Proceedings of the 5th National Symposium on Challenges and Opportunities for Sustainable Management of Groundwater Resources of Nepal

21 March 2014

Organized by

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5th National Symposium on Challenges and Opportunities for Sustainable Management of Groundwater Resources of Nepal

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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: Urban Environment Management Society (UEMS)/WaterAid Nepal

Partners: Asian Institute of Technology (AIT) Thailand, Asian Institute of Technology and Management (AITM) Nepal, ICRE- University of Yamanashi Japan, Kurita Water and Environment Foundation (KWEF) Japan

Editors

Pradeep Raj Joshi
Sarita Shrestha
Arati Aryal

Cover photo: Irrigating rice field in Silautiya VDC, Ward No. 4, Marchawar, Rupandehi (GWRDB)

Back cover photo: Participants of the 5th National Symposium on Groundwater (CREEW)

ACKNOWLEDGEMENTS

Organizers heartily extend thankfulness to all the authors for contributing valuable articles and presenting them at the symposium and to all the session chairs for kindly accepting the role and chairing the session. The organizers also acknowledge the rapporteurs of all the sessions for taking record of the presentations made.

The organizers sincerely express gratefulness to the opening session chairman Er. Mahendra B. Gurung, President of Nepal Engineer's Association; chief guest Prof. Dr. Bharat R. Pahari, Dean of Institute of Engineering,Tribhuwan University; guest Er. Shiv Raj Pathak, Act. Executive Director of Kathmandu Valley Water Supply Management Board; and keynote speakers Er. Pratap Singh Tater, President of Nepal Hydro-geological Association and Dr. Sangam Shrestha, Asst. Prof. of Asian Institute of Technology, Thailand.

The organizers wish to thank all the participants for attending and actively participating in the symposium.

Lastly, the organizers appreciate the support received from Asian Institute of Technology (AIT) Thailand, International Research Center for River Basin Environment at University of Yamanashi (ICRE-UY) Japan, Kurita Water and Environment Foundation (KWEF) Japan, Asian Institute of Technology and Management (AITM) Nepal, WaterAid Nepal, Urban Environment Management Society (UEMS) for the symposium.

Organizers: CREEW, SEN, ENPHO, KVWSMB & GWRDB

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INTRODUCTION

Background

Groundwater is the major source of water available for daily use and irrigation in many parts of Nepal. Climate variability/change, population surge and urbanization, contamination and degradation, over use and consequent land subsidence are some of the problems and issues in groundwater. Therefore this resource should be timely studied, researched, developed and managed for sustainable use.

In this context, 5th National Symposium on Challenges and Opportunities for Sustainable Management of Groundwater Resources of Nepal was jointly organized by Center of Research for Environment Energy and Water (CREEW), The Small Earth Nepal (SEN), Environment and Public Health Organization (ENPHO), Groundwater Resource Development Board (GWRDB) and Kathmandu Valley Water Supply Management Board (KVWSMB) in association with Asian Institute of Technology (AIT) Thailand, International Research Center for River Basin Environment at University of Yamanashi (ICRE-UY) Japan, Kurita Water and Environment Foundation (KWEF) Japan, Asian Institute of Technology and Management (AITM) Nepal, Water Aid Nepal and Urban Environment Management Society (UEMS) to mark the World Water Day 2014 as part of the Nepal National Water Week 2014 led by Water and Energy Commission Secretariat (WECS) of the Government of Nepal on 21 March 2014. The theme of the World Water Day 2014 was "Water and Energy".

Objectives

1) Share and be familiar with research activities on groundwater in Nepal.
2) Promote research and its utilization for management of groundwater.
3) Enhance networking, collaborations and cooperation for sustainable management of groundwater.

Themes

1) Water budgeting, climate change and modeling of groundwater
2) Quality, pollution/contamination and treatment of groundwater
3) Conservation of groundwater recharges area (e.g. Bhabar zone of Terai)
4) Use of groundwater (e.g. irrigation, domestic and industrial uses)
5) Development of groundwater market
6) Community water supply
7) Managed aquifer recharge (Artificial recharge of groundwater and rainwater harvesting)
8) Groundwater policy, regulations and governance
9) Groundwater as part of disaster preparedness (e.g. Kathmandu Valley)

Participants

The participants in the symposium were from GWRDB, KVWSMB, KUKL, Department of Irrigation, universities and research institutes, UN agencies, INGOs, NGOs and media. In total there were 59 participants (Annex II).

OPENING SESSION

Welcome speech

Dr. Suman K. Shakya (Executive Director, ENPHO) welcomed all the guests, participants, presenters, and representatives from different organization to share their valuable knowledge and better understanding to resolve groundwater problems and issues of Nepal and make sustainable use of the resource.

Keynote speech on "Challenges and Opportunities for Sustainable Management of Groundwater Resources of Nepal"

Er. Pratap Singh Tater, President of Nepal Hydro-geological Society

Background

Groundwater development in Nepal started in 1969 in the name of "Groundwater Resources Investigation in Nepal Terai" with the grant assistance of United States Agency for International Development (USAID). The investigation was limited to Western Terai from Nawalparasi to Kanchanpur. The investigation and development of groundwater took place under Groundwater Water Resources Development Board (GWRDB) through Groundwater Resources Development Project (GWRDP). Since then the investigation work in the unexplored area is still going on.

On the basis of investigation and feasibility study it was found that there is a vast potential of groundwater in the plain part of the Terai. The hydro-geological investigation of the region has indicated high potential of groundwater resources in Terai plains and Inner Terai valleys. Annual rechargeable groundwater resources in the Terai are estimated to be about 12 billion cubic meters (BCM).

Looking at the potentiality and availability of groundwater, the Department of Irrigation and Ministry of Agriculture through Agriculture Development Bank, Janakpur Agriculture Development Project and Department of Drinking Water and Sanitation started to extract groundwater in the development of irrigation and drinking water.

Though there are no proper studies on recharge, the studies indicate vast potential of groundwater recharge to be still under-utilized. The studies conducted in the Kathmandu valley have shown that groundwater extraction is very high. It is reported that the reimbursable potential of shallow aquifer is high than the deep aquifer.

Kathmandu Valley

Kathmandu is the capital and only metropolitan city of Nepal. It is, therefore, obvious that the population is growing rapidly and the opportunity of job is also increasing accordingly. With growing population the need of water is also increased. Uncontrolled population growth, rapid built-up of human settlement infrastructure and other urban structure, insufficient municipal water supply, development of industries (increase in economic activities), life style of people and lack of regulatory body have forced to tape all sorts of aquifers available Since early 80's, the Government started abstraction of groundwater from deep aquifers. Soon extensive drilling works were carried out by the government as well as private and public sector primarily to supplement surface water sources. Due to limited surface water sources the groundwater bodies are heavily utilized by the Government as well as public and private organizations. Hence the groundwater aquifers (water bearing strata) are under threat. The concerned government organization must act immediately, so that aquifers do not get contaminated.

Not only the quantity of Kathmandu Valley's groundwater but its quality is also depleting in alarming way to supply increasing water demand of growing urbanization by haphazard drilling of shallow and deep wells. Therefore, groundwater budget of Kathmandu Valley needs to be better managed for its sustainability. However, there are serious data lacking which are required for estimation of groundwater budget and its management. The study aims to obtain a precise data set establishing monitoring stations and using multiple tests, which are required to answer fundamental questions related to groundwater budget of Kathmandu Valley so that a clear pictures of aquifers, their mutual interactions as well as their interaction with rivers can be obtained.

Uncontrolled and haphazard urban growth, insufficient municipal water supply, increase in economic activities, changes in lifestyle of the people, lack of enforcement of rules and regulations have resulted in mushrooming of all types of wells tapping groundwater resulting in extensive groundwater mining. There are more than 1000 deep tube wells (700 tube wells inventory available) in Kathmandu used for mainly for drinking water and for industry. There are many shallow tube wells and dug wells (figure not known) used for day to day work in the houses. High abstraction of groundwater from shallow aquifers has dried up many old dug wells and *dhunge dharas* depriving many inhabitants from their only source of water. Those who could afford went deeper lowering the water table even more. Similarly high volume of abstraction from deep wells by NWSC (now KUKL) and other deep wells have lowered piezometric level (reported) in many wells especially in the northern and central groundwater districts which consist of most of the deep wells. Access to clean water is the basic human need and right, however in Kathmandu Valley, water these days have become a commodity available to those who can afford.

Due to uncertainty of the responsible authority to look after total groundwater resources, lack of systematic and regular monitoring works and largely unavailable data on groundwater, information on the groundwater status is merely a guess work.

Are we aware of groundwater ?

We know that once there is tube well whether shallow or deep water can be drawn through pumps. If the water quality is poor we can install the purification plant so that the water will be usable. If the existing tube well gets contaminated year by year with other elements/contaminants or the discharge of the tube wells slowly go down then aquifer below will also be contaminated which will contaminate whole connected aquifer system. There is no way to clean the contaminated aquifer which will definitely effect the groundwater environment. So new tube wells cannot be installed in that depth hence water supply will be affected.

Because the deep groundwater aquifer is very difficult to recharge or it takes years to replenish or recharge, so there must be a regulatory body to enforce the rules and regulation and monitor also.

The people of every ward of municipalities/VDCs must be aware of the real situation of extraction of groundwater and the effect of over extraction to the human health and future generation. This awareness program must be run through the professionals working in this field along with CBOs, NGOs, INGOs and local people.
The time has come to aware to the people of Kathmandu Valley as the people are digging for water knowing nothing about its adverse effects.

Public and Private Drilling Companies

There are private and public drilling equipment in the country which is fully involved in the drilling of tube wells and its development. The working methodology of most of the companies is not of adequate standard regarding tube well drilling. This drilling industry is working in adhoc basis. There are hardly any experts working with these companies. These companies are not well equipped with the minimum equipments they need. It has to be looked after by the concerned government institution.

What to be done ?

Though there is the policy and regulation drafted and approved by the government to look after the problem and conflict arisen due to groundwater extraction and its management but due to the lack of proper institution it is still not addressed. There is one institution called Groundwater Resources Board which is fully responsible for groundwater investigation, management, data keeping and policy formulation in the country. This is the only institute which has groundwater related professional and experts. But it has been limited to work only in Terai for irrigation. It is obvious that it is under Ministry of Irrigation. Similarly, in Kathmandu, Kathmandu Valley Water Supply Management Board under Ministry of Urban Development is established to manage the groundwater for drinking purpose. It is involved in extraction, development, water quality issues and over all problems regarding groundwater. But there is not a single groundwater expert in the institution yet. Therefore, to manage the groundwater especially in Kathmandu valley, the study must be done either through universities or by the experts or from the institution to find out the real source of water, aquifer system, potentiality of groundwater, recharge area and its conservation, extraction, licensing, water quality and issues regarding management.

Conclusion: There must be a strong institution which can enforce policy, regulation and implementation to address the issues, problems and conflict (which is going to happen soon ?) in the extraction and management of Groundwater in future. Groundwater Resources Development Board can be converted into Groundwater Authority to enforce policy and

Keynote speech on "Towards Sustainable Groundwater Management of Groundwater Resources"

Asst. Prof. Dr. Sangam Shrestha, Asian Institute of Technology, Thailand

Groundwater plays a very important role in the sustainable development of many countries by providing water for domestic, industrial and agricultural uses. In many cities, more than half of the potable water supply comes from groundwater. Some large cities such as Jakarta, Hanoi, and Beijing depend on groundwater as one of the main water sources. Myriad small towns and rural communities also depend on groundwater. For example, 60% of the rural population in Cambodia relies on groundwater, while 76% of people who do not have access to piped system depend on tube wells in Bangladesh. In urban areas, groundwater tends to be used more for industrial use than human consumption. Industrial use in total groundwater abstraction is 80% in Bandung and 60% in Bangkok. There is a strong correlation between groundwater use and Gross Domestic Product (GDP) in these cities

Despite the significance of groundwater for sustainable development, it has not always been properly managed, which often has resulted in depletion and degradation of the resource. Much emphasis has been given to groundwater resources development without giving careful attention to its management despite its strategic role in sustainable development. Without proactive governance, the detrimental effects of poor management will nullify (or even surpass) the social gains made so far. Many cities are already suffering from water insecurity as a result of rapid population growth and economic development. To maintain the advantages of groundwater as an important resource for sustainable development and also as a reserve of freshwater resource for current and future generations, groundwater management should be more strategic and proactive to cope with increased demand from rapid industrialization and urbanization including potential impacts of climate change.

The presentation provides the facts and figures of groundwater dependency; problems related groundwater over exploitation, implementation of various policy instruments and management practices and their results in some selected cities of Asia. At the end, various policy recommendations are discussed referring to successful cases from different parts of the world which might be suitable for sustainable groundwater management.

Remarks by Guest

Er. Shiv Raj Pathak, Act. Executive Director of Kathmandu Valley Water Supply Management Board (KVWSMB), discussed about the recently formulated Groundwater Management Policy 2069.

Remarks by Chief Guest

Prof. Dr. Bharat R. Pahari, the Dean of Institute of Engineering (IOE), Tribhuvan University urged the scientists, experts and professionals to make use of their knowledge and expertise for the development of the groundwater resources even under unfavorable and challenging situation.

Vote of thanks

Dr. Rabin Malla (CREEW) expressed sincere thanks to all the distinguished guests, presenters, participants, guests, volunteers and media people for participating in the symposium.

Closing remarks

Chairman of the inaugural session Er. Mahendra B. Gurung, President of Nepal Engineer's Association, discussed the importance of groundwater in context of Kathmandu Valley.

ORAL PRESENTATION SESSION

SESSION I: Groundwater policy, management and market

Chair: Prof. Ashutosh Shukla, Nepal Engineering College (nec)

Rapporteurs: Dhurba Raj Pandey, Niranjan Bista

Presentation abstract 1: Groundwater Resource Development Board (GWRDB) and its role in management of groundwater resources in Nepal

Surendra Raj Shrestha, Sr. Div. Hydro-geologist, GWRDB

Groundwater resources exploration and identification activities in Nepal started as early as 1967 through a technical unit under the Department of Irrigation. To enhance groundwater study and investigation activities and to delineate potential area for groundwater irrigation development, Government of Nepal (GON) has established Groundwater Resources Development Board (GWRDB) under then Ministry of Water Resources (MOWR) in 1976. The main objectives of the GWRDB are:

- to carry out Groundwater investigation, exploration and studies for irrigation, drinking water and other uses;
- to establish data base and effective information system of groundwater resources of Nepal and;
- to suggest the government to carry out necessary policy, law, act, regulation about groundwater resources of Nepal.

Groundwater Resources Development Board (GWRDB), located at Babarmahal, Kathmandu is responsible to carry out above mentioned activities through its 9 Branch Offices and with collaboration of other GWRDB's project offices. Groundwater Branch Offices are located at Biratnagar, Lahan, Mahottari, Birganj, Chitwan, Butwal, Dang, Nepalganj and Dhangadhi.

The study and research program carried out by the project indicates that about 7,26,000 ha land has good potential for shallow aquifer development. In addition, 3,05,000 ha land of the Terai has marginal potential. Similarly, about 1,90,000 ha land of the Terai can be irrigated exploiting deep aquifer.

Role of Groundwater Resources Development Board (GWRDB)

GWRDB may be the sole authority for systematize investigation, and management of groundwater in the country as per mandatory works given to GWRDB. The role of GWRDB can be vital for the sustainable management of the groundwater resources. In short its role is essential in following major works:

- Groundwater Investigation
- Groundwater Database Management
- Groundwater Regulation

GWRDB may be the sole authority to systematize investigation and groundwater management as per mandatory works given to GWRDB.

Type of database archive in GWRDB

Following type of database is available in the office:

- Groundwater map databases (Terai)
- Deep and shallow wells archive
- Groundwater Monitoring Network
- Groundwater chemistry archive

The GWRDB Office has well-equipped chemical lab in its office building with following analysis facilities:

- Microbiological Analysis
- Chemical Analysis
- Isotope Analysis

Groundwater is a valuable resource of the country; that is why, it is needed to have a responsible government agency to protect it, which will manage the depletion of the groundwater, licensing for the new tube well construction and metering the existing tube wells etc. in all parts of the country. In this context GWRDB can be the organization to do these works.

Presentation abstract 2: Water resources and supply in Kathmandu valley

Kathmandu Valley Water Supply Management Board (KVWSMB,) Suresh Das Shrestha
(presentation on behalf as a member of the study team)

Availability and supply of adequate water is a major issue for fast and haphazardly growing urban centers like Kathmandu Valley, it is even more so as the valley is extremely vulnerable to disasters like earthquakes. Kathmandu Valley has large number of deep and shallow groundwater sources; however their availability in times of disaster is a big question. Though community wells and meticulously crafted stone spouts *(Dhunge Dharas*) were once the principal source of supply, only 220 stone spouts remain at present many of them are dry. Inventory study carried out recently shows Kathmandu Upatyaka Khanepani Limited (KUKL) remains the principal supplier for both urban and peri urban areas. As the supply is not sufficient, it is supplemented by more than 700 deep wells, number of spring sources, stone spouts, community wells and private dug wells. The distribution is however skewed with 613 deep wells located in the Central Groundwater district (GWD), followed by 131 in the northern GWD. In the same manner 63% of the deep wells are in the service sector that includes hotels, hospitals and schools etc. followed by 29% in water supply which includes both KUKL as well as private vendors. Only 8% of the wells are in industrial sector. In recent years' tanker and bottled water vendors are fast growing in numbers with current supply of around 48MLD. Excessive ammonia, nitrate and iron are major problems with most deep wells along with *E. coli* in the shallow wells. Community water supply tapping spring sources have become quite popular in recent years with efficient water supply systems. Though there are large number of both deep and shallow water sources in and around identified internally displaced person (IDP) sites in the valley, many of them are unlikely to function in the event of disasters like earthquake as their preparedness is not known. The inventory requires regular updating for it to be useful for planners like KVWSMB, KUKL for effective water supply system as well as to ensure long term sustainable water supply planning especially now that groundwater policy for Kathmandu valley has been formulated and endorsed.

Presentation abstract 3: **Characteristics, impacts and regulations of groundwater market in Kathmandu Valley**

Vishnu Prasad Pandey[1,2,], Saroj Kumar Chapagain[3,4], Dibesh Shrestha[5], Sachin Shrestha[6], Futaba Kazama[1]*

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Groundwater market is an arrangement through which entrepreneurs pump and sell groundwater to customers, generally in monetary terms. In informal markets, water rights are not well defined or practiced and transactions are made without legal sanction. Informal groundwater markets for domestic use emerged in the Kathmandu Valley, a home for over 2.5 million people, since the mid-1990s in response to the increasing deficit in water supply, decreasing reliability in supply and unregulated use of groundwater. The markets emerged from Jorpati area in the mid-1990s is now spreading to nine different clusters consisting of at least 58 abstraction facilities.

Current abstraction mechanisms consist of 45 borings (50 to 320 ft deep) and 14 dug wells (20 to 50 ft deep) with submersible pumps. About 80% of the abstraction facilities have some form of treatment systems. The groundwater markets in the valley can be characterized as informal, segmented, localized, self semi-regulated and gradually developing. Total volume of groundwater supply in the valley's water markets is estimated at 15.00 Million-Liters-a-Day (MLD) in peak and 6.54 MLD in off-peak seasons, together accounting to 3.57 Million-Cubic-Meters (MCM) in a year; which is equivalent to NPR 870.8 Million/year. In terms of abstraction volume, Jorpati/Mulpani cluster is the largest one followed by Jhaukhel and Balaju/Bus-Park. The dry season supply by the groundwater markets is fulfilling 4.3% of 350 MLD water demand and 22.4% of KUKL supply.

The markets have positive impacts in terms of reducing the water supply deficits, however, their negative consequences are also visible in the form of decline in groundwater yield (14% of the entrepreneurs have experienced the decline), depletion in groundwater level (57% have observed the depletion; higher depletion in Jorpati and Manamaiju clusters), premature failure of wells (at least three cases), and lowering of pumps (at least four cases).

Some of the existing regulatory frameworks (e.g. acts, regulations, policies, etc.) have provided rooms to regulate the groundwater markets of different scales. The need, however, is the will and commitment of the government authority to regulate the market with necessary actions. Properly recognizing role of the groundwater markets as a water service provider and regulating the markets (e.g. specifying allowable yield at a particular location, water pricing, quality assurance, enabling environment for the service provides, etc.) through some formal mechanisms would be in the interest of the government, public and the service providers. As the Kathmandu Valley Water Supply Management Board (KVWSMB) is quite aware of the expanding groundwater markets, their contributions and impacts, some concrete steps towards that direction are expected in the near future.

Presentation Abstract 4: Groundwater Role in Climate Change Adaptation in Middle Hills of Nepal

A. Dixit, S.K. Yadav and Y. Satyal
Institute for Social and Environmental Transition-Nepal (ISET-Nepal), Chundevi, Kathmandu, Nepal

Groundwater in the form of spring flow is a key for maintaining the life support systems in the hills and mountains. The rain fed rivers mostly originating from the Lesser Himalayas derive from such sources. They maintain base flow in most of the Himalayan Rivers, and thus are critical in sustaining the aquatic ecosystems. They are the only source of water for drinking and irrigation in the upland areas, where the cost of developing and maintaining surface water schemes are high and hence are beyond the reach of common people. Despite its significance of groundwater has not always been properly managed, which often has resulted in its depletion and degradation that nullify the social gains made so far. The resource is under severe stress in Nepal's mid-hills due to many processes such as deforestation, haphazard construction of road and urbanization. Increasing climate variability also pressures this resource. As frequent and intense climate extremes amplify variability in precipitation, soil moisture and surface water, it will add to existing threats to freshwater resources and water management. However, assessment of climate impacts on groundwater in mid-hills of Nepal has not received adequate attention. To overcome this limitation, two catchments in Nepal's mid hills are being monitored throughout a hydrological year to investigate both the supply of groundwater and its demand. The discharge from the spring has been monitored on daily basis to see the variation in discharge throughout the hydrological year. A preliminary analysis shows that the discharge from spring source increases with onset of monsoon and decreases with withdrawal. This implies that any change in monsoon rainfall pattern will affect groundwater recharge and discharge of spring source. Participatory community survey in both catchments reveal that many springs are depleting due to change in rainfall pattern posing threat to agriculture which depend on these sources. Poor management, change in land use pattern and increasing demand renders groundwater source vulnerable to changing climate. This study aims to provide an overview of current groundwater issues and examine the effects of climate change on the groundwater resources in the two catchments. The investigations will explore opportunities and challenges of using groundwater resources as cornerstone of climate adaptation strategies. The preliminary findings suggest that groundwater management should be more strategic and proactive to deal with potential impacts of climate change. This requires better understanding of the dynamic relationship between groundwater and climate.

Presentation Abstract 5: Model-based Estimation of Land Subsidence in Kathmandu Valley, Nepal

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This paper is the first attempt to assess land subsidence hazard in the Kathmandu Valley, Nepal. Land subsidence is predicted based on a fully-calibrated groundwater flow model developed using SHETRAN, a coupled surface-subsurface modeling system. Results show most of the detrimental effects of groundwater (GW) pumping in the form of deep aquifer compaction is being received by peripheral areas of GW basin. The estimated subsidence is found to be most sensitive to the land cover of the recharge areas. Finally the spatial variation of land subsidence is mapped using GIS. In absence of land subsidence measurements, this paper unveils the subsidence hazard in the valley, which can help decision makers in hazard prevention management and give some building ideas for more detailed numerical modeling of the subsidence in future. This work can also provide a basis to design field investigations, monitoring networks for land subsidence and upgrading the present groundwater monitoring network.

Keywords: Groundwater abstraction, land subsidence, hazard, Kathmandu valley, SHETRAN

Open discussion

Prof. Ashutosh Shukla who chaired the first session appreciated that it was few of the symposiums he has attended that has given priority to the policy sector and kept it in the first technical session.

Romulas Okani (IWMI) questioned to Assoc. Prof. Dr. Suresh Das Shrestha how is RWH/RWR helping in groundwater recharge in Kathmandu Valley. Mr. Shrestha responded that the answer will come from his second presentation on "Impact of rainwater harvesting in Lalitpur Sub-Metropolitan City."

Romulas Okani (IWMI) queried to Shobha K. Yadav about her opinion if data availability becomes easy then habitation will increase which may bring water conflict in the area. Similarly, Dr. Sangam Shrestha (AIT) also asked to Shobha K. Yadav reasons for not using climate model and trying to forecast the climatic pattern in the study area. Shobha K.Yadav replied that artificial recharge ponds and Rain Water Harvesting will be adopted in Madan Pokhara while alternate sources of water will be used in another study area to minimize water conflict issues. Due to lack of resources, climate modeling could not be done on this project. However, they are doing the same for other projects of ISET Nepal.

Mohini Joshi asked her question to Er. Surendra Raj Shrestha regarding analyzing a sample for isotope costs about £ 45-55 and would GWRDB analyzes a sample at much lower rates for researchers. Mr. Shrestha in turn replied that the system has not been set up yet and a program will be carried out to evaluate the cost and in the 1st phase samples from outside won't be taken and we hope in the later years we can accept public samples too. Prof. Shukla congratulated the GWRDB for setting up such a sophisticated laboratory in Nepal.

Romulas Okhani (IWMI) questioned Pallav Kumar Shrestha how much accurate was the magnitude for land subsidence. Pallav Kumar Shrestha replied that there is not much land subsidence data available so the study was based solely on available data. The magnitude was not accurate so it may not be accurate to conclude.

Asst. Prof. Dr. Sangam Shrestha (AIT) inquired to Pallav K. Shrestha about the reliability of GW model calibration with surface water data and the reason behind using empirical equation of Champs and Beer as well as if some back casting has been done from the model. Pallav K. Shrestha replied that this is a first study in Nepal and there is lack of data regarding time. This is the simplest equation of land subsidence modeling and thanked Dr. Sangam for insightful remarks for carrying out back casting.

Assoc. Prof. Dr. Suresh Das Shrestha asked Pallav K. Shrestha that few years back students from a Japanese university conducted a similar study in Kathmandu using satellite imagery & remote sensing data and the hotspots are different to this study. Pallav K. Shrestha responded that due to lack of Remote Sensing Experts in Nepal, he could not focus on the satellite imaginary. He used Beer and Chang Equation because it was the simplest one. Clay composition and other factors may have caused in difference in result from Japanese group study.

SESSION II: Groundwater potential and recharge

Chair: Dr. Madhav Narayan Shrestha, Asian Institute of Technology and Management

Rapporteurs: Arati Aryal, Binay Sakanu

Presentation abstract 1: Impact Assessment on Shallow Groundwater from Rainwater Recharge in Patan Sub-metropolis

Suresh Das Shrestha, Central Dept. of Geology, TU

Bimonthly water level monitoring data from 77 community wells in wards 7, 8, 18, 19 and 20 of Lalitpur sub-metropolis, collected from 2065 to 2069, show effectiveness of rainwater recharge systems installed in 28 wells and 25 recharge pits in the area. Data analysis however show mixed results. Variation in rainfall pattern exerts far greater influence in water level of the area than few isolated rainwater recharge systems installed. The study was carried out from 2065 to 2069 however data base from only 2065, 67 and 69 were used for analysis as the rainfall amount were similar. Increase in average water level both in monsoon (84% of wells) and post monsoon (66% of the wells) in year 3 as compared to year 1 and under similar rainfall conditions, indicate groundwater recharge from RWH systems installed. The amount however dropped to 18 and 57% in year 5 indicating limited recharge probably from clogging of the recharge systems. Increase in minimum standing water level in 19 out of 34 wells and maximum standing water in 30 out of 34 wells in year 3; also indicate the effectiveness of the recharge systems. As in the average water level, the number decreases in year 5. Groundwater recharge is also reflected additional number of days of water availability in wells after the installation of RWH systems. The maximum number of additional days of water availability was 120. Seasonal water quality analysis carried out also reflects recharge pattern. Decrease in total dissolved solids (TDS), iron and ammonia concentration in monsoon season and consequent increase of *E. coli* and chloride in monsoon suggests recharge as well as transport of contaminants from surface during recharge. The impact in post monsoon period is just the opposite; there is decrease increase in iron, TDS, ammonia and decrease in *E. coli* and chloride when no recharging water is available as transport medium. Despite the recharge the community's perception is that of no change. One reason for that is though many wells have longer period of water available than usual as evident from the comparison of pre monsoon and post monsoon water level data from 2065 and later years, most wells still go dry in pre monsoon period. Thus increasing the number of recharge points in coming years and proper maintenance of the systems may be the only options available to address the growing need for water in the area.

Presentation abstract 2: Storage Potential in Shallow Groundwater Aquifer, Kathmandu Valley, Nepal

Mohini Joshi

Since immemorial time, groundwater has been an important source of water supply in Kathmandu valley. The extraction techniques practiced were sustainable and traditional before 1980's but now there has been sharp increase and the practices are unsustainable and mechanized.

Aquifer system in Kathmandu valley is isolated and independent to other aquifer outside valley. The recharge area (open space) is getting reduced considerably due to surface sealing and much of the rainfall draining out. Only way to increase the available groundwater resources is to artificially recharge excess water into the subsurface in suitable locations by proper planning.

The main purpose of this work is to visualize wells in subsurface, to develop probability maps (0 to 100 m) to find the shallow aquifer recharge area (gravel) and to calculate the potential of "shallow aquifer of Kathmandu Valley" using ArcGIS 10.1. This research work will help to preserve existing groundwater in the valley by identifying probable recharge areas and by documenting the existing map for further analysis over time.

The visualization of wells in subsurface revealed the presence of thick clay layer in the center extending all over the basin and gravel layer prominently in the Northern region and in some part of Southern region.

The probability maps developed for 0 to 100 m using Geo Statistical tool in ArcGIS 10.1 showed probability regions for finding gravels in Northern Groundwater District and some part of Sothern Groundwater District. More importantly, it showed few pockets in certain depth of 45 to 65 m in Central Groundwater district which has thick clay layer of more than 100 m in between.

After delineating the thickness from Fish Net in GIS and calculating the Total Aquifer Volume, the potential of shallow aquifer is calculated by multiplying Total Aquifer Volume with Specific Yield (storage coefficient i.e. 0.2). The result was found to be 1.907 billion m^3.

All together 150 bore hole logs were used for visualization of wells in subsurface and 198 borehole logs for calculating thickness of aquifer and developing probability maps. In this study gravels and clay were only considered in all the logs.

Presentation abstract 3: Study of Potential Groundwater Recharge Technique at Maru - Yetkha Area (Ward No: 19) Kathmandu

Hitendra Raj Joshi, DDC Lalitpur

Groundwater plays a vital role in water supplying system of Kathmandu city. Kathmandu is an urbanized valley filled with fluvio-lacustrine quaternary sediments. This study area is the core part of the ancient city which carries cultural and historical importance. World heritage site, the Kathmandu durbar square is also located on the peripheral of the study area. Ancient stone-spouts and antique wells can be observed at every carrefour and bends which carries historical and cultural importance. These stone-spouts and wells have been quenching the thirst of local denizens since long time. But now water demand has been escalated immensely due to the changing life style of people and over population as well. Hence groundwater extraction is ever rising while recharge is low. Flow net is used to study recharge zone and high extraction zone of groundwater in the study area. Flow net also does not show any remarkable recharge zone except at suntan gully.

The surface infiltration rate of rainwater is low in the study area for various reasons. The major reasons for low infiltration rate of rainwater into the shallow aquifer of the area are due to the surface and sub -surface layers of the black Kalimati clay and human activities. Sandy clay pockets exist in a perched form within the Black Kalimati clay horizon. Sandy clay pockets are not exposed but these pockets were encountered at shallow depth during infiltration test and infiltration rate is also remarkable. These sandy clay pockets are functioning as shallow-perched aquifer. Similar type of sandy clay pockets can be encountered at shallow depth at various locations. Soil samples from the sandy clay pockets are collected to study potentiality of recharge.

Sub-surface groundwater recharge techniques can be the appropriate method to recharge aquifer of this area because sandy clay pockets are encountered at shallow depth. Existing dried dug wells or dead wells which are scattered rampantly in the study area can be viable and economical medium to recharge groundwater because dug wells are already connected to the sand pockets. In the locations where sandy clay is encountered at the shallow depth recharge wells can also be designed to recharge groundwater.

Presentation abstract 4: Artificial Groundwater Recharge Method to Conserve Stone Spouts in Lalitpur – Sub Metropolitan City

P. Amatya[1], S. Duwadi[2], N. Bhandari[3]
[1]Nepal Rainwater Harvesting Alliance
[2]Society for Climate Change Study Nepal, SFCCSN
[3]Tribhuvan University

Kathmandu valley is suffering from severe water scarcity at present due to demand and supply gap. To meet this excessive demand KUKL as well as several private agencies are involved in groundwater extraction causing depletion of groundwater and threatening other sources of water such as stone spouts, dug well and ponds. To replenish groundwater and conserve traditional stone spouts different artificial groundwater recharge system has been implemented, however their effectiveness is still an enigma. Stone spouts are constructed using highly engineered technology that served water since Lichchhavi period to present and consist of shallow groundwater, intake, water conduits, spouts and drainage components. Among much hity, Aalok hiti located in Ikhachhen locality is one of the popular stone spouts in LSMC, which discharges 16,079.83 l/hr continuously & among this 76.09% water is used for household supply for 7 hours a day and water is supplied to more than 180 household in Ikhachhen. Various organizations are involved in artificial groundwater recharge in LSMC, for which they have implemented 7 types of recharge system. Basically all have recharge well but difference is presence or absence of sedimentation chamber, type and depth of filter media used, type and area of catchment. Study shows that 42.85% of recharge system has sedimentation chamber, in addition to this depth of filter media used varies from 8.33% to 62.5%. Types of catchment used are paved, rooftop and street for recharging groundwater but area of catchment area varies from 106.43sq.m to 1095.56 sq. m. 71.43% of recharge well do not have sufficient volume to accommodate amount of water that overflows from catchment area (i.e. recharge well must hold 2/3 of volume of water generated from catchment), which may cause flooding in the catchment area as well as only 28.57% of recharge well has manhole for the provision of Operation and Maintenance. Although all recharge well are circular in shape but depth varies from 2.4m to 10m and this is due to uneven distribution of natural gravel layer in LSMC, through which water is recharged. Stone spouts depend on the shallow groundwater aquifer, which can be recharged through artificial groundwater recharge mechanism and developed as one of the major alternative source of water. Although several agencies in LSMC are involved in artificial groundwater recharge, their practices are not according to theoretical norms and lack O & M in post construction period. So there is space for agencies to improve their practices and contribute much more in the sector of artificial groundwater recharge.

Open discussion

Assoc. Prof. Dr. Suresh Das Shrestha replied in response to the question of Padmaja Shrestha (ENPHO) for any difference in seasonal quality of the recharged groundwater that they found chemical parameters such as EC, Fe, etc. to decrease during monsoon probably due to dilution. However, microbial parameters were found to deteriorate.

Prof. Ahutosh Shukla (nec) asked Assoc. Prof. Suresh Das Shrestha about his views on reviving ancient *kulos* and why the study was based in Lalitpur district but not in Kathmandu. He also queried about water level in some of the ponds of his study area which were declined after recharging groundwater. Assoc. Prof. Suresh Das Shrestha explained that prior to RWH component; they carried quality tests of pre monsoon and monsoon season. The chemical quality decreased in monsoon. Going through literature, the valley has three Rajkulos. There is possibility of reviving ancient water supply systems and ponds in all three districts of Kathmandu Valley but most of them are either encroached by municipality or are at verge of dying. At one time, water was brought from Tika Bhairab to Kupondole for water supply. Some ponds have been revived and contain fish also. They have revived one in Khumaltar and are in process of reviving other too. They were working in Kathmandu too. They have started water recharge by RWH in Swayambhu area and in Ikapokhari in Chhetrapati. They are working at school, community and private level. He further clarified that the main cause for water declination and depletion is maintenance. Recharge pit is filled up of mud cake and plastic which are brought along with monsoon season. These clog the recharge system so manual maintenance is compulsory.

Suwash Dawadi (SFCCSN) raised his concern to Assoc. Prof. Suresh Das Shrestha that how a housing complex could serve IDP in case of emergency. Prof. Shrestha replied that housing apartments have their own sources such as deep tube wells, storage as well as treatment plants. So, in case of emergency such as earthquake internally displaced persons can be served by water from them.

A query was raised by Hemraj Bhattarai (SchEMS) to Assoc. Prof. Suresh Das Shrestha that many of the lakes and ponds are disappearing and drying. About 1/3 of the population are deprived of pure drinking water. Mr. Bhattarai wanted to know the situation in next 40-50 years and the better option: Melamchi or RWH. Assoc. Prof. Suresh Das Shrestha replied that practically speaking, Melamchi is not possible. RWH and shallow groundwater supply is better solution than Melamchi. Talking about the situation after 40-50 years, government will take some action on RWH.

Romulas Okhani (IWMI) asked Hitendra Joshi regarding the potential of recharging in the study area (Yetkha- Maruhiti) as it is highly built up. Hitendra Joshi shared that there are more than 100 wells in the area that are not yielding for more than a century. As they are connected to sand layers, they have a huge potential for recharging.

SESSION III: Hydro-geology and groundwater quality

Chair: Dr. Dhundi Raj Pathak

Rapporteurs: Sarad Pathak, Buddha Bajracharya

Presentation abstract 1: Status of Shallow Tube-wells Irrigation and Shallow Aquifer in Rupandehi District

S. Shah[1] and S.R. Shrestha[2]

[1] Groundwater Resources Development Board, Branch Office, Butwal

[2] Groundwater Resources Development Board, Babarmahal, Kathmandu

Most of the Terai areas of Rupandehi district show good potential for groundwater irrigation. About 23433 ha of agricultural land has been irrigated by about 13032 numbers of shallow tube-wells till date during different programs launched by Government of Nepal.

GWRDB Butwal has solely constructed 9010 number. of shallow tube-wells in different VDCs of Rupandehi District up to FY 2069/70. Based on the hydro-geological information like depth of the shallow tube-wells, aquifer thickness, static water level and discharge; groundwater potential map of the district shows that almost entire area of the district has good potential for shallow tube-well construction.

Based on the type of aquifer material the district can be classified into three major hydro-geological regions, namely Hard Formation, Medium Formation and Soft Formation form north to south. The aquifer materials in the northern areas of the districts consist of coarse sediments like gravels. The construction of shallow tube-wells in those areas is difficult and takes longer time by traditional drilling methods. The depth to the aquifer varies from less than 15 meters to 30 meters. Central part of the Rupandehi District consists of fine gravels and coarse sand as aquifer materials. These central areas are categorized as Medium Formation Zone. The depth to the aquifer varies from place to place. The southern part of the Rupandehi District consists of medium to coarse sand with few pebbles as aquifer materials. In this region, the depth to the aquifer material can be reached at the depth of 16-30 meters from the surface.

The discharge from shallow tube-wells in Rupandehi district varies greatly based on the type of aquifer materials. Generally northern part of the district has a higher discharge (in the range of more than 10 lps). The discharge decreases towards south. In the study area, the aquifers are mainly recharged by rainwater and also by the perennial streams like Tinau River, Danav River and their tributaries.

Groundwater recharge in the district is computed considering the annual precipitation of 2 m per year of which about 10% infiltrates to the system. Based on this the annual average recharge is 272 MCM. The annual extraction through irrigation STWs is calculated in the basis of average operation of 13033 (which is the total number of STW constructed within the district) STWs 6 hrs daily for 120 days a year. The total 168.89 MCM of groundwater is extracted through the shallow tube-well. Hence the groundwater balance in shallow aquifer is 59.58 MCM in Rupandehi district.

Presentation Abstract 2: Obstruction of natural flow of groundwater and its effect on land surfaces- a case study in Armala VDC of Kaski District

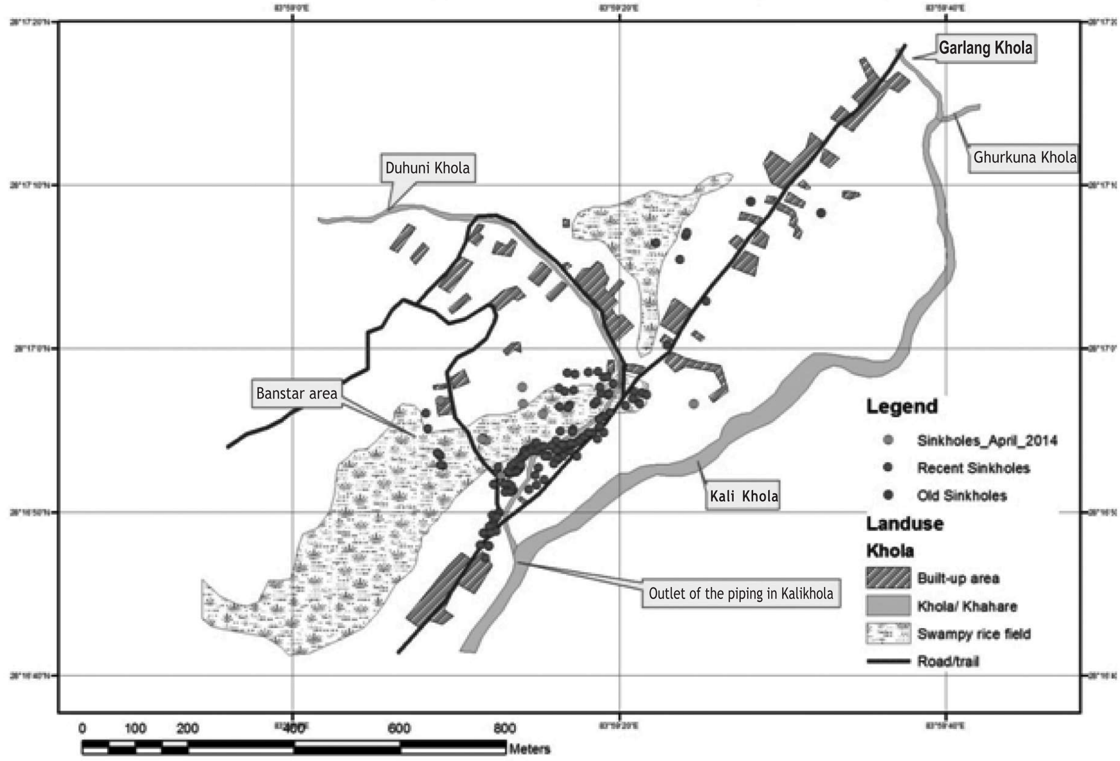
Shreekamal Dwivedi

Dept. of Water Induced Disaster Prevention (DWIDP),

Pulchowk, Lalitpur

White muddy water started to ooze in the Kali Khola on 9th November 2013 from the lower part of the 8 meter high cliff 20 meter downstream of the confluence with Duhuni Khola at Thulibesi in Armala VDC of Kaski district. Such phenomenon occurred also in the past about 30 meters upstream at the Duhuni Khola. On 18 November 2013 rice field subsided forming sinkholes about 600 meters north from the point of muddy water discharge. Such phenomenon of formation of Sinkholes continued for more than a month totaling more than 150 (this process is still ongoing). This created a big havoc among the local residents. Study was conducted to find out the cause of this phenomenon. The area comprised of 50 cm humus soil at the top, 2-3 meter boulder mixed gravel in the middle and thick layer of calcareous clayey silt at the base. Clayey-silt layer is of Lacustrine origin, formed by filling of the lake dammed by the debris brought by the Seti River which occurred in the geological past. The sinkholes are formed in the periphery of the swampy rice field where water logging was present since long time. Local authorities constructed pipe culvert raising the bed level of Duhani Khola (<5 meter) which flows from the middle of the Jaimure Phant area. This further enhanced the water logging in the area increasing the head. Further to this the Kali Khola degraded rapidly (1 meter per year) and shifted 45 meters towards Jaimure Phat eroding its bank. This prolonged flow of groundwater in the area created piping by liquefying the calcareous-clayey-silt layer forming cavities and underground channels. With increased head and nearing of the Kalikhola the pressurized slurry made the way out to Kalikhola, decreasing the pressure within the underground piping and cavities thus causing collapse of roof creating sinkholes. Further investigation is needed to locate the piping and remaining cavities without which it would not be possible to plan mitigation measures to stop further degradation of the area.

Location of Sinkholes formed in Thulibesi, Armala VDC Kaski District



Presentation abstract 3: **Arsenic Contamination of Groundwater of Bara District, Nepal**

Sadhana Pradhanang Kayastha

Central Dept. of Environment Science (CDES), Tribhuwan University

Groundwater is the main source of drinking water in the Terai region of Nepal. The communities depend on drinking water of dug wells and tube wells. Altogether 36 groundwater samples were randomly collected from dug wells and tube wells of Bara District, Nepal, during pre-monsoon in 2012. The depths of the well ranged from 10 to 70 m. Atomic Absorption Spectrometer (AAS) was used to measure the concentration of arsenic. About 50% of tube wells exceeded permissible values of WHO guideline (10 ppb) but 12% tube wells exceeded permissible values of Nepal interim standard of arsenic (50 ppb). The average age of contaminated tube wells is about 20 years. The risk of arsenic is high because the contaminated water has been continuously used for cooking, drinking and other purposes. This alarming situation therefore calls for measures to mitigate the problem.

Open discussion

Dr. Dhundi Raj Pathak highlighted that works in groundwater hydrology is not only limited in Kathmandu Valley as evidenced by the presentations.

Prof. Dr. Suresh Das Shrestha highlighted that situation of Armala can be seen as a case of unintentional rainwater harvesting that has gone wrong. In some cases, such as that of Beeshazari Lake in Chitwan, this phenomenon has brought distinct advantages but the people of Armala suffered due to the similar phenomenon.

Prof. Dr. Suresh Das Shrestha raised his query to Geologist Shreekamal Dwivedi (DWIDP) that in case of Armala, it seems unintentional RWH gone wrong. Dozers are being used to create artificial channels to drain waterlogged area they might aggravate the situation and was it right to suggest to use dozer and level the ground. Geologist Shreekamal Dwivedi explained due to lack of budget, dozer was used as the last resort to provide immediate solution in the area. He also highlighted that methane emission from rice field from the lower calcareous sediment might be another possible reason and it is a prospective research field and invited MSc. students to do their dissertation on this topic in collaboration with DWIDP.

Hemraj Bhattarai (SchEMS) wanted to know from Geologist Shreekamal Dwivedi about any relationship between flash flood in Seti with the Armala incident. Mr. Bhattarai also wanted to know about any such chance of such incident in Kathmandu area too in near future. Geologist Dwivedi replied there was no relationship between flash flood in Seti and Armala incidence. Armala VDC lies in calcareous area, where rainfall is high resulting in such incidence. Kathmandu and Pokhara have different geological formation, so there are no chances of such incidence in Kathmandu in near future.

CLOSING SESSION

Prof. Ashutosh Shukla, Nepal Engineering College, expressed happiness for annually holding the symposium by the organizers. He extended vote of thanks for all the participants and the organizers.

ANNEX I: PROGRAM SCHEDULE

Date: 21 March, 2014
Venue: Indreni Complex (Triveni Hall, 8th Floor), New Baneshwor
Registration: 8:40-9:00

CREEW · THE SMALL EARTH NEPAL-2001 · ENPHO Creating Eco Societies · GWRDB

Program Schedule MC: Ramesh Dhakal

OPENING SESSION		
9:00-9:05	Welcome speech	Dr. Suman K. Shakya, Executive Director, Environment and Public Health Organization (ENPHO)
9: 05-9:30	Keynote presentation: Challenges & Opportunities for Sustainable Management of Groundwater Resources of Nepal	Er. Pratap Singh Tater, President, Nepal Hydro-geological Association
9:30-9:55	Keynote presentation: Towards Sustainable Management of Groundwater Resources	Dr. Sangam Shrestha, Asst. Prof. Asian Institute of Technology (AIT), Thailand
9:55-10:05	Remark by Guest	Er. Shiv Raj Pathak, Executive Director, Kathmandu Valley Water Supply Management Board (KVWSMB)
10:05-10:15	Remark by Guest	Mr. Basu Dev Aryal, Executive Director, Groundwater Resource Development Board (GWRDB)
10:15-10:25	Remark by Chief Guest	Prof. Dr. Bharat R. Pahari, Dean, Institute of Engineering, TU
10:25-10:30	Vote of thanks	Dr. Rabin Malla, Center of Research for Environment Energy and Water (CREEW)
10:30-10:40	Closing remarks by Chairperson	Er. Mahendra B. Gurung, President of Nepal Engineer's Association

Photo Session and Tea Break (10:40-11:10)		
TECHNICAL SESSION I: Groundwater policy, management and market		
Chair: Prof. Ashutosh Shukla, Nepal Engineering College (nec) Rapporteurs: Dhurba Raj Pandey, Niranjan Bista		
11:10-11:25	Groundwater Resource Development Board (GWRDB) and its role in management of groundwater resources in Nepal	Er. Surendra Raj Shrestha, Sr. Div. Hydro-geologist, GWRDB
11:25-11:40	Water sources and supply in Kathmandu valley	Assoc. Prof. Dr. Suresh Das Shrestha Kathmandu Valley Water Supply Management Board (KVWSMB)
11:25-11:55	Characteristics, impacts and regulations of groundwater market in Kathmandu Valley	Dr. Vishnu Prasad Pandey, Research Faculty, Asian Institute of Tech. and Management (AITM)
11:55-12:10	Groundwater role in climate change adaptation in Middle Hills of Nepal	Ms. Shobha K. Yadav, Institute for Social and Environmental Transition-Nepal (ISET-Nepal)
12:10-12:25	Model based estimation of land subsidence in the Kathmandu Valley, Nepal	Mr. Pallav Kumar Shrestha, Institute of Engineering, TU
12:25-12:40	Questions and discussion	

Lunch Break (12:40-13:40)		
TECHNICAL SESSION II: Groundwater potential and recharge		
Chair: Dr. Madhav Narayan Shrestha, Asian Institute of Tech. and Management (AITM) Rapporteurs: Binay Sakanu, Arati Aryal		
13:40-13:55	Impact of rainwater harvesting in Lalitpur Sub-Metropolitan City	Asso. Prof. Suresh Das Shrestha, Central Dept. of Geology, TU
13:55-14:10	Storage potential in shallow groundwater Aquifer, Kathmandu Valley, Nepal	Ms. Mohini Joshi, Researcher
14:10-14:25	Study of potential groundwater recharge zone and recharge technique at Maru-Yetkha area (Ward no: 19) Kathmandu	Mr. Hitendra Raj Joshi, Researcher
14:10-14:40	Artificial groundwater recharge method to conserve stone spouts in Lalitpur Sub-Metropolitan City	Mr. Nabin Bhandari, Researcher, Society For Climate Change Study Nepal, SFCCSN
14:40-14:55	Questions and discussion	

Tea Break (14:55-15:10)

TECHNICAL SESSION III: Hydro-geology and groundwater quality		
Chair: Dr. Dhundi Raj Pathak Rapporteurs: Sarad Pathak, Buddha Bajracharya		
15:10-15:25	Status of shallow aquifer in Rupendehi District	Er. Surendra Shah, Hydro-geologist, GWRDB
15:25-15:40	Obstruction of natural flow of groundwater and its effect on land surfaces - a case study in Armala VDC of Kaski District	Shreekamal Dwivedi, Sr. Div. Eng., Dept. of Water Induced Disaster Prevention (DWIDP)
15:40-15:55	Arsenic contamination of groundwater of Bara District, Nepal	Sadhana Pradhanang Kayastha Central Dept. of Environmental Science, TU
15:55-16:10	Questions and discussion	
CLOSING SESSION		
16:10-16:15	Session close with remarks	Prof. Ashutosh Shukla, nec

ANNEX II: LIST OF PARTICIPANTS

S.N.	NAME	ORGANIZATION
Government organizations		
1	Bal Bdr. Thakurathi	KVWSMB
2	Chandra Lal Nakarmi	KUKL
3	Deepak Shrestha	KUKL
4	Er. Shreekamal Dwivedi	DWIDP
5	Er. Surendra Raj Shrestha	GWRDB
6	Er. Surendra Shah	GWRDB
7	Er. Tilak Mohan Bhandari	KUKL
8	Hitendra Joshi	DDC, Lalitpur
9	Keshab Ghimire	KVWSMB
10	Kumar Thakuri	KVWSMB
11	Ruku Praja	KUKL
12	Shiv Raj Pathak	KVWSMB
13	Sushil KC	KVWSMB
Academic / Research Institutions		
14	Assoc. Prof. Dr. Suresh Das Shrestha	CDG, TU
15	Asst. Prof. Robert Dangol	nec-CPS
16	Bibhuti Ojha	nec-CPS
17	Dhurba Raj Pandey	Golden Gate College
18	Dr. Dhundi Raj Pathak	Engineering Study & Research Center
19	Dr. Madhav Narayan Shrestha	AITM
20	Dr. Sangam Shrestha	AIT, Thailand
21	Dr. Vishnu Prasad Pandey	AITM
22	Hemraj Bhattarai	SchEMS
23	Mohini Joshi	TU
24	Prof. Ashutosh Shukla	Nepal Engineering College
25	Prof. Dr. Bharat R. Pahari	IOE, TU
UN Agencies and International Organizations		
26	Biju Dangol	Oxfam Nepal
27	Er. Utsav Bhattarai	IWMI
28	Pennan Chinnasany	IWMI

29	Romumas Okwany	IWMI
30	Vaskar Dahal	IWMI
NGOs and Others		
31	Anima Shahi	JVS
32	Arati Aryal	CREEW
33	Assoc. Prof. Dr. K. N. Dulal	CREEW
34	Bijaya Kumar Joshi	UEMS
35	Bimal Dahal	SFCCSN
36	Binay Sakanu	SEN
37	Bir Bahadur Khatri	SFCCSN
38	D. R. Pathak	SWMTSC
39	Dr. Jaya Kumar Gurung	NDRI
40	Dr. Rabin Malla	CREEW
41	Dr. Suman K Shakya	ENPHO
42	Er. Mahendra B. Gurung	Nepal Engineering Association
43	Er. Pallav Kumar Gurung	NDRI
44	Er. Pratap Singh Tater	Nepal Hydrological Association
45	Jon Maharjan	UEMS
46	Manohar Bhandari	SFCCSN
47	Nabin Bhandari	SFCCSN
48	Nammy Hang Kirat	SEN
49	Niranjan Bista	SEN
50	Padmaja Shrestha	ENPHO
51	Rajesh Sigdel	SFCCSN
52	Ramesh Dhakal	SEN
53	Sarad Pathak	CREEW
54	Shiva Acharya	UEMS
55	Shobha K. Yadav	ISET-Nepal
56	Sitaram Sapkota	SFCCSN
57	Subash Duwadi	SFCCSN
58	Sudan Shrestha	Moments Frame Them
59	Sudarshan Rajbhandari	SEN

ANNEX III

Technical Committee

Asst. Prof. Dr. Sangam Shrestha (AIT), Prof. Futaba Kazama (ICRE-UY), Dr. Vishnu P. Pandey (AITM), Assoc. Prof. Dr. Suresh D. Shrestha (CDG, TU), Dr. Suman K. Shakya (ENPHO), Mr. Dhiraj Pradhananga (SEN & Centre for Hydrology-University of Saskatchewan)

Organizing Committee

Dr. Rabin Malla (CREEW), Ms. Arati Aryal (CREEW), Mr. Sudarshan Rajbhandari (SEN), Mr. Niranjan Bista (SEN), Mr. Buddha Bajracharya (ENPHO)