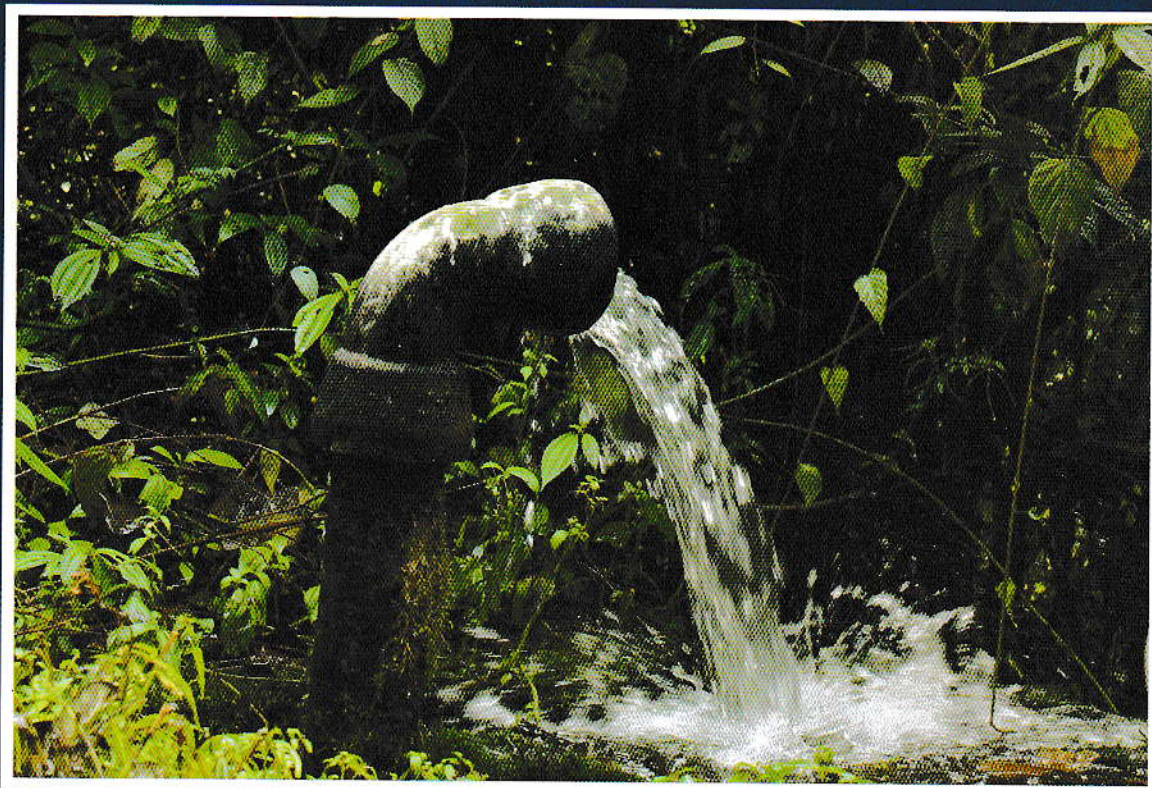




Proceedings of the 8th National Groundwater Symposium
"Challenges and Opportunities for Sustainable Management
of Groundwater Resources in Nepal"

20th March 2017, Kathmandu



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)

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Institute of Engineering (IoE), Tribhuvan University (TU)
Asian Institute of Technology (AIT), Thailand
Interdisciplinary Centre for River Basin Environment of University
of Yamanashi (ICRE-UY), Japan
Kurita Water and Environment Foundation (KWEF), Japan

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Back cover photo: Participants of the 8th National Groundwater
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Organizers

CREEW, SEN, ENPHO, KVWSMB, GWRDB

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PREFACE

Groundwater has become a major source of water for various purposes such as domestic, industrial and agriculture in Nepal. The increase in water demand increases the extraction of ground water without considering its management aspect, has put the sustainability of ground water aquifers under threats. The over extraction of this valuable resources result the depletion of ground water. Besides, the recharge of the aquifer from polluted surface water deteriorates the ground water quality. The unmanaged solid waste disposal, over use of pesticides etc. further pollutes the ground water quality. The study, management, and discourse on the ground water issue have become an urgent need for its sustainability.

Center of Research for Environment, Energy and Water (CREEW), The Small Earth Nepal (SEN), Environment and Public Health Organization (ENPHO) in collaboration with relevant government agencies like Kathmandu Valley Water Supply Management Board (KVWSMB) and Groundwater Resources Development Board (GWRDB) have been organizing National Groundwater Symposium that brings together the scholars, researchers, managers, policy makers and entrepreneurs to share the knowledge and discuss the various issues of groundwater.

The 8th National Groundwater Symposium on “Challenges and Opportunities for Sustainable Groundwater Resources Management in Nepal” was held on 20th March 2017 in the Hotel Annapurna, Kathmandu to commemorate the Nepal National Water and Weather Week 2017 on the occasion of UN World Water Day 2017. This symposium was supported by WaterAid Nepal, Water and Energy Commission Secretariat (WECS), Asian Institute of Technology (AIT) Thailand, Interdisciplinary Centre for River Basin Environment of University of Yamanashi (ICRE-UY) Japan, Institute of Engineering, Tribhuvan University (IoE, TU), Kurita Water and Environment Foundation (KWEF) Japan. The symposium was attended by 98 participants from universities, government and nongovernmental organizations, water companies and media.

The thematic areas addressed in the symposium included five major areas related to groundwater as enlisted below;

- Groundwater Science and Future Innovations
- Groundwater Utilization and Management

- Groundwater Quality and Quantity and its associated impacts (social, economic, environmental and human health)
- Groundwater and Climate Change
- Groundwater Policy, Regulations and Governance

The symposium began with the inaugural session followed by three technical sessions. Altogether eleven oral papers and four posters were presented in three technical sessions that included various topics on groundwater quality, quantity, management, and policies.

We hope the papers presented in the symposium will be useful guide for sustainability of groundwater. We look forward to continue the symposium successfully in the future as well.

Organizers
CREW, SEN, ENPHO, KVWSMB, GWRDB

KEYNOTE PRESENTATION

Save Groundwater: Secure the Water for Future

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Around two billion of the rural/urban population obtain drinking water from groundwater, which accounts for around 32% of the total drinking water supply. Today, 54% of the world's population lives in urban areas, a proportion that is expected to increase to 66% by 2050. Projections show that urbanization, combined with the overall global growth could add another 2.5 billion people to urban populations by 2050, with close to 90% of the increase concentrated in Asia and Africa. Major cities and municipalities in the region rely either fully or partially on groundwater as a part of the water supply network, where it is also used by small-scale rural or town water supply systems. For example, groundwater dependency is 70% for domestic and 60% for industrial water demand in Bandung-Indonesia, 45% in Ho Chi Minh – Vietnam and 100% in Lahore – Pakistan. Despite the significance of groundwater for sustainable development, it has not always been properly managed, which has often resulted in depletion and degradation of the resource.

Due to various pollution sources and climate change in urban areas, the quality and quantity of groundwater have become important issues for urban groundwater environments.

This key note lecture highlights the importance of groundwater resources, major issues related to groundwater development and management globally and locally. The way forward, sustainable management of groundwater resources is also presented. A successful case study on the application of the economic instrument to regulate groundwater resources in Bangkok, Thailand is highlighted. It is emphasized that economic instruments together with other provisions such as providing alternative water supply, groundwater zonation's, capacity building and awareness raising activities can enhance sustainable development and management of groundwater resources.

TECHNICAL SESSION I

Chair: Assoc. Prof. Iswor Man Amatya
Institute of Engineering (IoE), Tribhuvan University (TU)
Rapporteurs: Sushil Karki and Rajesh Giri

Application of Environmental Isotope Tracer and Hydrogeology Techniques in Identifying Recharge Areas of Mountain Spring Systems for Better Management Plans

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Springs are an integral part of the groundwater system and an important source for drinking and irrigation activities in the hill and mountain regions of Nepal. Despite the appreciation of springs as a livelihood driver for hill and mountain communities, a complete scientific understanding of spring system has so far not been comprehensively done primarily due to large data uncertainty. Environmental isotope and hydrogeology techniques have been applied to scientifically understand the complexity of spring systems in order to reduce data uncertainty and fill in the existing knowledge gap. The pilot projects are taken up in two catchments located in Baitadi and Doti districts of Nepal. Springs in Shikharpur VDC of Baitadi district are located between 1900 to 2500masl and they emerge at the contacts of phyllite and karstic limestone. Likewise, springs in Banlek VDC are located between 700 to 1100masl and they emerge at the contacts of colluvial soil and fractured quartzite. The stable isotopic variation in precipitation suggests that the altitude effect of -0.30% for $\delta^{18}\text{O}$ and -1.73 % for δD , and -0.26 % for $\delta^{18}\text{O}$ and -1.41 % for δD for Shikharpur and Banlek VDCs respectively. The local meteoric

line (LMWL) generated for Shikharpur and Banlek VDCs are $\delta\text{D} = 8.31\delta^{18}\text{O} + 13.41$ and $\delta\text{D} = 7.81 * \delta^{18}\text{O} + 6.22$, the slope and intercept for these equations suggest condensation effect in Shikharpur VDC and evaporation effect in Banlek VDC. The stable isotopic values of most springs in Shikharpur VDC lie above LMWL suggesting their source to be local rain events or rain events at a higher elevation with different wind speed and temperature. Whereas, stable isotopic values of springs in Banlek VDC lie closer and below LMWL suggesting altitudinal effect. Based on local geological setting and isotopic information the recharge areas inferred for springs in Shikharpur are located at the altitude of 994 to 1100 masl, which is much lower than where rainwater samples are collected (1954 and 2362 masl). Likewise, the recharge areas inferred for springs in Banlek are located at the altitude of 631 to 715 masl and it is also lower than where the rainfall samples are collect (733 and 936 masl). These suggest higher proportion of earlier year precipitation in the spring recharge and streams lying on the opposite valley to be potential recharge areas for springs of both site.

Groundwater Arsenic Mitigation Options: A Case Study of Rural Terai/Nepal



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This research aimed to find the socially acceptable, technically feasible, economically viable and environmentally sound options for arsenic mitigation in southern part of Nepal- Terai region, where groundwater is the main source of water supply. This study was conducted in rural part of Nawalparasi district.

For this study, 61 samples of tube well water were collected from Pratappur VDC Ward No. 1, 2 and Ramgram Municipality Ward No. 12, 13 of Nawalparasi district. Field study and focus group discussion (FGD) were also carried out in these VDC and municipality wards. The study finding revealed that arsenic level exceeded WHO standard in more than 50% of samples. Most of the dug wells found in study area are free from arsenic. The spatial distribution of selected tube wells were analyzed using GIS tools.

Study also elaborated the comparative result of arsenic test results using HACH Kit, WagTech Digital Arsenator and Atomic Absorption

Spectrophotometer. In every sample result is slightly different. The concentration level of arsenic is found to be dynamic and concentration level is slightly higher in pre-monsoon than in post monsoon.

The result further showed that community people are in favor of small scale overhead tank technology with treatment facility. However, acceptance levels of using Kanchan Arsenic Filter (KAF) and SONO Filter have negative result. Community people are not in favor of using these filters as it is tedious for regular use and cleaning. Some sample filtrate water from KAF and SONO Filter have negative result i.e. arsenic concentration level is found to be up to 100 ppb. Therefore, the mitigation to prevent further arsenic exposure is by providing alternative sources of safe drinking water. Studying the feasibility of possible alternative sources of arsenic free drinking water like extension of piped water supply, low cost dug well improvement, water supply through safe

wells and arsenic removal filter supply has to be planned according to the availability and sustainability, which should serve highly affected community.

Ramgram municipality is severely affected area, where large numbers of tube wells are found to be contaminated with Arsenic. Arsenicosis awareness campaign, health surveys and

mitigation activity must be conducted in the most severely affected Municipality/VDCs. A hydro geological investigation is one of the urgent study need to be conducted in Nawalparasi on the basis of blanket Arsenic Testing Program. This will help to prepare guidelines for future water supply system through tube well and to find safe aquifer around the hot spot area during the mitigation.

Assessment of Groundwater Risk to Pollution in Kathmandu: An Evaluation of Index-Overlay Methods



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Groundwater is vulnerable to contamination from human activities. The shallow aquifer is more likely to be contaminated with chemical pesticides, fertilizers and industrial wastes. When aquifer become highly polluted, contamination will stay for a long time and hard to remediate due their large storage, long residence time and physical inaccessibility. Therefore, preventive measures are the most-effective ways for averting risk to groundwater pollution. Vulnerability and risk assessment to pollution is the very first important step in determining the polluted and risk zones, which forms a basis for devising strategies for groundwater protection against contamination. Delineating vulnerable zones helps water resources managers shift groundwater development activities to other safer areas and hence minimize cost for groundwater treatment.

There are various methods for groundwater assessment such as index-overlay (e.g., DRASITC, GOD, and SI), statistical and process-

based. This study aims at evaluating three index-overlay methods for assessing pollution risk of shallow groundwater in the Kathmandu Valley. The Groundwater Risk Assessment Model (GRAM) model was used to compute the risk. Results showed that DRASTIC and SI methods are comparable for vulnerability assessment as both methods delineate around 80% of the groundwater basin area under high vulnerable zone. From the perspective of risk to pollution results, DRASTIC and GOD methods are comparable. Nevertheless, all the three methods estimate that at least 60% of the groundwater basin are under moderate risk to NO₃-N pollution, which goes up to 75% if DRASTIC or GOD-based vulnerability are considered as exposure pathways. Finally, based on strength of correlation between estimated risk and observed NO₃-N, SI method is identified as better one to assess vulnerability and risk to groundwater pollution in the area.

TECHNICAL SESSION II

Chair: Assoc. Prof. Sangam Shrestha
Asian Institute of Technology (AIT), Thailand
Rapporteurs: Madhu Neupane and Jinita Shakya

Study on Groundwater Depletion in Siraha District



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Unplanned urbanization, climate change and human encroachment on nature in the name of migration have resulted excessive depletion of groundwater throughout the world. Siraha district, in the Eastern Development Region of Nepal also face the problem of excessive groundwater depletion. The problems of water scarcity, inequitable distribution of water resources and more importantly drying spring sources and aquifers are common in the northern belt of Siraha district. Despite number of agencies like NEWAH, UEMS, FEDO, FEDWASUN working in close cooperation with WaterAid Nepal, the depleting groundwater level of the area still seems one of the major challenges for ensuring the water security of the residents of the area. This study mainly focused within the northern part of Siraha district to study the ongoing trend of groundwater depletion, analyze the reason behind it and give the solutions for the future so that it could be reflected in the works and policies that should be adopted in the future for addressing the water demand management of the area.

Siraha is one of the terai district of Nepal, which comprises granular alluvial sediments in the northern part below the churia foothills called Bhabar Zone and finer alluvial deposits in the southern part called Terai Plain. Despite the presence of a higher percentage of aquifer materials, Bhabar zone of the Siraha is facing continuous depletion in water level. Groundwater level mapping in the field, water table monitoring data from Groundwater Resource Development Board (GWRDB), focus group discussion (FGD) and interview with the local people and experts reveal that the problem of water table depletion is serious, especially in the Bhabar zone. The water level is continuously lowering in the upper part of the highway. Water level is depleting at a rate of 0.05 meters to 0.49 meters from 1995 to 2016 and 0.22 meters to 1.7 meters from the years of 2008 to 2016. The water table is at maximum depth in the month of April and after the start of May water table starts to rise. From September onwards, water level starts to decrease slowly. Groundwater flow direction

modeling through MODFLOW 2005 shows the southwest flowing direction of the water table is slightly increasing in the southwestern part below the highway.

Fluctuating water level and multiple aquifers present in the area makes the overall hydrogeological condition of the area very complex and demands the proper solutions incorporating legal, institutional and technical

aspects which will ensure water security of the residents of the area. Groundwater is the main input for daily uses but successive depletion of groundwater level in the northern part is a serious problem. Rainwater harvesting at the small river tributaries, watershed augmentation, increasing dependency on surface water, community level awareness campaign and water uses through deep tube wells can be options to tackle groundwater depletion for the area.

Monitoring and GIS Mapping of Groundwater Level Variations in Bhaktapur Municipality



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Water is the mainstay of survival. No life can exist without water, since water is essential not only for the existence of human beings, but also for animals, plants and other living beings. Groundwater is the most important natural resource required for drinking and household purpose to many people around the world. Around 50% of water supply in the Kathmandu valley is from groundwater system that consist of both shallow and deep aquifers (Jha et al., 1997; Khatiwada et al., 2002). Bhaktapur as one of the fast developing city of Kathmandu valley. uses groundwater as a major source and regular extraction of groundwater was done through ever increasing number of municipal, industrial and private wells. The aim of the present study is to provide the overview of current status of groundwater level of shallow aquifers and to analyze the spatial distribution of groundwater level in Bhaktapur Municipality. Monitoring of groundwater level and quality is useful to understand the impact of uncontrolled drilling of wells, point and non-point sources of pollutants.

Such studies provide early indications of change in groundwater resource and help to understand how to protect it. Around 500 wells, distributed throughout the municipality, were selected for the study. Spatial coordinates were registered on site for each well with GPS instrument and water depth below the ground level was measured manually during the winter season. The results indicate wide fluctuations in ground water depth across municipal wards and the ground water flow is found to follow surface relief in the study area. GIS map showing groundwater depth and level are developed and compared with surface relief map. The maps are very useful for urban planning and sustainable groundwater usage.

Study of Shallow Groundwater Hydrology of Kathmandu Valley

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Shallow aquifer, stone spouts (dhungedhara) and dug wells in the past and shallow dug wells and tube wells at present are supposed to use in more than two hundred thousands of private houses to meet deficit supply in Kathmandu valley. In case if abstraction of groundwater surpasses replenishing rate, this resource will be exhausted leading to the serious water crisis. Though few is known about replenishing time of aquifers, it is believed that deep aquifers take centuries to thousands of years to replenish whereas, shallow aquifer takes few weeks to few years depending upon aquifer thickness, rainfall pattern, soil permeability etc. Quick response is seen in shallow aquifer due to rainfall. Studies of residence time also justify more direct interaction of surface water with shallow than with deep aquifer groundwater. Often surface water and shallow aquifer groundwater act as a unit of which rainfall, surface runoff, ground recharge, evapotranspiration, interflow, groundwater sink, groundwater flow and abstraction from groundwater are major components.

To find whether the abstraction rate is subsiding replenishing rate and what will be future scenario due to climate changes, quantitative modeling is needed. Comprehensive modeling of shallow aquifer groundwater is lacking part of Kathmandu valley. In this study, “Precipitation Runoff Modeling System” (PRMS), the U.S. Geological Survey (USGS) package was used for modeling of surface hydrology. The response of calibrated/ validated surface model was fed to Unsaturated Zone Flow (UZF) package of three dimensional USGS model “Modular groundwater FLOW model (MODFLOW)” to develop shallow aquifer groundwater model. Inherently it is not common practice to keep records of a number of shallow tube wells with extraction rate per well elsewhere and same is the case with Kathmandu valley. Even sufficient observed record of groundwater table for shallow aquifer is not available which imposes major challenge to develop shallow aquifer groundwater model. In this study, abstraction rate from shallow aquifer was indirectly calculated by using PRMS

model. Little shallow aquifer groundwater level is available for a dry and wet season of year the 2016 which is collected by Working Group (WG-2) of WASH-Mia/ SATREPS project. Dry season data has been used for calibration and wet season data for validation.

Using surface and groundwater model, the impact of climate change and population growth on shallow aquifer groundwater was studied. Future precipitation data based on the climatological study was collected from Dr. K. N. Dulal and used for this study. Precipitation based on “Representative Concentration Pathway RCP 8.5 of the IPCC’s Fifth Assessment Report (AR5)” was used. The growth in groundwater extraction rate of 3% in outer areas, 1.5 % in

newly built up areas and 1 % in already built up areas was used.

Climatological impact study for the years 2016 to 2050 concluded that Kathmandu valley shallow aquifer groundwater is mostly dependent on precipitation pattern rather than on abstraction rate. Since precipitation will not be changing significantly, no major problems will be seen with shallow aquifer groundwater other than in the years around 2030

This study is also dedicated to find the capacity of shallow aquifer, space available for rainwater harvesting and to develop VDC wise map showing maximum possible pumping rate from the shallow aquifer in a sustainable way from Kathmandu Valley.

Estimation of Water Demand in the River Basins of Nepal

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The determination of water demand is pivotal for studies related to water resource management. Without information on the current and future water demand, the demand-supply, deficit-surplus studies are impossible. There have been many attempts at studying the water demand in Nepal, mostly focused on administrative boundaries like districts and zones. Some works have also been done for river basins like Koshi and Bagmati, but again with their own share of limitations. The weakest point that has been felt is in the use of demand coefficients from elsewhere instead of the Nepal specific ones. The study of water demand can be focused on mainly three sectors, domestic, irrigation and industrial. The water use for power sector is negligible in Nepal when we compare such use in thermal and nuclear power plants elsewhere. This study is an attempt at finding the more precise value of the sectoral water demand for all the major river basins of Nepal. The industrial water demand has been calculated based on water use coefficients termed as ‘liters per

employee per day’ for different types of industries. These coefficients are based on field observation and a questionnaire survey of different sample industries. The irrigation water demand is based on water use coefficient termed as ‘liters per ha per season’. These values have been calculated by the use of a software tool called CROPWAT (8.0) applied for different physiographic regions, soil types and crops. For the domestic water demand, water use coefficients termed as ‘liters per capita per day’ were used. These coefficients were fixed on the basis of the quality of life in different regions of Nepal and the government standards. Some industrial water use coefficients that have been calculated from the survey are 9646 and 100 liters per employee per day for beverages and dairy industries respectively. The industrial water demand for Kathmandu valley was found as 150 million liters per day. Kathmandu valley represents the upper portion of the Bagmati river basin. As this is an ongoing study, rest of the sectoral water demand values for whole Bagmati basin and other major river basins are under study.

TECHNICAL SESSION III

Chair: Er. Gautam Raj Karnikar

Advisor, Center of Research for Environment, Energy and Water (CREEW)

Rapporteurs: Ashish Sapkota and Rasila Koirala

Groundwater Management of Kathmandu Valley: Current Approach and Future Challenges

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The topic of groundwater management in the Kathmandu Valley is not new for researchers, water users and stakeholders. Water users from government water supply authority (KUKL) to private users are highly dependent on groundwater to fulfill the water demand of this capital city. 70 functioning deep tube wells of KUKL, licensed 319 private tube wells, 200 water vendors and about 1000 non-licensed deep tube wells are extracting groundwater within this valley. In this context, this paper discussed the current approach from Kathmandu Valley Water Supply Management Board (KVWSMB) for sustainable groundwater management of the valley. KVWSMB being the sole government entity responsible for groundwater management of the valley has been working on various aspect of the water supply management of the valley. It has been involved in various activities from licensing, regulation and monitoring of deep tube wells to planning and policy preparation for regulating the groundwater use in this valley. Till date KVWSMB has licensed more than 400 tube wells (KUKL and private) and

is in the process of licensing 200 more tubewells in this fiscal year. Currently, all the groundwater regulation works are governed by Groundwater Regulation Act, 2015 which has numerous provisions on the process of drilling deep tube wells according to the user's purpose. It is also involved in various research projects from inventory mapping of water bodies to a comprehensive study of groundwater resources of Kathmandu Valley. Currently, KVWSMB has issued new regulation act for tanker water regulation according to their water quality. The aim of the regulation act is to map the tanker water sources and test its water quality. Despite numerous effort from KVWSMB, the issue of groundwater regulation and management is still a challenging issue in Kathmandu Valley. Lack of proper database on groundwater abstraction scenario, lack of awareness about regulation on local level, haphazard deep tube well construction practices and lack of a comprehensive master plan are the major challenges for groundwater management of Kathmandu Valley for the future also.

Implications of Melamchi Water Supply Project in the Groundwater Resources Management of the Kathmandu Valley



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Water scarcity situation in Kathmandu Valley both in terms of quantity and quality is severe. Available water supply is not sufficient to meet even the basic water requirement and most of the households are using alternate sources. The present situation of groundwater exploitation is also severe and would deteriorate further in the near future. Kathmandu Upatyaka Khanepani Limited (KUKL) has planned to supply 170 million-liters-a-day (MLD) by the September 2017 and additional 340 MLD by the year 2024 for sustainable management of available surface as well as groundwater through inter basin transfer project Melamchi Water Supply Project (MWSP). This study aims to assess spatio-temporal distribution in groundwater availability, abstraction in pre- and post-MWSP scenarios and to suggest workable policy interventions (in existing groundwater legislations) for the sustainable management of the valley's groundwater. For this purpose, the data on water demand, and supply infrastructure were used to analyze the water deficit situation in the different time period of MWSP. The changes in groundwater levels, groundwater abstraction

rates, and aquifer characteristics were used to set the three dimensional groundwater model and analysis were done using Visual MODFLOW Flex and ArcMap. Results showed that groundwater abstraction from the individual wells is different, which as per 2009 estimate varies from 0.005 MLD to 2.955 MLD. In the last 11 years (2003-2014), the average groundwater level in the valley has declined from 1.47 m below ground level (bgl) to 11.65 m bgl (93cm/year). After the first phase of MWSP, if current pumping rate is reduced by 50 percent then there is a possibility to recover water level from 0.01 m to 26.82 m within four years. This shows the pumping regulation could be the important factor to get the recovery of groundwater level and hence regulating authority can regulate pumping rate from each well based on the aquifer properties. After MWSP supply, an appropriate monetary instruments on groundwater use may require; which may aim at charging high rate for groundwater abstraction in the new reservoir service areas of KUKL (inside the ring road), low in old reservoir service areas of KUKL, and no charge in the areas having neither new nor old reservoir's supplies from KUKL.

Key Constraints and Collective Action Challenges for Groundwater Governance in the Eastern Gangetic Plains

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Globally, irrigated agriculture is the main user of groundwater resources. Specifically, in the Eastern Gangetic Plains (EGPs), groundwater is the most critical common pool resource because the livelihoods of at least three-fourths of rural population depends on groundwater as the main source of irrigation. This chapter attempts to unravel the key constraints and opportunities for socially sustainable groundwater use, then looks at the way farmers shape the informal groundwater market and the outcome of collective action among the stakeholders. Findings showed that governments in these countries (and states) have placed priority to harness the groundwater potential in the EGP, yet still have limited success mainly due to a range of constraints. Land tenure characteristics, farmers' characteristics, energy related constraints, and institutional constraints are identified as major constraints for groundwater development. One of the key features of groundwater governance is the presence of an informal groundwater market. In part because of small land holding

and lack of farmers' investment capacity, small farmers depend on large farmers (who afford to install tube wells and purchase pumps). In such situation, the proper functioning of groundwater market depends on coordination among them and their collective efforts. However, poor social capital and low levels of collective action among farmers, especially, with landlords, still poses challenges. Results showed that initiatives such as organizing smallholders into water users' groups have been helpful in improving the groundwater management through collective efforts of smallholders such as the installation of tube wells and pumps in group. Furthermore, once farmers organized into groups their bargaining power increases that help improve the functioning of groundwater market, and plays role in changing the existing incentive structure.

SmartPhones4Water - Leveraging Citizen Science and Mobile Technology for Sustainable Water Management



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Water balances are foundational to characterizing competing interests in water-energy-food systems and should form the quantitative basis of water management decisions. Many water balance fluxes, like evapotranspiration, precipitation, and groundwater extraction, are difficult and expensive to measure on the ground with adequate spatial resolution, making remotely sensed data products attractive for use in water balance analyses. Questions regarding the uncertainty of remotely sensed fluxes remain, however, especially when ground-truth data are not available. New developments in sensing technologies, data processing and analysis techniques, and methods of knowledge communication are opening novel opportunities for Citizen Science. Therefore, to what extent can water balances be further constrained by well-conceived citizen science observations of fluxes (e.g. stream flow, precipitation, etc.) and/or parameters strongly influencing the estimation of fluxes (e.g. temperature, land

use, etc.)? SmartPhones4Water (S4W) is a U.S. based non-profit organization that, in coordination with Himalayan Biodiversity and Climate Change Center (HimBioCliCC), Delft University of Technology, CORAM-Nepal, NAMI, and Stockholm University, is investigating these themes within the Kathmandu Valley watershed as part of the S4W-Nepal pilot project. The goals of S4W-Nepal are to (1) improve the reliability of citizen science observations by evaluating innovative technologies and methods, (2) explore the synergies between citizen science and remote sensing, and (3) reduce uncertainty in the water balance, thus increasing our understanding of the nature and extent of groundwater extraction. Additionally, the effects of climate change on headwater streams and its unique biota are far more severe because of the restricted possibility of range shift. In this context, the regular monitoring of hydrological parameters together with the benthic community structure will increase our understanding of the ecohydrological responses.

S4W-Nepal aims to further constrain the water budget in the Kathmandu Valley, and further characterize headwater hydrological processes, by using underutilized sources of information, including precipitation, groundwater level, water level, and stream flow data collected by Citizen Hydrologists. At stream flow monitoring locations, low-cost staff gauges are installed, and water level data are collected with a smart phone by local residents using an open source Android data collection platform called Open Data Kit (ODK) Collect (Anokwa et al. 2009). Within ODK Collect, each water level observation requires the Citizen Hydrologist to enter the water level reading, save the current date, time, GPS coordinates, and take a photograph

of the observation. The data are automatically transmitted to a centralized Google Cloud database via ODK Aggregate. Stage-discharge curves for the selected sites are developed from monthly to bi-monthly observations of discharge with a SonTekFlow Tracker Acoustic Doppler Velocimeter (ADV) performed by local B.Sc. and M.Sc. science and engineering students. Additional research is planned to explore the precision and accuracy of Citizen Hydrologist water level and discharge measurements. In addition to the various themes including technical challenges, onsite training, frequent communication and effective motivations are being explored to make this campaign successful and sustainable.

ANNEX I: PROGRAM SCHEDULE

Date: 20th March 2017

Venue: Hotel Annapurna, Durbar Marg, Kathmandu

Registration: 9:00 am - 9:30 am



Program Schedule

MC: Deepa Neupane

INAUGURAL SESSION		
9:30 -9:35	Welcoming the Dignitaries on Dias	
9:35-9:40	National Anthem	
9:40-9:45	Lightening of the Traditional Oil Lamp by Chief Guest	
9:45-9:50	Welcome address	Mr. Jagat Prasad Joshi , Executive Director, Groundwater Resources Development Board (GWRDB)
9:50-10:15	Keynote presentation: 'Save Groundwater: Secure the Water for Future'	Dr. Sangam Shrestha , Assoc. Prof., Asian Institute of Technology (AIT), Thailand
10:15-10:20	Remarks by Guest	Ms. Tripti Rai , Country Representative, WaterAid Nepal
10:20-10:25	Remarks by Guest	Er. Bipin Dongol , Executive Director, Environment and Public Health Organization (ENPHO)
10:25-10:30	Remarks by Guest	Prof. Suresh Raj Chalise , Advisor, Small Earth Nepal (SEN)
10:30-10:35	Remarks by Guest	Er. Sanjeev Bickram Rana , Executive Director, Kathmandu Valley Water Supply Management Board
10:35-10:40	Remarks by Chief Guest	Er. Bhim Prasad Upadhaya , Secretary, Ministry of Water Supply and Sanitation (MoWSS)
10:40-10:45	Vote of thanks	Dr. Rabin Malla , Executive Director, Center of Research for Environment, Energy and Water (CREEW)

10:45-10:50	Closing remarks by the Chairperson	Mr. Madhav Belbase , Joint Secretary, Water and Energy Commission Secretariat (WECS), Chairperson, Nepal National Water and Weather Week 2017
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Group Photo Session and Tea Break (10:50-11:05)

TECHNICAL SESSION I

Chair: Assoc. Prof. Iswor Man Amatya, Institute of Engineering (IoE), Tribhuvan University (TU)

Rapporteurs: Mr. Sushil Karki, Mr. Rajesh Giri

11:05-11:20	Application of Environmental Isotope Tracer and Hydrogeology Techniques in Identifying Recharge Areas of Mountain Spring Systems for Better Management Plans	Ms. Ambika Khadka International Water Management Institute (IWMI) Nepal
11:20-11:35	Groundwater Arsenic Mitigation Options: A Case Study of Rural Terai /Nepal	Er. Ganga Datta Nepal Tribhuvan University (TU)
11:35-11:50	Assessment of Groundwater Risk to Pollution in Kathmandu: An Evaluation of Index-Overlay Methods	Dr. Vishnu Prasad Pandey International Water Management Institute (IWMI), Nepal
11:50-12:05	Questions and discussion	

Lunch Break (12:05-13:05)

TECHNICAL SESSION II

Chair: Asso. Prof. Sangam Shrestha, Asian Institute of Technology (AIT)

Rapporteurs: Ms. Madhu Neupane, Ms. Jinita Shakya

13:05-13:20	Study on Groundwater depletion in Siraha District	Er. Kabindra Pudasaini WaterAid, Nepal
13:20-13:35	Monitoring and GIS Mapping of Groundwater Level Variations in Bhaktapur Municipality	Er. Rajaram Prajapati Institute of Engineering (IoE), Tribhuvan University (TU)

13:35-13:50	Study of Shallow Groundwater Hydrology of Kathmandu Valley	Er. Balbhadra Adhikari and Prof. Dr. Narendra Man Shakya Nepal Electricity Authority (NEA); Institute of Engineering (IoE), Tribhuvan University (TU)
13:50-14:05	Estimation of Water Demand in the River Basins of Nepal	Er. Aashis Sapkota and Dr. Rabin Malla Center of Research for Environment, Energy and Water (CREEW)
14:05-14:25	Questions and discussion	
Tea Break and Poster Viewing (14:25-14:40)		
TECHNICAL SESSION III		
Chair: Er. Gautam Rajkarnikar , Advisor, CREEW		
Rapporteurs: Er. Aashis Sapkota, Ms. Rasila Koirala		
14:40-14:55	Groundwater Management of Kathmandu Valley: Current Approach and Future Challenges	Mr. Anoj Khanal Kathmandu Valley Water Supply Management Board (KVWSMB)
14:55-15:10	Implications of Melamchi Water Supply Project in the Groundwater Resources Management of the Kathmandu Valley	Er. Bhesh Raj Thapa Interdisciplinary Research Center for River Basin Environment (ICRE), University of Yamanashi (UY)
15:10-15:25	Key constraints and Collective Action Challenges for Groundwater Governance in the Eastern Gangetic Plains	Ms. Manita Raut International Water Management Institute (IWMI), Nepal
15:25-15:40	SmartPhones4Water - Leveraging Citizen Science and Mobile Technology for Sustainable Water Management	Er. Jeffrey C. Davids Delft University of Technology
15:40-16:00	Questions and discussion	
CLOSING SESSION		
16:00-16:15	Closing remarks	Dr. Rabin Malla , Executive Director CREEW

ANNEX II: LIST OF PARTICIPANTS

S.N	Name	Organization
Government Organizations		
1.	Er. Bhim Prasad Upadhaya	Ministry of Water Supply and Sanitation
2.	Mr. Madhav Belbase	Water and Energy Commission Secretariat
3.	Mr. Jagat Pd. Joshi	GWRDB
4.	Mr. Raj Kumar Gumaju	GWRDB
5.	Mr. Surendra Raj Shrestha	GWRDB
6.	Ms. Madhu Neupane	GWRDB
7.	Mr. Jeeban Regmi	Kathmandu Metropolitan City Office
8.	Dr. Dibya Ratna Kansakar	Department of Irrigation
9.	Er. Balbhadra Adhikari	Nepal Electricity Authority
10.	Er. Sanjeev Bikram Rana	KVWSMB
11.	Er. Rajeev Joshi	KVWSMB
12.	Er. Sushil K.C.	KVWSMB
13.	Er. Bodhraj Dahal	KVWSMB
14.	Er. Nabin Tiwari	KVWSMB
15.	Mr. Kamal B. Bam	KVWSMB
16.	Mr. Anoj Khanal	KVWSMB
17.	Ms. Roja Sapkota	KVWSMB
18.	Ms. Srijina Khadka	KVWSMB
19.	Ms. Sangita Acharya	KVWSMB
20.	Ms. Geeta Pokhrel	KVWSMB
21.	Mr. Bhaskar Khatiwada	KVWSMB
22.	Mr. Niraj Bal Tamang	KVWSMB
23.	Mr. Kishwor Acharya	KVWSMB
24.	Mr. Ram Chadra Dhakal	KVWSMB
25.	Mr. Sanjay K Mishra	Rural Water Supply & Sanitation Fund Development Board

Academic /Research Institutions		
26.	Mr. Ganga D.Nepal	TU
27.	Assoc. Prof. Iswar Man Amatya	Institute of Engineering, TU
28.	Mr. Rajaram Prajapati	Institute of Engineering, TU
29.	Prof. Dr. Suresh Das Shrestha	Central Department of Geology, TU
30.	Dr. SudipThakuri	Central Department of Environment Science TU
31.	Ms. Jinita Shakya	Central Department of Environment Science TU
32.	Ms. Rasila Koirala	Central Department of Environment Science TU
33.	Mr. Kabi Raj Khatiwada	Central Department of Environment Science TU
34.	Ms. Salina Madikarmi	Khowpa College
35.	Ms. Hishila Sujakhu	Khwopa college
36.	Mr .Robert Dongol	Nepal Engineering College
37.	Mr. Khem Raj Sharma	Nepal Engineering College
38.	Assoc. Prof. Sangam Shrestha	Asian Institute of Technology
39.	Prof. Dr. Subodh Sharma	Department of Environment Engineering, Kathmandu University
40.	Dr. Rijan B. Kayastha	Department of Environment Engineering, Kathmandu University
41.	Dr. Anish Ghimire	Department of Environment Engineering, Kathmandu University
42.	Ms. Anusha Pandey	NAMI College
43.	Mr. Nischal Devkota	NAMI College
44.	Mr. Wessel V Oyan	Rotterdam University
45.	Dr. Dhundi Raj Phatak	Engineering Study and Research Center/ CREEW
46.	Dr. K. N. Dulal	Hillside College of Engineering
International Non-Governmental Organizations (INGOs)		
47.	Ms. Tripti Rai	WaterAid Nepal
48.	Mr. Kabindra Pudasaini	WaterAid Nepal
49.	Mr. Dharma R. Chitrakar	WaterAid Nepal

50.	Mr. Paras Pokhrel	WaterAid Nepal
51.	Ms. Pramita Maharjan	WaterAidNepal
52.	Dr. Vishnu Prasad Pandey	IWMI Nepal/CREEW
53.	Ms. Manita Raut	IWMI Nepal
54.	Mr. Bhesh Raj Thapa	International Research Center for River Basin Environment, University of Yamanashi
55.	Mr. Pradyumna Rana	ICIMOD
56.	Mr. Akira Nishikori	JICA/SATREPS
57.	Mr. Jeff Davids	Smartphones for Water (S4W)
58.	Mr. Eliyah Moktan	Smartphones for Water (S4W)
59.	Ms. Annette Van Loose	Smartphones for Water (S4W)
60.	Ms. Sneha Rajbhandari	COCA-COLA
Non-Governmental Organizations (NGOs)		
61.	Dr. Rabin Malla	CREEW
62.	Dr. Salina Shrestha	CREEW
63.	Er. Ashish Sapkota	CREEW
64.	Mr. Sarad Pathak	CREEW
65.	Mr. Sushil Karki	CREEW
66.	Er. Deepa Neupane	CREEW
67.	Mr. Upendra Jung Sahi	CREEW
68.	Mr. Bipul Bhandari	CREEW
69.	Er. Gautam Raj Karnikar	CREEW
70.	Mr. Bishal Khatri	CREEW
71.	Er. Bipin Dangol	ENPHO
72.	Ms. Padmaja Shrestha	ENPHO
73.	Ms. Ritu Sharma	ENPHO
74.	Ms. Anita Bhujju	ENPHO
75.	Ms. Nabina K.C.	ENPHO
76.	Mr. Binod Bhandari	ENPHO

77.	Ms. Rosy Singh	ENPHO
78.	Ms. Pramina Nakarmi	ENPHO
79.	Mr. Jeeban Panthi	SEN
80.	Mr. Niranjan Bista	SEN
81.	Mr. Dilli Bhattarai	SEN
82.	Prof. Suresh Raj Chalise	SEN
83.	Dr. Jaya K. Gurung	NDRI
84.	Mr. Raj Babu Shrestha	Urban Environment Management Society
85.	Mr. Ramdeep Shah	Society of Public Health Engineers Nepal
86.	Dr. Indra Kalu	Bagmati River Basin Improvement Project
87.	Ms. Shobha Kumari Yadav	ISET-Nepal
88.	Mr. Kishor Subba	
Private Companies		
89.	Mr. Tyler Mc Mahon	Smart Paani
90.	Ms. Shova Lama	Geolife Line Nepal
91.	Ms. Lali Lama	Geolife Line Nepal
92.	Ms. Punjita Dahal	Geolife Line Nepal
93.	Er. Utsav Bhattarai	Water Modeling Solutions Pvt. Ltd./CREEW
94.	Ms. Ramita Shrestha	Nepal Environment and Scientific Services Pvt .Ltd
Media		
95.	Mr. Yadav Sharma	National Information Council
96.	Mr. Rajesh Thapa	Nepal Television
97.	Mr. Madan	Spot light magazine
98.	Mr. Laxman Thapa	Roadmap

ANNEX III: COMMITTEES OF THE SYMPOSIUM

Technical Committee

Assoc. Prof. Dr. Sangam Shrestha (AIT), Dr. Vishnu Pandey (IWMI), Dr. Divya Ratna Kansakar (DoI), Dr. Suresh Das Shrestha (CDG,TU), Prof. Dr. Narendra Man Shakya (IoE), Dr. Ravi Sharma Aryal (High Court, Patan), Dr. Bhoj Raj Pant (NAST), Assoc. Prof. Ishwor Man Amatya (IoE), Prof. Ashutosh Shukla (ISET-Nepal), Prof. Futaba Kazama (UY)

Organizing Committee

Dr. Rabin Malla (CREEW), Dr. Salina Shrestha (CREEW), Mr. Bipin Dongol (ENPHO), Ms. Rosy Singh (ENPHO), Mr. Dilli Bhattarai (SEN), Mr. Niranjana Bista (SEN), Mr. Surendra Raj Shrestha (GWRDB), Mr. RajKumar Gumanju (GWRDB), Mr. Navin Tiwari (KVWSMB), Mr. Anoj Khanal (KVWSMB)



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