Proceedings of the
7th National Symposium on Challenges and Opportunities for Sustainable Management of Groundwater Resources in Nepal

20 March 2016, Kathmandu, Nepal

Organized by

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Organized by
Center of Research for Environment, Energy and Water (CREEW)
The Small Earth Nepal (SEN)
Environment and Public Health Organization (ENPHO)
Kathmandu Valley Water Supply Management Board (KVWSMB)
Groundwater Resource Development Board (GWRDB)

Co-organized by
WaterAid Nepal

In association and supported by
Water and Energy Commission Secretariat (WECS)
Institute of Engineering (IoE), Tribhuvan University (TU)
Asian Institute of Technology (AIT), Thailand
Interdisciplinary Centre for River Basin Environment at University of Yamanashi (ICRE-UY), Japan
Kurita Water and Environment Foundation (KWEF), Japan

Editors
Robert Dongol
Sarita Shrestha

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Cover photo collage: Emergency water management in response to April, 2015 earthquake in Nepal (CREEW)
Back cover photo: Participants of the 7th National Groundwater Symposium (CREEW)

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The 7th National Symposium on 'Challenges and Opportunities for Sustainable Management of Groundwater Resources in Nepal' was organized in Kathmandu on 20 March 2016 as one of the event of the Nepal National Water and Weather Week 2016 to commemorate the World Water Day 2016. This symposium has been a great success and a remarkable platform for the researchers, academicians, policy makers, government and non-governmental officials, water entrepreneurs and other relevant stakeholders.

Altogether 13 technical papers were presented in the seventh sequel of groundwater symposium. These papers were organized under three broad thematic areas and presented in three different technical sessions followed by a panel discussion in the fourth session. The organizing committee expresses deep gratitude and sincere thank to the presenters, session chairs and rapporteurs.

Similarly, the organizers extend sincere gratitude to the distinguished dignitaries representing various governmental and non-governmental organizations during the inauguration session and also to all the participants for being a part of the symposium.

The organizers appreciate financial and kind contribution from Water and Energy Commission Secretariat (WECS), WaterAid Nepal, Institute of Engineering (IoE) of Tribhuvan University (TU), Asian Institute of Technology (AIT) Thailand, Interdisciplinary Research Center for River Basin Environment at University of Yamanashi (ICRE-UY) Japan, and Kurita Water and Environment Foundation (KWEF) Japan for the symposium.

There are few hands that always work behind the curtain for the success of any events. These hands never get tired. Lastly, the committee would take pride in acknowledging the efforts of all the staff members of CREEW, SEN, ENPHO, KVWSMB and GWRDB for their determined and relentless efforts which made the symposium – a real success.

Organizers
CREEW**,** SEN, ENPHO, KVWSMB, GWRDB

TABLE OF CONTENTS

PREFACE

In the absence of reliable surface water source and to meet the needs at various water use sector, not only the government agency but all those water dependent sectors are extracting the hidden resource–groundwater. Groundwater in Nepal has been a prominent source of water for domestic purpose, industrial use and irrigation. Water started flowing on wheels, in the recent years there has also been tremendous growth in water markets within the Kathmandu Valley. Groundwater from peripheral areas of the valley is being extracted and transported to the cities. This peripheral water extraction has jeopardized the water security at places. Extracting these valuable resources is not only depleting the level of groundwater, but also creating an avenue to get contaminated by the surface water that flows through the pores to fill the vacuum created due to massive water mining. Besides this, a global climate change, population growth, increased water demand and degradation of the environment could possibly degrade the quality and deplete the groundwater level. Therefore, this resource should be timely studied, researched, developed and managed for sustainable use.

Center of Research for Environment, Energy and Water (CREEW), the Small Earth Nepal (SEN) and Environment and Public Health Organization (ENPHO) in strong collaboration with the government agencies such as Kathmandu Valley Water Supply Management Board (KVWSMB) and Groundwater Resources Development Board (GWRDB) have been organizing Groundwater symposium at the national level, with an aim to share knowledge and experience amongst academicians, university graduates, government and non-government organizations, research institutes, entrepreneurs and other concerned stakeholders on the issues of groundwater.

The 7th sequel of National Symposium on 'Challenges and Opportunities for Sustainable Management of Groundwater Resources in Nepal' was held on 20th March 2016, in Hotel Radisson, Kathmandu to mark one of the major events of Nepal National Water and Weather Week 2016 with a theme "Water and Jobs" declared by UN- Water. This symposium was supported by WaterAid Nepal, Asian Institute of Technology (AIT) Thailand, Interdisciplinary Centre for River Basin Environment at University of Yamanashi (ICRE-UY) Japan, Kurita Water and Environment Foundation (KWEF) Japan, Institute of Engineering (IoE). The symposium was attended by 85 participants from relevant government organizations, academic institutions, research institutes of non-government organizations and water entrepreneurs. Many fruitful discussion and exchanges of ideas and opinions contributed to the success of the symposium. The thematic areas for the symposium were:

- Groundwater in the aftermath of disaster (e.g. April 25, 2015 earthquakes in Nepal)
- Socio-economic and market of groundwater (e.g. water tariff, public health, water and jobs)
- Impacts to groundwater (e.g. from withdrawal and various uses, pollution and climate change)
- Groundwater policy, regulations and governance

An official inaugural session was scheduled to kick off the symposium followed by three consecutive fruitful technical sessions in which all the submitted 13 technical papers under the aforementioned four thematic areas were organized and presented. The technical sessions were as follows i. Impacts to groundwater (e.g. from withdrawal and various uses, pollution and climate change), ii. Groundwater Policy, Regulations and Governance and iii. Water and Jobs. Each technical session was chaired by an expert from the relevant field and was supported by two rapporteurs. The symposium concluded with a panel discussion on Groundwater Policies and Water Jobs at the end, was a departure from the format used at previous symposia.

In a nut shell, the symposium was a success. This symposium has proven to be a well established platform till date for the interested academicians, researchers, water mangers and practitioners, policy makers to share their most recent research findings, studies and experiences in water management for sustainable development. We expect this to be continued in the future as well.

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TECHNICAL SESSIONS

TECHNICAL SESSION I

Impacts to Groundwater (e.g. from withdrawal and various uses, pollution and climate change)

Chair: Dr. Madan Lal Shrestha
Academician, Nepal Academy of Science and Technology (NAST)
Rapporteurs: Pramina Nakarmi and Isha Dhakal

Groundwater Resource Response to Changing Climate in Mid-hills of Nepal

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Mid-hills of Nepal is experiencing myriad of change due to climatic variability that cut across both bio-physical and social realms. Changes in temperature and precipitation are causing undesired change on system directly linked to livelihood, particularly water resources. Drying water sources and groundwater depletion are prominent impacts; the region is facing as a result of erratic and intense rainfall. Groundwater is a major source of water supply for vast number of population most of which is used for irrigation. Valleys are poorly characterized in terms of both the hydrological setting and water usage. Quantification of this enormous resource in term of supply, usage, seasonality and quality is inadequate and has not received considerable attention. This has resulted in depletion and degradation of water sources.

Two catchments of western Nepal were studied with the aim of understanding the potential impacts of climate change on groundwater availability. The study analyzed water samples for CFC and SF6 (groundwater residence time indicators) and weekly stable isotopes along with flow measurement of four selected sources. The analysis showed that groundwater residence times were short. This can cause serious implication in coming days with projections foreseeing a warmer and drier climate. It would exacerbate already challenging conditions for the management of resources. The situation is compounded further due to lack of effective government monitoring policies resulting in aquifer pollution and inequitable water allocation. The haphazard digging of shallow and deep tube-well for vegetable farming is further depleting this resource. The study suggests that it is imperative to have an understanding of groundwater vulnerability to climate variability for successful management of groundwater resources. It further documented opportunities and challenges of using groundwater resources at cornerstone of climate adaptation strategies which required formulation of good water governance strategies.

Study of Rocky Aquifers in Hill and Mountainous Area of Central Nepal "A Case Study of Melamchi Watershed"

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Groundwater Resources Development Board (GWRDB) is the lead agency for the drilling of the water wells for irrigation purpose especially in the Terai Plain to increase the irrigated land thereby increasing the crop production of the nation. The study on the groundwater utilization around the world has shown that these natural resources are already in stress due to overexploitation to meet the increasing demand and utilization as a result of growing population. Nepal is not left untouched by this problem. As a result the decreasing water table/piezometric surface have been reported from many locations within the country indicating less recharge than the discharge through wells, especially in the Kathmandu Valley. Such scenario has not been reported from the Terai and Inner Terai till date. However, such possibility in future can't be ruled out if the groundwater drafting is continued to meet the agricultural and domestic demand. Many reports have concluded that the springs and seepages at the mountainous areas that were basically utilized for the drinking purpose has gone dry in the recent time and few villages have been displaced due to water shortage. Such problem is expected to be much more severe in view of climate change condition.

In this regards, it is important to establish a methodology to explore groundwater in the mountainous terrain for better planning to avoid water deficiency problem in the mountainous area in the coming days. The present study regarding the "Study of Hard Rock Aquifers in Hill and Mountainous Area of Central Nepal" is envisaged as one of the milestone for GWRDB to make an approach to work in the mountainous terrain from the groundwater exploration and exploitation perspectives.

Transact with Water Quality and Associated Hygienic Symptoms in Eastern Region of Nepal

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In Nepal, the efforts to control health issues caused by poor drinking water quality are inadequate. For this reason, campaigns carried out by both the Government and Non-government agencies against open defecation have successfully snowballed throughout the nation as a control measure of water contamination from fecal matter. This paper shares the analytical transact of water quality and associated hygienic symptoms. The study covers analyses of 500 water samples, both from groundwater sources, and spring sources using standard protocol and discussion of the result in reference to National Drinking Water Quality Standard. The samples were collected from one VDC each of six districts: Morang, Sunsari, Dhankutta, Jhapa, Ilam and Panchthar. Stool samples from the water users were examined for some indicative contagion to measure the quality of water. The measured physico-chemical parameters were found within Nepal's guideline values, however majority of the water samples were contaminated with pathogenic contamination. No specific impact of industrial pollutants in drinking water was identified in the samples analyzed from the industrial corridors. Open defecation and poor handling practices of drinking water were found to be the major causes of bacterial contamination. Parasitic infestation was identified from the stool samples from all VDCs. The infestation rate was slightly higher in females and kitchen workers, substantially high in Terai districts compared to hilly districts. The study found that 70% of people drank water without any kind of treatment. Boiling is the common practices of disinfection of drinking water (65%).

The study indicates that water is contaminated at the point of use and also at sources microbiologically. Of the total stool samples (n=900) prevalence of any type of parasitic infestation was 10 %. Of the total infested samples, 58 % were Giardia 17 % by Ascaris and rest by others. 65 % of the households owned toilet. Soap and other hand washing materials

were present in 81% of the household, mostly put in nearby tap. Vectors were predominant in 74% of the households. The first and foremost step for control is to educate users on how water gets contaminated. It should be followed by capacity building of users in appropriate treatment measures. Stool infestation is common even though the households have toilets. Thus, the sources of infestation are not merely the sanitary systems but also other factors such as earthen floor and poor quality of water. Regular water quality checking is necessary due to risk of contamination over time. Emphasis of construction of sanitary latrines should be given to all households that would substantially reduce the fecal contamination and worm infestation. Industrial waste should be monitored in order to curb its impact on the health of the residents of the community.

Groundwater Quality of Kathmandu Valley in the Post-earthquake Scenario

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A powerful 7.6 magnitude earthquake struck Nepal on 25th April, 2015, with its epicenter in Barpak, Gorkha, about 80 km north-west of Kathmandu. This massive quake was followed by many aftershocks, notably 6.9 and 6.8 magnitude aftershocks on 26th April and 12th May respectively. Groundwater is one of the major sources of drinking water in Kathmandu Valley. The earthquakes and aftershocks are likely to have impacted groundwater. A study was conducted to assess various physico-chemical and microbiological parameters of water and to compare these with parameters of water analyzed before the earthquakes.

Following earlier procedure, groundwater samples were collected from different parts of Kathmandu Valley and analyzed according to the standard methods. The results indicate that turbidity, nitrate, ammonia, iron and manganese concentration of water samples in post-earthquake scenario crossed the Nepal Drinking Water Quality Standard (NDWQS) limit. However, heavy metal concentrations like copper, chromium, lead and arsenic were within NDWQS limit. It is assumed that the shaking of ground layer lead to the dissolution of inorganic ions in groundwater due to enhanced water-rock interaction, resulting in a significant decrement of pH. No significant change in concentration of tested ions was observed. More than 90 % of the samples tested positive to coliform presence indicating a potential risk of water-borne disease outbreaks in areas where groundwater is used for drinking. In order to secure the health from various water borne diseases, point of use treatment systems are recommended.

Environmental Isotope Analysis of Spring Water in Mountainous Regions for Better Management Plans: Case Studies in Doti and Baitadi Districts (Nepal)

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Groundwater, especially springs, is an important source for drinking and irrigation activities in the hills and lower mountain regions of Nepal. However, due to natural and anthropogenic processes, these springs are drying up. As a result, there are cases of migration of people and abandonment of agricultural land due to chronic lack of water supply. Even though spring water is the lifeline for many, there is negligible study on groundwater (springs) systems in mountainous regions of Nepal, leading to a lack of understanding in surface and ground water interactions. Hydro-geological characteristics of springs are unknown, for example, what is the source of springs? How and where springs are recharged? How long does it take to recharge springs? What is the lag time between rainfall and spring discharge? How climate and anthropogenic activities are affecting spring hydrology?

A comprehensive study to understand spring water system for sustainable utilization and distribution of water in order to build resilient communities is being implemented in mountainous region of Far-west, Nepal using environmental isotopes. Environmental isotopes (stable) analysis methods are used in the sub-catchment of Doti and Baitadi Districts. This analysis will aid in establishing a mass balance for springs, from which different contributions to spring water can be assessed. The study, by identifying these contributions, will help us understand the surface and ground water interactions and help in better quantifying spring sources, recharge areas, time required for spring water to recharge. This information can then be used to formulate scientifically valid water management plans aimed to increase reliability and availability of water for communities living in these regions by rejuvenating the drying springs. This study is the first of its kind in Nepal, and the study findings can be used in regions with similar hydrogeological setting (e.g. across Himalayas).

TECHNICAL SESSION II

Groundwater Policy, Regulations and Governance

Chair: Prof. Ishwor Man Amatya
Institute of Engineering (IoE), Tribhuvan University (TU)
Rapporteurs: Jyoti Dahal, Nishant Shrestha

Groundwater Policy, Regulation and Governance

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The groundwater is an indispensible natural resource for the drinking and socioeconomic development of Nepal. The proper investigations activities of this resource were started from B.S. 2024. In the same way the extraction and development in planning way of this resource was started from B.S. 2031. Since then, the extraction and development of the groundwater resource is rapidly increasing to meet multipurpose interests of the country. Now-a-days, groundwater resource has been most essential in both rural as well as urban areas of the Terai and Inner Terai and Kathmandu Valley in the realm of inadequate supply of surface water, increased population and climate change.

Within short period, about one dozens of plans, policies, rules, and regulations have been prepared regarding this valuable resource. Some of them are for investigation purpose, some are for extraction and development purpose and some are for protection and conservation purpose. Out of these, the Regulation of Groundwater Resources Development Board 2031; Water Resource Act 2049 and Water Resources Regulation 2050; Irrigation Policy 2070; National Water Plan 2005; Act of Kathmandu Valley Water Supply Development Board 2063 and Proposed Act of Groundwater Resource Development Authority 2072 etc are the main legislations.

It can be found that the earlier documents have given more emphasis on extraction and development activities while the new documents have given more emphasis on the protection and conservation activities. At present, the priority should be given to both conservation and development activities equally including the formation of new legislation regarding this natural resource. This idea will be able to balance the natural resource and to address the needs of the human beings equally. Moreover, it will help to maintain the good governance of the groundwater resources in the country as well.

Groundwater Management in California- A Century of Scientific and Legal Disconnect and the 2014 Sustainable Groundwater Management Act (SGMA)

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In 1913, the California legislature enacted the Water Commission Act (WCA). Among other things, the WCA established a statewide system for water rights permitting and regulation which is now administered by the State Water Resources Control Board (SWRCB). Additionally, the WCA established the scope of jurisdiction for permitting and regulation in Section 1200 of the Water Code to "surface water, and subterranean streams flowing through known and definite channels," collectively referred to as "surface water." Over the next 100 years, California's complex surface water rights system was implemented, while groundwater remained largely unregulated, except in cases of adjudication, which have been mostly limited to basins in Southern California. During this same century, significant developments in the science and understanding of groundwater were realized. The growing body of groundwater knowledge consistently reinforced the reality that water, both surface water and groundwater, was a continuum moving where gravity and geology would have it. Thus, California was left to struggle with a legal and management framework that was in direct contradiction with physical reality. The WCA had drawn a fictitious jurisdictional line "in the sand" as it were, between surface water, requiring permitting and management, and groundwater, which was strictly off the management agenda. Increasing agricultural, municipal, and environmental demands for water, rising concerns over the impending effects of climate change on California's water supply, increasing evidence of the interconnections between surface water and groundwater, and ongoing severe drought conditions collectively contributed to the passage of the Sustainable Groundwater Management Act (SGMA) in the fall of 2014. SGMA attempts to address California's century old scientific and legal disconnect, by requiring all groundwater basins in the State to come into a state of sustainability by 2040. SGMA defines sustainability as "the management and use of water in a manner that can be maintained during the planning and implementation

horizon without causing undesirable results." As specified in the SGMA, "undesirable results" include the following: chronic lowering of groundwater levels, reductions in groundwater availability, intrusion of saline water, degradation of water quality, land subsidence, and depletions of interconnected surface waters such as springs, lakes, and streams. SGMA mandates updates to groundwater basin delineations by the Department of Water Resources, formation of Groundwater Sustainability Agencies for all basins in the State, and development of Groundwater Sustainability Plans by 2021 or 2022. The process of establishing Groundwater Sustainability Agencies and drafting Groundwater Sustainability Plans will be a locally driven stakeholder process, with the State providing technical oversight, financial assistance, and administrative support. If, however, established Groundwater Sustainability Agencies fail to make progress towards bringing their basins into sustainability in accordance with defined milestones, the SGMA gives the SWRCB the authority to intervene and management the basin. Groundwater Sustainability Plans will be focused on quantifying sustainable groundwater yields by developing detailed water budgets and groundwater models for the Groundwater Sustainability Agencies.

Climate Policy, Conflicts and Cooperation in Peri-urban South Asia: Towards Resilient and Water Secure Communities

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A four year research project initiative in three countries Nepal, Bangladesh and India is executed by an international consortium of organizations (SaciWATERs, Wageningen University, Institute of Water and Flood Management Bangladesh, Jagrata Juba Shangha Bangladesh, ICIMOD and MetaMeta) and funded by the Netherlands Organization for Scientific Research (NWO). The objective of the project is to contribute towards the improvement of peri-urban water security by enhancing community resilience to urbanization and climate change through increased cooperation and reduction of conflict, producing opportunities for improved livelihoods for poor, marginalized and vulnerable groups and resulting in climate-smart water resources and climate change strategies, policies and actions at various levels. In Nepal, ICIMOD and MetaMeta are taking lead in this project and Kathmandu Valley is a research area. Kathmandu Valley, consisting of three historic city Kathmandu, Lalitpur and Bhaktapur, has been suffering from acute water shortage due to rapid urbanization. The bearing of water shortage is directly fulfilled from the peripheries of the city in the valley termed as peri-urban. Peri-urban areas are increasingly witnessing insecurity of water resources due to rapid urbanization and climate uncertainty (perceived change in temperature, rainfall pattern etc.). The effect is widespread, but poorly documented and considered in practice. The water (in) security in the peri-urban areas often leads to conflicts, contestations and cooperation's due to conflicting interests and varied groups. The study until now identifies peri-urban areas with the presence of such conflicts or cooperation in the rapidly urbanizing cities of Kathmandu through a mixed approach of quantitative and qualitative data analysis. The study was conducted in five Village Development Committees (previously) in Hanumante River Basin. They are Jhaukhel, Dadhikot, Sudal, Siddhipur, Lubhu and Godawari. An overview of the issues and emerging pattern of conflict and cooperation shaping Water in-security in peri-urban areas, rapidly growing urban areas which

depend on peri-urban resources, excessive extraction of groundwater resulting to reducing groundwater table (drinking, industrial use etc.), development of different industries in peri-urban areas linked to urbanization, and the outcomes of urbanization such as Hanumante river functioning as an "open drain", water priorities to urban dwellers and its implication on water (in-)security in peri-urban areas which is further aggravated by climate uncertainty.

Groundwater as Key for Dry Season Irrigation in Eastern Gangetic Plains: Extent of Use and Associated Constraints

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Past studies show that groundwater has potential to be the viable alternative to the surface irrigation in Eastern Gangetic plains. However, the potential has not been exploited because of the reasons associated with groundwater pumping, and the operation of groundwater markets. In this context, a survey was conducted with the aim to determine the extent of groundwater use including shallow tube well (STW) and pump ownership, energy options, and estimate of costs and returns. In addition, the survey also examined the constraints and challenges that limit the capacity of the farmers to harness the groundwater potential for irrigation. Primary data was collected from a total of 1,994 randomly selected households from three districts of Nepal (923 HHs) and four districts of India (1071 HHs) covering two districts, one each from Bihar and West Bengal. Farmers irrigated crops using a range of sources; however, groundwater was reported to be the main source by the large majority of the farmers in all seven study districts. In terms of providing continuous crop throughout the year, groundwater played major role. But the result showed that still a considerable proportion of land is under single crop or double crop. It shows the potential and need to expand the irrigation coverage. Further there is the scope to bring complete un-irrigated area in the coverage of either surface or groundwater. Result revealed that diesel is the main energy option for groundwater pumping. Even though some farmers reported using electric pump, with high coverage in Malda and Cooch Behar districts, the coverage was still low in most of the study areas because of insufficient electricity lines covering the cultivated fields and unreliable supply. Despite the fact that majority of the farmers still rely on diesel for groundwater pumping, timely and adequate supply, and price of diesel are limiting factors for diesel use in groundwater irrigation. Further, result revealed that average land holding size was small in Nepal, and in comparison to Nepal study districts, fragmentation of land parcel was high in India. Both the small land holding and fragmented land parcel could limit the potential to own the STWs. Since many smallholder farmers cultivated as tenant, such land tenancy situation could also limit STWs expansion. The groundwater market operated in informal basis. There were not any specific institutional settings for the operation of groundwater market in the study districts. As a result, some farmers reported paying more and unavailability of water at the time needed. Proper institutional set-up could help decide pricing on mutually agreed basis and ensure better availability thereby smooth functioning of the groundwater market.

Urbanization and Regulated Groundwater Use, the Changes and Challenges to Peri-urban Water Security in the Context of Changing Climate and Post-earthquake Kathmandu Valley

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Urbanization in Kathmandu Valley with its annual population growth rate of over four per cent has increased urban water demands and the peri-urban to urban water transfers by both state and private actors. These peri-urban areas are characterized by the mixed land and water uses resulting from the expanding urban sprawls and changing livelihood practices. The water demands in the peri-urban areas are also increasing, for both non-agricultural and the changing agricultural land and water uses. The traditional water sources are however degrading or drying. The dependency on groundwater resources has increased. In these changes multiple actors and multiple institutions have emerged in the management and governance of the peri-urban water resources. These processes of seeking water security involve reallocations and intensive uses of water sources thereby increasing intra and inter-sectoral contestations and bringing new forms of conflicts and cooperation. In addition, studies have marked climate change can add unpredictable challenges to these urbanization-induced changes in peri-urban water (in) securities in the valley. Based on household questionnaire survey, in-depth interviews, field observations, focus group discussions, and key-informants' interviews done at different periods between 2010 to 2016, and analysis of the literature, this study presents changes around peri-urban water security with focus on the challenges for the regulated groundwater use expected by the Groundwater Policy 2012 for Kathmandu Valley in the context of increasing urban expansion and dealing with the post-earthquake scenario and changing climate.

TECHNICAL SESSION III

Water and Jobs

Chair: Dr. Laxman Joshi
Environment and Public Health Organization (ENPHO)
Rapporteurs: Sheila Ghimire, Sarita Machamasi

Creating Water Jobs through Bio-Sand Filter Local Entrepreneurship

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Access to safe drinking water remains a key challenge in Nepal. To cope with this challenge, entrepreneurial sectors have been integrated with social ventures such as safe drinking water delivery. The idea of social entrepreneurship is now widely practiced. Non-entrepreneurial sectors including development works, health, and others adapt social innovations and approaches with entrepreneurial perspective to achieve their social goals through. These approaches instigate social changes, and moreover, these have the potential payoff that makes them sustainable and secures transformational benefit to society.

One of the ways Environment and Public Health Organization (ENPHO) is promoting safe drinking water is through a social business model. Initially, a business model was conceptualized for 1) Population penetration, 2) Lasting impact and social behaviour change, and 3) Sustainability and enhanced livelihood. The business model follows a decentralization strategy at individual entrepreneur level. The ENPHO Water Expertise and Training (WET) Centre has been capacitating individuals to become a Bio-Sand Filter (BSF) entrepreneur and to produce and promote BSF, a simple, well-proven, cost effective filter that can be built locally. A social business network BiFEAN (Bio Sand Filter Entrepreneurs Association Nepal) has been established and officially registered. Currently BiFEAN has 25 member entrepreneurs who promote BSF for safe drinking water in 20 districts of rural Terai. Establishment of BiFEAN resulted in a dramatic increase in the number of BSF users. Improved access to safe drinking water using BiFEAN network has reached over 152,000 people. Safe water promotion activities including WASH awareness programs have benefitted more than 160,000 people. In addition to health benefits, this social entrepreneurship venture is also making a significant contribution to community through local employment. At present 30 entrepreneurs with more than 100 employees are active in Terai region.

BiFEAN is increasing community exposure towards entrepreneurship while reducing the economic burden of health care and increasing livelihood at the same time. BiFEAN as a social entrepreneurship venture demonstrates a unique, autonomous, sustainable and replicable model with decentralized promotion and implementation approach. This approach has the potential to promote other WASH related innovations and technologies in Nepal and beyond.

Water Supply Management and Role of Private Tanker Association in Kathmandu Valley

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Under the premise of climate change and population increase, the rise in water shortages is evident, particularly in urban areas. Easy access to water is a fundamental right of all citizens in Nepal. The government's obligation towards managing easy water accessibility for its citizens is indisputable. However, the Nepal government has been unable to provide safe water to its citizens. On the other hand, about seven hundred privately owned tankers and other water industries supply five hundred thousand liters of water in Kathmandu Valley. The private sector is fulfilling the government responsibility in many ways.

Despite three decades of efforts, necessary rules and policies to regulate and support water supply system from the private sector, no significant progress has been made. The Valley Drinking Water Supply Tanker Entrepreneurs Association has been monitoring water quality in different water sources, providing trainings on disaster management and damage mitigation for drivers and co-drivers. During April 25, 2015 earthquake and fire incidents in the valley, as our social responsibility, we have been providing free water to disaster victims and for fire control. Unfortunately, there is no co-ordination by any government agency.

Again, there is a serious lack of essential co-ordination efforts from the government to support the water tanker sector especially during recurring fuel shortages and other difficult times. The monitoring mechanism is ineffective; the government is not serious to prepare necessary policies and laws to regulate the private sector water industry, despite the fact that this private sector is creating huge employment opportunities in the country where employment is a serious issue.

NIVARAIN Experience on Private Business on WASH in Urban Centers

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Rapid urbanization in Nepal has brought several key development challenges including immense pressure on drinking water sources and provision of sustainable sanitation facilities. Access to adequate and safe drinking water, proper waste, wastewater and faecal sludge management are prevalent issues in urban and peri-urban areas in Nepal. Several agencies including government line agencies are putting tremendous efforts to address these challenges in sustainable manner. The need of private sector engagement in water and sanitation has been clearly spelled out in key policies, guidelines related to urban water and sanitation. Consequently, private companies and local entrepreneurs have been providing water and sanitation services to the public at the cities, particularly in Kathmandu Valley. NIVARAIN private limited is one of the private companies that are providing services since 2011. The company has been established by the entrepreneur trained by ENPHO. Till date, NIVARAIN has provided technical and consulting support to establish 22 Decentralized Wastewater Treatment Systems (DEWATS) in Nepal. Similarly, more than 250 rainwater harvesting systems have been installed at the household and institutional levels. About 200 units of large biosand filter have been installed to treat drinking water at household level. NIVARAIN envisages scaling up its services contributing to reduce burden in urban water and sanitation sector.

PANEL DISCUSSION: GROUNDWATER POLICIES, AND WATER JOBS

Facilitator: Dr. Ram Chandra Bastakoti [1]
Panelists: Dr. Dibya Ratna Kansakar [2]
Dr. Ravi Sharma Aryal [3]
Mr. Ashutosh Tiwari [4]
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[3]Environment Protection Committee
[4]Sherpa Adventure Gear

A panel discussion towards the end of the symposium was organized, which was facilitated by Dr. Ram Chandra Bastakoti. The panelists for the discussion were Dr. Dibya Ratna Kansakar (Team Leader, Water Resources Project Preparation Facility, MoI/DoI/DWIDP/ADB), Dr. Ravi Sharma Aryal (Secretary, Environment Protection Committee) and Mr. Ashutosh Tiwari (CEO, Sherpa Adventures). Each panelist were allotted minimum of ten minutes to present their experience, views and learning on the issues related to groundwater. The central theme for the panel discussion was Groundwater Policies, Regulations and Water Jobs. All the panelists presented the importance of water in day-to-day life and highlighted the need to conserve these valuable resources for future as life can't sustain without water. After each deliberation, the participants from the floor raised the questions or clarifications to each relevant panelist.

Concluding Remarks

Dr. Rabin Malla, Executive Director, CREEW, closed the session by thanking all the participants, presenters with a promise to meet next year with the prominent issues of groundwater resources in Nepal.

ANNEX I: PROGRAM SCHEDULE

Date: 20 March 2016
Venue: Begnas Hall, Radisson Hotel, Lazimpat, Kathmandu
Registration: 8:40 am - 9:00 am

Program Schedule **MC: Ms. Nicky Shree Shrestha**

INAUGURATION SESSION		
9:00 -9:05	Welcoming the Dignitaries on Dias	
9:05-9:10	National Anthem	
9:10-9:15	Lightening of the Traditional Oil Lamp by Chief Guest	
9:15-9:20	Welcome address	Dr. Laxman Joshi, Executive Director, Environment and Public Health Organization
9:20-9:25	Remarks by Guest	Ms. Tripti Rai, Country Representative, WaterAid Nepal
9:25-9:30	Remarks by Guest	Er. Mahendra Bahadur Gurung, Co-Chair, Main Organizing Committee, Nepal National Week and Weather Week 2016
9:30-9:40	Remarks by NNW-WW 2016 Secretary	Mr. Sudarshan Rajbhandari, Acting President, The Small Earth Nepal
9:40-9:45	Remarks by Guest	Mr. Jagat Prasad Joshi, Executive Director, Groundwater Resources Development Board
9:45-9:50	Remarks by Chief Guest	Er. Suresh Prakash Acharya, Secretary, Ministry of Water Supply and Sanitation
9:50-9:55	Vote of thanks	Dr. Rabin Malla, Executive Director, Center of Research for Environment, Energy and Water
9:55-10:00	Closing remarks by the Chairperson	Mr. Dhana Bahadur Tamang, Secretary, Water and Energy Commission Secretariat

Group Photo Session and Tea Break (10:00-10:15)
POSTER VIEWING & DISPLAY SESSION (10:15-10:30)

TECHNICAL SESSION I: Impacts to Groundwater (e.g. from withdrawal and various uses, pollution and climate change)		
Chair: Dr. Madan Lal Shrestha, Academician, Nepal Academy of Science and Technology (NAST) Rapporteurs: Pramina Nakarmi, Isha Dhakal		
10:30-10:45	Groundwater Resource Response to Changing Climate in Mid-hills of Nepal	Ms. Shobha Kumari Yadav Institute for Social and Environmental Transition-Nepal
10:45-11:00	Study of Rocky Aquifers in Hill and Mountainous Area of Central Nepal "A Case Study in Melamchi Watershed"	Mr. Surendra Raj Shrestha Groundwater Resources Development Board
11:00-11:15	Transact with Water Quality and Associated Hygienic Symptoms in Eastern Region of Nepal	Dr. Jaya Kumar Gurung (Nepal Development Research Institute) & Assoc. Prof. Dr. Pranil Pradhan (Department of Community Medicine and Public Health, Institute of Medicine, T.U.)
11:15-11:30	Groundwater Quality of Kathmandu Valley in the Post-earthquake Scenario	Ms. Padmaja Shrestha Environment and Public Health Organization
11:30-11:45	Environmental Isotope Analysis of Spring Water in Mountainous Regions for Better Management Plans: Case Studies in Doti And Baitadi Districts (Nepal)	Ms. Ambika Khadka International Water Management Institute
11:45-12:00	Floor Discussion	
Lunch Break (12:00-13:00)		

TECHNICAL SESSION II: Groundwater Policy, Regulations and Governance		
Chair: Prof. Ishwor Man Amatya, Institute of Engineering (IOE), TU Rapporteurs: Jyoti Dahal, Nishant Shrestha		
13:00-13:15	Groundwater Policy, Regulation and Governance	Mr. Sagar Kumar Rai Ministry of Irrigation, Government of Nepal
13:15-13:30	Groundwater Management in California - A Century of Scientific and Legal Disconnect and the 2014 Sustainable Groundwater Management Act (SGMA)	Mr. Jeffrey C. Davids Delft University of Technology
13:30-13:45	Climate Policy, Conflicts and Cooperation in Peri-Urban South Asia: Towards Resilient and Water Secure Communities	Mr. Saroj Yakami Meta Meta
13:45-14:00	Groundwater as Key for Dry Season Irrigation in Eastern Gangetic Plains: Extent of Use and Associated Constraints	Dr. Ram Chandra Bastakoti International Water Management Institute
14:00-14:15	Urbanization and Regulated Groundwater Use, the Changes and Challenges to Peri-urban Water Security in the Context of Changing Climate and Post-earthquake Kathmandu Valley	Ms. Anushiya Shrestha Wageningen University
14:15-14:30	Floor Discussion	
Break (14:30-14:40)		

TECHNICAL SESSION III: WATER AND JOBS		
Chair: Dr. Laxman Joshi, Executive Director, Environment and Public Health Organization Rapporteurs: Sheila Ghimire, Sarita Machamasi		
14:40-14:55	Creating Water Jobs through Bio-Sand Filter Local Entrepreneurship	Mr. Rameswor Adhikari Environment and Public Health Organization
14:55-15:10	Water Supply Management and Role of Private Tanker Association in Kathmandu Valley	Mr. Bishnu Dahal Valley Water Supply Tanker Entrepreneurs Association
15:10-15:25	NIVARAIN Experience on Private Business on WASH in Urban Centers	Mr. Narendra Dangol NIVARAIN
15:25-15:40	Floor Discussion	
Tea Break (15:40-16:00)		
PANEL DISCUSSION: Groundwater Policies and Water Jobs (16:00-17:00) Facilitator: Dr. Ram Chandra Bastakoti Panelists: Dr. Dibya Ratna Kansakar, Dr. Ravi Sharma Aryal, Mr. Ashutosh Tiwari Rapporteurs: Pramina Nakarmi, Isha Dhakal, Sarita Machamasi		
CLOSING SESSION		
17:00-17:15	Session close with remarks	Dr. Rabin Malla, Executive Director, Center of Research for Environment, Energy and Water

ANNEX II: LIST OF PARTICIPANTS

S.N.	Name	Organization
Government Organizations		
1.	Mr. Jagat Prasad Joshi	GWRDB
2.	Mr. Surendra Raj Shrestha	GWRDB
3.	Mr. Krishna Prasad Upadhya	GWRDB
4.	Er. Sanjeev Bikram Rana	KVWSMB
5.	Mr. Anoj Khanal	KVWSMB
6.	Er. Nabin Tiwari	KVWSMB
7.	Ms. Durga Regmi	KVWSMB
8.	Mr. Yogendra Prasad Bhatta	KVWSMB
9.	Ms. Gita Acharya	KVWSMB
10.	Ms. Roja Sapkota	KVWSMB
11.	Ms. Sangita Acharya	KVWSMB
12.	Ms. Anju Subedi	KVWSMB
13.	Mr. Raj Kaji Ranjit	Education Committee
14.	Mr. Gyanendra Bahadur Karki	KUKL
15.	Mr. Sagar Kumar Rai	Ministry of Irrigation
16.	Dr. Ravi Sharma Aryal	Environment Protection Committee
17.	Er. Suresh Prakash Acharya	Ministry of Water Supply and Sanitation
18.	Er. Gautam Rajkarnikar	Department of Hydrology and Meteorology
19.	Dr. Dibya Ratna Kansakar	DOI/Water Resources Project Preparation Facility
20.	Mr. Dhana Bahadur Tamang	WECS
21.	Mr. Purushottam Sharma	WECS
22.	Dr. Pranil Pradhan	Institute of Medicine, T.U.
Academic/ Research Institutions		
1.	Prof. Iswor Man Amatya	IOE
2.	Dr. Madan Lal Shrestha	NAST/SEN
3.	Dr. Madhav Narayan Shrestha	AITM

4.	Mr. Prem Bahadur Rana	Thames International College
5.	Ms. Suyasha Regmi	Thames International College
6.	Ms. Shraddha Gurung	Thames International College
7.	Ms. Ashmita K.C.	Thames International College
8.	Mr. Rabindra Jyakhwo	Khwopa College
9.	Ms. Anushiya Shrestha	Wageningen University
10.	Mr. Jeffrey C. Davids	Delft University
11.	Ms. Jyoti Dahal	Nepal Engineering College
12.	Mr. Nishant Shrestha	Nepal Engineering College
13.	Ms. Palpasa Prajapati	AIT
UN Agencies and International Organizations		
1.	Ms. Tripti Rai	WaterAid Nepal
2.	Dr. Ram C. Bastakoti	IWMI
3.	Dr. Pennan Chinnasamy	IWMI
4.	Dr. Romolus Okwany	IWMI
5.	Ms. Ambika Khadka	IWMI
6.	Mr. Saroj Yakami	MetaMeta
7.	Mr. Otto Hoffhann	MetaMeta
NGOs and Others		
1.	Dr. Rabin Malla	CREEW
2.	Mr. Robert Dangol	CREEW
3.	Dr. Salina Shrestha	CREEW
4.	Ms. Sarita Shrestha	CREEW
5.	Ms. Meera Prajapati	CREEW
6.	Mr. Sarad Pathak	CREEW
7.	Mr. Upendra Jung Shahi	CREEW
8.	Mr. Nihit Bhattarai	CREEW
9.	Mr. Utsav Bhattarai	Water Modeling Solutions Pvt. Ltd.
10.	Dr. Laxman Joshi	ENPHO
11.	Ms. Padmaja Shrestha	ENPHO
12.	Mr. Rameswor Adhikari	ENPHO
13.	Ms. Pramina Nakarmi	ENPHO

14.	Ms. Isha Dhakal	ENPHO
15.	Mr. Subin Kalu	ENPHO
16.	Mr. Niranjan Bista	SEN
17.	Mr. Sheila Ghimire	SEN
18.	Ms. Sadip Bohara	ENPHO
19.	Ms. Sarita Machamasi	ENPHO
20.	Mr. Sudarshan Rajbhandari	SEN
21.	Ms. Nicky Shree Shrestha	SEN
22.	Mr. Suman Shah	Smart Paani
23.	Mr. Suraj Kumar Singh	SmartPaani
24.	Dr. Dhundi Raj Pathak	SWMTSC
25.	Mr. Narendra Man Dangol	NIVARAIN
26.	Ms. Reshma Shrestha	CIUD
27.	Dr. Jaya K. Gurung	NDRI
28.	Ms. Anjana Upadhayay	CEMAT Water Lab. Pvt.
29.	Ms. Renu Shrestha	CEMAT Water Lab
30.	Ms. Sabitri Tripati	Nepal Engineering College
31.	Mr. Prakash Paudel	JVS
32.	Ms. Shobha Kumari Yadav	ISET-Nepal
33.	Er. Mahendra Bahadur Gurung	Pancheshwor Bikash Pradhikaran
34.	Ms. Anjali M. Sherpa	500 B Solutions Pvt. Ltd.
35.	Mr. Mingma G. Sherpa	ENPHO/500B Solutions Pvt. Ltd
Media		
1.	Ms. Shanta Lamsal	Online Samachar
2.	Mr. Sangam Ghimire	Photographer
Entrepreneur		
1.	Mr. Ashutosh Tiwari	Sherpa Adventure Gear
2.	Mr. Arabinda Subedi	Sherpa Adventure Gear
3.	Ms. Rijuta Maharjan	Sherpa Adventure Gear
4.	Mr. Bishnu Dahal	Valley Water Supply Tanker Entrepreneurs Association
5.	Mr. Narayan Shrestha	Valley Water Supply Tanker Entrepreneurs Association
6.	Mr. Kumar Raut	Valley Water Supply Tanker Entrepreneurs Association

ANNEX III: COMMITTEES OF THE SYMPOSIUM

Technical Committee

Prof. Narendra Man Shakya (IOE, TU), Assoc. Prof. Dr. Sangam Shrestha (AIT), Prof. Dr. Suresh Das Shrestha (TU), Dr. Vishnu Prasad Pandey (AIT), Ms. Padmaja Shrestha (ENPHO), Mr. Robert Dangol (CREEW), Er. Surendra Raj Shrestha (GWRDB), Prof. Futaba Kazama (ICRE-UY), Assoc. Prof. Nishida Kei (ICRE-UY)

Organizing Committee

Dr. Rabin Malla (CREEW), Ms. Sarita Shrestha (CREEW), Mr. Sudarshan Rajbhandari (SEN), Mr. Niranjan Bista (SEN), Dr. Laxman Joshi (ENPHO), Mr. Sushil K.C. (KVWSMB), Er. Nabin Tiwari (KVWSMB), Mr. Anoj Khanal (KVWSMB), Mr. Krishna Prasad Upadhyay (GWRDB)

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