) enumerates that one in every four households has at least one member going abroad for jobs and other opportunities, with 80% of them being male. This movement of the rural population has resulted in a scarcity of labor and investment in rural areas.

Agriculture is the main source of income for most of the households and about half of the households had food sufficiency for less than six months\(^4\) while 25% of households had sufficient food for the full year. Some 75% of households had at least a household member working elsewhere, most of them being male; almost half of those working abroad were in India, with the remainder working in Malaysia and the Gulf countries (Notes from field interviews, 2014).

**Issues related to agricultural productivity**

The majority of the population in Nepal depends on subsistence mixed farming systems such as integrated cropping, forestry and livestock (Joshi & Maharjan, 2007). Although agriculture accounts for almost 33% share on GDP, productivity of the sector is low, adoption of improved technology is limited, and even though 80% of the cultivated area is devoted to cereals, there is growing food trade deficit and food insecurity (CBS, 2011). Production of major food staples like rice and wheat are insufficient to feed the population. In the first half of 2013 Nepal imported rice worth US $ 55 million (Kathmandu Post, 2013).

Although there has been progress in some areas, the overall agriculture sector in Nepal is still in a low development stage, as highlighted by a number of indicators in Table 1.

**Table 2: Some indicators related to the agricultural sector in Nepal**

<table>
<thead>
<tr>
<th>Indicators</th>
<th>2010/2011</th>
<th>Comparisons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Productivity of agricultural labor($/person)</td>
<td>$700/person</td>
<td>1/4(^{th}) of the non-agriculture labor productivity</td>
</tr>
<tr>
<td>Agricultural land per household (ha/household)</td>
<td>0.7</td>
<td>1.1 in 1995/96</td>
</tr>
<tr>
<td>Percentage of holdings operating less than 0.5 ha</td>
<td>51.6%</td>
<td>40.1% in 1995/96</td>
</tr>
<tr>
<td>Productivity of cereal crops (kg/ha)</td>
<td>2,481</td>
<td>4,191 in Bangladesh, 5,706 in China and 2,883 in India.</td>
</tr>
<tr>
<td>Agricultural exports</td>
<td>$248 million</td>
<td>Imports is $621 million</td>
</tr>
<tr>
<td>Poverty based on cost of basic needs approach</td>
<td>25%</td>
<td>42% in 1995/96</td>
</tr>
<tr>
<td>Irrigation coverage seasonal(%) of cultivated area</td>
<td>54%</td>
<td>40% in 1995/96</td>
</tr>
</tbody>
</table>

Source: Agriculture Development Strategy Nepal (MOAD 2013)

\(^4\) Food sufficiency is one of the parameters used in Nepal to measure the level of poverty by the government and other agencies like the Swiss Agency for Development and Cooperation (SDC) and Department for International Development UK DFID). Having food sufficiency of less than six months is categorised as economically poor. Different methods are used to measure food self-sufficiency, with the most popular practice being to ask respondents directly.
The weak performance of agriculture has created strong incentives for a large part of the most productive labor force (the ones in the 20 to 40 age group) to seek employment abroad. In 2009-10 almost 300,000 and in 2010-11 almost 350,000 went abroad to seek employment, mostly to Malaysia and the Gulf countries (Sijapati & Limbu, 2012).

Agricultural land per capita has declined due to the combined effects of several factors, including, inheritances, loss of agricultural land to urbanisation, and degradation of land. Smaller sized and more fragmented farms make it more difficult to realise economies of scale and also to provide sufficient livelihood for smallholder farm families. For those households with a farm size less than 0.5 ha, the average farm size is 0.25 ha and therefore often insufficient to generate an income above the poverty level (MOAD, 2013).

In scheme-1, supported by DDC, the farmers have been growing two crops annually; rice is planted in the whole command area whereas wheat is planted in about two-third of the command area, resulting in the cropping intensity of about 165%. The DADO\(^5\) provided only occasional support, the last being two years ago, when they received improved varieties of vegetable seeds. There has been a small change in cropping patterns but no evidence of a change in cropping intensity. With irrigation and the market only 2 km from the command area, 2 out of 30 users have started growing fresh vegetables, replacing part of the wheat crop. The income contribution from fresh vegetables is significantly higher than from wheat, despite the fact that the prices obtained from the sale of vegetables, being less than they expected. There has also been a need to invest in appropriate storage facilities for vegetables, as some of the vegetables produced deteriorated before sale, due to a lack of proper storage. Current productions of rice and wheat are presented in Table 2.

In scheme-2, supported by Helvetas, an annual rice crop is grown on 100% of the command area, and a wheat crop is grown on 90% of the command area, giving a cropping intensity close to 190%. The farmers have never received support from the DADO. There was no clear evidence of an increase in cropping intensity; however after improved irrigation 10 out of 82 households have replaced some of the wheat crop with vegetables. The closest market for this community is the district headquarters, approximately 20 km from the scheme. Due to an unreliable road and public vehicle service, some products are sold in the village and most is used for domestic household consumption. Farmers in the scheme area are generally not motivated to change their cropping patterns on a large scale, due to limited access to markets and the command area being far from the village for day-to-day supervision. However, following the improvement in irrigation facilities, significant increases in production were recorded by all users (Table 2), with the biggest increases being among the tail-end farmers.

In scheme-3, the present cropping intensity is close to 165%, with a crop of rice being grown in the whole command area, and a second crop of wheat being grown on about two-thirds of the land area served by the irrigation system. The farmers were not interested in

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\(^5\) DADO: District Agriculture Development Office
replacing wheat or rice with vegetables, as the irrigation was not reliable for the whole year. The reluctance to change cropping patterns was also due to lack of knowledge required for growing vegetables and due to lack of storage facilities to properly store them. They also expressed opinions that the local market is too small and that they didn't have linkages to access bigger markets.

Table 2 compares productions of schemes 1, 2 and 3. The results show cropping intensities are almost identical but there are significant differences in the average production in the three schemes. Schemes 1 and 2 which have improved irrigation facilities have higher productions and net benefits when compared with scheme-3. Scheme-2 has the highest production and net benefits, demonstrating there could be differences in production and incomes, despite having similar physical facilities.

Table 2: Average production of cereal crops and net benefits in the schemes studied

<table>
<thead>
<tr>
<th>Scheme</th>
<th>Present Cropping Intensity</th>
<th>Current Average Production (kg/hectare)</th>
<th>Annual Gross Return and Input (US $/hectare)</th>
<th>Gross Return</th>
<th>Input</th>
<th>Net Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rice paddy</td>
<td>Wheat</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scheme 1</td>
<td>165%</td>
<td>4,200</td>
<td>878</td>
<td>1,686</td>
<td>1,013</td>
<td>672</td>
</tr>
<tr>
<td>Scheme 2</td>
<td>190%</td>
<td>4,327</td>
<td>1,102</td>
<td>1,824</td>
<td>1,080</td>
<td>744</td>
</tr>
<tr>
<td>Scheme 3</td>
<td>165%</td>
<td>2,166</td>
<td>775</td>
<td>1,011</td>
<td>880</td>
<td>131</td>
</tr>
<tr>
<td>Average</td>
<td>173%</td>
<td>3,564</td>
<td>918</td>
<td>1,507</td>
<td>991</td>
<td>516</td>
</tr>
</tbody>
</table>

Source: Author’s calculation from field data

Table 3: Increases in production after improved irrigation

<table>
<thead>
<tr>
<th>Schemes</th>
<th>Average Production of Cereal Crops (kg/ha)</th>
<th>Increase %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Before improved irrigation</td>
<td>After improved irrigation</td>
</tr>
<tr>
<td>Rice paddy</td>
<td>Wheat</td>
<td>Rice paddy</td>
</tr>
<tr>
<td>Scheme 1</td>
<td>Data not available</td>
<td>4,200</td>
</tr>
<tr>
<td>Scheme 2</td>
<td>2,367</td>
<td>620</td>
</tr>
<tr>
<td>Scheme 3</td>
<td>2,166</td>
<td>775</td>
</tr>
<tr>
<td>Average</td>
<td>2,266</td>
<td>698</td>
</tr>
</tbody>
</table>

Source: Author’s calculation from field data

The results obtained from the study of these three schemes may not be statistically significant; however, the results provide realistic data to support of the fact that improved irrigation has had a highly positive impact on rice and wheat crop yields, with average yield increases of 88% and 42%, respectively (Table 3). The increased production can be attributed mainly to improved irrigation, as the farmers did not adopt any changes to the seed used (e.g. varieties), fertilisers and technologies. The results also show average gross returns from the three schemes of US$ 1,507/ha. The return/ha is still lower than the country’s average of US $ 1,700/ha (MOAD, 2013). The users of these schemes have, on average, 0.3 hectares

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6 1 US $ ~ 90 Nepalese Rupees at the time of study
of land, which means an average gross return of only US $ 452 annually. Therefore, despite the improved production, gross returns are still very low.

**Environmental Issues and Farmers’ Perceptions of Changing Climatic Conditions**

As a developing country with a low capacity for adaptation, it is predicted that the Nepalese people, particularly small farmers whose livelihoods is solely reliant on agriculture and natural resources, are highly affected due to further intensification of rainfall variability and heat waves (Shrestha & Aryal, 2011). The rates of warming in the Himalayan region are significantly higher than the global average (ICIMOD, 2009). The Department of Hydrology and Meteorology has stated that between 1975 and 2006, the average temperature of Nepal had increased by 1.8°C (Malla, 2008), compared to a global average increase of 0.6°C over the past three decades (Hayhoe et al., 2007). The changes are predicted to cause more floods and droughts, which will lead to a loss of lives and increased food insecurity (IWMI, 2013).

FMIS users within the schemes studied have experienced an impact of changing climatic conditions in recent years. The most common perception is that weather patterns are becoming more harsh and unpredictable. Farmers reported that rainfall patterns were becoming increasingly unpredictable, with delays in the start of rainfall, with the rain being of shorter in duration and more intense. Also, there were perceptions about prolonged periods of drought, flash floods and increasing temperature levels. The invasive weed *Banmara* was perceived as increasingly replacing native species. Many farmers also reported that the water discharge of some springs, which are the main source of drinking water, has significantly declined. In addition to the more erratic weather conditions, a higher incidence of pests and diseases was also reported to be adversely affecting the productivity of crops such as potato and tomato (Field notes Dailekh March 2014).

Although in-depth analysis of the impact of diverting water for irrigation was not carried out, farmers’ interpretations suggest that there is no perceivable impact on the ecology of the stream and adjoining areas, as FMIS had been running for more than 100 years and the changes in climatic conditions and vegetation were observed in the recent years. Although FMIS users are continuously adjusting to the changing climatic conditions, their perceptions imply that there is an urgent need to conduct further research on the impact of climate change on FMIS, and also develop sustainable practices to strengthen resilience to climate change.

**Recommendations and Conclusions**

**Institutional Arrangements for Supporting FMIS**

With the existing policies and Acts, the District Development Committee (DDC) has been given a clear mandate for planning and development of small-scale FMIS, by coordinating concerned government and non-government line agencies in the district. The DDC can be

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7 *Banmara* is a local name of a vegetation species whose scientific name is *Mikaniamicrantha*, also known as Bitter Vine. In the local language *Banmara* means ‘forest killer’.
considered the most appropriate organisation to plan, coordinate and facilitate the support activities for small-scale FMIS in the district. However, the following changes are regarded as being necessary to enable the DDC to effectively perform its job.

- DDC could be proactively engaged in coordinating all the FMIS stakeholders and could play the role of facilitator and monitor, rather than the role of implementer of projects and programs.
- A specific unit devoted to FMIS could be established within DDC to coordinate all FMIS stakeholders in the district. External organisations could play a role in strengthening the capacity of DDC.
- All the available funds could be channelled through DDC in the district. This would not only aid in the planning process, but also avoid duplication of support from available financial sources.
- The planning process of DDC and VDC indicates there are only forward processes and no mechanism for FMIS users’ feedback before finalising village and district development plans. Two-way flow of communication needs to be ensured at all stages of planning and implementation.

At the central level, the policies associated with the Ministry of Irrigation and Ministry of Agriculture Development, which have enabled the Department of Irrigation and District Agriculture Development Offices to plan and support FMIS independently, could be revised so that there will be single ministry, department and mechanism for planning, budgeting and monitoring of FMIS activities.

Existing policies and Acts primarily mandate MOFALD through its department DOLIDAR, to support small-scale FMIS. However, the current organisational structure in DOLIDAR and budget allocation suggests small-scale irrigation is not getting the priority. Considering the prospect and importance of FMIS and the associated involvement of a large number of stakeholders in small-scale FMIS, a specific small-scale FMIS division within DOLIDAR could be established. The division would be responsible for coordinating FMIS stakeholders and donors at the central level, and provide necessary support to the FMIS unit in DDC.

**Governance in FMIS**

The study revealed that traditional irrigation practices in FMIS have often favoured large land-holders and head-end users. An equitable policy and associated acts and regulations related to water distribution needs to be formulated with stakeholders’ participation, and be implemented effectively. The implementation of the policy can be started by FMIS seeking external support.

Since social inclusion is a very slow process, longer-term support could be provided to address both structural and social problems. Increased effort is required at the policy, legal, institutional, programming and project levels, to change the attitudes of people and to establish social equity. In addition to improving the physical infrastructures of FMIS, social inclusion aspects could be strengthened through the rigorous social mobilisation at the
pre-construction, construction and post-construction stages of the scheme, with the former being the most important. Through social mobilisation, more equitable water distribution and benefit sharing practices can be encouraged, and thus ownership and participation can be enhanced. The practices of public hearing, review and social auditing could be made mandatory in all supported schemes, to ensure transparency and accountability.

**Productivity and Income**

Most FMIS users are following traditional farming practices due to a lack of knowledge, a lack of proper storage facilities for agricultural products, and poor linkages with the markets where they could potentially get a fair price for their products. The farmers have limited access to, or are unable to take risks trying, new crops, seeds, and improved farming technologies, in the face of unpredictable climatic conditions and an increased incidence of pests and diseases. Therefore, in addition to reliable irrigation, the following recommendations are made to help increase productivity and incomes on a sustainable basis:

- Expand and improve agricultural research and extension services by involving universities, the private sector, cooperatives and NGOs.
- Minimise the gap between current and potential yields by providing timely access to quality agricultural inputs, including seed, fertilisers and tools, at affordable prices.
- Promote high value and off-season crops. Establish efficient and equitable agricultural value chains, insurance provisions and proper storage facilities at appropriate locations that have the potential for increasing benefits and reducing risks to smallholder farmers.
- Improve land use planning and management so that land is used efficiently and sustainably. Gradually transform subsistence farming into commercial farming that is connected to the local, national, and international markets.
- Increase the resilience of farmers to climate change events and disasters, by building on farmers’ observations and adaptation. A coordinated effort is required from all supporting agencies to promote sustainable soil management practices and water storage and conservation measures. Additional research is required to identify appropriate adaptation measures for different physical and socio-economic conditions.

**Functionality of Irrigation Systems**

The steep landscape, fast-flowing streams and unpredictable floods and landslides, are common features in mid-hills of Nepal, and affect the physical components of FMIS and obstruct their functionality. Regular repairs and maintenance works are essential for the efficient operation of FMIS. In the absence of a suitable Operation and Maintenance (O&M) system, most FMIS are not functioning properly. In addition, due to poverty, many communities cannot replace major capital items when they break down. Therefore, by improving the quality of the initial construction work, this can help prolong the functionality of irrigation systems by making them better able to withstand various physical stresses. This study has shown that even by only improving the irrigation physical infrastructure, considerable increases in productivity can result.
For establishing sustainable O&M systems, collective ownership of the schemes by the concerned users is of utmost importance. Ownership of FMIS cannot be equated with the individual property ownership. However, if the farmers can generate substantial incomes from FMIS and all the users benefit equitably from the system, joint ownership can enhance. Addressing unfair distribution of water, issues of discrimination and social exclusion are underpinning components of increasing participation and ownership.

The User Committees (UC) of the schemes cannot provide long-term voluntary service, and the Caretaker will not be motivated to continue an involvement if the income from taking care of FMIS is not significant. Also, due to a lack of legal status and authority of UC to collect and mobilise O&M funds, and sometimes due to misuse of funds from the UC, FMIS users have gradually stopped contributing to the O&M fund. Thus the FMIS needs to be provided with long-term institutional support from supporting organisations to establish proper O&M systems and achieve benefits on a sustainable basis.

**FMIS Plan and Information Management**

Globally, in the 21st century, water planning has been mostly based on river basins taking into account the core values of IWRM, although the principles of IWRM have been interpreted in many ways. Any plan related to FMIS in Nepal should also optimize the balance of social equity, economic efficiency and environmental sustainability. These can be achieved through enabling the environment and, establishing appropriate institutions and management tools.

In the context of Nepal, the District Small Irrigation Master Plan (DSMIP) initiated by DOLIDAR in 2011 and further improved in 2013, is a positive move for FMIS development, particularly in mid-hill districts where the number of FMIS is large, schemes are small in size and local in nature. The DSIMP can have a significant impact in consolidating and coordinating all the available FMIS support in the district. It can also enhance informed and transparent decision making processes through information management. However, in the longer-term, a holistic plan relating to the use and management of all available water resources needs to be developed to achieve the broader goals of IWM.

**Conclusions**

All of the above recommendations are inter-related and inter-dependent. They are also directly or indirectly linked with, and affected by many other factors, including politics, business and economics, health, education, infrastructure support, international policies and strategies, technological advancement, social and cultural norms and values, and climate related considerations. Further research is required to identify

- Appropriate solutions to FMIS problems situated in different physical and socio-economic conditions.
- Adaptation measures so as to increase the resilience of farmers to climate change events and disasters.
Nepal is attempting, for the second time, to draft a new constitution. Officially, Nepal has been declared The Federal Democratic Republic of Nepal, although the categorization / definition of federal states and territories remains unclear, as there has been no change in the previous administrative divisions within the country. However, even within this context, the spirit of the recommendations from this study will remain valid.

In reviewing the original goals of the study, the analysis and findings have identified many issues and problems that have hindered the development of small-scale FMIS in Nepal. This report provides evidence of inefficiencies associated with productivity, inequities in the distribution of water, and a lack of coordination of efforts by different supporting agencies for the development of FMIS. The case study approach applied in this study cannot be regarded as being statistically significantly based, and the final recommendations may be inadequate to cover all aspects of FMIS. However the recommendations from the study can potentially provide a basis for helping address issues relating to achieving practical improvements to FMIS in Nepal.

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THE SCENARIO OF INTERVENTION STRATEGY ON SMALL SCALE IRRIGATION SYSTEMS IN NEPAL

UTTAM RAJ TIMILSINA*

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(plain) area occupy 14%, inner terai (plain with higher land slope)/Sibalik area occupy 13%, mountain area occupy 30%, high mountain area occupy 20% and Himalayan area occupy 23%. The plain and sibalik 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 engaged in agricultural profession. The land holding position of Nepalese farmers is not so suitable and profitable to adopt

* Former Deputy Director General, Institution Development Division, Department of Irrigation, Nepal
mechanized farming technologies. About 75 percent household 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. Nepal has very long history of Small Scale Irrigation Systems (SSIS) managed by farmers themselves with traditional flooding type of irrigation culture. Even now, the overall irrigation coverage by SSIS mostly situated large numbers in hills and mountains of Nepal is more than 60 percent. 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 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. Irrigation development project were initiated for supplementary type of irrigation facilities. 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 excess 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.

**The past and present interventions scenario on SSIS/FMIS**

It is somehow known that the first attempt of initiation of intervention on SSIS/FMIS was started with minor irrigation program under Department of Minor Irrigation (DoMI) in 1966. About 100 irrigation schemes covering 40,000 ha. in 20 terai and 10 hill districts were constructed under that program. Due to lack of professional manpower and other hidden reasons, the minor irrigation program was merged to then DIHM in 1971. Farm Irrigation and Water Utilization Division (FIWUD) under DoA was established in 1973 to continue the intervention on SSIS, initiating Participatory Irrigation Management (PIM) approaches with users participation of 25% of the construction/development cost. FIWUD approach of irrigation development and management was successful in demonstrating importance of users participation in irrigation development and management. Since
Small Scale Irrigation Systems: Challenges to Sustainable Livelihood

1980, the intervention strategies of Government on SSIS was the physical rehabilitation with the involvement of Governmental as well as other non-Governmental agencies to support mostly on physical rehabilitation of SSIS/FMIS. In 1986 Irrigation Management Project (IMP) was started with the specific aim of software technology promotion to improve irrigation management practices on AMIS as well as SSIS/FMIS. In 1987 FIWUD under DoA and irrigation component of MoLD were also merged under newly structured DoI focusing with the intervention strategy in mass scale in irrigation development and management. Various Governmental agencies under Ministry of Water Resources, Ministry of Agriculture (FIWUD), Ministry of Local Development, Ministry of Forest and Soil Conservation as well as Non Government Organizations (INGOs) like ILO, CARE-Nepal, UMN, SNV, GTZ, HELVETAS, were actively involved to implement various irrigation programs on SSIS/FMIS. Different irrigation programs implemented with subsidy/support on SSIS/FMIS development by various organizations/Institutions under the guidelines of first Irrigation Working Policy, 1988, Water Resources Act 1992, Irrigation policy 1992, Water Resources Regulation (1993), were Irrigation Line of Credit (ILC/WB, 1989-1997), Irrigation Sector Project (ISP, SISP/ADB, 1989-2002/), NISP (1998-2005), Community Surface Irrigation Program and Shallow Tubewell Programs (ADB/Nepal, 1983-1994), Mechi Hill Irrigation Project (SNV, 1988-97), Special Public Work Program (ILO/SPWP Dhaulagiri project 1990-97), GTZ (Dhaging Project), Rasuwa-Nuwakot Irrigation Project, Gulmi-Arghakhanchi Irrigation Project, Bagmati Watershed Project, Begnas Tal Rupa Tal Watershed Project, Koshi Hills Agriculture and Rural Development Project (KCHARDEP), WECS/IIMI/FORD Action Research Project in Indrawati Watershed Basin, SINKALAMA Irrigation Project etc. These were the past programs and their output and outcome were practically limited to physical rehabilitation of irrigation schemes. Even these days the support service on SSIS/FMIS as well as Medium Scale Irrigation System (MSIS) is continuing with various projects like CMIASP, IWRMP (Component A), Shallow and deep Tubewell programs under Ministry of Irrigation and Community Irrigation Project (CIP) under Ministry of Federal Affairs and Local Development. Similarly NGOs, INGOs like LILI-HELVETAS, IDE/Nepal (with non-conventional water application or micro irrigation) are also implementing programs on SSIS with slightly modified intervention strategy of participatory approach, users friendly approach but the performance of sustainability to provide effective irrigation service delivery during the dry season for year round irrigation is not achieved so far and would not be achieved even in future due to conceptual gap or not approaching modified intervention strategy for overall irrigation modernization focusing irrigation water application and efficient utilization.
Rationality of future intervention on SSIS for Irrigation Modernization

Irrigation modernization— 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 capital-intensive techniques, such as canal lining and land leveling. The technological side is only one aspect of modernization and other aspects with equally important are fundamental changes in the institutional arrangements and regulations and improvements in the performance and efficiency of water users and their organizations.

According to FAO estimation, world’s 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 irrigated land is 300 million ha which is only 20 percent of that arable land. 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 viewpoint 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. 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. 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 and 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. In the design data requirements 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. 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 activities were neglected, water courses and fields channels were demolished, iron gates were stolen or broken, and drainage ditches were again converted into fields. Even now, participation of all water users and related stakeholders are not practiced properly, WUA's are not properly organized and trained to take their responsibilities. Similarly irrigation policy, rules and regulations are not properly implemented, ultimately irrigation governance is not established. With the impacts of those, there is increasing trend of gap between irrigation potential created and utilized. Therefore intervention with the concept of irrigation modernization including improvement of existing irrigation system performance is now perceived as a more pressing need than developing new irrigated areas. There is a great scope and necessity of intervention for modernization of SSIS covering policy related issues, technology related issues, irrigation governance related issues, physical system related issues, socio-institutions related issues, knowledge and skills related issues, participation and synergy related issues, financial and economical issues, environment related issues. To increase land and water productivity of existing irrigated agriculture as well as for water conservation, food security, food rights, and poverty reduction, a modernized intervention approach is proposed with mode and methods for revitalizing the systems for ensuring water and food security, and its sustainability.

**Area of Irrigation Modernization Interventions on SSIS**

- **Intervention for physical rehabilitation of irrigation infrastructure** 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 for micro irrigation development wherever possible** 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 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 intention 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.

**Constraints of irrigation modernization during intervention**

Successful modernization is not straightforward 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.
Expected achievements of modernized intervention:

- **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.

**Conclusion**

From the viewpoint of necessity and scope of modernized intervention on SSIS 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 the intervention strategy of government, socio-economic condition and understanding level of water users. Among the mode of irrigation modernization intervention, intervention on micro irrigation in hill and mountain of Nepal is best suited. Therefore the development of micro irrigation is assumed to provide 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 increased 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 to about 11 million ha in 2012 and is likely to grow faster in coming years. The micro and sprinkler irrigation coverage together up to 2012 is increased to 55.0 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 those continents have coverage as follows. Europe has 61%, America has 47%, Africa has 30%, Asia has 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 mass scale intervention.
strategy on it, 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 intervention 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 SSIS/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 pipe system water delivery from those storage tanks for seasonal water application with efficient micro irrigation 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 intervention for year round irrigation focusing towards micro irrigation as a greater opportunity for water saving and efficient water utilization.

**Recommendation / Way Forward**

A Study and action research to demonstrate a model of overall irrigation modernization on SSIS/FMIS specially situated in hill and mountain area to develop idea/theme for future intervention strategy is recommended. A joint study and action research program with the involvement of Government Organization and INGOs like IWMI/Nepal, IDE/Nepal at a represented suitable site of hill SSIS/FMIS is proposed for the development of in-system multi spaced water storage tanks along canal delivery and distribution points and adoption of micro irrigation technology with pipe system water delivery from those storage tanks for seasonal water application with efficient micro irrigation system, replacing traditional flooding type surface irrigation whenever and wherever possible.
Introduction

Small scale water management systems of Pakistan in this study is threatened by several external and contextual pressures. Irrigation management is a dynamic concept and it is more so in this age of fast economic changes and integration of local economies with international economies through trade liberalization, population growth and outmigration, and changing resource availability in changing climatic conditions. Changing rainfall patterns and intensity as well as frequency are the major contributing factors to climate change. Irrigated agriculture in general, and rainfall dependent irrigation systems in particular are potential victims of such climate changes. The macro-level changes threaten sustainability of local irrigation systems by changing benefit-cost ratio (Lam, 2001). The deterioration of natural resources can be traced back to colonial rule (Gilmartin, 1994; Mustafa, 2001). The Colonial rulers, with high degree of bias towards sub-ordination of nature through use of technology, took centuries old water resource institutions as outdated. They were forced to compete with global markets (Hardiman, 2002). This approach of commoditization of nature and natural resources through use of technological advancements continued in post-colonial national state (Agarwal and Narain, 1997). Pakistan’s water management policies,
in this context, are continuation of colonial policies (Gilmartin, 2003).

The irrigated agriculture of Pakistan is dependent upon the canal network mainly built in 20th century. Due to the inability to develop new water reservoirs for its internal as well as cross boundary problems, the country is facing a dire shortage of irrigation water. As a result of the focus on the canal irrigation in major national policies, very little is known about indigenous irrigation irrigation systems and its potentials. Out of total cultivable area of 24.6 million hectares; 6 million hectare is under Indigenous irrigation systems (PARC, 1995). The small scale indigenous irrigation systems i.e. Karezes in Balochistan, water tobas in Cholistan desert, snowmelt kuhls system in Northern Pakistan, Rod-kohi (spate) irrigation systems in Punjab and Balochistan are among the oldest self-governing irrigation systems of the world. These systems are mostly found in remote areas and tribal settings. They are not just a source of water. They are in reality social cultural and political thread holding these communities together. In areas where Spate, Karez or Tobas are used as a source of water, not land but water is the limiting factor both in quantity and timing of availability and need. In northern areas, however, it is the land and ability to harness flows of water have been the limiting factor on the livelihoods.

These irrigation systems are operating since millennia as a source of livelihood sustenance in remote areas of Pakistan. Spate irrigation dates back to 3000 BC as an economic source to some civilizations in Pakistan areas (Meadow, 1991). These systems are the least developed. Type of farming systems under this technology in Pakistan have only marginal returns. This technology also suffers from lack of research as well as the remoteness of communities that it serves. The spate, snow-melt and karez systems are predominantly found in mountain areas of Pakistan. The knowledge about the communities who built them is not known well, but the systems still symbolize the community collective action and indigenous knowledge.

The cases in this study have gone through shocks of regular climate variability and floods with varying degree of success in different management regimes and resource conditions. They are now exposed to climate related shocks and disturbances at a pace never experienced before. Different modes of external assistance have been recently provided to indigenous irrigation systems with varying degree of success. The purpose of this study is to evaluate different modes of assistance program in these systems.

Methodology

There are many ways to measure performance of irrigation systems and management institutions. The technical measures include the concepts of marginal productivity of water, crop per drop of water approach, water use efficiency from resource perspective. The measurement of performance of overall irrigation systems is also done by investigating at conveyance losses and thereby looking at maintenance of the systems, canal lining etc. The
irrigation institutions effectiveness are measured by considering water adequacy at different locations in systems and across different periods of a year. Another important aspect is the conformance of the rules and regulation, maintenance of the systems by the members of the irrigation system. (Tang, 1992).

The broad objective of the research is to understand impact of different modes of assistance influencing sustainability of indigenous irrigation systems. So the major focus is on how external assistance by different agencies affects entities in Anderies et al (2004) framework.

<table>
<thead>
<tr>
<th>Anderies et al. (2004) framework for SES sustainability.</th>
<th>Modified framework for case study irrigation systems</th>
</tr>
</thead>
</table>

The water rights in these systems have stark differences from other systems in similar condition. The main reason for this variation is the uncertainty involved in frequency and intensity of rainfall situation. The major rules about appropriation and other provisions in spate areas are challenges relating to spate flows. These rules generally vary from system to systems depending on management structure and nature of flows in the areas. These rules generally include:

- Rules about construction and maintenance
- Rules about sequence of irrigation

**Spate Irrigation Systems**

The spate irrigation systems (locally known as Rod Kohi) is a type of water management in which water is produced by non-incidental rainfall. The command areas gets water with high sediments loads to irrigate lands. These are highly unpredictable and need high labor requirements to build diversion structures and lateral channels.

The laterals and field channels are dug collectively. The irrigation rights were given to the members of irrigation system proportionate to labor contribution based on system capacity to the contributing landowners. The information about communities who actually dig these systems is not known (Dera Ghazi Khan Gazetteer, 1896-1897). The irrigators, from the experience of centuries are familiar with the nature and behavior of water flows as well
as their requirements to use it. Farmers divert water from the main spate bed by building earthen diversion structure (Gandh) to divert it into the field channel (Kas or Wah). This is done through contribution in the form of labor and materials determined in units of pair of oxen. The (Jora) is and customarily determined proportionate to haqooq (irrigation rights) and land holding. The irrigation system (spate) then divert water into sub-channels by constructing earthen structure (Wakra) and then join together to install earthen diversion (Wakree) to raise water level to enter into the fields. The rights of fields to be irrigated from a particular kas or kassi are well codified. Once the fields from a particular Wakra are irrigated. It is not allowed to go to next diversion downstream and so on if the first one is breached. The earthen structures build collectively are often washed away by severe floods and the farmers are to join again to build them with the hope to capture water in next spate.

![Figure 1: A simplest spate irrigation system (Adapted from Tesfai and Stroosnijder, 2001)](image)

The practice of field level water distribution varies from system to system depending on location of fields, ownership of adjacent fields, and water turn. The fields are irrigated by field to field method depending on field level from inlet and water turn. One important source of fertility in spate farming is silt brought with the flood water. In field to field type of irrigation, most of the silt mixed with humus settles in first fields. The fertility as well as height of this field is higher than the subsequent fields in turn. On the other hand, some spate systems have independent inlet for each field. In this type of water distribution, the productivity of spate water is generally higher than field to field irrigation method (FAO, 2010). This type of system provides flexibility in water distribution. This type of irrigation helps to adapt ‘one field in a sequence’ and better monitoring and enforcement of rules. However, after state intervention projects for permanent engineering structures to divert water was constructed. Concrete structures were constructed to help benefit
local people but most of them failed. The irrigation department was given responsibility to construct structures. There was no supervision and maintenance responsibilities with them. This has become reasons for deterioration. There has been complete existing physical infrastructure failure due to sediment deposition, nature of topography, and speed of floods (ADB, 2007; Ahmed and Khan, 2007). A survey in Baluchistan showed that only 34% of 47 agency developed schemes are functional systems (Groundwater consultant, 1991 cited from Steenbergen, 1997).

**Water Ponds (Toba) in Cholistan**

Irrigation ponds (toba) are one of the most important common property resources in the arid and desert areas economy of Punjab, Pakistan. These are the biggest source of irrigation and drinking water for livestock and human beings of the area. These ponds are ancient, and serve the needs of the poorest of the poor inhabitants of the area. Their conservation and management is important for soil conservation and agricultural production of such arid environments. Unfortunately, indigenous toba irrigation has been in a process of rapid decline due to strong control of state and lack of interest of common people in these systems.

Primary source of water for these ponds is summer rain which comes in the range of 100-200 mm. Rainwater is collected in a natural depression or man made ponds locally called "tobas". It is reported that there are about 600 tobas in Cholistan, where desert inhabitants store run-off water. Traditionally, each tribe and clan controls and manages their tobas. The water from these points is used for human and livestock drinking and limited scope of cultivation of vegetables or fodder if sufficient water is available. The communal relations are primarily based on ownership of tobas and grazing lands. The governments and some development agencies approach to develop commercial agriculture in the areas with pre-dominant agro-pastoral economy has further deteriorated the social thread and collective action.

![Figure 2: Water ponds in Cholistan's Desert Ecology](image)
Karez Systems in Balochitan
Karez system is a unique type of irrigation systems irrigating lands by gravity force to make water flow through tunnels. Karez systems are found in more than 20 countries and serve a considerable command area for livelihood sustenance of millions of people worldwide. In Pakistan, Karez systems are found in Balochistan province and are managed by community in the tribal society of province (Khan and Nawaz, 1995). According to an estimate, there were more than 3000 Karezes in the province in 1970s. Karez systems are managed and maintained by local communities and are very old source of water. Water distribution in karez systems is mostly in shabanas (local term of 24 hours cycle). Water distribution is highly equitable between head and tail end land parcels and tribal social life and culture revolve around Karezes in area (Mustafa and Qazi, 2008)

Currently, the karez systems are at the brink of annihilation due to wrong government and donors policy to popularize tubewell to modernize agriculture in Balochistan. Limited ground water economy is dying due to fast extraction of water and Karez water is also dried. This has adverse impact on the sustainability of agriculture as well as social set-up of the local communities.

Figure 3: A view of Karez (Source: IUCN)
Snowmelt Kuhl System in Northern Pakistan

Northern areas are primarily dependent upon water from snow/glaciers as the melted water is brought to settlements through water channels locally called ‘Kuhls’. Kuhls were build by local communities as the melted water fulfills dometric, livestock and irrigation needs. The kuhls not only provide water for human needs but also become a major source of social capital and collaboration in other walks of life. The tribal chiefs or Mirs, before officially abandoning chiefdom in 1970s, also mobilized local labor to build some bigger kuhls to support relatively large scale agriculture in the area.

Water distribution is done through Warabandi. The fixed roster for irrigation is generally practiced. It is maintained more strictly during the periods of low supply and high water demand. Vegetables and food crops get high priority for irrigation followed by food crops and trees respectively. In some areas, the trees get water at night time while in other places, the tail end fields get water turn at night time.

Since 1970s, the Public Works Department worked on kuhls construction and maintenance. The Kul intervention is implemented with engineering designs. However, most of these interventions failed due to lack of understanding of system specific needs for construction. This is typical example of government construction departments that they are only staffed with engineers. They donot consult with local users to get benefit of their centuries old knowledge about the systems. Aga Khan Rural Support Program (AKRSP) undertook intervention of Kuls seeking and identifying local knowledge and applied local knowledge in different phases of Kuhls development and maintenance. This approach has been very successful and not only for maintenance of conventional command areas. This approach has been effective in new areas where kuhl irrigation systems were implemented. AKRSP has provided training to farmers for cultivation, introduction of new crops, value chain, education, livestock etc so that the farming can be made profitable and competitive. This approach has been successful as it has not solely focused on water but also how the local communities can enhance their farming based livelihoods in a sustainable manner.

Figure 4 & 5: Irrigation in Northern areas (Kuhls and Water Streams)
**SES Entities and different modes of assistance**
The assistance in this study is taken as key area of investigation that will directly affect infrastructure and infrastructure provider entities in Anderies et al (2004) framework. Keeping in view the interlinked nature of the framework, this will in turn, affect sustainability and robustness of other entities in the framework.

**Modes of Assistance and their direct impact on Resource Infrastructure and Infrastructure Providers**

<table>
<thead>
<tr>
<th>SES Entities</th>
<th>Major Threats to systems</th>
<th>Response to Threats by different modes of assistance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public infrastructure providers</td>
<td>Lack of Training for specific flood diversion structures</td>
<td>Community level based on Indigenous knowledge</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Government Assistance approach</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Indigenous and Scientific Knowledge based Mixed approach</td>
</tr>
<tr>
<td>Public infrastructure</td>
<td>High failure rates of diversion structures and bunds and siltation</td>
<td>Local masons build low-cost structures with locally available material and there is less loss in case of flood damages</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Engineering designs based on scientific knowledge</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Training of experts and communities to work with each other to resolve challenges posed by global climatic and economic forces</td>
</tr>
</tbody>
</table>

Based on the above given table and discussion of case study systems and intervention in these systems, following synthesis can be proposed:

**Synthesis from case study systems**

<table>
<thead>
<tr>
<th>Systems</th>
<th>Infrastructural Interventions</th>
<th>Impacts</th>
<th>Overall condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spate (Tribal areas of Punjab)</td>
<td>Customary rules; Local material based diversion structures</td>
<td>Strong collective action;</td>
<td>Good</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spate (settled areas of Punjab)</td>
<td>State Law and management interference; concrete structures</td>
<td>Deteriorating collective action; devastated concrete diversions; conflicts among community</td>
<td>Poor</td>
</tr>
<tr>
<td>System Type</td>
<td>Characteristics</td>
<td>Evaluation</td>
<td></td>
</tr>
<tr>
<td>-----------------------------------</td>
<td>-------------------------------------------------------------------------------</td>
<td>-------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Karez (restricted tubewell areas)</td>
<td>Traditional karez based social structure</td>
<td>Strong collective action and self governance</td>
<td>Good</td>
</tr>
<tr>
<td>Karez (tubewell installation areas)</td>
<td>Electricity subsidy to promote agricultural production</td>
<td>Deep water table and dried karez systems</td>
<td>Poor</td>
</tr>
<tr>
<td>Water Ponds (Tobas) unlined material</td>
<td>Locally Managed and build Tobas</td>
<td>Equity, social cohesion and sustainable maintenance</td>
<td>Good (in terms of collective action)</td>
</tr>
<tr>
<td>Water Ponds (Tobas) with cement lining</td>
<td>Govt. Intervened or NGOs built cemented ponds</td>
<td>Created social conflicts, livestock based pastoral economy and inequity as maintenance problems</td>
<td>Poor</td>
</tr>
<tr>
<td>Snow-melt systems (Kuhls) with participatory assistance</td>
<td>AKRSP work honoring indigenous knowledge</td>
<td>Strong local action and improved livelihoods</td>
<td>Very Good</td>
</tr>
<tr>
<td>Snow-melt systems (Kuhls) with non-participatory assistance</td>
<td>Govt. intervened and some NGOs or foreign funded in form of irrigation structures</td>
<td>Structures not matching the system requirements with very high cost(s)</td>
<td>Poor</td>
</tr>
</tbody>
</table>

The synthesis of case study systems shows that Government and its line agencies mostly try to handle problem using fixed engineering and infrastructural approach. The donor agencies and many NGOs also find this model of fixed tools to fix problem as dominant strategy for implementation and achieving organizational objectives. However the indigenous water management system in this paper has quite different infrastructural and institutional challenges and entire livelihood as well as culture and sociology of the remote societies are dependent on these resources. Any assistance without proper understanding of system dynamics can lead to catastrophic results. The study suggests that government departments needs to shift their focus from supply side to demand driven interventions.

External assistance can be beneficial provided:

- Local knowledge and scientific knowledge are mixed to best fit the problem.
- State bureaucracy and line departments should not challenge collectively decided resource institutions.
– System specific R&D is needed to meet local needs through proper research.

– Public investment is needed in provision of research based suitable seed varieties, cattle breeds etc. which is otherwise not possible due to weak patent and intellectual property regime in Pakistan.

– Engineers must be trained in mountain irrigation structure needs and the engineering teams must be multidisciplinary to understand social and anthropological aspects of local communities.

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Socio-Institutional Aspect of Irrigation Development
Small Scale Irrigation Systems: Challenges to Sustainable Livelihood
Over the last decades, FMISs in Nepal have undergone various changes that have been presented on a regular basis at these FMIS Trust conferences (Shivakoti et al., 2005; Lam 2010; Pradhan et al., 2015). We might mention—though the list is far from exhaustive—the lack of manpower due to migration, technical innovations, integration of water policies (with, for example, the creation of formal Water Users Association- WUAs), more interaction with the Department of Irrigation (DOI), the urbanization process, etc. These are part of a context of change that is affecting different fields: social, economic, environmental, technical and political, which are all interlinked. For example, demographic growth has put pressure on natural resources, so some technical or political solutions have been implemented to address the issue. In this context, I would like to point out two types of dynamics that irrigation systems come up against, this reflection being based on two examples of farmer-managed irrigation systems (FMIS) in the Teraï plain. The reason I have chosen to present these two examples is that similar changes have occurred in their respective dynamics of water management. We will have to define and describe these dynamics but, in sum, we can say that they appear to be both a kind of split in the system's management and a concentration of water management around the village unit. These dynamics may seem contradictory but this is not necessarily the case. It is important to mention these dynamics because they do not provide better water management on a scale of the water stream or even of the irrigation system, and they negatively impact the poorest farmers and their livelihoods.

* Researcher at CNRS-Centre for Himalayan Studies (UPR 299) e-mail: oaubriot@vjf.cnrs.fr
TWO DYNAMICS

One of the dynamics falls within the process of the individualization of water access that is, whenever possible, the use of individual tubewells. This individualization is linked to two phenomena. The first phenomenon is an increasingly monetized agriculture and therefore intensive crop rotations, for which the use of individual techniques (such as tubewells) fits into the same logic of high productivity as a result of personal efforts and investments, and more generally into the logic of the market economy. The second phenomenon is the atomization of the natural resource management process that has been taking place since the 20th century. Research in the middle mountains or low mountains has shown that the area used by farmers around their houses has shrunk, that the management of natural resources has become individualized. In Gulmi, for example, there is no longer any common grazing land so cattle stay in the cowshed all day long. Pastures have lost their lineage-based management—that is collective management—and have been divided and individually appropriated. Moreover, each family uses less land, and the land itself has been regrouped around the house (when land is divided between brothers, one of them goes to live near the land situated the furthest away) (Aubriot 2004). Forests have been closed and farmers have planted trees on their land \textit{(kharbari or bari)}, as also observed in Palpa: “the growing use of private trees around fields and permanent stalling contribute to farms withdrawing into themselves and to a certain individualization regarding their management” (Bruslé \textit{et al.}, 2009: 548). Therefore, all natural resources are to be found closer to the house, and this is an ongoing process, with domestic water being stored locally through rainwater harvesting systems or tanks and being piped from the water tap. So, due to demographic growth and to pressure on land, water and wood, and “in order to reduce the time needed to access resources, farming activities are now grouped around the farmstead” (Smadja, 2013: 226). The dynamics of natural resource management have therefore shifted towards an atomistic, more individual type of management, which concentrates the resources used around the house within a smaller available space for each household. We have already shown that individual water rights have been created during this individualization process of space management and agrarian intensification (Aubriot, 2004: 31-32). I must point out that these water rights pertain to an individualization of \textit{water distribution} within collective irrigation systems, not to the individualization of \textit{water access}, as is now the case with tubewells. Examples of irrigation in the Teraï have to be analysed in the light of this individualization process.

The second dynamics refer to water management which, though there is some active collective management, tends to be more focused on and organized at village level compared to the whole irrigation network or the water course. This may be due to political issues or to the rehabilitation of a dam or a canal - which implies the creation of a formal WUA, as stipulated by the water policy - as we will now see through two examples which are both to be found in the upper part of the Teraï, in the Siwalik foothills. The results I am presenting
here are part of ongoing research, so some of them may be provisional and require further investigation.

**THE WESTERN CASE: A SPLIT IN FAVOUR OF A NEW BALANCE OF POWER**

The irrigation system located in the west, in Rupandehi, diverts water from a river that runs from the Siwalik mountains. This network extends over 5 km and covers about 300 ha, with the 70 ha upstream being added after migrants from the hills (Pahari) settled here from the late 1960s onwards and cleared the forest and diverted water. At first, this part had its own separate dam, which was built in 1972 (or 1977 according to some versions), but it was washed away twice. Farmers therefore decided to share the old dam, the one bringing water to 4 different areas which were called “mauja” or village units for tax collection purposes during the Rana period (Fig. 1). This diversion of water by the new settlers has created problems for water users downstream who seem to get less water than before.

This case is very interesting in that the so-called ‘sukumbasi’ or squatters (since they have no property rights) now have better access to water than the so-called ‘traditional land right holders’ or ‘real landholders’ (and thus implicitly, ‘real water right holders’) located downstream. In 1998, irrigators in the upper part were able to take advantage of their upstream location near the dam, making the most of the political troubles during the Maoist period to start using the old dam and the canal that previously delivered water only to the 4 mauja. They gradually diverted more and more water into their secondary canal. At about the same time irrigators downstream began to clean the canal less regularly, so it shrank and now has a very limited capacity. However, the canal supplying areas downstream is not completely dry because it receives water from a second, more sporadic source: a gully that collects runoff water from the Siwalik when it rains.

There are various reasons why the cleaning of the canal has failed to mobilize irrigators downstream over the last 6 to 10 years: some explanations are specific to irrigators upstream, who say that since they themselves maintain the dam, irrigators downstream do not feel the need to clean it; moreover, the canal gets water from the drainage of their upper fields so there is less of a need for these people to clean the section of the canal up to the river. Some other explanations are common to both groups: urbanization of the village in between affects use of the canal; the presence of individual tubewells prompts a lack of interest in the canal; and more generally, there is a lack of interest in agriculture, especially among young people who have become ‘sukhi’ (they do not want to work hard) and, as older people have told us, “they do not want to use the spade”. We might also add, as has been described in many places in India (Janakarajan, 1993; Palanisami and Easter, 2000; Aubriot, 2013), that there is a lack of interest in the collective canal on the part of leaders and men of influence who are often the first to invest in individual tubewells: this competition between individual and collective irrigation, between surface and groundwater use, is also one of the reasons why
there has been collective negligence with regards cleaning the canal. Before, when the four villages downstream used to clean the canal, 150 to 200 people worked together, whereas nowadays it seems much more difficult to motivate everyone, especially in villages where the former canal management leader has not been replaced.

The persons most affected by this change in practices are those who, for their livelihood, rely solely on agriculture and on the canal (because they have no tubewell): they are the poorest and generally do not have the capacity or high enough social status to launch any collective action. With the canal being less effective, they rely on rain for their agriculture.

Let us have a look at the discourses regarding this situation. Nowadays farmers upstream say that farmers downstream no longer use the canal that comes from the dam and that the dam is theirs. There has therefore been a complete reversal in their power relations which has benefited irrigators upstream; this may be linked to the various factors we mentioned before (such as tube wells, urbanization, a lack of interest in agriculture), as well as to the political situation, since they started to use the dam during the Maoist period. This has come about through the reconstruction of local history, by claiming that the dam is theirs. At the same time they do not hesitate to portray themselves as very active, organized, as having created a committee (a WUA), as having set up dividing weirs, while irrigators downstream are less concerned about cleaning the canal.

So here we can see the results of the two dynamics we were talking about: first of all a split, a disruption in the old irrigation management system due to a lack of involvement in
cleaning the canal and interference in the use of the canal caused by urbanization. Among the various reasons that go to explain this lack of involvement is the competition between surface and groundwater, that is the individualization of water access that tubewells offer. Secondly, we can see a strengthening of the group of irrigators upstream (around their ‘sukumbasi’ territorial identity – we still have to check whether the creation of the WUA is linked to the rehabilitation of the dam) along with a disruption in the management of the old network. As we have seen, this strengthening results in a complete turnaround in power relations, a new balance of power that is being built between upstream and downstream, that is to say, between those who have no property titles and those who have inherited ancestral rights, with each side backing up its arguments with elements taken either from the past or from the present-day context (thus long-term settlers emphasize the fact that they are landholders whereas irrigators upstream focus on the creation of the WUA; those downstream accuse those upstream of diverting water and those upstream say that those downstream do not need the canal because they receive water anyway). This is an illustration of an example of legal pluralism which is quite frequent in Nepal.

THE EASTERN EXAMPLE: A TECHNICAL RENOVATION REINFORCING THE VILLAGE UNIT
The second example is to be found in Sunsari, eastern Terai, where we can see how a change in technique may induce a change in management. This case refers to the water-sharing system along the first seven kilometres of a water course which is supplied by resurgences in the Siwalik foothills and irrigates about 1,000 hectares that spread over a dozen hamlets and villages (Fig. 2).

In the East, irrigation networks do not look exactly the same as those in the western Terai. Traditionally, water is diverted, not by using a diversion weir, but by sharing the flow of the water course. Therefore, the water course is gradually divided and it becomes impossible, after a few divisions, to distinguish between the stream and the canal. Indeed a canal and a river look no different in terms of their size, shape, topography or structure. Interestingly, in the eastern Tharu language, the word for water course and for canal is the same: “païni”!

Here, competition between upstream and downstream exists and is heightened both by the fact that Paharis have settled upstream in an area where the land has been cleared (as in the Rupandehi case) and by the fact that the water intake in one of the villages is now a concrete diversion dam, which tends to divert more water than before, when they used a local temporary weir. Thus, this village has been able to extend its irrigated area while it seems that villages downstream receive less water and actually suffer from a shortage of water, especially in their downstream areas. However, interviews show that villagers downstream do not accuse the new device of causing this drop in water flow but the settlements upstream. How can we explain this situation: where a new intake diverts more water but is not held accountable by those suffering from a shortage of water and who live further downstream,
while only the Paharis, new settlers upstream, are regarded as the guilty party?

I see four main reasons. The first one relates to the symbolic sphere associated with the dam: it is a new technique, a symbol of the modern world, to which they, the Tharus, belong, as they shake off the image of a backward ethnic group. It is also a symbol of their link with the public administration, their political and social capacity to ensure funding from the State for a project (the dam was indeed built by the DOI), so it is also a symbol that goes against the image of an isolated group, which has often been attributed to the Tharus.

The second reason is social, and is related to the relations between different groups and to the fact that Tharus have the impression that they have been invaded by hill people, and that their customary rights over land and water been violated.

The third reason is linked to the second one, but is more specifically related to the strength of kinship relations. The village that built the new intake, as well as villages downstream from it, have their canal managed mainly by Tharus. When they need water to be released, they go and ask the village upstream—where they have relatives—to release more water. This way of getting more water is based on a consensus, an informal kinship-based management system that villagers downstream do not seem to want to change.

Fig. 2: Sketch of the eastern case: irrigation areas along a stream
The fourth reason is to put the blame on others, to not show one’s own failings; here a lack of mobilisation with regards cleaning the canal, which -as in the western case- is due to urbanization, and to the existence of individual pumps that destroys any motivation landowners may have had regarding the collective channel. However, I should nuance this statement somewhat since those who own fish ponds are interested in the canal for filling their ponds! (see C. Sarrazin’s paper in these proceedings). The lack of motivation is to be found among villagers whose fields are situated in the lower part of the village rather than among those in the upper part, since the ponds are in fact located in the upper part.

So here we see that a number of factors are interlinked. However, the building of the new intake with the help of the Department of Irrigation and the rule of creating a formal WUA seems to have strengthened the power of the village that uses this dam; it has favoured the scale of the village to the detriment of any other scales, especially that of the stream.

Even if this is not the purpose of my paper, I would like to point out that technical changes such as improving the diversion intake or accessing underground water using individual pumps, affect water access and therefore the social dynamics around the collective management of canals. Techniques have all too often been seen only as material artefacts, whereas they are first and foremost social instruments, social objects.

**CONCLUSION**

The two main dynamics I have focused on here - more individualized water access (through pumps) which contributes to the split in some existing water management systems, as well as to a reinforcement of the village or community unit as the water management unit - run counter to integrated resource management. The growing number of individual entities or small entities which do not, or rarely, consult each other does little to help establish a form of management that ensures a fairer distribution of the resource. Hence “small” is not always “beautiful”, especially if nothing is done to counterbalance the dynamic of the split in water management along a stream or within an irrigation system. Because such a split does not favour interaction and better management on a larger scale, those who suffer are the poorest, those furthest downstream and such dynamics worsen the situation, rendering access to this “political and social” resource that is water, more and more unequal.

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INTRODUCTION
The collective management of groundwater through tube well user groups has been a central element of Nepal’s shallow tube well development programmes in the Terai-Madhesh. The acquisition of tube wells for groups of farmers is particularly important as marginal farmers face difficulties in meeting the costs of boring their own well and purchasing pump sets. This paper however, based upon research in the East and Central Terai, notes how the success of initiatives have been limited in the context of an inequitable social formation, with deeply entrenched feudal agrarian relations.

A first set of challenges is linked to becoming a member of a user group. Tenant farmers face considerable difficulties in joining user groups without landlord support. Furthermore, in the context of mass out-migration, women from the rising number of female headed households also face difficulties in joining user groups, due both to gender ideologies and lack of access to the required documents. Aside from this, the spread of groundwater interventions and awareness of how to form a user group is itself highly selective, and is often linked to pre-existing social networks. A second set of challenges are associated with existing user groups. Unlike other cooperatives, farmers from a similar socio-economic background cannot be grouped together, as membership is dependent upon where one’s land is located in relation to the command area of the well. In a context where marginal farmers share wells and sometimes pumps with larger and politically powerful land owners, elite capture is widespread.

* Fraser Sugden is Social Scientist at IWMI- Nepal.
This paper nevertheless, emphasises that this approach to groundwater provision must still be up-scaled, but with modifications to the process of group formation and greater engagement with women. It also proposes a new approach through farmer collectives, whereby similarly situated farmers both lease land and tubewells.

**METHODOLOGY**

There are three main sources of data for this report. The first is analysis of secondary data, in particular, the Nepal National Sample Census of Agriculture. The second is data from a series of previous and ongoing studies in the eastern Tarai by the author. The third source of data is 30 interviews and focus groups conducted during field visits to Morang and Dhanusha districts between April and August 2012. There were five focal VDCs (Thadi Jijha and Ekrahi in Dhanusa and Jhorahat, Thalaha and Bhaudaha in Morang), where the research was focussed, although neighbouring VDCs were also included for the qualitative analysis to gain comparative perspectives. Interviews were unstructured, and focused specifically on the dynamics of landlord-tenant relations and the different options for accessing groundwater, based on a set of key themes. Interviews were carried out with farmers from different socio-economic groups, although the focus was on more marginal (owning less than 0.5ha of land) and tenant farmers. Finally, a quantitative survey was carried out in Dhanusha and Morang in the five focus VDCs as part of a separate IWMI study was also integrated into this report to provide insights into tube well ownership and use by tenant farmers.

**AGRARIAN STRUCTURE IN THE STUDY SITES**

Land inequalities in the east and central Terai were solidified in the wake of expanding feudal state formations from the 16th to 19th century. The Sen Kingdom of central Nepal in the 17th century was the first significant state formation which encompassed Morang and Dhanusha. This was followed by the Gorkhali dynasty, the founders of the present day Nepali state in the late 18th century (Gaige, 1976). The enforcement of a tax collection system similar to the zamindari system of India which propped up local elites, and the distribution of land grants to bureaucrats, fostered the emergence of a powerful landlord class. Even indigenous communities of the jungle belt to the east were gradually subordinated to feudalism as land grants encouraged the contraction of the forest frontier (Sugden, 2013). Inequality intensified during Nepal’s Rana period in the 19th and early 20th century when the Tarai was a key source of revenue for the regime through agrarian taxation (Regmi, 1978).

In the 1950s and 60s, Nepal saw state implemented land reforms to enforce ceilings on land and the abolition of the traditional agrarian tax collection hierarchy (Adhikari, 2006; Regmi, 1976). Despite the stated objectives, there was limited political commitment to change, and reforms failed to create real transformations in agrarian relations. Ceilings were weakly enforced and a limited amount of land was redistributed, driven in part by the fact that landlords were distributed into the state alliance (Alden-Wily et al., 2008).
Despite some market driven changes and a decline in the power of large landlords in Dhanusha, land inequality remains deeply inequitable, particularly in the Morang focal VDCs where landlordism remains dominant. In Dhanusha, the primary axes of inequality today is between the larger land owning farmers from the upper and middle castes and a large class of landless labourers, marginal farmers and tenants at the base of the agrarian structure. In the Dhanusha focal VDCs, the largest owner cultivators with more than 2 hectares represent only 9% of the total sample, yet they own nearly a third of the cultivated land. Of particular significance however, is the large number of households who are completely landless. Landless labourers represent 15% of the sample in Dhanusha, while tenant farmers without any land of their own represent 3%. At the same time, an even larger number of households own small plots of land (usually less than 0.2ha) while also renting land. These part-tenants represent 23% of the sample in Dhanusha.

By contrast, in Morang, the large local land owning class is smaller and less powerful, with less than 2% of sampled households owning more than 2 hectares of land. However, a group which is not included in the sample (as they do not cultivate) is a powerful class of absentee landlords with vast estates. Many of these landlords are descendants of the feudal functionaries who were given jungle land grants under Rana rule in the 19th century, whereby land was cleared, and indigenous forest dwelling communities were subjugated as tenants and labourers. As a result, landlessness is even higher in this region, with 30% of respondents being landless labourers, 16% as tenants, and 23% as part tenants. 69% of tenants and labourers are from Dalit communities and three marginalised indigenous groups the Bantar, Rajbanshi, and Jhagar.

### Table 1: Land ownership in focal VDCs

<table>
<thead>
<tr>
<th>District</th>
<th>% 'marginal' owner cultivators with &gt;0.5 hectare</th>
<th>% 'medium' owner cultivators with 0.5-2 ha</th>
<th>% 'large' owner cultivators with &lt;2 ha</th>
<th>Land owning non cultivator (rents out only)</th>
<th>% part tenants</th>
<th>% pure tenants</th>
<th>% landless labourers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dhanusha</td>
<td>% 25.56</td>
<td>20.30</td>
<td>9.02</td>
<td>23.31</td>
<td>3.01</td>
<td>15.04</td>
<td>3.76</td>
</tr>
<tr>
<td></td>
<td>n 34</td>
<td>27</td>
<td>12</td>
<td>31</td>
<td>4</td>
<td>20</td>
<td>5</td>
</tr>
<tr>
<td>Morang</td>
<td>% 12.20</td>
<td>13.01</td>
<td>1.63</td>
<td>22.76</td>
<td>16.26</td>
<td>30.08</td>
<td>4.07</td>
</tr>
<tr>
<td></td>
<td>n 15</td>
<td>16</td>
<td>2</td>
<td>28</td>
<td>20</td>
<td>37</td>
<td>5</td>
</tr>
</tbody>
</table>

**Agrarian stress and demand for irrigation**

Over recent years, there has been a strong perception amongst respondents that the risks of agriculture have increased, due to climatic and non-climatic pressures (Sugden et al., 2014). Climatic changes farmers have observed include an increase in extended dry spells and late monsoons, more frequent extreme precipitation events such as floods, greater winter chilling and increased temperatures in the summer. While this has been acknowledged in the literature from the region (Bartlett et al., 2010; Practical Action, 2009; Sharma, 2009),
there are also non-climatic pressures which are equally significant, and linked to external economic forces linked to rising costs of diesel and fertiliser, and a spiralling costs of living (Pant, 2011; Sugden et al., 2014).

In the context of climate stress, accessing irrigation water ‘on demand’ through groundwater pumping has become increasingly important. While investment in tubewells and pump sets is commonplace amongst richer land owning farmers, for marginal farmers, and in particular, tenants, the range of adaptation options is far more limited (Sugden, 2014). Their marginal holdings and surplus appropriation through rent and usury mean the available cash in the household to invest in irrigation is limited. Many tenants, after giving up a portion of their harvest as rent, are not even meeting their subsistence needs on their land. In this context, the likelihood of them having sufficient capital to invest in a tube well or pumping equipment is extremely limited. It shows that most tube wells and pump sets in Dhanusha are owned by medium and large owner cultivators, and none are owned by tenants or part-tenants.

Table 2: % households with tube well

<table>
<thead>
<tr>
<th>Farmer category</th>
<th>Morang</th>
<th>Dhanusha</th>
</tr>
</thead>
<tbody>
<tr>
<td>part tenant</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>pure tenant</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Small owner cultivator (&lt;0.5)</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>Medium owner cultivator (0.5-2)</td>
<td>0</td>
<td>32</td>
</tr>
<tr>
<td>Large owner cultivator (≥2)</td>
<td>NA*</td>
<td>17</td>
</tr>
</tbody>
</table>

Source: survey by author (2013)
* The number of large owner cultivators in the Morang sample is too small to make any concrete conclusions

Figure 3: Ownership and use of pumping equipment in Dhanusha
Source: survey by author (2013)
The constraints to investment are amplified for tenant farmers who do not have ownership rights to their land (Sugden, 2014). Tenants have no incentives to bore a well on land which does not belong to them and could be taken back by the landlord at any time. Tenancy agreements are all oral in nature, and thus are quite insecure. Although those classified as ‘part tenants’ also have a plot of ‘owned’ land, these plots are generally very small and are often far from the larger rented plots they seek to irrigate. The installation of a tube well for just a tiny plot of owned land (usually less than 0.2ha) is not considered a viable investment given the small area which would be irrigated when compared to the cost of installation.

In this context, the marginal farmers who cannot bore their own tube well must purchase water from their wealthier counterparts through an informal water market. Similarly, those who own a well but no pump set, can rent a pump set. When deciding whether or not to rent a well and pump set, the potential for increased yields is often balanced out by the considerable expense and risk it entails. The primary cost lies in the rental of a pump set from the well owner, which varies from Rs150 to Rs300 per hour. Local level monopolies often drive up the price in the context of under developed groundwater markets (Bhandari and Pandey, 2006). In villages where there are few tubewells and pump set owners, the price often increases as farmers have less choice. Added to this include the cost of getting diesel to the village, which is reportedly higher in more remote communities.

Field level data suggested that marginal and tenant farmers have far fewer incentives to rent equipment or wells, when compared to their owner cultivating counterparts. Renting tube wells is a considerable expense for farmers who are also giving away a considerable portion of their annual product as rent, or who own only a very small plot. However, it is particularly acute for farmers renting land on a sharecropping contract. An earlier study from Morang (Sugden and Gurung, 2012) has shown how sharecroppers in particular have considerably reduced incentives to invest on their land in productivity improving technologies given that for each unit of investment, the land lord will retain half. However, for fixed rent tenants such as those renting land through the thekka system (and owner cultivators), the entire incremental product accrued from enhanced allocation of technology such as irrigation, as well as labour, will be retained by the tiller.

The reduced incentives for sharecroppers to invest on their land can be reduced if landlords contribute to costs. Landlords however, only rarely contribute to the costs of irrigation (Sugden, 2014). For example, it was reported that if the land was very fertile, tenants could bargain with them so they will make some contributions for irrigation costs. Many of the farmers who rent out land in Dhanusha are not large landlords, and give away excess holdings to tenants either to generate an additional ‘rent’ for the family, or in some instances, due to labour shortages. It is often in the interests of these smaller land owners to invest on the land, so as to maximise their income. However, in stark contrast, the absentee landlords who predominate in Morang often have vast estates, and alternative income sources through salaried employment. With rent being collected through a kamtiya or agent, they often have limited interest in the land itself, and thus contributing to or encouraging investments in irrigation is a low priority.
A second constraint relates to the risk of investment for marginal rent paying farmers. At present few tenant farmers can meet their subsistence needs at current levels of productivity, particularly while paying rent. Although investment in groundwater could potentially increase yields to above subsistence levels, this is considered too much of a risk for many tenants, particularly if other stresses result in a low yield. For example, wheat is considered a particularly risky crop, and unseasonal heavy rains in April and May 2012 had ruined more than half of the wheat crop in some parts of Morang. Farmers often prefer to leave land fallow during the dry season and engage in menial labour, an attractive option in districts such as Morang, where there are opportunities available in brick kilns, factories and the many bazaars along the highway.

In light of the constraints in accessing irrigation for marginal and tenant farmers, it is easy to see why food security becomes a critical issue. Yields are low due to climate stress, reduced incentives and limited capacity to invest in irrigation and other inputs. A majority of marginal and tenant farmers reported that they could meet their food needs off the land alone, with most also purchasing grain staples from the market. It is for this reason, that off farm labour is increasingly important to supplement these fragile livelihoods. In light of the limited labouring opportunities locally at a time of rising costs, especially in Dhanusha, migrant labour is increasingly the norm. This includes labour to Indian urban centres such as Delhi, as well as the longer term migration of farmers to the Gulf economies and Malaysia. Migration itself nevertheless, only sometimes offers opportunities for upward mobility, and past research found that wages and conditions overseas were often far below what migrants were led to believe, while significant loans taken to facilitate migration, put further economic strain on already fragile livelihoods (Sugden et al., 2014).

GROUNDWATER USER GROUPS FOR MARGINAL AND TENANT FARMERS

Introduction to government groundwater initiatives

Groundwater user groups have been central to the Nepal governments shallow tube well expansion programme, whereby a group of farmers jointly install and operate a tubewell. Given the constraints outlined above for farmers in accessing irrigation, such initiatives are implemented for good reason. Collective ownership and management of pump irrigation systems are appropriate when small land holdings in the context of high boring costs make individual ownership unviable (Shah and Bhattacharya, 1994).

Schemes in Nepal include the ADB funded community groundwater sector irrigation project (CGISP), and Agricultural Perspective Plan (APP) Shallow Tubewell project and more recently, the Indian government funded Shallow Tubewell project. Some schemes provide only tube wells to groups, while others such as the Indian government funded scheme also provide pump sets as well.
The first stage for farmers to who wish to benefit from government shallow tubewell initiatives is to form a Water User Association (WUA) which must include farmers cultivating a contiguous command area of 20 bigha (13.4ha). Within each WUA are smaller Water User Groups (WUGs), each of which manage a tubewell with a 4 bigha (2.68ha) command area. Farmers need to collectively form a WUA, and submit an application to the local Groundwater Resources Development Board divisional office. The size of the group varies according to the number of farmers owning land in the command area. In some schemes such as the CGISP, farmers could directly apply as a user group without needing to form an association first (Mccarl, 2013). Within the WUGs, farmers usually pay a nominal maintenance fee for the well and if applicable, the pump set. Non-members can usually also use the well on the payment of a fee. The farmer who uses the well and/or pump for his land is responsible to pay whatever it costs in diesel.

While the distribution of tubewells through user groups has considerable potential to overcome scale constraints to water access for marginal farmers, this research has identified considerable ongoing challenges for the poorest producers to benefit from these schemes which are rooted in the land inequalities outlined above.

**Land ownership**

A first challenge relates to land tenure and ownership amongst users. Accessing groundwater through government initiatives is a particular challenge if one does not own land in the area one wants irrigated. In order to register a user group and apply for a well, an organised group of farmers needs to establish a committee and travel together to the government Groundwater Development Board regional office. It is however, the responsibility of landlords to group together to fill in the paperwork for a set area of land. If the tenant has no land of their own, or owns land in a different location from the rented plot they want to irrigate, then they cannot apply on their own. With the limited interest of many landlords, particularly those who are absentee as noted above, this is a significant barrier for tenants to benefit from these programmes. Tenant farmers in who were interviewed complained that they would like to apply for a well, but their urban based landlords were disinterested. This is also problematic for women, as pointed out in Mccarl (2013). With male out-migration, women are increasingly in charge of managing irrigation on the land, a task previously the domain of males (Sugden et al., 2014). However, as many do not have access to the land ownership documents, they face challenges becoming a member of a user group, and like tenants, rely on the support of male relatives or (often absent) husbands to become part of a group.

There are also challenges associated with the need to install 5 tubewells in a 20 bigha command area if one is to benefit from the schemes, an issue which was found to be particularly critical in Mccarl’s (2013) study from Dhanusha and Morang. While this requirement has been in place to improve the efficiency of tubewell installation, farmers...
faced considerable difficulties in forming a user group in such a large command area, particularly when the holdings are often very small, and are often rented. Coordinating many small land owners was considered impractical by farmers, and most respondents cited the desire to apply only as a small user group for a single tubewell (McCarl, 2013).

Poorly functioning committees and elite capture

Another challenge relates to the way in which WUGs function. Groups require a functioning committee to ensure the water is used fairly and to oversee the maintenance of the pump sets. However, despite this, committees often ceased to function after the acquisition of a pump set and well. Even amongst functioning committees, there were reports in Dhanusha of conflict over allocation of water and a mistrust of the leadership. There was for example, anger in one village in Dhanusha that the leader of the user group took no initiative to replace a pump set which was stolen. In some instances, there were perceptions that there had been a misappropriation of resources.

There were also several instances of ‘elite capture’ reported by poorer farmers who were interviewed, and even outright exclusion. This is unsurprising given that unlike other agricultural development schemes, membership of a user group is dependent upon the command area of the land one cultivates, not their socio-economic status. Inevitably therefore, very marginal producers must share a well with much richer cultivators and landlords with very different water demands, leading to conflict over resources.

In Baijnathpur VDC of Morang, an absentee landlord took a lead in establishing a well through a government scheme which was supposed to be for the benefit of a group of farmers from the Bantar community. However, once the well was built he took control of it and now he uses it for his own purposes, mostly to irrigate ten bighas of his own land which is rented out to tenants. No other farmers, including tenants from other plots, are allowed to use it. In another village in Dhanusha, there was anger that a user group leader and wealthier farmer had applied to a government scheme to bore a well in the name of a user group, yet when the well was built, he used it mostly for his own needs and other group members did not get the share of the water they were entitled to.

In the same village, it was reported how fraudulent groups are created to further the interests of rich farmers. For example in the context of the a rule that there should be minimum of four members in each WUG, for each four bighas of land, there were reports of the father, brothers and wife of a single household applying as a ‘group’, so they can get a free tubewell installed. Then when the well is built it basically becomes a private well belonging to one household and others have to pay a rental fee.
Selective geographical spread

Aside from direct elite capture, probably the most significant factor which affects the poorest households capacity to benefit from groundwater interventions is the selective way in which they are spread geographically. It did not appear that such opportunities for installations of wells through WUAs/WUGs were widely publicised, and the journey to the local groundwater divisional office to register a group was often impractical for farmers in remote villages. Under most of the groundwater projects, farmers have to visit the divisional office to fill in a form, and many farmers were not familiar with the process and the paperwork required.

In this context, it appeared that it was normally through local connections and social networks that user groups receive support (Sugden, 2014). For example, in one VDC of Morang, a significant 65 tube wells were built as part of a government programme. It was reportedly easier for farmers there as an employee from the groundwater office had been from that VDC. Five to seven years ago the employee informed the farmers about the scheme so they knew the process, and prospective user groups had their application ready by the time the project started. The groups were able to benefit by receiving a pump set as well. However, in the adjoining VDC there was no such leader to organise the farmers. The farmers were discontented that they were too late to receive a free pump set, as this provision had been discontinued by the time they heard of the scheme.

In a similar vein, in a Phulgama of Dhanusha one of the local people had a contact with a local NGO, through which they learned of the APP shallow tubewell program. Two to three people then went to Jaleshwar to submit an application. The village eventually received Rs 800,000 worth of support for 20 user groups, encompassing 100 households. Only 10% of homes were left out as their land was beyond the command area of the wells. It is worth noting that in this village, almost all households were from the relatively better off Yadav community, and most had their own land with holdings from two to three bighas on average. However, villages home to marginal cultivators and traditionally excluded communities were often inadvertently sidelined. For example, in villages such as Sitpur, of Bhaudaha in Morang, almost all the farmers are marginal sharecroppers from the Rajbanshi and Bantar ethnic group. The community is away from the main road, access to social networks is limited, and there are less well educated ‘leader farmers’ with connections with the bureaucracy and knowledge of the latest opportunities. As one would expect, there were few groundwater interventions, with only two wells in the village, both of which were private. The majority of farmers in the village did not even rent a well, yet depended on rainwater. A similar example is Singya Madan VDC of Dhanusha. Most households were sharecroppers or very small holders with a large Dalit majority. The community is far from Janakpur, and it takes several hours to reach the village during the wet months. There were reportedly no user groups in the villages which were visited, and only a few richer farmers had pump sets and wells and rented them out.
Ways forward for collective management of groundwater

Based upon this paper, a number of lessons emerge. Firstly, it is clear that there must be an avenue for unregistered tenant farmers or women to become members of user groups without written support of land owners. Tenants represent a significant proportion of farmers, and women’s role in agriculture is only set to increase with male out-migration, yet access to land and tenure documents for both women and tenants remains elusive. A flexible system must be initiated, whereby farmers can register in a WUG based upon use of the water resource rather than a system grounded in land ownership. These rights could be transferred following a change of tenant. Furthermore, the 20 bigha requirement for a larger WUA should also be considered (see IWMI study by McCarl 2013) given the impracticalities of forming a set of WUGs for such a large area of land. Individual WUGs should be given the opportunity to apply directly for a tubewell.

Secondly, tubewell distribution should also involve the distribution of pump sets. Most well owners also own pump sets and rent them out as a ‘package’. It is the pump and not the well which offers the revenue for the richer farmers, at the expense of poorer water buyers, with high diesel prices often being used to mask monopoly rents. If farmer groups have access to tubewells but can not raise the capital to invest in a pump set, they will still have to pay a considerable sum to rent one from a richer farmer. Distribution of pump sets either through subsidies or through low interest loans would reduce the dependence of groups on pump owners. This is a feature of some recent groundwater programmes.

On a more radical level, tube well user groups could also be combined with more innovative forms of land tenure. Agarwal (2010) makes a compelling case for a reinvented group approach to farming which can overcome contemporary agrarian stresses such as feminisation of agriculture, diminishing plot sizes and landlessness. This approach would move beyond just taking a group approach to installing and managing a tubewell, but would extend the farmer groups scope to include pooling of resources for other inputs, and most importantly, the pooling of land itself.

For example, in India there have been a number of successful initiatives in collective leasing, whereby landless farmers form a group and jointly lease a plot of land from a land owner (Agarwal, 2010; Landesa, 2013). This increases tenants’ bargaining power, gives them a contiguous plot which is easy to irrigate. Similarly, the pooling of capital makes investments more feasible and pooling of labour allows farmers to benefit from the groups’ collective knowledge. Such an approach could be easily integrated with government groundwater schemes, whereby a farmer collective also becomes a WUG, jointly receives a well and/or pump set. A set of collectives could even unite to form a larger WUA. If successful, this could pave the way for a new approach to agriculture for the most marginal farmers, overcoming the scale constraints posed by marginal and rented holdings.
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TRADE-OFF BETWEEN EFFICIENCY AND EQUITY IN A FARMERS' MANAGED IRRIGATION SYSTEM: A CASE STUDY FROM GHILING, UPPER MUSTANG, NEPAL

GOVINDA BASNET*

INTRODUCTION

Water management norms are embedded in locality specific physical and ecological conditions and are interwoven with history, cultural, economic, political and technological foundations of any society (Mosse, 2003; Baker, 2005; Boelens and Doornbos, 2001; Zimmerer, 2000). Social differentials such as caste, class, and power structures prevailing in a society underlie an individual's access to and control over water.

Rules for water allocation, repair and maintenance of the irrigation systems and selection of authorities have been institutionalized in social systems through years of practice and persistence (Scott and Coustain, 1995; Baker, 2005). However, the rules are responsive to changes in social systems forced through various factors like enhanced interaction of local people with wider economic forces, foreign employment, or hydrological changes. While operational rules have been responsive to external or internal pressures, some of the collective choice and constitutive rules (Schlager and Ostrom, 1992) like eligibility criteria for participation in water management authority, which are deeply embedded in social institutions, are more persistent and unresponsive to local pressures.

A field study was conducted in Ghiling of upper Mustang, Nepal as a part of broader study in six villages of Upper Mustang on interrelationship between struggle for water rights and change in social institutions. Ethnographic methods integrating comparative and historical approaches were followed. This study teases out the factors and process of change in priority of the people in relation to reshaping of institutional arrangement.

* An anthropologist and freelance consultant.
SOCIAL FEATURES

Water rights and management of resources is closely linked with the rules of parental property inheritance in upper Mustang. The customary laws governing inheritance have their roots in the traditionally practiced fraternal polyandrous marriage system. In this system of marriage, all the male siblings (excluding the one who enters into clergy) would marry a single woman. If younger brothers decide to bring their own wives and live separately they will not be entitled to any parental property. The eldest brother inherits all the parental property. Although monogamous marriage system has become a common practice today, the rule of property inheritance system is intricately linked with the polyandrous system of marriage. The impartible primogeniture system of property inheritance creates two classes of people: those inheriting the parental property called Dhongba, and those who are not entitled to parental property called Farang Marang. A Dhongba inherits all the parental property and he may give a small portion of land to his younger brothers called Farang and unmarried sisters called Marang. This system of property inheritance prevents the further fragmentation of household property, especially the land. The Dhongba also refers to both the number of allotments and the households holding these allotments. A household may hold more than one Dhongba.

Eligibility to become a member of the village council for the management of resources is largely defined by property inheritance classes. Only the members of Dhongba class are eligible to hold a post in the council. Being a Dhongba entails additional responsibility and also entitles a household to privileges. Altogether, there are 60 households in the village out of which 40 are of Dhongba and 20 households are of Farang Marang. All the people in the village are Gurungs.

WATER MANAGEMENT

Field and water sources

The village is located at an elevation of 3,550 m msl. Compared to other villages in upper Mustang, this village has greener landscape with meadows lying in the middle of settlement and many poplar trees lining the gullies in the field. Since the village receives annual rainfall less than 200 mm, crop production is totally dependant on irrigation. Single cropping is followed. Wheat, naked barley, and buckwheat are the major crops grown in three-year rotation. In a given year, one crop is grown in one field each. The standard sequence of rotation is buckwheat -wheat-naked barley. This sequence is adapted to suit the manure
requirements of the crop. Naked barley is the most manured crop followed by wheat. Buckwheat is never manured.

These crops are grown in three agricultural fields, all of them running parallel to one another along the slope. These three fields are called Le Chhuimi, Lho and Dhong having an area of 19.93 ha, 20.4 ha, and 35.7 ha respectively (Figure 1).

The main source of water for irrigation is the Tamagang Khola, a snow-fed stream. This stream feeds water into 1.1 km–long Lhoi Hyura, the main canal that irrigates bulk of the cultivated area. There are many smaller water sources originating in the village itself. The Lhoi Hyura feeds a large water reservoir called Jhuin. During the crop growth period, water is stored in the reservoir every night and released the following morning to irrigate the fields. Stored water, when let out, lasts about 6 to 9 hours depending on the level of water flow in the canal. Another water source, Yutang Chhu, originating in the village, and a canal Mekhi Hyura, a canal at the lower section of the field, and other smaller reservoir ponds are also the integral part of the irrigation system in the village.

Water allocation

Water is allocated to households on the basis of landholding size. Water allocation is also dependent on the types of crop grown. For the purpose of water allocation and selection of authorities, all the households in the village are divided into four groups called Chhyo. These four Chhyos are Sa Tang Te, Sa Tang Me, Jha Tang Te, Jha Tang Me. The grouping of a household in a given group is permanent and it has been practiced since long. However, this classification is not a spatial grouping in the village. The number of Dhongba and Farang/
Marang households in these different groups is shown in the following table.

Table 1: Number of households in different irrigation groups in Ghiling

<table>
<thead>
<tr>
<th>Chhyo</th>
<th>No of Dhongba</th>
<th>No of households with 2 Dhongba</th>
<th>No of Farang/Marang</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sa Tang Te</td>
<td>12</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Sa Tang Me</td>
<td>12</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>Jha Tang Te</td>
<td>13</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>Jha Tang Me</td>
<td>9</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>46</td>
<td>6</td>
<td>20</td>
</tr>
</tbody>
</table>

Every year after the completion of the first regular repair of the canals and the reservoirs, dice are cast among these four Chhyos to decide the turn for irrigation. All the plots within a field are allotted water either from the canal or from the reservoir, but not from both. So if a plot is to be irrigated with the reservoir water, one cannot irrigate with the canal water even if it is available. The dice are cast to decide which Chhyo gets first turn to irrigate with the canal water and which one gets with the reservoir water. The Chhyo which gets first turn to irrigate with the reservoir water will be the last one to irrigate with the canal water and vice versa. In a given day, two Chhyos will be irrigating, one from the reservoir and another from the canal. Usually, the reservoir water does not last all day and the irrigator has to wait until the following day to irrigate the fields.

Within each Chhyo, households are arranged in a fixed order for irrigation, which remains the same year after year. The Ghempa, the chief of the council, decides the timing of irrigation for each of the three major crops. Since a particular crop is grown in block in one of the three fields, one field is irrigated completely before moving to the next. This fixed rotation of the turn within a Chhyo wasset in 1990 and has remained same. Prior to that, no turns used to be set and whoever goes first to the canal or the reservoir in the morning would get the water until he or she finishes irrigating all the plots. Disputes to get the water turn were a common scene.

Authorities

A village council is constituted to manage water and other village commons like pastureland, forest, and community land. The Ghempa Chhe, or the chief Ghempa from outside the village serves both as the protector of the village and a higher authority for resolving disputes within the village.

The village has undergone many changes in different times in institutional arrangement of water management. Under the current system, the village council comprises one Ghempa, two Ngiwa, one Dhungi and two Dhrappa. The Ghempa is the chief who decides
on cropping calendar, timing for irrigating crops, settling disputes, management of other community resources like forest, pasture land, community land etc. The two Ngiwas work as assistants to the Ghempa. The Dhungi is responsible mainly for keeping the record of all the expenses and income of the community works like expenses for canal and reservoir repair and maintenance, income from fines, collection of crop share called Phutok for community land etc. The Dhurappas are the crier for the village to hold meetings or other village gatherings. A member of the Bista family from Chhoser, one of the most northernmost villages in the region serves as the Ghempa Chhe.

The posts of the Ghempa and the Dhungi are swapped among two households every two years. These are the only two households in the village called Ghyawa Dhongba, a hereditary senior Dhongba. As Ghyawa Dhongba, they are entitled to tether one of their horses in a meadow surrounded by cropping fields even during the crop growing season. For all other households this practice of tethering a horse would not be allowed and if anyone’s horse is found there a fine would be imposed. This privilege of tethering a horse in the middle of meadow bestows a superior status on the holder. The Ghyawa Dhongba are also exempted from contributing labor for some community works.

Two Ngiwas have tenure of one year, and are selected in rotation from among Dhongba households. If a household does not have a male member present in the village, female members can also serve as the Ngiwa. The Dhurappa, the crier, is also rotated among the males of the Dhongba households. This post is exclusively held by male and rotates on the seniority basis. Four eldest Dhongba males of the village are selected as the Dhurappa and once a person is selected he has to serve for three years in alternate years. The Dhurappa keeps the fines collected from late comers in the meeting. The Ghyawa Dhongba are exempted from this responsibility of serving as the Dhurappa.

Other two posts important for management of the agricultural activities in the village are Rongya and Kawa Takye. The Rongya adjudicates the disputes arising out of crop depredation by stray animals. This respected post is held only by a Dhongba. The person has to have a good knowledge of local crop ecology as the stages of crop growth, productivity of the field etc are taken into account for deciding the compensation amount. The Kawa Takye detains the stray animals. Every year three persons are selected to serve as the Kawa Takye. The Kawa Takyes keep all the fines collected from the owner of animals entering the field.

No Farang Marang are allowed to hold any of these posts. Although the village does not have differentiation based on the caste system, the inheritance system is the major social differential in the village. The exclusion of the Farang Marangs is not only limited to holding of these posts in the village council but also extends to restriction in their participation in many rituals. This institutional arrangement of water management was formed two years ago.
CHANGING INSTITUTIONAL ARRANGEMENT

The institutional arrangement for the management of water sources have undergone changes over the years. The issues of efficiency and equity underlie such changes in institutional arrangement. In addition to the people's shifting priority of efficiency and equity, external factors also played role in ushering in the change in institutional arrangement.

The villagers have changed the institutional arrangements more than once in recent past when faced with such a situation. The case illustrates that people experiment with different institutional set-up at different times, and such changes sometime revert back to the system which they have discarded in the past.

Institutional arrangement prior to 2004

Before the formulation of the current institutional arrangement for water management in 2004, the previous arrangement lasted for 14 years. How and why the institutional arrangements were changed at these two different times show the dynamics of functioning of an institution and the process of its change. Although different groups of people within the village had their own interests in enforcing or resisting such changes, the Ghempa Chhe is also involved in bringing about such changes who tries to negotiate the conflicting interests of different groups. Such changes are legitimatized only after the consent of the Ghempa Chhe. The previous institutional arrangement was devised in 1990 with the support of the Raja, then Ghempa Chhe of the village, out of a dissatisfaction of both the local people and the authorities of that time. Until then, only two households, called the Ghyawa Dhongba, could hold the posts of the Ghempa and the Dhungi. Each of them would hold a post for five years and then swap the responsibilities after its tenure is over. No other households in the village could hold these posts, and they would think it was an undemocratic practice to let only two households hold these posts year after year. And since these posts would not entitle to any direct material benefits, these two households also resented the public discontent. Out of this popular dissatisfaction of the local people, a new system was designed so that other households also could hold the post of the Ghempa. While changing this system of authority, rules for allocation of water were also changed. Prior to this, anyone who reaches the reservoir first in the morning would get the water. In such a first- come- first- serve water allocation disputes were commonplace. A system of fixed rotation among households within different irrigation groups was devised.

In the changed system, four Ghempas were selected, one from each of Chhypo. The turn of a household within a Chhypo to serve as Ghempa would be fixed in the same order as the one for irrigation. This system of rotation would ensure that each Dhonga household would get an opportunity to become a Ghempa instead of a hereditary Ghempa, as previously practiced. If a household does not have a male member in the village, a female member could also work as a Ghempa. In the event of a household holding two Dhongbas, it had to hold the
post twice. The post of the Dhungi was abolished and these four Ghempas would themselves keep the record of village accounts. Other posts of the council such as Dhurappa, Rongya, and Karwa Takye were same as what they are today. Similar to the current institutional arrangement, this arrangement also excluded Farang Marang households from holding any of the council’s post.

Reasons for change in 2004

Although the changed institutional arrangement was more equitable, at least for Dhongba households, the initial fervor of the changed system soon lost the momentum, and over the years, the system started degenerating. The arrangement became so ineffective that after 14 years of following this apparently more equitable form of authority selection, villagers again devised another institutional arrangement for managing agriculture and irrigation activities. The reasons cited for non-functioning of this arrangement are:

i. In the new arrangement, all the Ghempas taking up the responsibility would not have any experience of or the hands-on skill of the post. Compared to their previous counterparts, who were hereditary Ghempa and thus had rich experience and knowledge, these new Ghempas’ lack of experience of and knowledge about the post greatly limited their ability to discharge the responsibilities effectively. Moreover, since the tenure of these Ghempa was only for one year, any skill they learn in the first year could not be carried to the next year. Viewed against the backdrop of the performance of the hereditary Ghempa, which people often do, these new Ghempas’ performance would not appear satisfactory. In addition to managing agricultural and irrigation activities in the village, these Ghempas are also responsible for management of common resources like forest, pasture, and community land about which they know little, mostly due to their far distance from the village. Some of these Ghempas had little knowledge about the boundaries of the forest the village shares with Chhuksang village located to the south, and other pasture lands, which would put these Ghempa in a disadvantageous position for management of these common resources and in negotiating with other villages.

ii. For complex reasons, some Ghempas were unable to command the necessary respect from the community, thereby affecting not only their performance but also directly impacting on the confidence people had in the Ghempa institution. Traditionally, the post was held by males but with the new system, sometimes females could also serve as Ghempa, especially when male members were absent from the village. Many people today claim that some women Ghempa were unable to command the confidence of the community, which had been accustomed to male Ghempa. Lack of confidence in an individual’s ability to serve as Ghempa diminished their ability to make decisions and implement. Laxity in implementation of community rules led to encroachment of community lands.

iii. Holding the Ghempa post is a community obligation for a household, which
is widely perceived as not rewarding materially as the Ghempa do not get any
direct remuneration from the community fund. As four Ghempas were collectively
working at any given time, some of them would eschew the responsibility hoping
that another Ghempa would do the job. There was not any clear division of work
among them. Not only was there lack of incentive for doing a good job, but also
there were not any punitive measures if they failed to execute their duties.

iv. Over the years, villagers started suspecting that some Ghempas were not working
honestly. Some Ghempas were said to have favored their relatives and being lenient
on charging fines. Some were even suspected of misappropriating community
resources like felled trees along the irrigation canals. The Ghempas manage the
grains collected as Phutok (crop share) from the community-owned land, and use it
for meeting community expenses and preparing Chhyang (local beer) for rituals and
village functions. The expenses incurred by Ghempas during the village functions
are also met from the community funds. These Ghempas were also alleged to have
indulged themselves inappropriately with the community funds, especially by
preparing large amount of Chhyang for their personal consumption.

**External agency**

Although these issues combined to erode the effectiveness of the Ghempas, the impetus
to change the institutional arrangement was provided by the process of resolution and the
outcome of a dispute between Ghemi and Ghiling villages over access to and control of a
pastureland. The outcome of this resolution led to appointment of a new Ghempa Chhe.

Prior to 1974, when the village was incorporated into Ghemi Village Panchayat from
Chhuksang, a member of the Thakali family from Tukche would serve as Ghempa Chhe
of Ghiling. With this administrative change, the Raja of Mustang was asked to become
the Ghempa Chhe of the village. He remained the Ghempa Chhe until 2004, when the
villagers decided to request the nephew of Raja to serve as the Ghempa Chhe of the village.

The process of changing of Ghempa Chhe began after the resolution of the dispute by the
Raja. The villagers of Ghiling resented the decision of the Raja in the dispute and the case
was taken to the District Administration Office (DAO). The decision of DAO was viewed
as much favourable to the Ghiling village. Following the decision of the DAO, the villagers
requested the nephew of Raja to accept the post of Ghempa Chhe.
The new Ghempa Chhe, together with the villagers redesigned the institutional arrangement
that is similar to the one existing before 2004.

**CONCLUSION**

Communities are often grappled with a situation where they have to decide whether the
principle of efficiency or the equity should hold the primacy. And choices a community
makes on such issues reflect the underlying norms and values of the community. The case of Ghiling illustrates how the principles of efficiency and equity were played out differently at different times with the changing priority of the larger section of the society. This demonstrates how institutions are remade through “resistance and reinterpretation by individual agents in daily struggles for property rights” (Robbins, 1998).

REFERENCES


PART III

PANEL DISCUSSION

CHALLENGES IN THE DAYS AHEAD
THE PLENARY SESSION

Mr. Iswer Raj Onta, Chair of GWP South Asia, was the chairperson of the session. The panelists were Dr. Narpat Singh Jodha, Dr. Barbara Van Koppen, Dr. Luke A. Colavito, Mr. Madhav Belbase and Mr. Kenichi Yokoyama. Dr. Khem Raj Sharma was the rapporteur of the session.

Dr. N.S. Jodha highlighted that we are passing through a critical phases where circumstances are not conducive and the nature-society interaction is undergoing changes. Dr. Jodha further added that market has its own role to play and climate change is a new challenge. The modern education system is not being able to prioritize the importance of nature-society interaction. So, it is important that as long as we keep people and nature together, the future will be bright.

Dr. B.V. Koppen was of the view that the lesson from Nepal, from these two days FMIST seminar was enormous. She highlighted the importance of Multiple Use System (MUS) of water sources and as such multipurpose infrastructures are sustainable. Both the governmental and non-governmental sectors along with the Water User Association (WUA) can work together towards this. She further explained that the gender issues are intense as lots of changes with women’s role in the society, most of the households are women-headed as men migrate for job. She raised an important issue about the meaningful participation of women in WUA in the changed circumstances.

Dr. Luke A. Colavito focused on issues on surface irrigation and small scale/pond irrigation. Big changes/trends are being observed in agriculture and reduced labor availability resulting in focus on high valued horticulture. But there is under investment in irrigation for high valued crops. The Agriculture Sector Strategy in the pipeline needs to address this issue. There is also a need of future investment in this area like pipe water system for irrigation can be used for multiple uses. For this shift to high value crops, it is important to develop
agriculture value chain and addressing the gap in agricultural community and irrigation community in dealing with adaptation to climate change. He further emphasized on the need of irrigation to be a part of LAPA (Local Adaptation Plan of Action) process and FMIST has a role to play.

Mr. Madhav Blebase gave the latest status of irrigation infrastructure development in the country and highlighted four major challenges or issues in Irrigation System of Nepal. Firstly, year round irrigation- the country has about 29% of irrigated land with year round irrigation and thus agriculture is not profitable. Secondly, he explained the gap between agricultural land and irrigation potential land - though the country has about 3 million ha of agricultural land only 1.76 million ha has potential for irrigation (1.35 million ha already developed), and the challenge is how to provide cost effective agricultural technology including irrigation to such land. Thirdly, the sustainability of Irrigation System-FMIS initially sustainable, but most of them are not sustainable as they are not been able to generate resources for maintenance. The main reasons for such un-sustainability are out -migration of people resulting onto shortage of labor for canal operation and maintenance. Haphazardly constructed local roads have damaged irrigation canals in many areas posing a challenge for their rehabilitation. In spite of access to the market for the agricultural produce; such roads have brought the market to the villages replacing the local products. As we are in transition phase, lack of commercialization is one reason for FMIS not being sustainable. Fourthly, the Climate Change- Monsoon floods have damaged many irrigation systems in recent years and maintenance is beyond the capacity of farmers. Changing rainfall pattern and intensity will bring a change in hydrological analysis and the time series analysis used so far is no longer working.

For these major challenges, Mr. Belbase proposed six prompt actions. Firstly, for year round irrigation- since water availability in Nepal vary on spatial and temporal scale, the country need to develop large projects including inter-basin transfers for spatial management and for addressing seasonal or annual variability of water flow in the rivers. For this we need to go for medium sized dams. Secondly, Groundwater- there are best and easily renewed aquifers in Terai which can be used. The major issue related to groundwater use is energy need for pumping such water. In addition to electricity, options like solar pumps needs consideration. Third prompt action is blue-water pumping- Nepalese rivers carry huge silts and pumping in monsoon (June - September) is creating problem. So, it is better option to pumping water only for remaining 8 months for 2-3 crops. Fourthly, the Non-conventional Technologies - ponds, springs and rainwater collection for multiple-use including irrigation specifically for marginal lands. The Fifth action is Small and Medium Irrigation Systems- reviewing crop water requirement is important for small and medium irrigation systems as
the rainfall is unreliable in Nepal. The sixth prompt action is *Sustainability*: Cooperative irrigation mode is suitable for FMIS as well as small and medium sized irrigation system. In the Irrigation Act in making provision for decentralized irrigation board shall be envisioned for management of large irrigation system. In the context where irrigation transfer was not successful, for sustainability of irrigation systems, irrigation should not be a free service and there is a need to establishing Irrigation Development Fund which shall provide money to cooperatives and irrigation boards.

**Mr. Kenichi Yokoyama** said that the seminar was a good combination of case studies, policies and strategies. He expressed ADB’s perspective on FMIS as ADB is working on FMIS over 30 years. He referred project completion reports and made a claim that 60 to 70% FMIS intervened are found generally satisfactorily. However, he felt the need for developing quality infrastructures. Irrigation system management is another challenge. To address this WUA strengthening process needs further improvement. Design, procurement and contract management are important for successful and quality irrigation system and infrastructures. He said FMIS is a dynamic process of development and FMIST need to be strong knowledge centre for policy advocacy. FMIST can also play a role to strengthen the National Federation of Irrigation Water User Association, Nepal (NFWUAN).

The Chairperson **Mr. Onta** asked Dr. Khem Raj Sharma to express few words. Dr. Sharma said that most of the surface irrigation systems developed by the government were constructed for seasonal irrigation and therefore besides water augmenting, there is a need to modernize those systems to make them year round. He also highlighted on the need for enhancing the irrigation water use efficiency as foreseen in the National Water Strategy.

Mr. Onta summarized the session and offered vote of thanks.
ANNEXES
ANNEX.1. SEMINAR PROGRAM

Farmer Managed Irrigation Systems (FMIS) Promotion Trust, Nepal
Sixth International Seminar
on
"Small Scale Irrigation Systems: Challenges to Sustainable Livelihood"
15 and 16 February 2015

**Program Schedule Details**

**Venue:** Hotel Himalaya, Kupondole, Kathmandu, Nepal

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity and Person/s</th>
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<tbody>
<tr>
<td>8.15-9.00 am</td>
<td>Participants' Registration</td>
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<tr>
<td></td>
<td>Mr. Samundra Sigdel, Farmer Managed Irrigation Systems Promotion Trust (FMIS Promotion Trust)/, Rukmani Adhikari, Jalsrot Vikas Sanstha (JVS), Mr. Bharat Sapkota, JVS</td>
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<td>Chair</td>
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<td>Chief Guest</td>
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<td>Master of Ceremonies</td>
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<td>Mr. Naveen Mangal Joshi, Chairman, FMIS Promotion Trust</td>
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<td>Dr. Mohan Man Sainju</td>
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<td>Mr. Prakash Gaudel, JVS</td>
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<td>Ms. Anju Rana</td>
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<td>9.00</td>
<td>Welcome Speech</td>
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<td>Mr. Sushil Subedee, Member-secretary, FMIS Promotion Trust</td>
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<tr>
<td>9.15</td>
<td>Introduction of the Seminar Theme and Papers</td>
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<td>Dr. Upendra Gautam, Founding Chair, and Advisor, FMIS Promotion Trust</td>
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<td>9.25</td>
<td>Activities of FMIS Promotion Trust during 2010-2014 also highlighting the publication of &quot;Trajectory of FMIS&quot;</td>
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<td>Mr. Suman Sijapati, Vice Chairperson FMIS Promotion Trust</td>
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<td>9.35</td>
<td>About the book</td>
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<td>Mr. Basu Lohanee, Divisional Engineer, Department of Irrigation</td>
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<td>9.40</td>
<td>Releasing the Book: Trajectory of FMIS</td>
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<td>9.45</td>
<td>Remarks on the book</td>
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<td>Mr. Kenichi Yokoyama, Coutry Director, ADB</td>
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<td>9.50</td>
<td>Announcement of FMIS Promotion Trust's Icons of Honor : 2015</td>
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<td>Ms. Anju Rana</td>
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<td>Dr. Barbara Van Koppen</td>
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<td>Dr. Narpat Singh Jodha</td>
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<td>Dr. Prachanda Pradhan</td>
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<td>Introduction of Icons of Honor</td>
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<td>Dr. Luna Bharati, IWMI</td>
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<td>10.00</td>
<td>Presentation of Honor:</td>
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<td><em>Dosallah Odhayera</em> (presenting shawl)</td>
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<td>Reading out the Commendation Plaques</td>
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<td>Mr. Naveen Mangal Joshi</td>
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<td>10.15</td>
<td>Keynote Speech: &quot;Community-managed water development: multiple use water services&quot;</td>
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<td>10.30</td>
<td>Keynote Speech: &quot;My research and advisory work in Mountain Region of HKH&quot;</td>
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<td>Dr. Narpat Singh Jodha</td>
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<td>10:45</td>
<td>Keynote Speech: &quot;Why focus on small scale irrigation systems?&quot;</td>
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<td>Dr. Prachanda Pradhan</td>
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<td>Dr. Mohan Man Sainju</td>
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<td>11.10</td>
<td>Concluding seminar initiation and Vote of Thanks</td>
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<td>Mr. Naveen Mangal Joshi</td>
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<td>11.15-12.00</td>
<td>Group Photo and Hi-Tea at the Garden, Himalaya Hotel</td>
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<td>II. Parallel Seminar Sessions</td>
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<tr>
<td>Parallel Session-1</td>
<td>FMIS Cases/Contribution at the Himalaya Hall</td>
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<tr>
<td>Session Coordinator: Mr. Sushil Subedee</td>
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<tr>
<td>Sub-session-1</td>
<td>Strategizing FMIS at the Rato Baithak Hall</td>
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<tr>
<td>Chairperson: Mr. Shital babu, Regmi, former Secretary, GoN</td>
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<td>Reporter: Young Professional / Student</td>
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<tr>
<td>12.00-12.30</td>
<td>&quot;Effects of Irrigation on Crop Diversity&quot;</td>
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<td>Paper presentation by Dr. Wei Zhang</td>
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<td>Floor Discussion</td>
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<td>&quot;Water Management Strategies: A Combat Against Climate Change Adversities&quot;</td>
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<td></td>
<td>Paper presentation by Dr. Md. Abdul Ghani</td>
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<td>Floor Discussion</td>
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| 12.30-1.00   | "Farmers Managed Irrigation Systems of Nepal: Assessment of The Elements Contributing to Their Sustainable Operation and Maintenance:"
|              | Paper presentation by Pradip Raj Pande, Deepak Pandey, and Deepak B Singh                      |                  |
|              | "Bhungroo: The Power & Savior of Poor Women Farmers; A Case Study on Poor Centric, Women Managed Small Scale Irrigation in India"
|              | Paper presentation by Dr. Paul Biplab Ketan, Jain Trupti                                      | Floor Discussion |
|              | Floor Discussion                                                                                |                  |
| 1.00-1.30    | "Water and the Rural Poor: Interventions for Improving Livelihoods in Asia "                     | Floor Discussion |
|              | Paper presentation by Dr. Puspa Raj Khanal                                                     |                  |
|              | Concluding Remarks by the Sub-session Chairperson                                              |                  |
| 1:30-2:30    | Lunch Garden, Himalaya Hotel                                                                    |                  |
|              | **Sub-session-2. (Parallel Session-1 continued)**                                               | **Sub-session-2. (Parallel Session-2 continued)** |
|              | Chairperson: Mr. Shiva Kumar Sharma, Joint Secretary, GoN                                      | Chairperson: Dr. Puspa Raj Khanal, FAO, |
|              | Reporter: Young Professional / Student                                                          | Reporter: Young Professional / Student |
| 2:30-3:00    | " Review of Major Donor Assisted Projects in Farmer Managed Irrigation Systems "                 | Floor Discussion |
|              | Paper presentation by Mr. Ashish Bhadra Khanal                                                  |                  |
| 3.00-3.30    | " Benefit Multiplication Through Multiple Water Use System: Comparison of Single Functional and Multi Functional Irrigation System in the Mid Hills of Nepal "
|              | Paper presentation by Mr. Anand Gautam                                                         | Floor Discussion |
|              | “Low-Cost Manual Well Drilling Village Mistries Make Ground Water Accessible for Irrigation"
<p>|              | Paper presentation by Dr. Robert Yoderand Deepak Adhikari                                       | Floor Discussion |</p>
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<tr>
<td>3.30-4.00</td>
<td>Irrigation Water Management for the Local Livelihoods: Experiences from the Integrated River Basin Management Project in Koshi Basin.</td>
<td>&quot;from Farmer Managed Irrigation Systems (FMIS) in the Himalayas to Farmer Managed Natural Regeneration (FMNR) in the Sahel: Links, Lessons &amp; Implications for Agricultural Research, Climate-Smart Rural Development and Development Cooperation.&quot;</td>
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<td>Paper Presentation by Ms. Bhawani S. Dongol</td>
<td>Paper Presentation by George F. Taylor II</td>
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<td>Floor Discussion</td>
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<tr>
<td>4.00-4.30</td>
<td>&quot;Underutilized Irrigation Water and Vulnerable Livelihood of Small Farmers in Zambia.&quot;</td>
<td>Concluding Remarks by Sub-session Chairperson</td>
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<td>Paper presentation by Dr Rajendra Uprety</td>
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<td>Floor Discussion</td>
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<td>4.30</td>
<td>Tea at the Pre-function Area</td>
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**Monday, February 16, 2015 (4 Fagun, 2071)**

Parallel Sessions (Continued)

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<tr>
<td>Sub-session-3</td>
<td>Chairperson: Dr. Keshave Prasad Sharmaformer DG, Department of Hydrology and Meteorology</td>
<td>Chairperson: Mr. Surya Nath Upadhyay, Secretary General, JVS</td>
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<td>Reporter: Young Professional / Student</td>
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<td>Paper presentation by Mr. Ganesh Khaniya</td>
<td>Paper presentation by Dr. Umesh Nath Parajuli</td>
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<td>9:30-10:00</td>
<td>&quot;Role of Small-Scale Irrigation Systems in the Strategies Developed By Terai Farmers to Access Water.&quot;</td>
<td>&quot;Socio-Economic Impacts Due to Climate Scenarios in Mustang-Nepal&quot;</td>
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<td>Paper presentation by Dr. Aubriot Olivia</td>
<td>Paper presentation by Mr Jagat k. Bhusal, Mr. Santosh regmi, Ms. Parju gurung, Dr. Janak I nayava and prof. Bhim p. Subedi</td>
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<td>Floor Discussion</td>
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<td>Paper presentation by Mr. Raj Kumar G.C., Dr. Luke A. Colavito</td>
<td>Paper presentation by Dr. Fraser Sugden</td>
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<td>Concluding Remarks by Sub-session Chairperson</td>
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<td>1030-1100</td>
<td>Tea break at the Pre-function Area</td>
<td>Sub-session – 4</td>
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<td>Chairperson: Ms. Rudrika Rai Parajuli, Advisor, Livelihood, DFID</td>
<td>Chairperson: Mr. Bubanesh Kumar Pradhan, former Secretary, GoN</td>
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<td>1100-1130</td>
<td>&quot;Impact of Climate Change to Farmers of Small Scale Irrigation Systems in Chiang Mai, Northern Thailand&quot;</td>
<td>Role of Water User Association in Successful Operation and Management of Adhikhola Irrigation System, Syangja, Nepal</td>
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<td>Paper presentation by Dr. Juthathip Chalermphol, Dr. Ganesh P. Shivakoti</td>
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<td>And Mr. Ram C. Bastakoti</td>
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<td>Floor Discussion</td>
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<td>1130-1200</td>
<td>&quot;Variation Insuccess of Different Modes of Assistance: An Institutional Analysis of Small Scale Irrigation Systems of Pakistan&quot;</td>
<td>&quot;Case of Community Participation for Hydram Integrated Micro-Irrigation System&quot;</td>
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<td>Paper presentation by Dr. Muhammad Asif Kamran, Mr. Muhammad Sadiq Hashmi, Mr. Raza Ullah, Dr. Ganesh P. Shivakoti</td>
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<td>Paper presentation by Mr. Ram C. Bastakoti, Ms. Manita Ale, Ms. Andganesh P. Shivakoti</td>
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<td>1230-130</td>
<td>Lunch</td>
<td>Sub-session – 4</td>
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<td>130-200</td>
<td>Trade-Off Between Efficiency and Equity in A Farmers' Managed Irrigation System: A Case Study from Ghiling, Upper Mustang, Nepal&quot;</td>
<td>&quot;Improving Small-Scale Farmer Managed Irrigation Systems in the Mid-Hills of Nepal from an Integrated Water Management Perspective&quot;</td>
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<td>Paper presentation by Dr. Govinda Basnet</td>
<td>Paper presentation by Mr. Thakur Thapa</td>
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<td>Floor Discussion</td>
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<tr>
<td>200-230</td>
<td>Place and Role of Nepalese Ponds ('Pokhari') in the Tarai Region and Their Link With Small-Scale Irrigation Systems</td>
<td>The Scenario of Intervention Strategy on Small Scale Irrigation Systems in Nepal&quot;</td>
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<td>Paper presentation by Ms. Caroline Sarrazin</td>
<td>Paper presentation by Mr. Uttam Raj Timilsina</td>
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<td>Floor Discussion</td>
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<td>230-300</td>
<td>&quot;Bisses, irrigation canals in the Valais of Switzerland&quot;</td>
<td>&quot;Non-Conventional Method of Irrigation for Livelihood Enhancement (A Case Study of Micro-Irrigation Piloting in Ripin Dhotar Irrigation System)&quot;</td>
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<td>Paper presentation by Armand Dussex</td>
<td>Paper presentation by Mr. Bashudev Lohanee</td>
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<td>Floor Discussion</td>
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<td>Concluding Remarks by Chairperson</td>
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Plenary Session: Himalaya Hall

Session Coordinator: Ms. Sabitri Tripathi, Professor, Nepal Engineering College

Chairperson: Mr. IR Onta, Chair, GWP South Asia

Rapporteur: Dr. Khem Raj Sharma, Program Director, nec

300-400 | Panel Discussion on "Agenda Ahead" Panelists: Dr. Narpat Sing Jodha Dr. Barbara Van Koppen Dr. Luke A. Colavito Mr. Madhav Belbase Mr. Kenichi Yokoyama Concluding remarks with a vote of thanks from the session chair |

400 | Tea at the Pre-function Area |
PARTICIPANTS: A MOMENT OF TOGETHERNESS
PRESENTATION OF HONOR AWARD
OPENING SESSION

Barbara Van Koppen being honored with the traditional Nepali shawl by Naveen Mangal Joshi

Narpat Singh Jodha being presented the commendation plaque by Suman Sijapati

Prachanda Pradhan being presented a bouquet by Sushil Subedee

FMIST office bearers with the honored personalities

A view of the opening session

Mohan Man Sainju, Chief Guest delivering remarks
PARTICIPANTS IN THEIR PENSIVE MOOD
ANNEX.3. FMIST: ORGANIZATIONAL FACT SHEET

FMIS PROMOTION TRUST ORGANIZATIONAL FACT SHEET

Conceptualization: Consolidated Management Services Nepal (Pvt.) Ltd. (CMS) conceptualized the Trust as a non-partisan, non-profit, voluntary, and professional organization dedicated to FMIS promotion. Viewing FMIS as a techno-cultural heritage, the promotion work was to be carried out through activities pertaining to FMIS inventory, seminar, dialogue, research, student enrichment scholarship, icon of honor award (to the national and international researchers/scholars/practitioners), training, recognition to and dissemination of best practicing FMIS.

Founders: The founding chairman of the Trust was: Upendra Gautam. Founding members were: Rajan Subedi, Krishna Murari Gautam, Amrit Bahadur Karki, Lava Raj Bhattarai, Abinash Pant, Ajay Lall Shrestha, Prachanda Pradhan, Binayak Bhadra, Surya Nath Upadhyay, Hari Upreti, Deb Raj Basnet, Trilok Man Sing Pradhan, and Sachin Upadhyay.

Seed money: In the very beginning, seed money (totaling about hundred thousand Nepali rupees) was contributed to the Trust by Upendra Gautam, Rajan Subedi, Lava Raj Bhattarai, Krishna Murari Gautam, Amrit Bahadur Karki, Abinash Pant, Ajay Lall Shrestha, Prachanda Pradhan and Surya Nath Upadhyay.

Date of establishment: 7th June 1998 (24 Jestha 2055 B.S.)

Legal status: Registered under the Association Registration Act 2034 with the Kathmandu District Administration Office, Ministry of Home Affairs, the Government of Nepal (GoN).

Basis of operation: The Trust Constitution when it was registered with the GoN and under this constitution, election of the executive committee of the Trust is held after every three years.
**International advisers:** The international advisers to the Trust since its founding are: Dr. Richard Reidinger, Dr. Robert Yoder, and Dr. Douglas Mary

**Patron:** Prachanda Pradhan is patron of the Trust. The Trust decided to bestow this honor on him on 29 November 2005.

**Resource mobilization and sustainability:** In 1998–2004, the Trust welcomed the Ford Foundation support (about one hundred thousand USD) as it helped its own program to grow. On top of this support, during this period itself and afterwards, the Trust adopted prudent resource mobilization measures such as i) purchase of share from the stock market, ii) investment in bank debentures, iii) micro-irrigation line of credit administered by a local cooperative, iv) executive officers of the Trust charging a fee for the Trust’s professional activities and returning the fee as donation to the Trust, v) cost-effectiveness in operations through partnership by networking, vi) deposits in saving cooperatives to gain higher interests, and vii) smart and independent operation of the Trust through a host-organization arrangement.
Farmer Managed Irrigation Systems Promotion Trust
Kathmandu, Nepal
November 2015