

**Proceedings of the National Symposium on  
Challenges and Opportunities for Sustainable  
Management of Groundwater Resources of the  
Kathmandu Valley, Nepal  
28 December 2009**



**Organized by**



**Center of Research for Environment  
Energy and Water (CREEW)**

**The Small Earth Nepal (SEN)**

**Supported by**

**Kurita Water and Environment Foundation (KWEF)**

**&**

**ICRE, GCOE, University of Yamanashi**

**Kurita Water and  
Environment Foundation**



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**Challenges and Opportunities for Sustainable Management of Groundwater**  
**Resources of the Kathmandu Valley, Nepal**

**28 December, 2009**

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## Foreword

Groundwater is an invisible resource, a subsurface part of the natural water cycle. It constitutes an important source of water supply for domestic, industrial, and irrigation uses. Groundwater provides 50% of the present Kathmandu Valley water supply including extraction from both shallow and deep aquifers. The groundwater of Kathmandu valley is under immense pressure; about 20 million cubic meters is extracted annually. It is being heavily used for drinking and other activities, by an ever increasing population resulting in a decline of its water level. The groundwater quality in the Kathmandu Valley is contaminated due to polluted surface water, leachate, and sewage. None of groundwater sources, such as dug-well, deep tube wells, stone spouts, ponds, and piped water in the valley is guaranteed free from fecal contamination. Hence, the challenges and opportunities for sustainable management of groundwater of the Kathmandu Valley in the coming decades are so huge that appropriate policies and measures require the cooperation of many disciplines.

This proceeding contains the report and presentation of the National Symposium on the Challenges and Opportunities for Sustainable Management of Groundwater Resources of the Kathmandu Valley, Nepal which was held in Kathmandu on 28 December 2009. The main objective of the symposium was to identify quantitative, qualitative and legislative issues of groundwater use in the Valley. The symposium also aimed to explore remedial measures to improve quality of groundwater in the Valley. Experts on groundwater highlighted the over exploitation of groundwater and its ever deterring quality in the Kathmandu Valley during the symposium. All raised a common voice that the identified groundwater recharge areas are to be preserved and this is only possible with strong legislations and their implementation. The experts, representing various governmental and non-governmental organization, discussed the sustainable management of groundwater of the Kathmandu Valley. They have expressed their opinion on the tariff for groundwater extraction; they have a common voice that it is not a free resource. Rainwater harvesting, preservation of recharge areas, tariff implementation and need of clear categorizations of groundwater users and treatment of groundwater were discussed.

Groundwater, being a very important component of water resources of the Kathmandu Valley, is to be addressed seriously. There is an urgent need of decision support system of integrated water resources management in the Valley. The symposium is a noble start of networking and discussion among the experts and organizations, who have serious concerns with the groundwater of the Kathmandu Valley.

We hope that this publication will be useful to disseminate information about the groundwater status, challenges and opportunities for sustainable management of the groundwater resources of the Kathmandu Valley.

**CREEW & SEN**

## **Acknowledgements**

First and foremost, our thanks goes to the seminar presenters, who are also the authors of the paper, for their contribution through presentations, sharing materials and discussions throughout the seminar. We would also like to extend thanks to our team of panelists who have given their valuable inputs during the panel discussion session.

We would like to thank Dr. Roshan Raj Shrestha (UN Habitat) and Dr. Sangam Shrestha (AIT) for their keynote speeches. We are grateful to Dr. Khada Nanda Dulal (CREEW) and Mr. Jagadish Karmacharya (SEN) for chairing the first technical session and Mr. Dhiraj Pradhananga (SEN) and Mr. Sanjeev K Dhungana (CREEW) for chairing the second technical session. We would also like to thank Dr. Sangam Shrestha for moderating the panel discussion session. Thanks go to Ms. Maneesha Shakya (CREEW) and Mr. Shakti PC (SEN) for rapping the panel discussion session.

We are also thankful to all the participants of the symposium who have contributed through their valuable presence and active participation during the symposium. Along with the symposium we also organized the Nationwide Open Photography Competition with the theme "Groundwater: today's matter, manage it sustainably for better future". The best twenty photos were exhibited on the venue. We would like to thank all the participants of the competition who have contributed to the symposium and competition through their photo entry. We would also like to thank ECCA for providing us with the photo boards for the photography exhibition. We would express our gratitude the panel of judges from CREEW, SEN and photography experts, Mr. Chandra Shekhar Karki and Mr. Sarad Rai for judging the photography competition.

Lastly, we would like to thank all the volunteers and personnel involved during the symposium who have worked hard for the success of the symposium and preparing this proceeding.

**CREEW & SEN**

## List of Abbreviations

AIT	Asian Institute of Technology
APHA	American Public Health Association
BGR	Bundesanstalt für Geowissenschaften und Rohstoffe
CREEW	Center of Research for Environment Energy and Water
DMG	Department of Mines and Geology
DUDBC	Department of Urban Development and Building Construction
DoI	Department of Irrigation
ECCA	Environmental Camp for Conservation Awareness
EIA or IEE	Environmental Impact assessment / Initial Environmental Examination
ENPHO	Environment and Public Health Organization
GoN	Government of Nepal
GCOE	Global Center of Excellence
GW	Ground Water
GWRD	Groundwater Resources Development
ICIMOD	International Centre for Integrated Mountain Development
ICRE	International Research Centre for River Basin
JICA	Japan International Cooperation Agency
KMC	Kathmandu Metropolitan City
KUKL	Kathmandu Upatyaka Khanepani Limited
masl	Mean above sea level
MCM	Million Cubic Meters
MLD	Million Liters per Day
MPPW	Ministry of Physical Planning and Works
MoU	Memorandum of Understanding
NGOs	Non-Governmental Organization
NGOFUWS	NGO Forum for Urban Water and Sanitation
NWSC	Nepal Water Supply Corporation
NWSC/CES	Nepal Water Supply Corporation / Consumer Electric Show
PPP	Public Private Partnership
RWH	Rain Water Harvesting
RWR	Rain Water Recharge
SEN	The Small Earth Nepal
SC	Supreme Court
UNDP	United Nations Development Programme
UEMS	Urban Environment Management Society
WHO	World Health Organization
WHO GV	WHO Guideline Values
WEP	World Food Programme
UY	University of Yamanashi

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# Opening Session

## Welcome Speech

Mr. Sanjeev Kumar Dhungana  
CREEW

Warm good morning to everybody! Respected keynote speakers, paper presenters, panelists, session chairs, judges and winners of the photography competition, representative of different governmental and non-governmental organizations, media, colleges and universities, other invited guests and participants, hearty welcome to the National Symposium on Challenges and Opportunities for Sustainable Management of Groundwater Resources in the Kathmandu Valley, Nepal.



We, the symposium organizers, are delighted to have your valuable participation and inputs to the symposium jointly organized by the Center of Research for Environment Energy and Water (CREEW) and The Small Earth Nepal (SEN). Both CREEW and SEN are non profit making, non-governmental organizations working in the field of water and other disciplines of the environment.

The phenomenon of groundwater recharge is obstructed while the rate of haphazard over exploitation is increasing day by day. If this situation remains for longer time period, it is believed that Kathmandu valley will be deprived of groundwater after a century. So there is an urgent need of sustainable management of groundwater resources of the valley.

We hope this symposium will be a milestone to uncover the quantitative, qualitative and legislative issues of groundwater and address possible solutions for its sustainable use in future.

Your active participation and valued inputs are expected in this symposium to generate fruitful outcome in desired direction.

Before I hand over to Ms. Kanchan Shrestha I would like to welcome you all once again. It is our great pleasure to have you here today. Thank you very much for accepting our invitation.

## Introduction of the Symposium

Ms. Isha Manandhar

SEN

On Behalf of the organizing committee, I would like to welcome you all once more to the National Symposium on Challenges and Opportunities for Sustainable Management of Groundwater Resources of the Kathmandu Valley, Nepal. We realize that the challenges and opportunities for sustainable management of groundwater resources in the coming decades are huge hence appropriate policies and measures are required through the cooperation of many disciplines. Henceforth we have experts working on various sectors of groundwater resources management gathered here so as to identify the problems associated with groundwater resources management and find concrete solution towards it. The main objectives of the symposium are:

- To identify quantitative, qualitative and legislative issues of groundwater use and find remedial measures to improve quality of groundwater in the Valley.
- To identify groundwater recharge potential and prospects of artificial recharge along with raising awareness on the current status and significance of groundwater in the Kathmandu Valley.

Parallel to the symposium we have also organized a Nationwide Open Photography Competition with the theme “Groundwater: today’s matter, manage it sustainably for better future”. The competition was open from 13 December to 25 December 2009. The result of the competition and the prizes to the respective winners will be announced and given in a while. Among the photo entries, we have selected 20 best photos and put it on display for public view.

This symposium is just an initial step to achieve our objective. We aim to extend this program further in the future .We are planning to publish a proceeding of the symposium. Moving on to the main agenda of the symposium, we have inaugural session followed by two technical sessions. The first session deals with challenges for ground water resources management and comprises of 5 presentations. The session is chaired by Dr. Khada Nanda Dulal and Mr. Jagadishwor Karmacharya. The second session is focused on opportunities for groundwater resources management and comprises of 4 presentations. The session is chaired by Mr. Dhiraj Pradhananga and Mr. Sanjeev Kumar Dhungana. The technical session will be followed by panel discussion.

We have team of six panelists, experts working on different sectors of groundwater who will be discussing on the issues like preserving the groundwater recharge areas, imposing tax/tariff for groundwater extractors and groundwater treatment techniques. The session is moderated by Dr. Sangam Shrestha, Asian Institute of Technology and will be concluded by Mr. Dhiraj Pradhananaga, President, SEN.

I hope this symposium will be a great success.



## **Prize Distribution of the Nationwide Open Photography Competition**

Parallel to the symposium, a Nationwide Open Photography Competition with the theme “Groundwater: today’s matter, manage it sustainably for better future” was also organized. The competition was opened for 13 days from 10 December 2009 to 23 December 2009. The main objective of the competition is to raise awareness on significance of groundwater and its current status in the Kathmandu Valley, giving a platform to emerging photographers and find an innovative way to address the environmental issues through the lens. Any amateurs who have interest in photography including the professionals could apply for the competition.

The top five entries were selected by a panel of judges. Cash prizes and certificates were awarded during symposium. Twenty top photos were displayed at the venue. The panel of judges for the competition included Mr. Chandra Shekhar Karki (Nature Photographer), and Mr. Sarad Rai (Photography lecturer, KU) and representative from CREEW and SEN.

The winners of the competition were awarded prizes during the symposium by Dr. Sangam Shrestha, Mr. Sarad Rai, Prof. Futaba Kazama and Dr. Roshan Raj Shrestha.

### **The winners of the competition are as follows:**

First:	Mr. Subhadin Gautam
Second:	Mr. Sisan Baniya
Third:	Mr. Darpan Adhikari
Consolations:	Mr. Prajwal Bhattarai Mr. Milan Budhathoki

# Keynote Speech

## Rainwater Harvesting for Groundwater Recharge in the Kathmandu Valley

Dr. Roshan Raj Shrestha

Water for Asian Cities Programme, UN-HABITAT



Dr. Roshan Raj Shrestha represents UN HABITAT, Water for Asian Cities Programme as a Chief Technical Advisor for South East Asia. He has a post graduate degree in Limnology (Institute of Limnology, Austria) and doctoral degree in Applied Natural Science (University of Natural Resources and Applied Life Science in Austria). Dr. Shrestha has more than 20 years working experience on water and sanitation sector. He has contributed to the introduction of the household drinking water

treatment technologies, ECOSAN, Constructed Wetland Systems for Wastewater Treatment and the ECO HOME concept in Nepal by incorporating rainwater harvesting, groundwater recharge, waste water recycling, dry toilets and reuse of human excreta for crop production. Dr. Shrestha's contributions have earned several national and international awards, including the Third World Academy of Sciences Award in 2000 and the Kathmandu Metropolitan City Environment Awards in 2004.

### Abstract

The population of the Kathmandu Valley has almost doubled in the past few decades. To meet the increasing demand, natural resources are overexploited, depleted and degraded. The residents of the valley are tapping into the groundwater with rising intensity as they face acute water shortages. The extraction of groundwater is six times higher than the recharge capacity; as a result the water table is declining. With decline in water table, people have started using strong pumps to extract the groundwater which have further aggravated the problem. The rising population has contributed to increasing pollution, which has also contaminated the groundwater sources making it unfit to drink. Urbanization, construction of housing complexes and apartments has further added pressure on the groundwater resources which is extracted in huge amount absolutely free of cost. The situation now is that most of the well, stone spouts, ponds in the valley have dried up due to this unsustainable extraction and use of groundwater resources. We must search for alternatives that help to reduce the pressure on the groundwater. One of the mitigation measures to manage the groundwater resource can be rainwater harvesting, as rainfall (primary source of water) in the Valley is quite high about 1900mm per year which can be stored and utilized to meet the rising water demand.

# Groundwater and Climate Change: No Longer the Hidden Resource

Dr. Sangam Shrestha  
Asian Institute of Technology, Thailand



Dr. Sangam Shrestha represents Asian Institute of Technology (AIT) in Thailand as an Assistant Professor. His teaching and research expertise lies in climate change and water resources, groundwater development and management and integrated water resources management. Dr. Shrestha is also a Research Fellow of Institute for Global Environmental Strategies (IGES), Japan and a visiting faculty in University of Yamanashi, Japan.

## Abstract

Groundwater used to be a hidden resource that was out of site, people had to dig to get access to it. However, today it is not. Due to ever increasing demand of freshwater either by population growth or by lifestyles of people and due to climate change, the importance of groundwater is increasing.

Analyzing the global use of groundwater (i.e. more than 50% groundwater used for drinking, 40% is being used by industries and rest 20% is being used for irrigation), we can easily deduce that the groundwater use trend is increasing. Groundwater management includes many challenges like land subsidence, decline in groundwater table, groundwater contamination from anthropogenic and natural sources and salt water intrusion which are all results of over extraction and use of the groundwater.

Kathmandu is also not away from these challenges of groundwater management; falling groundwater table and contamination have been prevalent. Additional to this there is no clear policies on groundwater management, there is no groundwater use right and enforcement of the existing groundwater laws is also very weak. Beside this, although there are many organizations working in the field of groundwater management, no coordination among them has been observed. Also the lack of human resources who have clear knowledge on groundwater, lack of database and monitoring system to check on the groundwater use and extraction have further aggravated the problem.

There is also additional concern of climate change that will have major impact on the groundwater use and availability. Rainfall being the primary source of all surface and groundwater, the shift in the rainfall pattern and the amount of rainfall due to climate change will have major effect on the groundwater storage and recharge. Also change on landuse pattern due to the climate change will impact the groundwater recharge capacity and potential.

Adaptation includes two main things – Mainstreaming adaptation concern in water or groundwater management plan and increasing the volume of groundwater in aquifers.

The solution to these groundwater problems can be technological which includes water transfer i.e. bringing water from the area having abundance water and rainwater harvesting techniques etc. that focus on wise use of water, Institutional which includes regulating the people to ultimately regulate the use of the groundwater use, Instrumental which focus on the policies relating to the groundwater i.e. groundwater use right, rules and pricing of groundwater extraction, and the Indirect approach which includes the policy arrangement beyond groundwater because there are many factors that affect groundwater use like agricultural policies.

## Technical Session I

Chairs—Dr. Khada Nanda Dulal and Mr. Jagadishwor Karmacharya

### Application of Stable Isotopes (D and $^{18}\text{O}$ ) to Evaluate the Groundwater Recharge Characteristics in Kathmandu Valley, Nepal

S. K. Chapagain<sup>a</sup>, S. Shrestha<sup>b</sup>, T. Nakamura<sup>a</sup>, V. P. Pandey<sup>c</sup> and F. Kazama<sup>c</sup>

International Research Center for River Basin Environment

University of Yamanashi, Japan

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Asian Institute of Technology, Thailand

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University of Yamanashi, Japan

Dr. Saroj Kumar Chapagain represents International Research Center for River Basin Environment (ICRE) and University of Yamanashi, Japan as a Post-doc researcher. Groundwater/Surface water quality, Groundwater contamination and remediation, Isotope hydrology are his field of research interests.



#### Abstract

Overexploitation of groundwater has led to a severe decline in groundwater level and well yield over the recent years in Kathmandu Valley. Therefore, understanding of groundwater recharge system has become important for a sustainable groundwater use of this area. The previous traditional hydrogeological methods adopted to study groundwater have not been sufficient to delineate the groundwater recharge system. In this study, a first detailed investigation of stable isotopes (D and  $^{18}\text{O}$ ) of water sources were made for the evaluation of groundwater recharge characteristics. The values of  $\delta\text{D}$  and  $\delta^{18}\text{O}$  ranged  $-66.2\text{‰}$  to  $-43.6\text{‰}$  and  $-9.6\text{‰}$  to  $-6.3\text{‰}$  respectively in deep groundwater and  $-59.7\text{‰}$  to  $-44.9\text{‰}$  and  $-8.2\text{‰}$  to  $-6.6\text{‰}$  respectively in shallow groundwater. The  $\delta\text{D}$ - $\delta^{18}\text{O}$  plot of groundwater fell close to the constructed LMWL ( $\delta\text{D}=8.2\delta^{18}\text{O}+9.5$ ); and it has suggested the dominance of rainfall and the minimum effect of evaporation during the recharge of groundwater in the basin. Groundwater dating (tritium- $^3\text{H}$  analysis) indicated the lack of modern recharge in deep groundwater; whereas, the chemical and isotopic results suggested modern recharge and a relatively low residence time of shallow groundwater. The stable isotopic composition was spatially varied in deep groundwater; whereas, the dominance of lighter stable isotopes towards the edge of the basin suggested the origin of deep groundwater from high altitude recharge; however, there was a minimum effects of such high altitude recharge towards the central part of groundwater in the basin. The study suggested protection of the high altitude areas from the human intervention, and need to be managed for enhancing the natural recharge of deep groundwater in the basin.

# Enumeration, Mapping and Water Quality Assessment of Traditional Stone Spouts in Kathmandu Metropolitan City

Ms. Pramita Maharjan<sup>a</sup> and Prakash Chandra Amatya<sup>b</sup>

<sup>a</sup> Central Department of Environmental Science, Tribhuvan University, Kirtipur

<sup>b</sup>NGO Forum for Urban Water and Sanitation, Nepal

Ms. Pramita Maharjan represents NGO Forum for Urban Water and Sanitation as a Liaison Officer. She holds a Master's degree in Environmental Science from Tribhuvan University, Kirtipur.

## Abstract

The study was carried out to enumerate and map traditional stone spouts in Kathmandu Metropolitan City (KMC) and identified 165 numbers of traditional stone spouts. While in Lalitpur, Bhaktapur, Kirtipur and Madhyapur Thimi, there were 61, 87, 11 and 65 stone spouts respectively. Altogether 165 stone spouts in KMC among which 59.4% of the spouts are in working condition, 20% do not exist and remaining 20.6% of the spouts are in not working condition. The stone spouts are not equally distributed in all the wards. Maximum no of spouts is found in ward no. 35 and minimum number of spouts is found in ward nos. 2, 11, 13, 22 and 30. The wards not having stone spouts were 23, 24, 25, 26, 27 and 28. Gyan Dhara had the highest discharge rate of 70243.9 LD in wet season whereas Kaldhara and Pandheri Dhara had the lowest discharge.



The physio-chemical and microbiological analyses of the 50 water samples from stone spouts of KMC in two different seasons- wet (July- August) and dry (October – November). The pH of 26% of water samples were below WHO guideline value. Similarly, 28% of water samples were found to exceed WHO guideline value for iron content. Appearance of iron in spout water does not possess adverse health impact, but still the excess iron concentration makes the water yellowish colour, so it has to be treated well to make it acceptable for drinking. Hardness and chloride content of all water samples were within the WHO guideline value. The value of nitrate was within the limit of WHO permissible value for drinking water. Almost all the spouts water were found to be microbiologically contaminated with coliforms which may be due to infiltration of various kind of pollutants, domestic waste water, industrial waste traveling in the ground water and contaminating the underground environment.

Kathmandu, the only metropolitan city of Nepal, is facing water crisis. Its area is 50.67 sq. km and is divided into 35 municipal wards. The total water demand is about 96 million liters per day whereas the supply is less than 60 million liters per day a (KUKL, 2008) which is insufficient for the total population of 671846. Water has become a serious problem for the people of Kathmandu both in terms of quantity and quality. Current water demand of the city has increased

tremendously because of the rapid growth of population and urbanization. Therefore people have to depend on various traditional sources such as tube well, wells, stone spouts.

Traditional stone spouts are probably the oldest methods of using local water sources, which is still in excessive use due to depleted water supply from pipeline system. The city has preserved a large number of traditional stone spouts from Licchavi Period (500-800 A.D). The value and importance of the traditional stone spouts is declining due to haphazard urbanization and unplanned construction, therefore policies formation regarding traditional stone spouts conservation, preservation and maintenance should be done.

## **Regulatory Framework on Groundwater in Nepal**

Advocate Basanta Adhikari  
Pro Public, Nepal

Mr. Basanta Adhikari represents Pro Public as an advocate. His area of interest is environment and water law, public interest litigation, legal protection of refugees, and human rights.

### **Abstract**

The rapid and haphazard over extraction of groundwater illegally has increased resulting in depletion of groundwater resources, low recharge of the groundwater and declining groundwater table. To continue groundwater as a sustainable resource, existing legislations should be implemented effectively and also need specific and comprehensive regulatory framework for groundwater use and extraction is necessary. Regulatory framework could be in the form of license for groundwater extractors, limitation on ground extraction level or tariff system to control commercial extraction and use. Analyzing the rate of groundwater depletion and extraction, legislation for sustainability of the groundwater resources and appropriate legislation should be formulated. Recently, in a case, the Supreme Court a report has given a verdict to implement licensing requirement and arrange use of recycled water by business



# Groundwater and Food Security

Mr. Madhukar Upadhyaya

Institute for Social and Environmental Transition-Nepal (ISET-Nepal)

Mr. Madhukar Upadhyaya represents Institute for Social and Environment Transition as a Research Director. He is currently involved in Local Water Management and is also a professor at SchEMS (School of Environment Management and Sustainable Development).



## Abstract

Though human society used groundwater by making wells and *karaz* for thousands of years, it was only in the second half of 20<sup>th</sup> century that this source became one of the key components of development. Exploitation of groundwater was at the core of the green revolution in Asia (1965-1985) that provided food security to millions of people. Cereal production doubled in just two decades, which helped maintain food price and improve livelihood of nearly two billion people. Contrary to the common belief that groundwater could be harnessed unlimited, researchers believe that penalty of over-exploitation is now coming due, and the results could be catastrophic, first for the most populous countries (Seckler *et al.* 1998) and eventually to many others. In China and India alone, 130 and 175 million people respectively are being fed by over pumping of aquifers. Saudi Arabia has already planned to stop its wheat farming from 2016 as its groundwater has depleted severely. With current state of groundwater use and the level of dependency on it for food production, the global food security will come under intense pressure if countries such as China begin to import even a small portion of its food requirement from international market. Hence, though groundwater is local its implications are not local but global.

Increasing number of districts in Nepal are reporting food shortages (WFP, 2009). The rising number of squatters, landless, forest encroacher, and travelling labour are also indicators of food problem. The shortage so far has been met by food produced in Terai. Given the changing food habits and the economic base of society, meeting demand of water intensive food is a major challenge for water managers. The emerging climatic pattern indicates that agriculture in general is likely to suffer a serious setback in the coming days. The food shortage for 2010 is estimated to be about 400,000 tons (GoN, 2009) as the long drought and delayed monsoon hampered food production in 2009. That considered as a major shift in climate of the region, pressure on groundwater in Terai will increase to meet future food requirement. The additional challenge related with groundwater is that it is limited, its level declining, and its monitoring is also difficult.

Problems associated with over-abstraction of groundwater in Kathmandu valley is a wake up call to look at the larger picture of this valuable resource. Falling groundwater in the valley and examples from other countries where falling groundwater has affected food production, are

signals that warn us in using groundwater to meet future food requirement. Besides using it prudently, there is a need to consider groundwater in its wider perspective. This can be done by considering groundwater augmentation through proper management of green water (soil moisture) in the catchment (Upadhyaya, 2009). The conventional approach of managing blue water (springs, streams and rivers) only has ignored the crucial role that green water (soil moisture) plays in maintaining groundwater. Theoretically, increased green water storage time and space increase groundwater availability. However, a clear understanding of area specific (hills, valleys, plains) groundwater situation, assessment of inflow and outflow (extraction) and mechanism to monitor recharge and depletion is required to promote the concept. In addition, further discussion would be necessary to help develop policy and mechanism to mobilize incentives (David and Kauffman, 2009) from the blue water users to green water managers.

## Technical Session II

**Chairs: Mr. Dhiraj Pradhananga and Mr. Sanjeev K Dhungana**

### **Research Work for Groundwater in Kofu and Kathmandu**

Prof. Futaba Kazama

Department of Eco-Social System Engineering, University of Yamanashi, Japan

Dr. Futaba Kazama is a Professor in International Research Center for River Basin Environment (ICRE), Interdisciplinary Graduate School of Medicine and Engineering, University of Yamanashi, Japan. She received D.Eng. Degree in Environmental Chemistry from Hiroshima University, Japan. Her research interest resides in water, and lake water. Currently, she is sub-leader of 'Environmental Dynamics' Typology Group in Global Center of Excellence (GCOE) Program of University of Yamanashi.



#### **Abstract**

For sustainable use of groundwater resources, it is important to understand availability of groundwater, direction of groundwater flow, identification and protection of rechargeable areas, and development of affordable technology for groundwater treatment to safeguard the public health. To enhance understanding of groundwater systems by means of scientific researches, The Global COE Program of University of Yamanashi (UY-GCOE) is carrying out research activities in Japan and abroad. This paper highlights the research activities in Kofu in Japan and Kathmandu in Nepal.

In geologically complex and fragile Kofu River (KRB) in Japan with very steep river slope, where alluvial fan area of the basin has river bed higher than the surrounding area, sources of shallow groundwater were identified by analysing major dissolved ions using ion chromatograph and water – oxygen and hydrogen isotope ration using mass spectrometer. Further application of similar approach in Kathmandu Valley in Nepal by analysing organic, inorganic carbon, heavy metal, arsenic, basic cation and anion and stable isotope of deep and shallow groundwater suggested the poor- connectivity of shallow and deep aquifers in the valley. These results demonstrate the potential of geochemical and isotopic analysis for identifying recharge characteristics. Presentation of such information on an easily understandable map enhances visualization of groundwater and its recharge system for decision maker and the public.

Further analysis of water demand and estimated groundwater storage potential above the water table suggests that additional storage in Kathmandu Valley, if could be filled fully by means of artificial or managed recharge, could meet water demand for nearly four years. However, high ammonia content in the valley's groundwater is a limiting factor for usability of available groundwater resources. Various pollutant sources and its process of diffusion affect the

groundwater quality and its method of treatment before use. For the purpose of ammonia removal from the valley's groundwater resources, our research demonstrated that bioprocess to be the most suitable methods for the treatment compared to other expensive and complex treatments.

Based on the highlights provided in this paper about research activities and achievements of UY-GCOE, we can conclude that sustainable utilization and management of groundwater resources requires great effort for continuous generation of scientific knowledge about groundwater system; and strong collaborative efforts may help to achieve this objective in efficient manner.

## **Potential for Shallow Groundwater Recharge from Rainwater in the Kathmandu Valley under the Perceived Impacts of Climate Change**

Dr. Suresh Das Shrestha  
Urban Environment Management Service (UEMS)  
Central Department of Geology, Tribhuvan University

Dr. Suresh Das Shrestha represents Central Department of Geology, Tribhuvan University as an Associate Professor. He has received his Doctorate degree from Osaka City University, Japan and is also a Fulbright Post Doctor Fellow. He is a member of Climate Change Council and an advisor to the minister for environment since 2009. His area of interest is studying the possible impact of climate change on groundwater resources and formulating policies for groundwater extraction for KUKL and Studying the impacts of rainwater recharge on shallow groundwater in Patan area.



### **Abstract**

Groundwater, which has been a sustainable source for centuries in the Kathmandu Valley, was extracted traditionally using mainly *dhungedharas* (stone taps) and rower pumps by the general public. Excessive utilization of groundwater resources have resulted in rapid lowering of groundwater level in the Valley resulting in drying up of the wells. Although only 379 deep tube wells have been recorded, approximately 700 deep tube wells are estimated to be in operation. These are mainly for commercial uses to meet the growing needs of the haphazard urbanization. The number of houses in the Valley has tripled since 1971, sealing the infiltration areas for groundwater recharge. Erratic rainfall patterns and extended dry periods, attributed to climate change, are expected to have negative consequences for the groundwater in the Valley. To face such challenges, adaptation measures need to be explored such as exploitation of hard rock aquifers in the southern valley, installation of infiltration dams in the north, rainwater collection and recharge and rehabilitation of identified infiltration ponds. Extensive rainwater harvesting and recharge program need to be launched in the water stressed areas to minimize the impact

from decreasing groundwater level. Long term and effective policy are also necessary for effective utilization of groundwater

## **Policy framework for Rainwater Harvesting in Urban Nepal**

**Mr. Prakash Chandra Amatya**

National Steering Committee on Rainwater Harvesting, Ministry of Physical Planning  
NGO Forum for Urban Water and Sanitation

Mr. Prakash Chandra Amatya, is a member secretary to the National Steering Committee on Rainwater Harvesting under the Ministry of Physical Planning and Works, Government of Nepal. He is an executive director to the NGO Forum and holds EMBA, M. Sc. in microbiology and PGD in Environmental Management. He is a visiting faculty at School of Environmental Management and Sustainable Development.

### **Abstract**

The groundwater of Kathmandu is heavily extracted and the recharge area is also decreasing. The drying stone spouts and depleting dug wells are clear indications. The alternative solution to conserve the water shortage is rainwater harvesting which is mostly ignored until recently. Kathmandu receives maximum amount of rainfall during the monsoon season. This rainwater can be tapped and utilized for drinking and other purpose after appropriate treatment. Rainwater harvesting can also be used to recharge the drying groundwater sources. In Nepal the rainwater harvesting technique promotion began from 2002 through awareness campaign organized in five different schools. In January 2006 National Conference on Rainwater Harvesting was organized and hosted along with the Ministry of Physical Planning and Works, other concerned government agencies and UN Habitat Water for Asian Cities. During this conference the government acknowledged rainwater harvesting to be adopted to recharge the groundwater sources. Later Department of Urban Development and Building Construction also formulated building construction guidelines that emphasized on rainwater harvesting. Kathmandu Metropolitan City also announced to provide 10 percent rebate on building permit upon installation of rainwater harvesting system in the household and similarly, the Dharan Municipality decided for 30 percent rebate. In June 2009, working policy on Rainwater Harvesting was approved by the government of Nepal with the goals to contribute in protection of environment, improve quality of life, strengthen socio economic development, minimize scarcity of water and recharge the groundwater sources



### **Status of Groundwater Condition in Kathmandu Valley and its Potential Impacts**

Mr. Naba Raj Shrestha  
Department of Irrigation

Mr. Naba Raj Shrestha represents Department of Irrigation, Groundwater Division as a Senior Hydrogeologist. He has also been involved as geologist in Department of Mines and Geology. He has received Post Graduate Diploma in Exploration Geophysics from International Institute Aerial Survey and Earth Sciences, Netherlands and another Post Graduate Diploma in Petroleum Exploration and Management from Trondhiem University, Norway. He has received his M. Sc. degree in Geophysics from Banaras Hindu University.



**Abstract**

The impact of groundwater extraction in the Kathmandu Valley can be divided into different phases. The impact was negligible up to 1983 as the extraction was limited. Water demand was fulfilled by surface sources. Groundwater extraction was made from few tube wells, dug well and *dhungedharas* only. Population in the Valley increased with the development, industrialization and urbanization and sharply raised the demand for water. Nepal Water Supply Corporation developed well fields to supply drinking water to the increasing population. Number of private tube wells and commercial extractors also grew. Hence after 1984 the impact on the groundwater resources became clearly visible and is increasing faster since then. In 2004, records showed that the daily overdraft of groundwater was about 20 MLD. The decreasing recharge areas and declining groundwater table have already resulted in drying of shallow tube wells and the later one can result in land subsidence as well.

The groundwater quality is deteriorating due to leaching of contaminants from improper waste disposal by factories, industries and households. Hence for better management and conservation of the groundwater resources rainwater harvesting, infiltration dams and artificial recharge techniques can be used. Other water sources like hard rock aquifers and karst aquifers need to be explored. Regular monitoring of the groundwater quality and water level should be made. Formulation of policy and guideline for investigating, monitoring and licensing and regulating groundwater are also integral part of groundwater sustainability.

## Panel discussion

### Challenges and Opportunities for Sustainable Management of Groundwater Resources of the Kathmandu



Mr. Dhiraj Pradhananga framed the questions for the panel discussion. There were three major questions for the panel discussion which would solve the present problems of groundwater to some extent. The questions were:

**1. How to preserve the ground water recharge areas for the Kathmandu valley?**

*Some potential groundwater recharge areas for Kathmandu Valley have already been identified. Remedial policy plans and actions and organizations and roles for the preservation of groundwater recharge area have to be identified.*

**2. How to enforce tariff and/or tax for groundwater extractors?**

*How the tariff should be imposed, whether it should be pre-use or post-use. How should it be monitored?*

**3. How to promote and implement groundwater treatment techniques?**

*There are serious concerns related to groundwater treatment; not only shallow water but also deep groundwater is contaminated.*

Mr. Pradhananga handed over the session to Dr. Sangam Shrestha to moderate the session.

Panelists of the discussion were:

1. Dr. Suresh Das Shrestha, UEMS and Central Department of Geology, Tribhuvan University, Nepal
2. Mr. Basanta Adhikari, Pro-Public, Nepal
3. Mr. Naba Raj Shrestha, Department of Irrigation, Nepal
4. Prof. Futaba Kazama, University of Yamanashi, Japan
5. Dr. Narayan Upadhyaya, ENPHO, Nepal
6. Mr. Indra Kumar Maharjan, KUKL, Nepal

Each of the panelist were asked for their opinions on the above three questions. The entire panelist expressed their view on the three questions and came up with strong recommendations. Following are the views of the panelist.

### **Dr. Suresh Das Shrestha:**

Regarding the first question on how to preserve the ground water recharge areas, Dr. Suresh Das Shrestha focused on:

Potential recharge areas for shallow and deep groundwater are already identified but unfortunately these are the areas that are being rapidly developed. Planned development in these areas for groundwater recharge is needed. The practice of sealing the entire surface area should be discouraged. Regulations should be in place for landowner to maintain effective groundwater recharge by rainwater. Policies for monitoring the regulations should also be formulated. The whole of the Kathmandu Valley has potential for shallow groundwater. Thus future construction activities should have mechanisms for rainwater harvesting and recharge pits.

To the second question on how to enforce tariffs or tax for the ground water extractors, he opined: Currently, only deep tube wells are taxed, which is also nominal. Any commercial use of the Groundwater should be discouraged and tariff should be imposed on all uses. For any commercial use, the size of the extraction should be monitored and charged according to the use and size of the well. The extractors should have the permission for the extraction, should be registered and must have the license. The renewal of the license must be checked regularly. Large quantities of groundwater extractors and users such as apartment and housing and complexes and industries should be charged higher tariffs. However, they are still not identified as commercial user even though in most cases, groundwater is their only source of water. Although, it is said that there are 700 wells, the data is not clear as the extraction of groundwater is not registered.

To the third question on how to promote and implement ground water treatment techniques, he opined that the people are unaware about the groundwater quality they use daily. They also do not realize the importance of the treatment system. Even if the importance is felt, they are not sure how to get the water test and or able to bear the costs of such testing. So as the solution to this problem, he recommended that:

- People should be made aware about the quality of the water and its importance.
- Develop simple and easy water testing and treatment kits which can be used by the local people themselves; especially during monsoon season.

### **Mr. Basant Adhikari:**

According to Mr. Adhikari, the reason for the groundwater depletion is due to lack of policy for ground water use. The haphazard construction in the valley has disturbed areas that have recharge potential. Regarding the first question, Mr. Adhikari focused on the need for laws and policy for the protection of catchment and watershed area. Groundwater recharge should be strengthened by properly harvesting rainwater and directing it to the recharge pits.

To the second question on how to enforce tariffs or tax for the ground water extractors, he opined the commercial use of water should be charged. Licensing and monitoring is essential to regulate

tariff and taxes. In addition, there should be limits on ground water extraction to maintain sustainability. However, the water to fulfill the daily basic needs should be available to everyone without any cost. However, it is desirable to put quantity limitation on such extraction to avoid misuse in the name of domestic use. There should be a mechanism in place to channel the fund from commercial groundwater use to improve the access of those impoverished.

To the third question on how to promote and implement groundwater treatment techniques, he opined that appropriate groundwater treatment techniques should be researched and developed by the scientific and social community and identified techniques should be recognized by law. There should be mandatory requirement for waste water treatment by big commercial complexes, industries and housing companies.

**Mr. Naba Raj Shrestha:**

Mr. Naba Raj Shrestha agreed to Dr. Suresh Das Shrestha and Mr. Basanta Adhikari on identifying the potential groundwater recharge areas and protecting them from any form of encroachment. In Pakistan such recharge area is protected and there was positive response in maintaining groundwater level from depletion. There is need for considering groundwater recharge in two perspectives. Shallow groundwater recharge is easy and quick. Only requirement is the availability of potential recharge area. Hence efforts should be made not to reduce the groundwater recharge area. The paved areas inside individual and organization premises should be discouraged. On the other hand, deep aquifers exist below thick clay layer in Kathmandu, which make infiltration and traveling of water to aquifer very slow and taking unusually long time period. Hence natural recharge of deep aquifers is practically impossible and artificial recharge is the only reasonable way and hence should be explored. One way for artificial recharge is to utilize the deep tube wells, which reaches the deep aquifers.

Mr. Shrestha pointed that the water is a basic human need and drinking should be given the first priority. He emphasized that lack of laws and tariffs on groundwater use and management has promoted its use for commercial purposes. The extraction of groundwater for commercial use at least in the valley should be banned.

Regarding treatment techniques, he suggested focusing on deep aquifers rather than shallow aquifers. Identification of contaminated deep aquifers is necessary and their use should be determined according to the level of contamination. As treatment of groundwater is expensive, relevant organizations should take the lead in groundwater treatment for safe drinking water.

**Prof. Futaba Kazama:**

During the discussion Prof. Kazama shared some experiences from her country Japan. She emphasized that groundwater is a natural resource and should be accessible by everyone. But to sustain the quality and quantity of groundwater a nominal tax should be charged. It is important not only to collect the tariffs but also develop a goal and a system on how the funds generated will be utilized. This would ease the collection of tariffs. Collection of tariffs for the identified goals is also an opportunity to increase awareness to the public on the significance of groundwater, its treatment and sustainability.

**Dr. Narayan Upadhyaya:**

Dr. Upadhyaya discussed the degrading groundwater quality. He shared that only a few decades ago the groundwater quality met WHO standards. However, recent water quality testing of the well and stone spouts of the valley show that most of them do not meet the national standards. Regarding the first question, he noted that the further urbanization of the valley will directly impact the groundwater quality and quantity. Government should also give priority to formulating policies and implementing them to provision license, regular monitoring of the extraction of groundwater and the quality.

He highlighted the increasing contamination of manganese in the groundwater which requires expensive treatment methods compared to other contaminants such as ammonia, nitrate and iron. To prevent exacerbation of the situation, over extraction of the groundwater has to be controlled.

**Mr. Indra Kumar Maharjan:**

Mr. Indra Kumar Maharjan from Kathmandu Upatyaka Khanepani Limited (KUKL) agreed rapid urbanization and construction has to be checked as one of the first steps to prevent further deterioration of groundwater in the valley. It is becoming increasingly difficult to preserve the groundwater recharge area such as Bansbari, Bode and Manohara. Artificial groundwater recharge has to be considered for deep aquifer recharge. There are around 20 deep tube wells that are not in operation which could be utilized for artificial recharge. All stakeholders must come together to preserve groundwater and use it sustainably.

He drew attention to the bureaucratic system that requires a significant amount of paper for establishing any organization but almost none for utilizing one of the most valuable resource, groundwater. The tariff system should be such that it encompasses the variation in depth and extraction amount. Institutionalization of the committee along with appropriate policy, tariffs and monitoring is necessary. Considerable work is also needed in updating the current status of the groundwater; although 700 deep tube-wells are reported there is information of only 339 deep tube-wells.

He shared that his organization is using isolation treatment for iron removal and central removal for ammonia removal. He stressed that Nepal needs to develop a culture of research and collaboration between colleges, universities and organizations such as industries and corporate houses.

After the panelists shared their views on the proposed questions Dr. Sangam Shrestha posed the question to the panelists on the failing enforcement of the laws relevant to water resources.

To this question, Mr. Adhikari said - although Nepal has one of the best policies proper regulations are not in place for the implementation those policies. In some cases the policies are also formulated in the interest of the donor and do not fulfill the needs of the other stakeholders. There is also lack of ownership of formulated regulations as they are prepared by consultants

working for the donor agencies. He also gave an example of wide implemented property right policies as there was no donor intervention.

Referring back to the technical session, Dr. Sangam Shrestha asked panelist views on whether KUKL should be categorized as an individual user for commercial user.

Mr. Adhikari opined that KUKL should be categorized as the commercial user among the three categories of users currently framed by the laws, which are individual, collective and commercial. According to the current legislation the Nepal Water Supply Management Board and KUKL have been formed to serve the public, but they have to be licensed to use the water. However, the licensing is not enforced. The categorization can be discussed as the water is being used by individuals.

Mr. Maharjan elaborated the recent changes in legislation restructuring in the water utility to the water management which established Kathmandu Valley Water Development as the overall regulator. KUKL functions only as an operator which extracts water and supplies to the public. The Tariff fixation committee which assigns the tariff for the water that is supplied by KUKL. As KUKL cannot regulate the price of the water it supplies like the bottle water companies it cannot be considered as a commercial user of groundwater. Thus, KUKL has categorized different than individual or commercial user.

Dr. Sangam Shrestha questioned the feasibility of imposing an indiscriminate tax on public to Dr. Suresh Das Shrestha. Dr. SD Shrestha explained that it might be more feasible for commercial users such are housing complexes and bottling industries to take the responsibility of supplying water to their surrounding water. This would lessen the responsibility of KUKL to supply water to those areas.

Dr. Upadhyaya opined that the taxation system should be based on the similar principle as the polluter pay principle. Mr. Maharjan emphasized that there should be clear policy on how the tariff will be used to preserve groundwater.

Dr. Sangam Shrestha summarized the panel discussion and highlighted the key findings.

- Government should have clear policy and regulation on land use to preserve groundwater
- Tariff should be imposed on commercial users.
- Over extraction of groundwater has to be regulated to maintain the groundwater quality. Simple water treatment techniques at the point of use should be promoted.

## Closing Session

### Concluding Remarks Mr. Dhiraj Pradhananga SEN



Mr. Dhiraj Pradhananga (SEN) concluded the symposium summarizing the entire gist of the technical session and panel discussion session of the symposium. He highlighted the key conclusions and recommendations of the entire technical session as well as the panel discussion.

The key recommendations from both the technical sessions were that collaborative research is needed to understand and to conserve the groundwater resources in the Valley. Framework policy that encompasses regulatory mechanisms for maintenance of water reservoirs and its sustainable use is required.

The panel discussion stressed the need for strong legislation and implementation on rainwater harvesting, preservation of groundwater recharge, and tariff for commercial groundwater use. A clear categorization of groundwater users and treatment of groundwater were also discussed. Addressing the various issues of the groundwater necessities a decision support system for integrated water resources management in the Kathmandu Valley.

**Vote of Thanks**  
Ms. Kanchan Shrestha  
SEN

On behalf of the organizing committee, I would like to thank everyone involved in making this symposium a grand success. I would like to thank our key note speakers Dr. Roshan Raj Shrestha and Dr. Sangam Shrestha for their addresses. I would also like to thank our presenters and panelists



- Prof. Futaba Kazama, University of Yamanashi, Japan
- Dr. Roshan Raj Shrestha, Water for Asian Cities Programme, UN-HABITAT
- Mr. Basanta Adhikari, Pro-Public, Nepal
- Mr. Naba Raj Shrestha, Department of Irrigation, Nepal
- Dr. Suresh Das Shrestha, UEMS ,Central Department of Geology, Tribhuvan University, Nepal
- Dr. Narayan Upadhyaya, ENPHO
- Mr. Prakash Amatya, NGO Forum, National Steering Committee on Rainwater Harvesting
- Mr. Madhukar Upadhyaya, ISET-Nepal
- Ms. Pramita Maharjan, NGO Forum
- Dr. Saroj K. Chapagain, University of Yamanashi, Japan
- Mr. Indra Kumar Maharjan, KUKL

Our sincere thanks go to all the participants of the symposium for their presence and input. We express appreciation to our rapporteurs Ms. Maneesha Shakya and Mr. Shakti P.C. We would also like to acknowledge the judges for the photography competition “Groundwater: Today’s Matter, Manage it Sustainably for Better Future”, Mr. Sarad Rai and Mr. Chandra Shekhar Karki for sparing their time and effort. We would like to congratulate all the winners of the competition once again and also thank all the participants that submitted their photo entries for the photography competition.

Our heartfelt thanks also go to all the volunteers and the team who have worked tirelessly for over a month to put this symposium together: Ms. Isha Manandhar, Mr. Chakshu Malla, Mr. Ishwor Barakoti, Mr. Madan Adhikari, Mr. Prakash Shrestha, Ms. Sunita Khatiwada and Ms. Sangeeta Maharjan. We express our gratitude to Mr. Poojan Bhandari, Mr. Arun Prasad Bhattarai and Mr. Jeeban Panthi for their contribution during the symposium.


We express our sincere appreciation to Kurita Water and Environment Foundation (KWEF) and University of Yamanashi for their constant support towards a successful symposium.

## Annex I: Presentation Slide

### Rainwater Harvesting for Ground Water Recharge in Kathmandu Valley: Potentials and Challenges


Dr. Roshan Raj Shrestha  
Regional Technical Advisor, South Asia  
Water for Asian Cities Programme

April 06, 2009




### Kathmandu Valley Water Supply & Demand

- Current water demand of the Valley is about 280 MLD.
- Only about 86 MLD supply in dry season
- 105 MLD supply in wet season






2




### Heavy Extraction of Ground Water

- Groundwater abstraction rate is 6 times higher than the limit of its abstraction resulting in lowering of groundwater table 2.5 meters every year (MPPW, 2002).
- Arsenic, Ammonia and Nitrate detected in deep aquifer from many parts of the valley (ENPHO, 2005).
- Shallow groundwater aquifer which feeds water to dugwells, handpumps and traditional stone spouts is also vanishing due to sealing of ground surface and destruction of recharge basin due encroachment from infrastructure development.

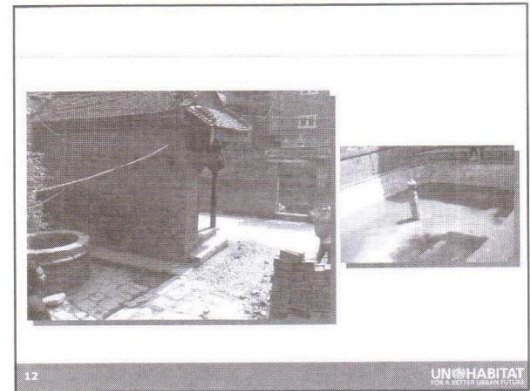
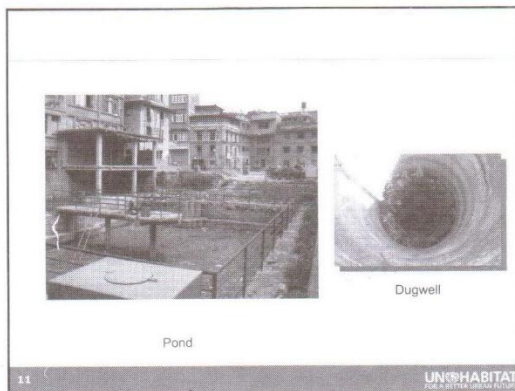
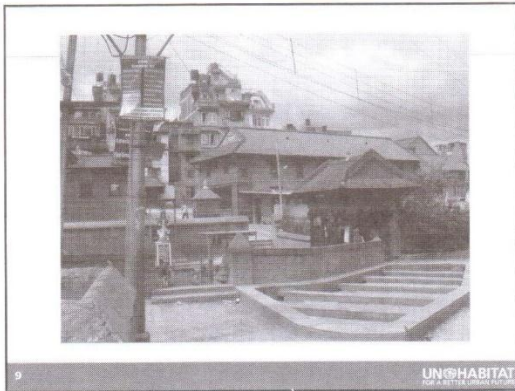
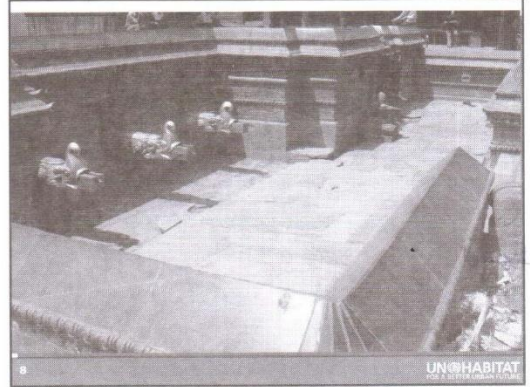

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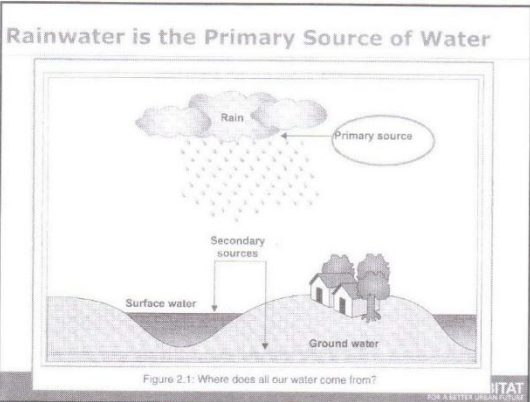
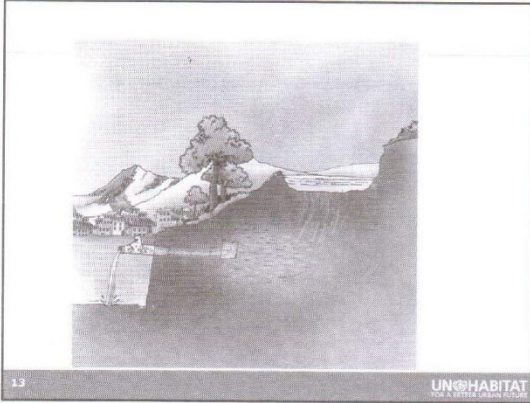


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Alternative Water Sources





- King Parakramabahu 1 (1153-1186) – Sri Lanka said that “let not one drop of water that falls on the earth in the form of rain be allowed to reach the sea without being first made useful to man”

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- In South Australia, 42 % of the population drink rain water.
  - In Bangladesh, rainwater is one of the major alternative options for drinking in arsenic affected areas.
  - In Germany, 50,000 Rain water harvesting systems are installed every year.
  - In Singapore Changi Airport, each month, 63,500 tons of rainwater is used for flush toilets and to cool the terminal buildings, such water accounts for 28 to 33 % of the water used, resulting in saving of approx USD 390,000 per annum. Similar, concept is also adopted in Frankfurt Airport in Germany
- 17 UN HABITAT FOR A BETTER URBAN FUTURE

- Gansu’s province, China is one of the direst and poorest states in China where an annual precipitation of 300mm supplies water for 2 million people and supplementary irrigation for 236,400 hectors of land.
  - In India, it has been used extensively to directly recharge groundwater at rates exceeding natural recharge condition resulted in groundwater level increases from 5 to 10 meters in just two years.
- 18 UN HABITAT

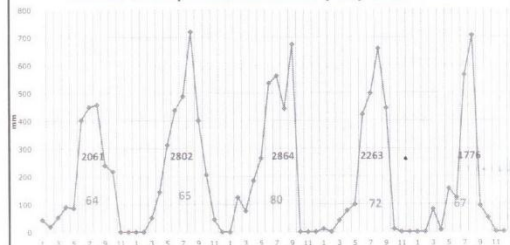
## Potential of Rainwater Harvesting in Kathmandu Valley

- The average rainfall in the Kathmandu Valley is estimated around 1900 mm: more than twice the world average.
- Approximately 1.2 billion m<sup>3</sup>/year or 3353 MLD of rainwater falls in the 640 sq.km Valley.
- This is about 12 times the present water demand (102 million m<sup>3</sup>/year) and nearly 20 times times the expected water supply from the Melamchi Water Supply Project (170 MLD)
- If only 10% of the Kathmandu Valley area is to be utilised for rainwater harvesting, 128 million cubic metres per/ year could be recharged

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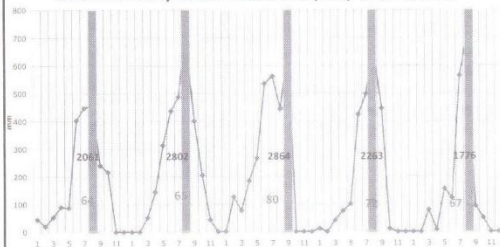
Rainfall in Swoyambhu Kathmandu (mm) 2005 to 2009



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Rainfall in Swoyambhu Kathmandu (mm) 2005 to 2009



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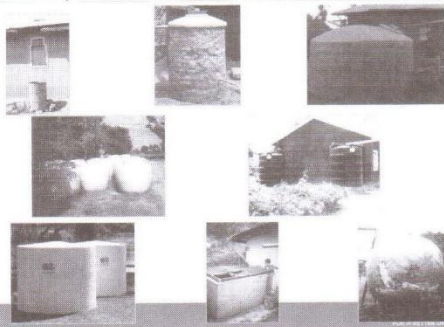
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Present Challenge is how to store and collect Rainwater ?

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Collection of Rainwater in tanks and Jars  
May not be solution for Kathmandu

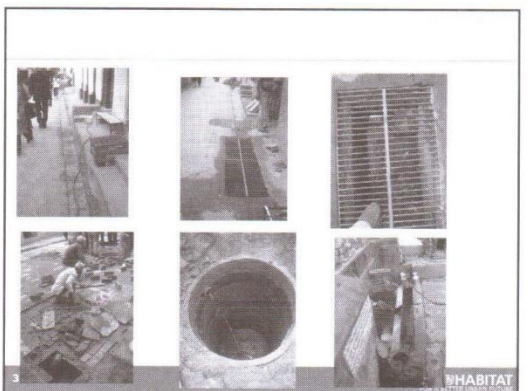
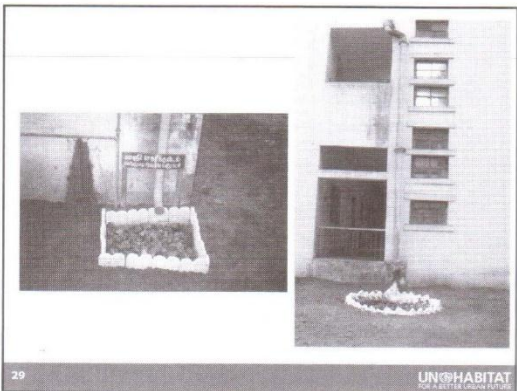
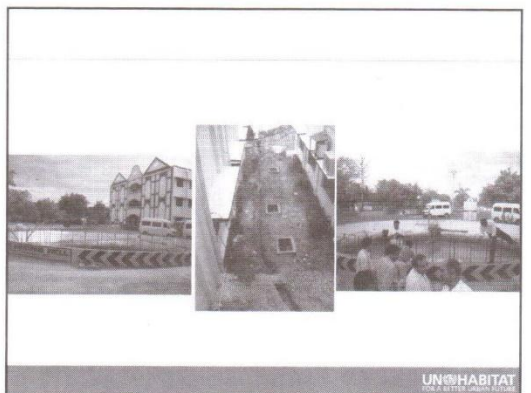
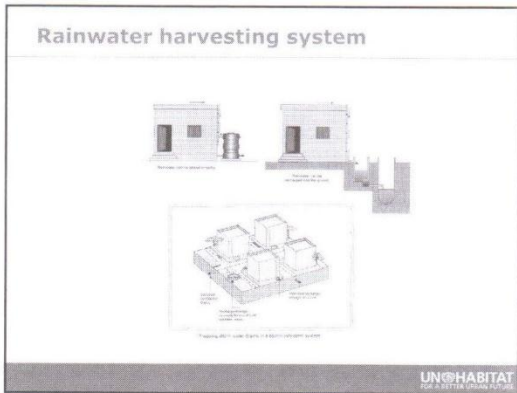
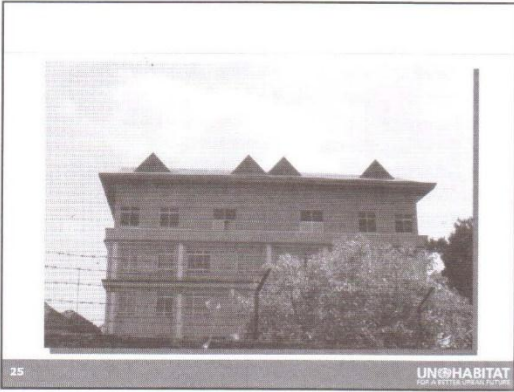


Rainwater in Kathmandu



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### Challenges

- Make the citizen responsible
- Ground water extraction regulation
- Rainwater harvesting policies and its enforcement
- Groundwater Recharge vs. Water Quality
- Groundwater Recharge Techniques and Recharge Zone
- Research and Development

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### Role of Researchers

- Monitoring of Groundwater Quantity and Quality
- Impact on Aquifer due to Recharge
- Identification of Recharge Zone
- Simple techniques on Nitrogen Removal (Ammonia and Nitrate)
- Support in Development of Groundwater Regulation Policies

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### RWH Mandatory in India

- all new buildings with a roof area of more than 100 m<sup>2</sup> (**Delhi**), 250 or more (Indor), 300 m<sup>2</sup> (**Hydrabad and state of Andra Pradesh**),
- all new buildings irrespective of roof area (**Haryana, Chennai**), and all plots with an area of more than 1,000 m<sup>2</sup> that are being developed (**Delhi, Mumbai and Kanpur**).
- for all public establishments (**Rajsthan and Gujrat**) and all properties in plots covering more than 500 m<sup>2</sup> in urban areas (**Rajsthan**)
- for residential complexes including apartments on a plot area of 2,000 m<sup>2</sup> and above, commercial complexes on a plot area of 1,500 m<sup>2</sup> and above and industrial units on a plot area of 10,000 m<sup>2</sup> and above (**Goa**)

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### India

- Rebate of six per cent offered on property tax for implementing RWH in **Indor**
- New water and sewer connections provided only after implementation of rainwater harvesting systems in **Chennai**
- An annual award for the best rainwater harvesting practice in **Goa**
- Financial assistance up to 50 % of the total cost of project for Housing Societies in **Delhi** adopting RWH in worst affected areas.

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### Other Examples

- **Sumida City** offers subsidies up to ¥1 million (US \$7,500) per rainwater utilisation project
- Local governments of **Takamatsu City, Toyota City, Kamakura City** and **Kawaguchi City** have begun subsidising or providing loans for RWH
- Loans of \$ 200, repayable over a 3 years of period covered not only the cost of RWH tank also some income generation activities in **the Philippines**
- Changi Airport **Singapore** saves approx. S\$ 390,000/year of water bill by installing RWH. Similarly experience with **Frankfurt** airport
- Construction of over 10 million 1 – 2 cubic meter ferrocement jar in **Thailand** between 1985-91.

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### Other Examples

- Gansu's province, **China**, with an annual precipitation of 300mm supplies water for 2 million people and supplementary irrigation for 236,400 ha of land
- In **Germany** grant of \$600 to \$1200/HH and further subsidy of \$3/m2 of roof area linked to recharge pit.
- Annual charge of \$1.5/m2 land where rainwater flowed into sewerage network in **Berlin**.
- Austin **Texas** : 30% subsidy for cisterns upto \$500 and sells rain barrel below actual cost.
- Commercial entities eligible upto \$40,000 rebate and provides property and sales tax exemptions

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UN HABITAT  
FOR A BETTER WORLD

# Groundwater and climate change: No longer the hidden resource

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## Presentation outline

1. Importance of groundwater
2. Current groundwater management challenges
3. Impacts of climate change on groundwater
4. Adaptation strategies to manage groundwater
5. Conclusions and future issues

## Importance of groundwater

### ✓ Globally, groundwater provides

- ~ 50% of current potable water supplies (serving nearly 2 billion people)
- ~ 40% of self-supplied industry
- ~ 20% of water use in irrigation



## Importance of groundwater

### ✓ Asia and the Pacific, groundwater

- provides drinking water to nearly 32% of population
- serves as a major source of irrigation water use
  - ~ 60% of the total agricultural water use in India
  - ~ 50%, 50%, 65% and 70% of total agriculture water supply in Shangdong, Henan, Beijing and Hebei provinces of China resp.
  - > 40% of crop water requirement in Pakistan Punjab
- contributes to industrial water use
  - ~ 82% in Metro Manila (Philippines), 80% in Bandung (Indonesia), 60% in Bangkok (Thailand), 57% in Ho Chi Minh City (Vietnam), 15% in Tianjin (China)

## Importance of groundwater

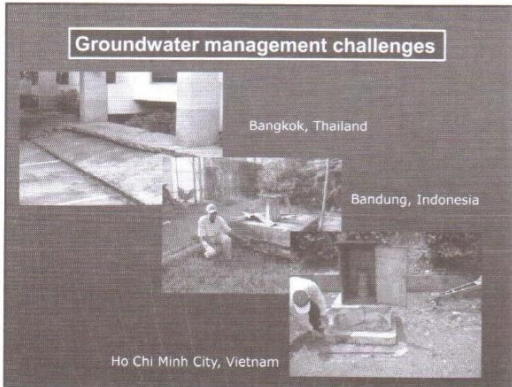
### ✓ Groundwater use trends in Asia

- Philippines: Industrial and domestic use increased annually by 14% and 11.5% resp. (1988-2001)
- Ho Chi Minh City, Vietnam: Groundwater withdrawal steadily increases, 34% of total demand
- Tianjin, China: exploitation (1991-2002) has exceeded safe yield in most districts

## Groundwater management challenges

### ✓ Over-extraction of groundwater resulted in:

- Land subsidence
- Depletion in groundwater table
- Groundwater contamination (e.g. from arsenic, fluoride and ammonium)
- Salt water intrusion



### Groundwater management challenges

- ✓ Groundwater contamination from anthropogenic and natural sources
  - Major contaminants are arsenic, fluoride, ammonium, chloride etc
  - In Lamphun province (Thailand), fluoride concentration is up to 15mg/l as against standard of 0.7mg/l
  - In Tianjin (China), groundwater contains high concentration of fluoride and dental fluorosis rate is 41% in urban area (Xu et al. 2008)

The Distribution of Fluoride in Confined Aquifer III of Tianjin

### Groundwater management challenges

Asian cities	Role of groundwater	Groundwater problems
Dhaka (Bangladesh)	Sole source	Falling groundwater levels
Tianjin (China)	Major source	Land subsidence
Nagpur (India)	Major source	Pollution from urban area
Jakarta (Indonesia)	Minor source	Salinity intrusion
Cebu city (Philippines)	Major source	Sal. Intrusion, pollution
Jaffna (Sri Lanka)	Sole source	Sal. Intrusion, pollution
Bangkok (Thailand)	Major source	Sal. Intrusion, pollution
Tokyo (Japan)	Major source	Pollution
Kathmandu (Nepal)	Major source	Falling groundwater levels

Source: World Bank (1998), JICA

### Groundwater management challenges

- ✓ Lack of clear policies on groundwater management and weak enforcement of groundwater laws
- ✓ Lack of coordination between organizations responsible for groundwater management and overlapping of responsibilities
- ✓ Lack of human resources with adequate knowledge on groundwater resources management
- ✓ Lack of groundwater database and monitoring system

### Potential impacts of climate change on groundwater

- ✓ Impacts on groundwater due to change of temperature and precipitation
  - Shift in precipitation ultimately shift in water balance of aquifer by increase or decrease of recharge.
  - Shift in precipitation also make surface water more unreliable which may force to development of groundwater resources.

Page 22: Temperature, Precipitation and evaporation. The net evaporation is the difference between evaporation and precipitation. Runoff is the difference between precipitation and evaporation. Evaporation is the loss of water from the surface of the ocean, lakes, rivers, and soil. Precipitation is the amount of water that falls from the sky as rain or snow. The maps show the distribution of these factors across the globe.

Source: IPCC Technical Paper VI

### Potential impacts of climate change on groundwater

- ✓ Degradation of groundwater quality by sea level rise
  - Sea level rise is expected due to melting of ice sheets and glaciers as a result of global temperature rise. Rise in sea level would allow saltwater to penetrate farther inland and upstream in low lying river deltas (IPCC, 1998).

Chloride concentration in Pira Pradseng aquifer, Bangkok  
Source: Babel et al 2006

Regions Vulnerable to Sea Level Rise  
Source: Hoffmann, groundwaterjournal.com

### Potential impacts of climate change on groundwater

✓ Potential impacts on groundwater due to landuse change caused by climate change

▪ Climate change studies suggest that some Asia-Pacific forests and vegetation may experience some initially beneficial effects from climate change and enhanced atmospheric CO<sub>2</sub> concentrations.

▪ Studies suggest significant shifts in the distribution of tree species in China in response to warming of 2–4° C, including the migration of forest communities into non-forested areas of East China (CSIRO 2006). The increase in forest area may increase the groundwater recharge in East China.

✓ Potential degradation of groundwater by afforestation and carbon sequestration



### Adaptation strategies to manage groundwater

✓ Mainstreaming adaptation concerns into (ground) water management plans to cope with current and future climate change impacts

✓ Increasing groundwater volumes in aquifers, maintaining groundwater ecosystems by various measures

### Adaptation strategies to manage groundwater

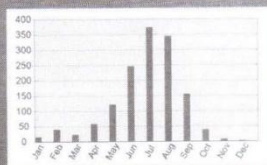
Technological options

Institutional Solutions

### Adaptation strategies to manage groundwater

✓ Technological options

- Water transfer
- Increased recharge
- Conjunctive use of groundwater and surface water
- Water saving technologies and changing use patterns



Average monthly rainfall (mm) in Nepal



### Adaptation strategies to manage groundwater

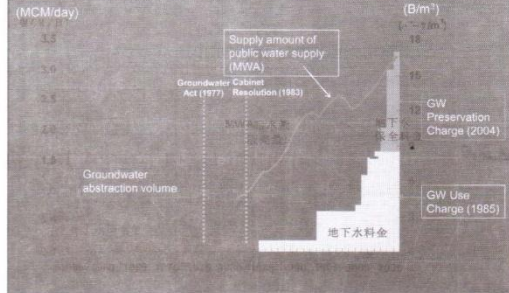
✓ Institutional solutions

- Collective and community action approaches
- Instrumental approaches: rights, rules and price
- Indirect approaches: institutional and policy arrangements beyond groundwater

### Summary of local groundwater management cases

Case	Country	Size (ha)	Type of management	Measures
Panjgur	Pakistan	2,000-3,000	Informal norms	Ban on dug wells
Mastung	Pakistan	2,000-3,000	Informal norms, committee	Spacing rules, zoning
Nellore	India	1,500	Informal norms, local government	Water saving, recharge, ban on boreholes
Saurashtra	India	Scattered	Informal norms, religious leaders	Recharge, regulation of wells

### How Bangkok tackled with excessive abstraction of groundwater?




### Conclusions and future issues

- Climate change will add to existing pressure on groundwater resources.
- Many countries have not been successful in coping with current groundwater problems, so extra effort will be needed to counter the additional negative effects of climate change.
- Promote water harvesting technologies with suitable policies (incentives and disincentives).
- Promote local groundwater management with support from central/regional government.
- Need of extensive research at local scale.

Thank you very much for your attention!




## Outline



1. Background
2. Stable isotopes technique
3. Sampling and analysis
4. Results and discussion
5. Conclusions and future prospects

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## Background



### Kathmandu Valley

- Total area: 664 km<sup>2</sup>
- Population: >2 million (9%)
- Av.elevation: 1300 masl
- Climate: Semi-tropics warm and temperate
- Rainfall: Monsoon  
Av. annual: 1700 mm

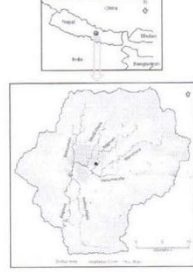



Fig. Location map of study area

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## Background: current need




### Need of Groundwater management strategies

- I. Groundwater use policy
- II. Groundwater restoration activities
  - Conservation and management of natural recharge area, Artificial recharge of groundwater

Requires details understanding of GW resources

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## Background: current need



### Earlier studies of GW

- Warner et al. 2008
- Gurung et al. 2007
- JICA/ENPHO 2005
- Acre International, 2004
- Khatiwada et al. 2002
- HMG/N 1998
- Jha et al. 1997
- JICA 1990
- Binnie & Partners, 1973

1970

### Study includes

- Quantification of GW quality (1990, 1997, 2002 etc)
- GW recharge (Geological approach) (1990, 1991)

Gap ??


- Groundwater recharge system:
  - Source/origin of groundwater recharge
  - Hydraulic Interactions of water sources
  - Groundwater residence time

Research need

Evaluate the groundwater recharge characteristics

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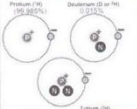
## Isotopic technique



### Stable isotopic approach

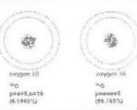
- Since last 2 decades; used in GW study
- Natural tracer, useful to complement the traditional method

Isotope: Atoms of element with same no. Electron & Proton but different number Neutron (Mass)  
Almost similar chemical but different physical properties



Protium (1H)  
(99.98%)

Deuterium (2H or D)  
(0.02%)



oxygen 16  
mg  
99.9826431


oxygen 18  
mg  
0.0173528

Water molecules (H<sub>2</sub>O):  
<sup>1</sup>H<sub>2</sub><sup>16</sup>O and also <sup>1</sup>H<sub>2</sub><sup>18</sup>O and <sup>1</sup>H<sup>16</sup><sup>18</sup>O

- Changes on relative proportion of isotopes; physical and chemical process (evaporation, condensation, precipitation)
- Develop unique isotopic compositions (ratios of heavy to light isotopes)
- Reflect process, Origin of groundwater

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## Isotopic technique



### Measurement of Stable isotopes (D and <sup>18</sup>O)

- Isotope ratios [D/<sup>1</sup>H and <sup>18</sup>O/<sup>16</sup>O]: δ unit: δD, δ<sup>18</sup>O [‰]
- Expressed in relation to international standard "Standard Mean Ocean Water" or (Vienna-SMOW)

$$\delta D = \left[ \frac{(D/H)_{\text{sample}}}{(D/H)_{\text{standard}}} - 1 \right] \times 1000 (\text{‰})$$

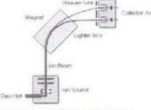
$$\delta^{18}O = \left[ \frac{(^{18}O/^{16}O)_{\text{sample}}}{(^{18}O/^{16}O)_{\text{standard}}} - 1 \right] \times 1000 (\text{‰})$$

Heavier: enriched

Standard value (Sea water)

Lighter: depleted


+5  
0  
-5  
-10



Basic principle of Mass spectrometry

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## Sampling



### Collection of sample

- Major GW extraction area
- Deep well (n= 42)>80m
- Shallow well (n=13)<20m
- River (n=8), Rainfall
- Pre monsoon (April) monsoon (Aug) 2007

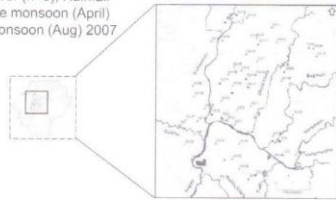



Fig. Sampling location

## Analysis




### Major analysis

**In-situ analysis:** pH, EC, ORP, WT, Salinity


**Laboratory analysis:**

- Organic/inorganic carbon (DOC and IC)
- Heavy metals (Cu, Cd, Zn, Cr, Pb, Fe, Mn)
- Arsenic (total and dissolved form)
- Basic cation (Na<sup>+</sup>, K<sup>+</sup>, Ca<sup>2+</sup>, Mg<sup>2+</sup>, NH<sub>4</sub><sup>+</sup>-N) and anion (SO<sub>4</sub><sup>2-</sup>, Cl<sup>-</sup>, PO<sub>4</sub><sup>3-</sup>-P, NO<sub>3</sub><sup>-</sup>-N, HCO<sub>3</sub><sup>-</sup>)
- Stable isotope (D and <sup>18</sup>O)
- Tritium (<sup>3</sup>H)

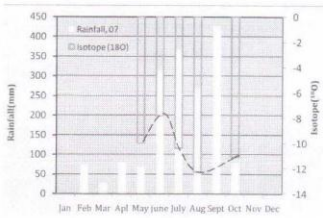
- ✓ Deep GW quality
- ✓ GW type
- ✓ GW recharge



## Results and discussion




### I. Stable isotopic ( $\delta^{18}\text{O}$ ) variation on rainfall

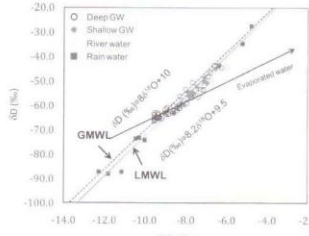


- Range ( $\delta^{18}\text{O}$ ) = -12.3 to -6.4 ‰
- Weighted average ( $\delta^{18}\text{O}$ ) = -9.4 ‰

## Results and discussion




### II. Relationship of $\delta\text{D}$ and $\delta^{18}\text{O}$

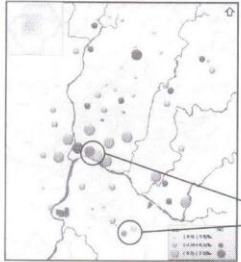


- GW derived from rainfall without subsequent modification
- Influence of open water source / evaporation is less likely

## Results and discussion




### III. Spatial distribution of $\delta^{18}\text{O}$ in GW



- Isotopic composition ( $\delta^{18}\text{O}$ )
- Widely ranged in deep GW (-9.6 to -6.3 ‰)
- Central part: heavier isotopes
- Edge of the basin: Lighter isotope
- Narrow range and heavier isotope in shallow GW
- Indicate heterogeneous recharge source of the GW

Possibility of hydraulic connection?

## Results and discussion



### IV. Hydraulic interaction

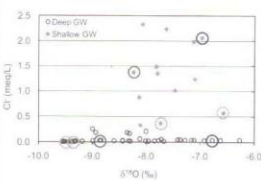
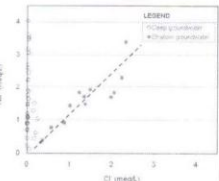
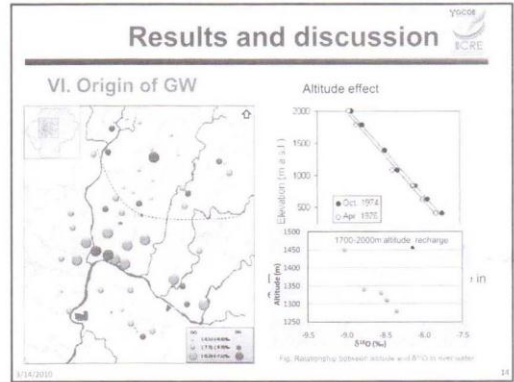
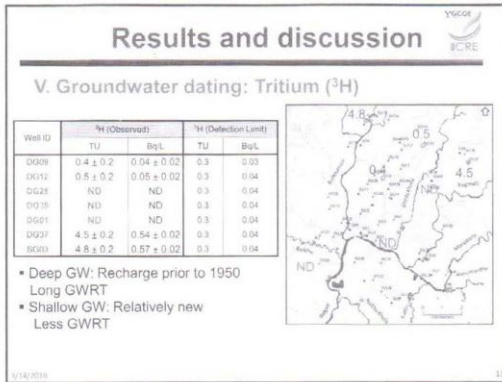



Fig. Cl and  $\delta^{18}\text{O}$  in shallow and deep groundwater

Fig. relationship of Na<sup>+</sup> and Cl<sup>-</sup> in groundwater

- Hydraulic connection poor between shallow and deep GW
- Different GW origin



## Conclusions

- Northern part deep groundwater: high altitude rainfall
- Delineate the effective area of high altitude recharge
- Poorly hydraulic interaction exist between shallow and deep groundwater and within deep GW
- GW dating: suggest recharge of GW prior to 1950
- Shallow GW: Relatively lower residence and recharge from the local area of rainfall

### Suggestions

- Reduce the human intervention in the northern part
- To enhance groundwater restoration:
  - Deep GW: Focus at high altitude recharge
  - Shallow GW: Local area management

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## Further research

- Establish the "altitude effects": Origin of GW
- Tool for identifying/assessing Artificial Recharge
- Identification on pollution source

We kindly request/invite to Join and support the GW research; further collaborative research

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## Acknowledgements

University of Yamanashi

International Research Center for River Basin Environment

Environment and Public Health Organization

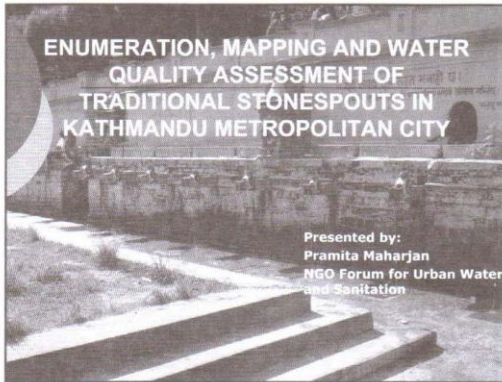
The Center of Research for Environment Energy and Water

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**Thank you very much for your attention**

Kindly Requested for comments & suggestions

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### Brief Overview

- Introduction
- Objective of the Study
- Limitation of the Study
- Study Area
- Methodology
- Results
- Discussion
- Conclusion
- Recommendation

### Introduction

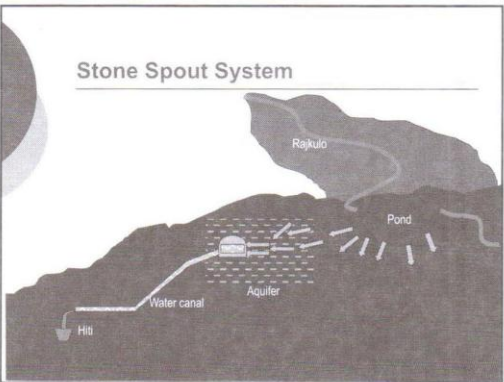
- Water is fundamental civilization. From early civilization society has to provide themselves with adequate supplies of fresh water but over the time however traditional ingenuity has been replaced by the new technologies.
- Piped water supply began in 1891 with the Bir Dhara Works in Kathmandu.

### Demand Vs Supply

- Total water demand 96MLD where as supply less than 60 MLD and total loss due to leakage is 38% in KMC. (Source: KUKL 2008)
- Due to inadequate and intermitted water supply, people are once again flocking back to traditional water sources to meet daily water needs.

### Traditional Stone Spouts

- The water spouts at manmade depressions are normally discharging through stone spout.
- Stone spouts are beautifully carved stone elements and locally called 'Dhungedhara'.
- Stone spout system utilise ground water, rain water and surface water to serve continuous flow through out a year.
- The most old spout with historical evidence is at Handigaun, Kathmandu (550 AD).



## Objectives of the Study

- General Objectives
  - The general objective of this study is to assess the water quality of traditional stone spouts of Kathmandu Metropolitan City (KMC) and to identify the situation of stone spouts in KMC.
- Specific Objectives
  - To enumerate and map the traditional stone spouts in KMC.
  - To explore and evaluate the condition of the stone spouts for their possible contribution to Kathmandu city water demand.

## Limitation of the Study

- This study is limited to Kathmandu Metropolitan City area only. Thus the findings may not generalize the whole Kathmandu district.
- The study was conducted for only two seasons- Dry and Wet Season.
- The study concentrated only within the niche of the stone spouts. The upper water supply system to the source and the downward drainage channel system weren't the part of the study.
- Total Coliform count was only studied in microbiological analysis.

## Study Area

### Kathmandu Metropolitan City

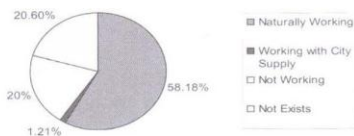
- The only metropolitan city in Nepal.
- Situated at an altitude of 1350m above the sea level.
- The city is spread over an area of 50.67 sq. km.
- Population of city was 6,71,846 (census 2001)
- Comprised of 35 wards.

## Methodology

- Enumeration and Mapping
  - Base line data - Kathmandu Metropolitan City Ward profile – 2001
- Water quality assessment
  - 25% Sampling points randomly selected. Purposive random sampling technique
  - Fifteen parameters were analysed (for wet season- Aug,08 and dry season-Nov,08)
  - Physical, Chemical and Microbiological parameters were considered
  - Standard Methods Prescribed By APHA (1998) and Trivedy and Goel (1984)

## Results

- Enumeration and Mapping
  - Total 165 stone spouts were identified in KMC.



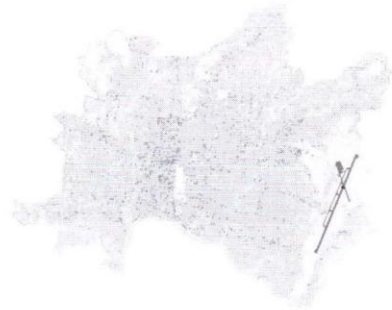
## Ward wise distribution of stone spouts

- No stone spouts were found in Ward no. 14,23,24,25,26,27 and 28.
- Maximum no of spouts were found in ward no.35 i.e. 18 and only one spout was observed in ward no. 2,11,13,22 and 30.

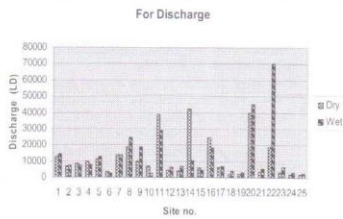
### Zone wise distribution of spouts

Zone	No. of Spouts	No. of Wards
City Centre	26	6
City Core	36	8
North	30	5
East	64	7
West	9	3

### KMC Map with stone spouts



### Water discharge in dry and wet season

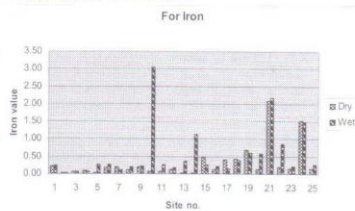


### Discharge range

- Discharge
  - The discharge value lies within the range (1898.9 – 39815.6 LD) in dry and (2468–70243.9 LD) in wet season.
  - Highest discharge value found in Gyan Dhara (70243.9LD)

### Water Quality

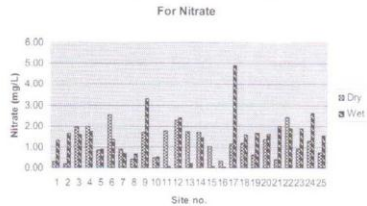
#### Water quality assessment



### Iron

- Average value of iron content in dry and wet season was 0.54 mg/l and 0.30 mg/l respectively.
- Maximum iron content was observed in Gairi Dhara I. (3.04mg/l)

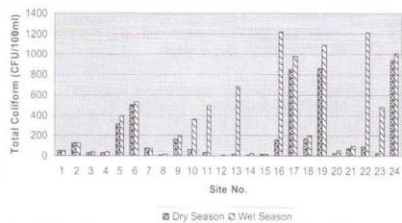
## Nitrate



## Nitrate

- Average value of nitrate content in dry and wet season was 1.50 mg/l and 1.21 mg/l respectively.
- Maximum nitrate content was observed in Sinamangal Hiti. (4.90mg/l)

## Microbiological Water Quality



## Discussion

- Present study identified 165 stone spouts in KMC while NGO Forum for Urban Water and Sanitation in 2006 listed out 172 stone spouts in KMC. The spouts number has been decreased due to the haphazard urbanization in the city.
- The total discharge rate in wet and dry season was 70243.9LD and 45235.6 LD respectively.
- The average discharge rate has also decreased as compared to the study by NGOFUWS in 2006.
- The change in discharge rate is due to haphazard urban development, New construction sealing the surface from recharging the ground water and excessive extraction of ground water to quench the thirst.

## Discussion

- Significant variations were observed in pH, temperature, hardness, nitrate, iron and phosphate content of water samples in the two test seasons dry and wet.
- 26% of the water samples were found below WHO Guideline Value given for pH.
- 28% of the water samples were found to exceed WHO guideline value for iron content.

## Chemical parameters within the standard

- Nitrate, ammonia, chloride, phosphate concentration and total hardness was found within WHO GV for all the samples tested.
- CFL/100ml of water samples exceeded the WHO Guideline Value of 0CFU/100ml. Coliform contamination was observed in almost all samples tested in both dry and wet seasons.
- The main causative factor of microbiological and chemical pollution is due to improper disposal of domestic sewerage and seepage of city drainage on the path of stone spouts.

## Conclusion

- Enumeration and mapping gives necessary information to list out the existing number of spouts in the City.
- Total discharge change over time in spouts was observed from the study.
- Municipal water supply in Kathmandu reaches only around 55% of the population. So, water supplied by City supply has greatly reduced. The water supply- demand gap is increasing which is fulfilled by traditional water sources (stone spouts).

## Microbial contamination

- None of the samples so tested crossed the WHO GV for Total Hardness, Nitrate, Chloride content of 500 mg/l, 50 mg/l and 250 mg/l respectively.
- Almost all the spouts water tested were found to be microbiologically contaminated in both the wet and dry seasons. So, it needs to be treated before drinking.

## Recommendation

- Government, concerned agencies and local people should pay greater attention to the protection, preservation and maintenance of the traditional water sources.
- Quality and quantity control of ground water should be done. Excessive extraction of ground water should be controlled. This can be done by recharging rainwater in the stone spouts source.
- Drainage and household wastes should not be kept near the source and protected from seepage of such wastes in stone spouts.

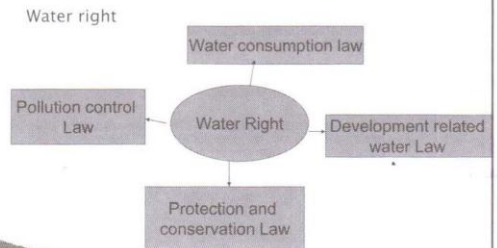
## Groundwater Act imperative

- The traditional stone spouts which are left unmanaged and unused should be maintained and user committee should be formed to keep good condition.
- Necessary laws will have to be framed, enacted and enforced to control and protect the drinking water, water sources and maintain the appropriate environmental sanitation.
- Awareness building and motivational programs regarding water pollution and its possible health impacts should be organized by City Supply and other concerned agencies to make people aware and conscious about the quality of drinking water.

## Regulatory Framework on Ground water in Nepal

Advocate Basant Adhikari  
Pro Public  
28 December 2009

## Regulatory Dimensions



## Water related legislations

- › Interim Constitution 2007
- › Water Resource Act 1992 is an umbrella legislation
- › Water Resource Regulation 1993
- › The Drinking Water Regulation 1998 specifically deals with drinking water and sanitation
- › Nepal Water Supply Corporation Act 1989
- › Water Supply Management Board Act 2006
- › Water Tariff Commission Act 2006
- › The Local Self Governance Act 1999

## Ground Water Regulation

- › Interim Constitution 2007 guarantees right to environment and health
- › State policy to protect and promote environment and sustainable development
- › Water Resource Act 1992 defines water resource which includes ground water

## Legislation ...

- › Ownership vested in the state as public trust
- › Beneficial use of water without affecting others (section 4)
- › Requirement of license is also applicable to ground water
- › Community water users for collective uses

## Exception for license

- › Individual and collective use of water for drinking, irrigation and domestic use
  - › For operating water mill
  - › Individual use for transportation (DUNGA)
  - › Land owner can use water available in his/her land as prescribed
- All commercial use of water requires license for ground water extraction

## Ground...

- › Water resource should be used in a way that does not create environmental degradation (soil erosion, flood, or others)
- › Environment protection Act 1996 prohibits to create significant adverse impact in environment and requires EIA or IEE
- › Water Supply Management Board Act : Kathmandu Valley Water Supply Management Board has responsibility of regulating, controlling or limiting the ground water extraction

## Principles

- › Public Trust (state domain)
- › Precautionary principles
- › Intergenerational equity
- › Principle of no harm to other
- › Equitable utilization (equity in water resources)

## Individual use vs. commercial use

- › Ground water extraction by industries
- › Ground water extraction by hotels
- › Ground water extraction by water bottlers
- › Ground water extraction by water vendors
- › Ground water extraction by KUKL
- › Ground water extraction by big housing companies etc

## Supreme court response

- › Pro Public filed a Public Interest Petition to regulate commercial use of ground water
- › Case was prepared on the basis of numbers of technical reports, situation studies etc
- › SC issued order to constitute an study committee consisting of ministry of water resource, experts and petitioner in order to submit report SC

## Report of the Study committee

- › 700 deep tube well identified
- › Decreasing by 2.5 meter per year
- › In some places 7–15 meter per year
- › Low ground water recharge
- › One window licensing mechanism
- › Separate Ground water Management Act
- › Promotion of rain water harvesting and ground water recharge

## Decision

- › Supreme court recently (paush 1) issued mandamus to implement licensing requirement
- › Mandamus to make unlimited extraction of ground water
- › Mandamus to arrange the use of recycled water by business houses such as hotels, nursing homes, housing etc
- › Prepare action plan within 3 months (from the date of receiving order) and submit to SC
- › Monitoring Division will monitor the progress

# Groundwater Quality in the Kathmandu Valley of Nepal

Bhoj Raj Pant, PhD

Nepal Academy of Science and Technology

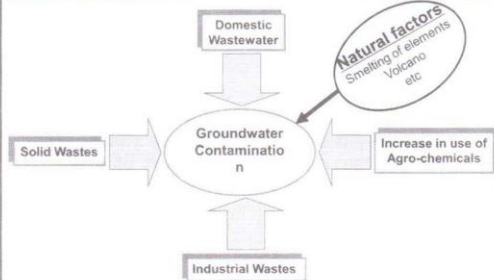
Nepal Academy of Science and Technology (NAST)

## Background

- Treated water supply is limited in the Kathmandu valley
- Population of the valley : **1.6 million** (CBS, 2001)
- Estimated water demand : **~145 million L/day**
- Supply of drinking water : **~115 million L/day**
- Dependency on ground water : **45%** (MOPPW, 2003)
- Total sustainable water withdrawal : **~26 million lit/day** (Stanley and Macdonald, 1994)
- Current water extraction rate : **~59 million lit/day** (NWSC 1992)
- Groundwater is considered safe for drinking purpose
- Increased groundwater pollution – Increases the health risks

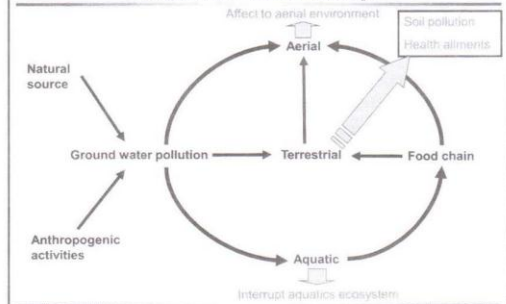
Nepal Academy of Science and Technology (NAST)

## Pressure for Deterioration of Ground Water Quality



Nepal Academy of Science and Technology (NAST)

## Pollutants Diffusion Pathways



Nepal Academy of Science and Technology (NAST)

## Motivation for the Work ?

- Increased water demand for various applications.
- Heavy use of groundwaters.
- Declined water quality of surface and groundwaters.

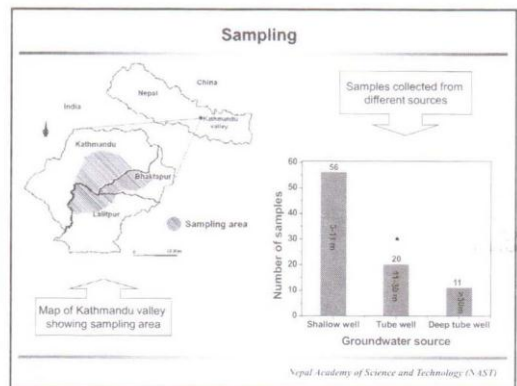
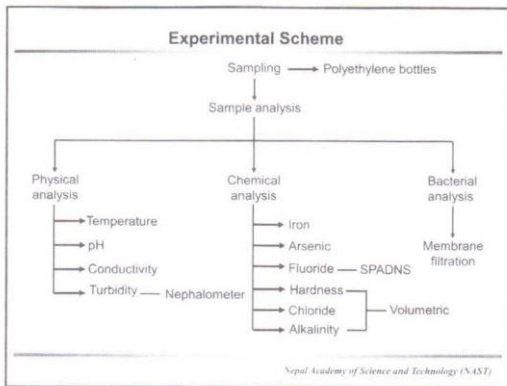
Nepal Academy of Science and Technology (NAST)

## Objective

This work was aimed;

- To study the water quality situation of groundwaters in the Kathmandu valley.
- Assess the contaminants level in the groundwater aquifer.

Nepal Academy of Science and Technology (NAST)



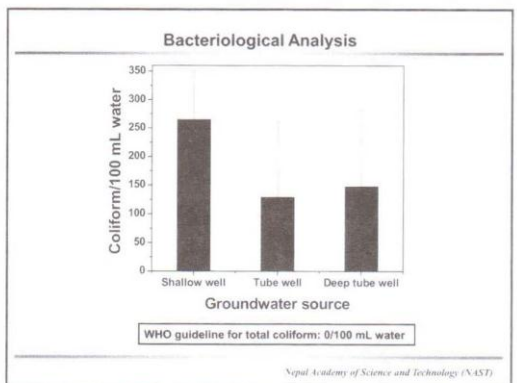
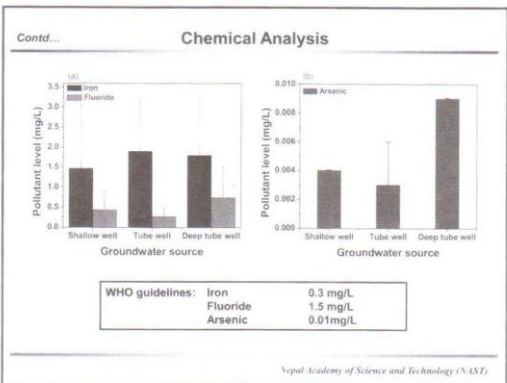
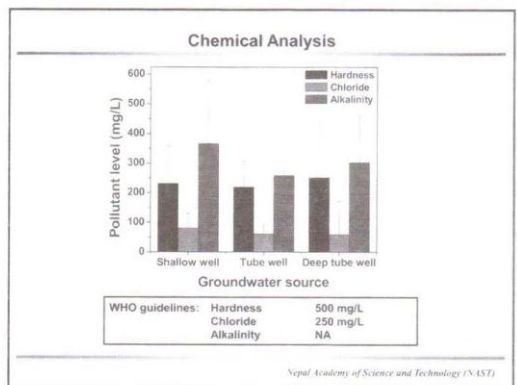
### Physical Analysis

Table : Physical analysis of groundwater samples

Ground water source	Physical parameters			
	Temperature (°C)	pH	Conductivity (µS/cm)	Turbidity (NTU)
Shallow well	18.6	7.1	875.8	45.9
Tube well	17.9	7.0	576.8	54.8
Deep tube well	20.3	7.0	704.2	33.2

**WHO guidelines :** Temperature (°C) NA  
 pH 6.5-8.5  
 Conductivity 500 µS/cm  
 Turbidity 5 NTU

*Nepal Academy of Science and Technology (NAST)*



### Conclusions

- Electrical conductivity (EC), turbidity, iron, and total coliform exceeded the WHO drinking water quality recommendations.
- Hardness, alkalinity, chloride, arsenic, and fluoride concentrations agreed the water quality standard.
- Groundwater in the valley is highly vulnerable to iron and coliform bacteria.

*Nepal Academy of Science and Technology (NAST)*

### Recommendations

- Iron and coliform containing water is suggested for adequate treatment before use.
- Effective maintenance of water reservoirs.
- Proper discharge of household wastes.

*Nepal Academy of Science and Technology (NAST)*

### Team Members

Bhoj Raj Pant, PhD	Chemist
Sujen Man Shrestha, PhD	Chemist
Mrs. Tita Prasai	Microbiologist
Mr. Gopal BK	Helper

*Nepal Academy of Science and Technology (NAST)*

## Groundwater and Food Security

Madhukar Upadhyaya  
Institute for Social and Environmental Transition-Nepal  
Kathmandu  
Email: madhukaru@gmail.com

## Groundwater abstraction- key for The Green Revolution in Asia (1965 to 1985)

provided food security to millions

- pulled the region back from the edge of famine.
- within 20 years, cereal production and yields doubled,
- reduced the food price
- improved livelihoods for an estimated 1.8 billion people.

The penalty of mismanagement is now coming due, and the results could be catastrophic for the most populous countries ... (Seckler *et al.*, 1998)

Water has become the single most important constraint to increased food production in a growing number of countries .

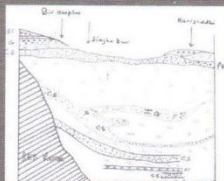
- Groundwater overdraft in excess of sustainable levels exceeds
  - 25 percent in China. 130 million people are being fed by over pumping aquifers
  - 56 percent in parts of northwest India. 175 million people fed by over pumping aquifers
- Saudi is closing its wheat farms and will import wheat from 2016
- Nepal -- from net exporter to net importer

- A major question
  - What will happen to our food security if countries like China begins to import even 5% of its food need from international market?
  - WFP has already cut its food aid
  - Increasing number of districts are reporting food shortages
  - How long can Terai supply food to hills?

## Defining Groundwater

- Relation between Green water (soil moisture) and blue water (springs, streams and rivers)
- More green means more blue water
- Emphasis on managing blue water only has ignored the role of green water in augmenting blue water

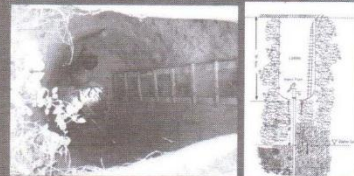
Need to understand ground to understand groundwater



## Situation we face



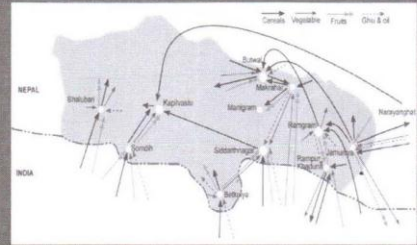
Underground hand pump



## Nepal Food Situation

- 54 % households produce sufficient food
- 46 % households have shortage
  - > 9 months 22%
  - 6 - 9 months 12%
  - 3 - 6 months 9%
  - < 3 months 3%
- Recent events
  - Land fallow until August in Tarai
    - 20% in 2006, 70% in 2009
  - Drought killed new plantation
  - Groundwater falling from 50 to 70 meters

## Rural Urban Food System



## Food problem indicators (?)

- Rising number of squatters, landless, forest encroacher, and travelling labor
- When garlic travels 5000 km from China to get to my kitchen
- Potato travels 1500 km Bhutan
- Changing habits and preference increased demand for water intensive food
- Chinu, Junelo declining
- Desakota –(money to buy) more food import

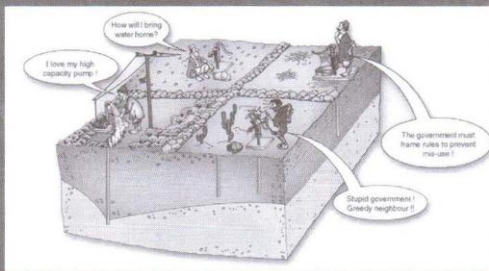
### Kodonomics



Supports a large informal economy.

- Groundwater is limited
    - area available,
    - recharge opportunities
  - Groundwater is complex
    - Identifying, interpreting and monitoring of inflow outflow is difficult
  - Falling water levels, with or without abstraction,
    - increases pumping cost,
    - shallow wells go dry, and
    - decline of environmental values (baseflow)
- permeability, porosity and depth of sediments  
rainfall  
seasonality  
overdraft situation  
infiltration rates  
pollution load

## Competition for groundwater use



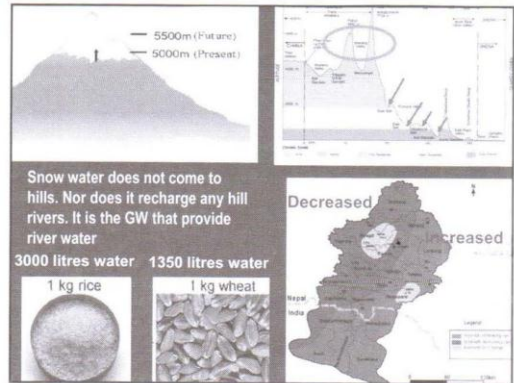
## Gujrat case



- Groundwater is local, its implications are not
- Problems associated with overabstraction of groundwater in Kathmandu valley - a wake up call to look at the larger picture of this valuable resource

## Countries investing in land for food

Investor	Target	Hec.	Status
Bahrain	Philippines	10000	Deal signed
China	Zimbabwe	101171	Deal signed
Libya	Ukraine	250000	Deal signed
Qatar	Kenya	40000	Deal signed
UAE	Pakistan	324000	Deal signed
S. Korea	Sudan	690000	Deal signed
Saudi Arab	Tanzania	500000	Requested
Jordan	Sudan	25000	Deal signed



## Securing food and Groundwater

- We do not have clear understanding of groundwater situation (in hills, valleys, plains) and implications of their depletion
- Given the changing food habits and the economic base of society, meeting demand of water intensive food is going to be a major challenge for water managers.
- Existing groundwater will be depleted faster than one can plan for alternatives (e.g. import of food)


## Securing food and Groundwater

- Communities have no incentives to manage green water which is key to sustain groundwater (aquifer) sources
- Unequal power relations in the land acquisition and use can put the livelihoods of the poor at risk.
- Blue water users have ignored the role of green water augmenting blue water.
- Emerging global climate stress will impact the water regime (but we do not know how, where, when etc.)

## Way forward


- Clear understanding of the area specific groundwater situation.
- Assess inflow and outflow (abstraction) and mechanism to monitor if depletion is faster than inflow.
- Assessment is relatively easy with records of springs and their flow (can be done by local governments)
- Strict rules on specific land area that are key in recharging aquifer
- Policy and Mechanism to mobilize incentives from the blue water users to green water managers.

## Research Work for Groundwater in Kofu and Kathmandu



Futaba Kazama

International Research Center for River Basin Environment (ICRE)  
University of Yamanashi



### Today's presentation

- Introduction of the research activity in Kofu Basin
  - Usefulness of stable isotope technique for identification of groundwater recharge area-
- Continuing research work doing at Kathmandu Valley


### Importance of Research Work for Groundwater Management

**For sustainable water use**

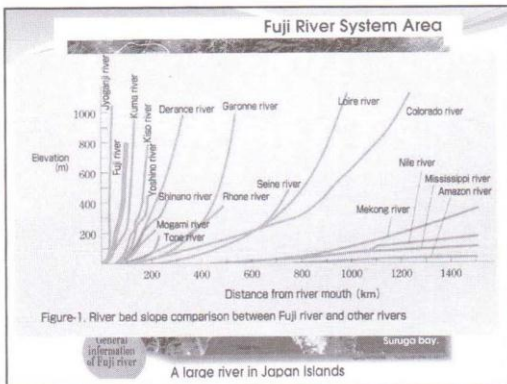
- Where is recharge area of groundwater?
- To which direction groundwater is flowing?
- How amount of water is there?
- How amount of water is recharged ?

**For preservation of groundwater quality**

- What is the pollution source of groundwater?
- How pollutant is diffused in groundwater?
- What are the adequate methods for



### Introduction of the research activity in Kofu Basin



- Very complex and fragile geological feature
- Very steep river slope

- Many collapsed area in mountain side
- Enormous locks and sands carried by river water
- Accumulation of locks and sands

Alluvial fan area  
Rivers with its riverbed higher than the surrounded areas

## くらしを呑み込んだ自然災害の猛威


The outrage of natural disaster devouring lives and communities

昭和34年災害


### History of the Fuji River Flood Control


This presents the major events related with Fuji River flood control from the 9th century to the 20th century.

<p>825 The river in the Kai country flooded. An officer reported to the Emperor.</p> <p>927 An embankment completed and its amount reported to the Ministry of Taxation.</p> <p>1542 A severe flood at Fuji river, system Kamanashi river, and Mitsu river.</p> <p>1580 Lord Shingen Takeda started the flood control project since that flood.</p> <p>1586 Lord Shingen Takeda completed the Shingembankment in Fyoo.</p> <p>1583 Fushiki river flooded and damaged the Miyuki embankment. The embankment was reinforced with tree plantation.</p> <p>1621 An embankment construction started at Kagayuta village.</p> <p>1674 Kanyoga embankment completed.</p> <p>1696 The river law established.</p>	<p>1917 Fuji river flooded. Fushiki river flow direction changed.</p> <p>1921 The government established a branch office for Fuji river flood control.</p> <p>1935 Fuji river flooded.</p> <p>1942 The Flood Reg. is issued.</p> <p>1959 Fuji river flooded.</p> <p>1964 The river law updated completely.</p> <p>1966 Fuji river Construction Basic Plan established. The estimated large flow amount decided.</p> <p>1974 Fuji river Construction Basic Plan updated. The estimated large flow amount increased.</p> <p>1982 Fuji river flooded.</p> <p>1990 Fuji river Embankment Management Basic Plan established.</p> <p>1996 River Channel Preparation project completed.</p>
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## Groundwater in Kofu Basin







Rainwater Sampling




Groundwater Sampling



River water Sampling



Major dissolved ion (anion, cation)  
Using ion- chromatograph



Water-oxygen and hydrogen isotope  
Using equilibration method

$\delta D = \pm 1.0\text{‰}$   
 $\delta^{18}O = \pm 0.1\text{‰}$

## ~ 安定同位体 Stable Isotope ~

水素 H



Masa

窒素 N



Masa

酸素 O



Masa

炭素 C



Masa

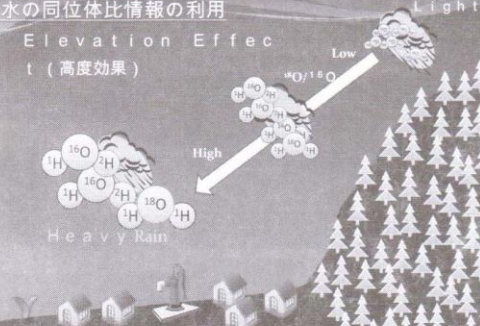
硫黄 S



Masa

## 水の同位体比情報の利用

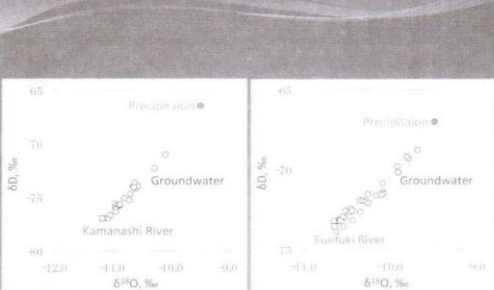
### Elevation Effect (高度効果)



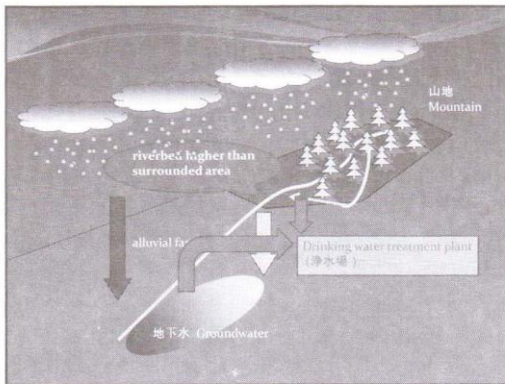
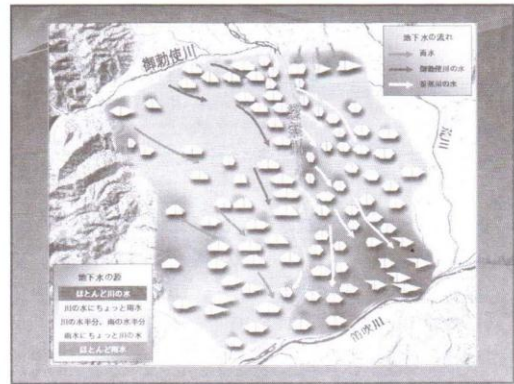
Light Rain (Low elevation) → High  $^{16}O/^{18}O$  and  $^2H/^1H$

Heavy Rain (High elevation) → Low  $^{16}O/^{18}O$  and  $^2H/^1H$

山や $^2H$ 、 $^{18}O$ がどのくらい蓄まれているか?



Measured stable isotope ratio in Fofu alluvial fan



**Groundwater in Kathmandu Valle**

Evaluation of Groundwater Quality and Recharge Characteristics in Kathmandu Valley, Nepal

Saroj Kumar CHAPAGAIN  
PhD thesis defense  
August 03, 2009

YG004  
ICRE

The preliminary study of deep groundwater recharge systems in Kathmandu Valley, Nepal

Takashi Nakamura, Sangam Shrestha, and Futoshi Kazama  
Department of Eco-soc'el System Engineering, University of Yamaguchi  
(4-7-10 Takada, Kofu, Yamaguchi, JAPAN)

**Sampling**

Collection of sample

- Major GW extraction area
- Deep well (n= 42)>80m
- Shallow well (n=13)<20m
- River (n=8), Rainfall
- Pre monsoon (April), monsoon (Aug), 2007

Fig. Details of sampling location

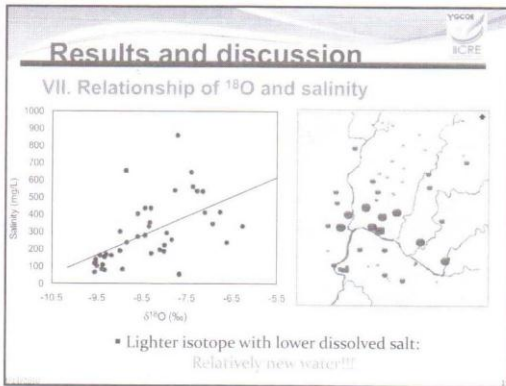
**Analysis**

Physicochemical analysis

In-situ analysis: pH, EC, ORP, WT, Salinity  
Laboratory analysis:

- Organic/inorganic carbon (DOC and IC) → ✓ Deep GW quality
- Heavy metals (Cu, Cd, Zn, Cr, Pb, Fe, Mn)
- Arsenic (total and dissolved form)
- Basic cation (Na<sup>+</sup>, K<sup>+</sup>, Ca<sup>2+</sup>, Mg<sup>2+</sup>, NH<sub>4</sub><sup>+</sup>-N) and anion (SO<sub>4</sub><sup>2-</sup>, Cl<sup>-</sup>, PO<sub>4</sub><sup>3-</sup>-P, NO<sub>3</sub><sup>-</sup>-N, HCO<sub>3</sub><sup>-</sup>) → ✓ GW type
- Stable isotope (D and <sup>18</sup>O)
- Tritium (<sup>3</sup>H) → ✓ GW recharge

ICRE



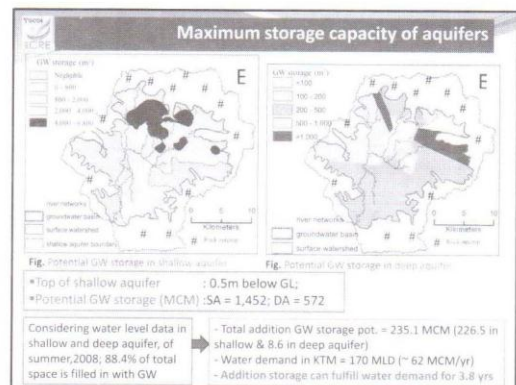
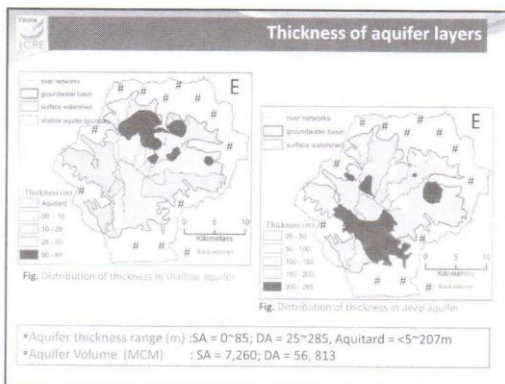
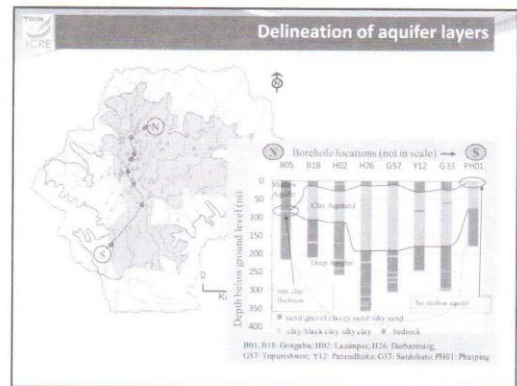
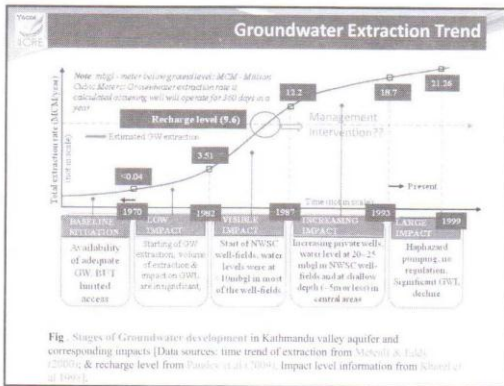
## Assessment of Groundwater Resources in Bagmati River Basin, Nepal

**YGCOE**  
ICRE

Vishnu P. PANDEY (G07DEA03)

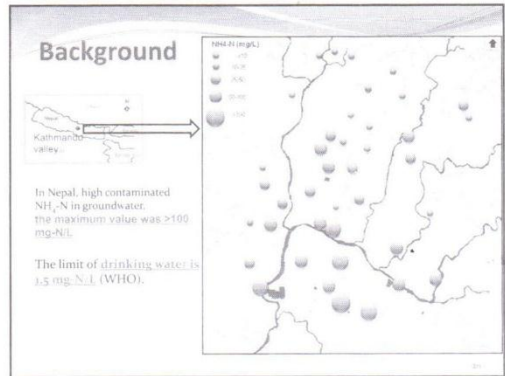
Supervisor: Prof. Futaba KAZAMA  
Department of Eco-Social System Engineering,  
Interdisciplinary Graduate School of Medicine and Engineering,  
University of Tokushima, Japan

December 21, 2009  
Lab Meeting (Kazama Lab)



# Trial of Groundwater Treatment in Kathmandu

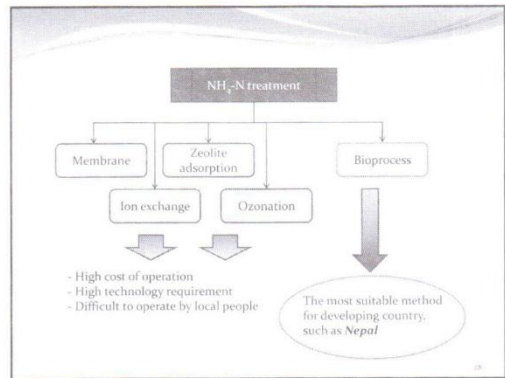
## -Ammonia removal-



Groundwater is used directly without any treatment

Groundwater treatment system by sand filtration and chlorination

On-site groundwater quality analysis



### Background

- Simultaneous nitrification and denitrification (SND) is "the two microbial reactions occur at the same time in the same reactor".
- Potential of SND system are (1) eliminate the need for separate tanks required in conventional  $\text{NH}_4\text{-N}$  treatment, and (2) saving space and time.

Phase III	$\text{NH}_4\text{-N}$	$\text{NO}_2\text{-N}$	$\text{NO}_3\text{-N}$	P	COD
Raw groundwater	10	-	1.7-2.9	<0.05	5-7
After sand filtration	7-8	-	5.3-7.5	<0.05	5-7
After bioreactor	2	-	9-13	<0.05	5-7
After charcoal	0.3-1.4	-	13	<0.05	4-5

**Problem**

- Unstable in flow rate (controlled flow rate 216 L/d)

## Summery

- To improve the sustainable water use at a river basin, we need to design a water management system based on scientific knowledge.
- For estimation of recharge area of groundwater, stable isotope technique is strong tool.
- We want to continue this work for better groundwater management in Kathmonadu with Local researchers and students.



Thank you for your attention!

## Potential for Shallow Groundwater Recharge from Rainwater in Kathmandu Valley under the perceived impacts of climate change

Presented by

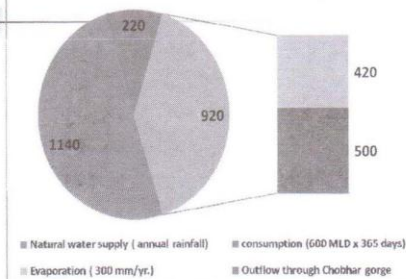
Suresh das Shrestha, D.Sc.

On behalf of  
Urban Environment Management Service (UEMS)

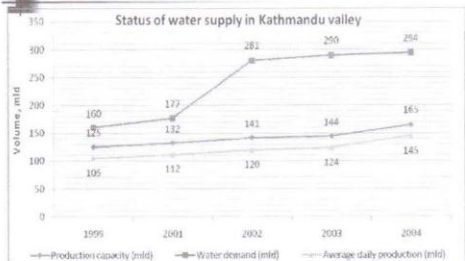
## Groundwater use in Kathmandu Valley

- Since ancient times .
- In the past- Shallow Groundwater: use through dug wells and *dhunge dharas* (stone spouts)
- At present-
  - Shallow groundwater- dug wells, *dhunge dharas*, borings, tower pumps etc.
  - Deep groundwater: Since 80's- through deep wells- mostly over 200m.
  - Approx. 700 deep wells drilled so far- through consultations.
  - Present study- 379 deep wells- no information on other wells.

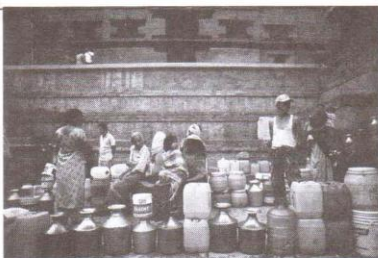
Gross estimate of water availability and use (in mcm)



## Water supply status- NWSC, 2004



The deficit in supply has forced people to alternative sources- shallow GW



Are we going to allow this forever?



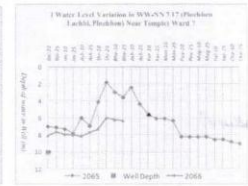
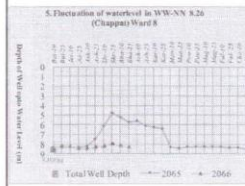
### Shallow groundwater status:

- Most of the dharas in the valley- dry up after rainy days
- Water table in dug wells fall rapidly after the rainy days.

Primarily due to:

- Growth in population- Growth in water demand
- Decrease in recharge

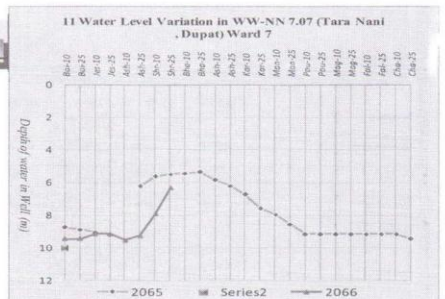
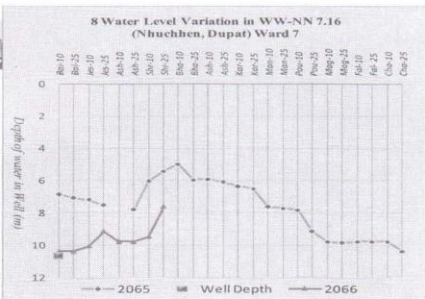
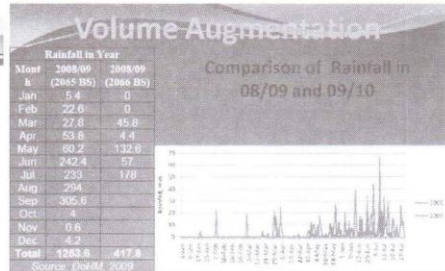
### Rapid fall in water table after rainy season

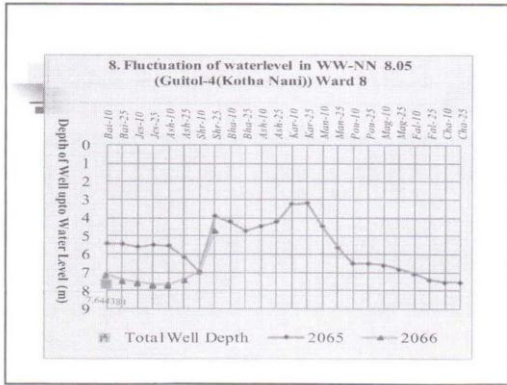


### Perceived impacts from Global climate change

Global Climate changes taking place is expected to result in

- Erratic rainfall pattern
- Increase in extreme conditions- extended dry period to spurts of intense rainfall. these are already being observed:





### Mitigation and adaptation measures

Necessary actions needed to be taken towards

- Regulating haphazard urban growth
- Promotion of eco friendly urban measures
- Formulation of effective and workable policy for water resources.

### Regulating the urban growth:

Population growth prediction in 1994

Area	1991	% growth rate	2001	% growth rate	2011	% growth rate	2021
Municipal	598,528	5.0	975,000	-4.0	1,446,000	-2.0	1,759,000
Rural	466,371	2.0	571,000	-1.2	506,000	-2.0	414,000
Total Valley	1,064,899	3.8	1,546,000	2.3	1,949,000	1.1	2,173,000

Source: GOV, 1994

### Household increase from 1971-2001

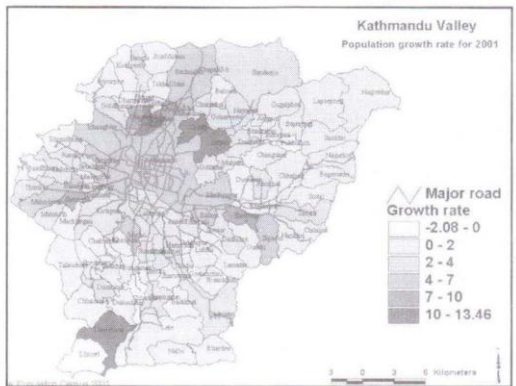
Table 6.15: Number of household from 1971-2001

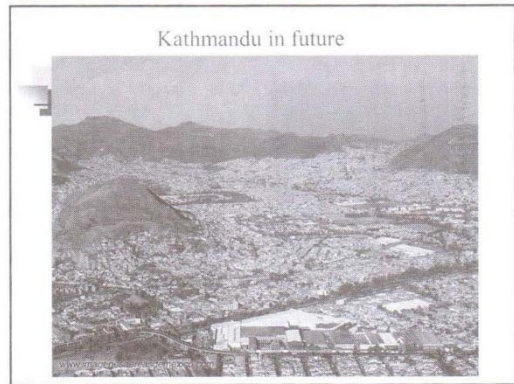
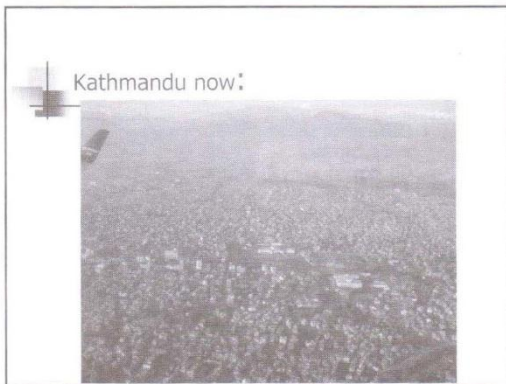
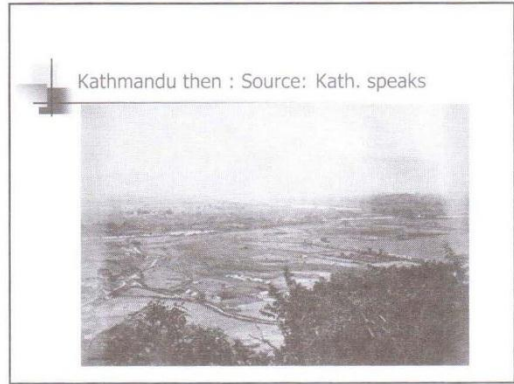
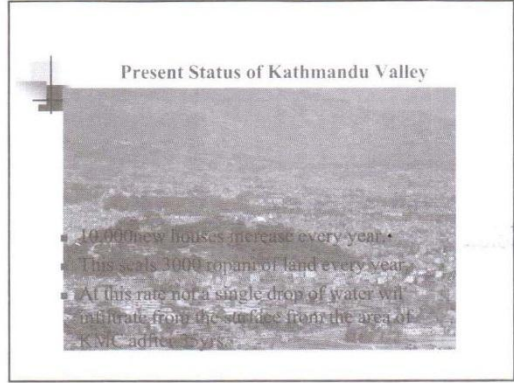
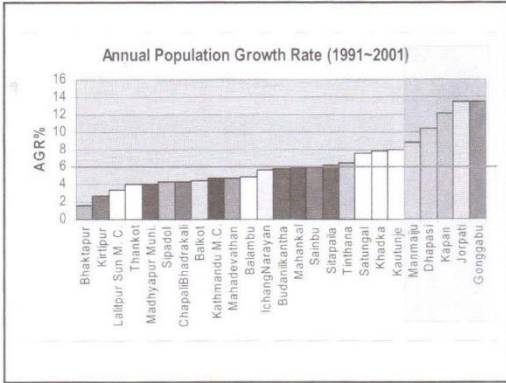
Year	1971	1981	1991	2001
Kathmandu	59,507	67,933	127,196	235,387
Lalitpur	26,578	29,943	45,682	68,922
Bhaktapur	18,908	25,047	28,160	41,253
<b>Kathmandu Valley</b>	<b>104,993</b>	<b>122,923</b>	<b>201,038</b>	<b>345,562</b>

Source: Urban Growth and its Impact on the Livelihoods of Kathmandu Valley, Nepal Prayok Pradhan and Ranjith Perera February 2005 UMP Asia Occasional Paper No. 63

### Builtup area in Kathmandu Valley(hectars)

District	1955	1978	1991	2000
Kathmandu	2,363	3,990	6,185	9,913
Lalitpur	729	1,198	1,674	2,860
Bhaktapur	238	965	1,058	3,699
<b>Total</b>	<b>3,330</b>	<b>6,152</b>	<b>8,917</b>	<b>16,472</b>

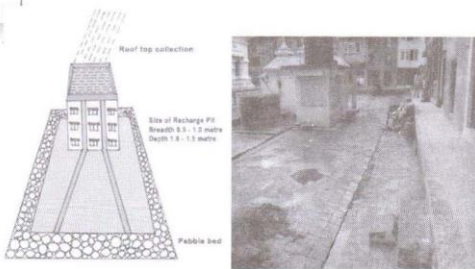




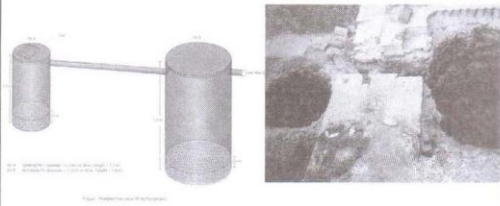
Promoting eco friendly urban developments-  
RWH and RWR



Rainwater recharge



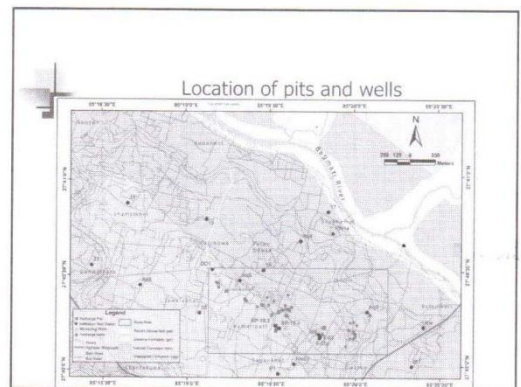
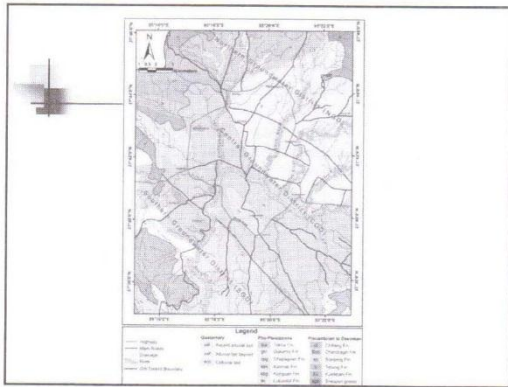
Recharge pits



Rainwater Harvesting in KTM Valley

- Depends on Surface and subsurface Geology.
- General rule being: surface recharge is possible in places where there are dug wells and Dhunge dharas.





### Water quality analysis

Ward	Total Wells	Iron (Fe - mg/lit)								
		Pre Monsoon			Start of Monsoon			Monsoon		
		<0.3	0.3 - 3	>3	<0.3	0.3 - 3	>3	<0.3	0.3 - 3	>3
7	10	3	1	6	3	4	3	10	0	0
8	11	0	4	6	3	7	1	6	4	1
18	14	5	5	2	9	5	0	7	7	0
19	5	2	3	0	3	2	0	3	2	0
20	8	4	3	1	5	3	0	5	1	2
<b>Total</b>	<b>48</b>	<b>14</b>	<b>16</b>	<b>15</b>	<b>23</b>	<b>21</b>	<b>4</b>	<b>31</b>	<b>14</b>	<b>3</b>
<b>Percent</b>	<b>100</b>	<b>29.17</b>	<b>33.33</b>	<b>31.28</b>	<b>47.92</b>	<b>43.75</b>	<b>8.33</b>	<b>64.58</b>	<b>29.17</b>	<b>6.25</b>

### Water quality

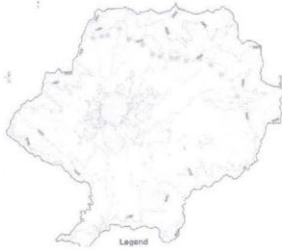
Ward	Total Wells	EC (µS/cm)								
		Pre Monsoon			Start of Monsoon			Monsoon		
		<500	500 - 1500	>1500	<500	500 - 1500	>1500	<500	500 - 1500	>1500
7	10	1	9	0	1	9	0	0	9	1
8	11	0	8	2	1	9	1	0	10	1
18	14	2	10	0	7	7	0	8	6	0
19	5	0	5	0	1	4	0	2	3	0
20	8	1	7	0	2	6	0	1	7	0
<b>Total</b>	<b>48</b>	<b>4</b>	<b>39</b>	<b>2</b>	<b>12</b>	<b>35</b>	<b>1</b>	<b>11</b>	<b>35</b>	<b>2</b>
<b>Percent</b>	<b>100</b>	<b>8.33</b>	<b>81.25</b>	<b>4.17</b>	<b>25.00</b>	<b>72.92</b>	<b>2.08</b>	<b>22.92</b>	<b>72.92</b>	<b>4.17</b>

Ward	Total Wells	Nitrate (NO <sub>3</sub> - mg/lit)					
		Pre Monsoon		Start of Monsoon		Monsoon	
		50 mg/lit	>50 mg/lit	50 mg/lit	>50 mg/lit	50 mg/lit	>50 mg/lit
7	10	5	5	9	1	10	0
8	11	6	4	9	2	11	0
18	14	7	5	11	3	14	0
19	5	0	5	4	1	5	0
20	8	8	0	7	1	8	0
<b>Total</b>	<b>48</b>	<b>26</b>	<b>19</b>	<b>40</b>	<b>8</b>	<b>48</b>	<b>0</b>
<b>Percent</b>	<b>100</b>	<b>54.17</b>	<b>39.58</b>	<b>83.33</b>	<b>16.67</b>	<b>100.00</b>	<b>0.00</b>

### Alternative measures

- Explore hard rock aquifers in the south of the valley- partly exploited at present by the pvt. Tankers.
  - Nounmule, bosan khola, satmule, springs total-500 L/s
- Amec,2001-Installation of infiltration dams in the recharge areas in the north.
- Rehabilitate - identified infiltration ponds, Rain water harvesting

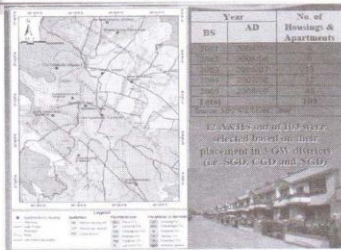
### Potential locations for infiltration dams

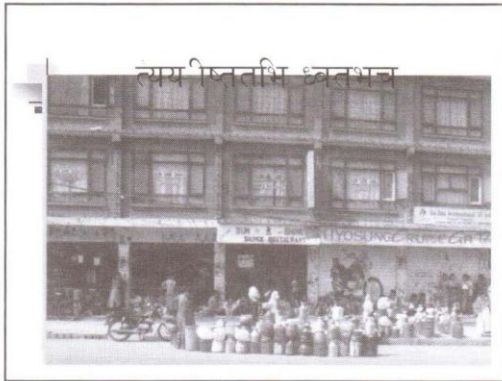


### Formulation of effective water resource policy

- Access to clean water is the basic right of every citizen, however commercial exploitation by some individuals may deprive many from exercising this right.

### Rise in commercial apartments





### Groundwater Recharge and Safe Yield

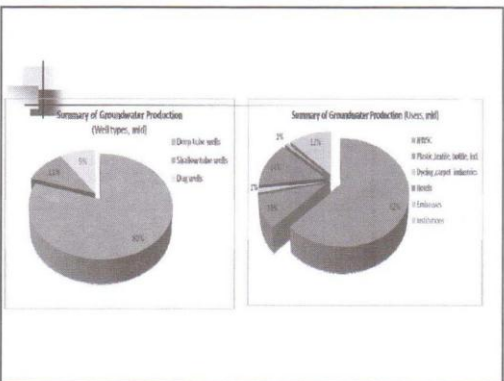
- Binnie and partners (1989) – 30-40MLD (MPPW-2002)
- JICA (1990)- 15MLD
- Gautam and Rao (1991) – 12.6MLD

St. Id.	Location	Geol.	Geomorp.	Infiltration Rate (cm/min)			Remarks
				Pre-monsoon	Monsoon	Post-monsoon	
<b>Lalitpur Submetropolis</b>							
18	Jhamsikhel	cpq	Terraces	1.5	1.144	1.236	H
19	Purna Chandi, Gabhal	kimf	Terraces	1.486	1.2	0.9	H
20	Jawlokhet	cpq	Terraces	1.013	1.018	1.114	H
16	Pulchowki	kimf	Slope	0.713	0.344	1.117	M-H
P1	Lagankhet	cpq	Terraces	0.497	0.755	0.627	M-H
15	Sonecpa	kim	Low Land	0.635	0.011	0.127	L-M
21	Dihobighat	kimf	Low Land	0.469	0.056	0.18	L-M
22	Mhamkata	kim	Terraces	0.018	0.007	0.14	L-M
17	Sankhatal	kim	Low Land	0.616	0.017	0.021	L-M

St. Id.	Location	Geol.	Geomorp.	Infiltration Rate (cm/min)			Remarks
				Pre-monsoon	Monsoon	Post-monsoon	
<b>KTM Metropolis</b>							
23	Bahokata	gkr	Terraces	1.419	0.625	1.734	H
24	Nara Baneskhori	gkr	Terraces	1.7	1.76	0.932	H
2	Fansidham	gkr	Slope	0.581	0.034	0.561	M-H
4	Kalkasidham	gkr	Terraces	0.122	1.062	0.203	M-H
5	Old Baneskhori	gkr	Terraces	0.64	1.592	0.257	M-H
8	Gamsala	gkr	Terraces	1.375	0.765	0.33	M-H
13	Timkase	gkr	Slope	1	0.726	0.325	M-H
24	Sama Bharingga	kim	Low Land	0.719	0.088	0.594	M-H
33	Fadara Bhabhuresi	gkr	Terraces	0.27	0.176	0.835	M-H
3	Bhagwati Bahal, Naxal	gkr	Terraces	0.423	0.455	0.313	M
04	Tokha Road	gkr	Low Land	0.225	0.087	0.364	M
9	Bansa Tole, Boudha	gkr	Low Land	0.242	0.091	0.044	L-M
6	Shyamnagar	kim	Terraces	0.052	0.013	0.054	L
11	Kulandi	kim		0.086	0	0.15	L-M
71	Amokhel	gkr	Slope	0.145	0.058	0.207	L-M
14	East Chowk height	kim	Terraces	0.025	0.009	0.571	L-M
P5	Babar Mahal	kim	Low Land	0.1	0.019	0.12	L-M
7	Keshavnagar	kim	Terraces	0.625	0.1	0.34	L-M
10	Bansil	kim	Low Land	0.819	2.034	0.043	L-M

### Groundwater abstraction

- Stanley Int. (1994)- GW abstraction BY NWSC-54MLD (91.6% from deep wells)
- Optimizing water use project-2004- NWSC – abstraction as 47MLD and 13MLD from other sources-totalling 60MLD of GW abstraction.
- KUKL (2009)- total GW abstraction from 49 operating wells-23.5MLD
- Total water demand (2004) -294 MLD, Max. daily KUKL Production-145 MLD



Station Id. No.	Location	Site morphology	Percolation rate (cm/min)
16	Lagsukhel	Terraces	0.5
20	Kamal Bhusyal, Bhaktapur	Terraces	0.01
6	Habar Mahal	Low land	0.1
5	Dhapasi height	Terraces	0.2
4	Sarakhusi	Low land	1.6

Station Id. No.	Location	Site morphology	Percolation rate (cm/min)
w1	Thumel		0.49
w2	Chabahil		0.22
w3	Dhumburahi	Terraces	0.33
w4	Swarambhu	Slope	
w5	Dalla		
w6	Khustbu	Lowland	0.34
w7	Gwarko	Lowland	0.30
w8	Sundhara, Patan	Slope	0.06
w9	Bhainsapati	Slope	0.53
w10	Dhoka Tole	Terraces	0.06
w11	Banasthali	Terraces	0.58
w12	Yangal		0.06

Station ID. No.	Location	SITE MORPHO	Percolation Rate (cm/min)
6	Mimbharwan	slope	0.033
11	Kalanki, Lampati	Slope	0.055
12	South of Creative Academy School, Kirtipur, Nagau	Slope	1.89
17	Pulchowki Behind UN- building)	Slope	0.6
31	back side of Nepal Medical College, Attarhel	Slope	0.14
20	Jawalhel, Ekanta Kuna	slope	1.11
32	TU, Infront of Girl's Hostel	Slope	6.34
2	Backside of Le-Restaurant, Garadhara	Slope	0.39

Estimation of water availability and use:

Natural water supply ( annual rainfall)		1.14 billion m <sup>3</sup>
consumption (600 MLD x 365 days)	220 million m <sup>3</sup>	
Evaporation (300 mm/yr.)	420 million m <sup>3</sup>	
Outflow through Chobhar gorge	500 million m <sup>3</sup>	1.14 billion m <sup>3</sup>
Balance		0

*water optimization and pilot project, 2001*

### Summary of groundwater production- Melamchi dev. board, 2000

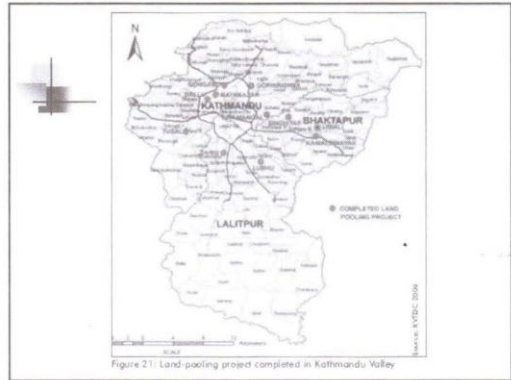
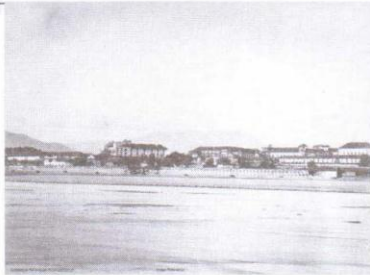
User	Deep tube wells MLD	Shallow tube wells MLD	Dug wells MLD	Total MLD	Percent of Total
NWSC	23.8	2.05	3.31	29.17	63
Plastic ,textile, bottle, Ind.	2.47	1.30	0.71	4.46	10%
Dyeing ,carpet industries	0.07	0.32	0.19	0.58	1%
Hotels	5.51	0.90	0.12	6.53	14%
Embassies	0.43	0.00	0.00	0.43	1%
Institutions	5.23	0.41	0.03	5.67	12%
Total from wells	37.51	4.99	4.36	46.86	100%
estimate from springs				1300	
Total groundwater supply				59.86	

### Impact of Groundwater Mining

- Declining GW table observed.
- Land subsidence- none reported so far.
- Areas prone to Land subsidence-
  - Highest WL (water level) decline
  - Areas with high % of compressible clay and silt layers- Metcalf and eddy, 1999)

All three GD are prone to land subsidence.

Thapathali (Source\_ Cap C. Taylor, 1862-1865)

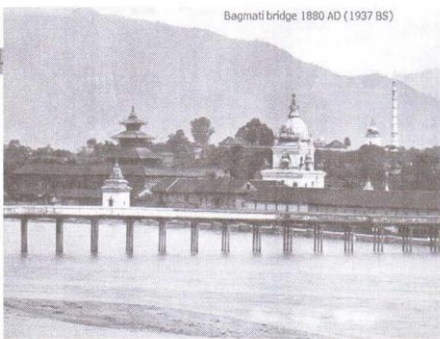



- KUKL alone abstracts 63% of the total groundwater abstraction from certain cluster areas.
- No indication of land subsidence yet, no studies have been initiated so far.
- High population growth in Gongabu, Kapan, Jorpati, Dhapasi area-all identified as groundwater recharge areas have increased surface sealing thus decreasing infiltration further while increasing the extraction.

#### Expected input from the floor:

- While monitoring groundwater use and abstraction is necessary for future planning, how effective will be regulating GW in the absence of other alternatives.
- For effective GW management - licensing, regulating and monitoring by one body is required. Could GWRDB be an effective organization to do it?
- GW mining for commercial purpose-should it be allowed? eg. Mineral water, soft drinks, beer etc.
- Ultimate cause for groundwater mining is the haphazard urbanization, what measures is required to regulate it?
- Investigations for alternative options of water sources – RWH, hard rock aquifers etc.

Bagmati bridge 1890 AD (1937 BS)

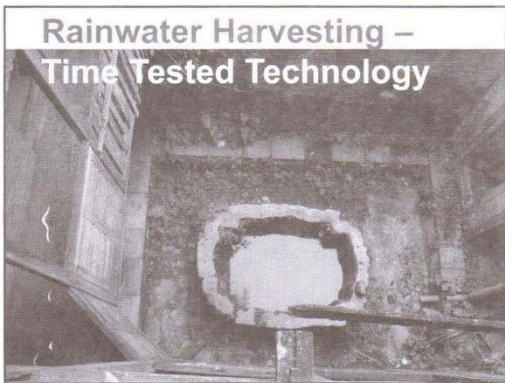
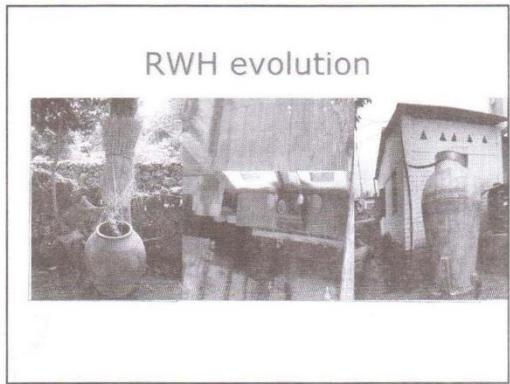
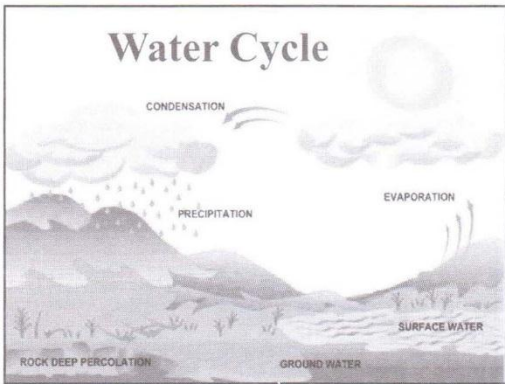


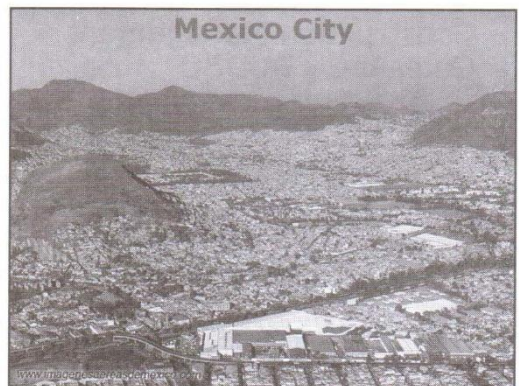
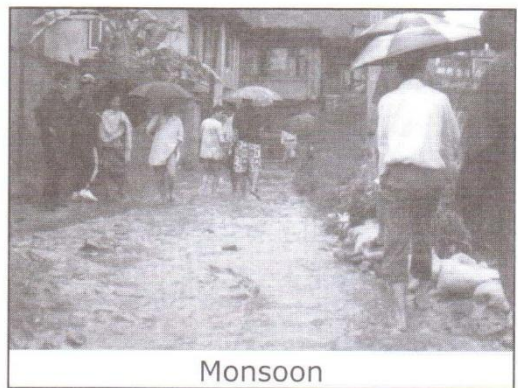
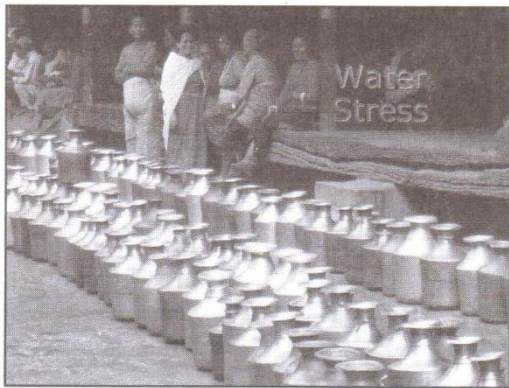


Policy  
framework  
for Rainwater  
Harvesting in  
Urban Nepal

Prakash Amatya

National Steering  
Committee on Rainwater  
Harvesting







Nepal hosted SAARC level Regional High-level Meeting on Rainwater Harvesting and passed the 9 point resolution.



## Working Policy on Rainwater Harvesting 2009

### Goal

- to contribute to the protection of the environment,
- to bring about positive changes in the quality of life and
- to strengthen the socioeconomic development through the collection, storage and use of rainwater as a complementary source of supply to benefit areas inhabited particularly by the poor, marginalized and disadvantaged groups, which do not have access to the basic water supply and
- to minimize the scarcity of supply in urban areas,
- to provide a replacement to arsenic-contaminated groundwater sources and to recharge the groundwater reserve.

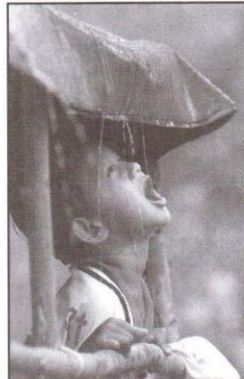
### Objective

- To adopt rainwater as a reliable source for domestic water supply by practicing appropriate technologies for its collection, storage and use.
- To promote necessary construction of facilities, collection, storage, treatment and use of rainwater at domestic level by enhancing public awareness of rainwater as an appropriate complementary resource.
- To develop a system of rainwater harvesting to meet the need of settlements, schools, public institutions and communal places located in high lands or other areas where other alternative resources are not easily available.
- To maintain the environmental balance through the protection of the environment by facilitating the recharge process of groundwater reserve.

### Working Policy

1. Mutual support and coordination shall be established with governmental and nongovernmental agencies in relation to the development of technology for rainwater harvesting.
2. Public-Private-Partnership (PPP) shall be promoted for the development and implementation of rainwater technology.
3. Public awareness shall be enhanced vis-à-vis the collection, storage and use of rainwater, together with the development of appropriate methods for rainwater harvesting at local level.
4. In order to promote the use of rainwater harvesting technology in the construction of houses in urban and rural areas, institutional guidelines/directives shall be prepared and enforced, and other necessary provisions shall be stipulated in the Building Codes. Special provisions shall be defined to use this technology in housing projects, buildings, apartments and land development programmes as well in the construction of communal and industrial buildings.

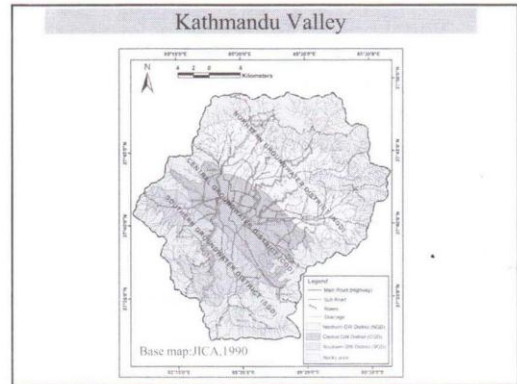
5. This technology shall be utilized for groundwater recharge and to increase the water availability at water sources, stone spouts and ponds
6. Rainwater harvesting technology shall be used to provide water to areas located on high lands/communal places where there is scarcity of other water sources.
7. Use of arsenic-contaminated water shall be discouraged at institutional level by developing rainwater harvesting technology.
8. A guideline shall be developed through the Department of Water Supply and Sewerage for the adoption of appropriate technology for rainwater collection, storage, treatment and utilization at household and community level.
9. The capacity of NGOs local bodies and communities shall be enhanced,



**FREE**  
**Rain**  
**delivery**  
**service to**  
**your**  
**home**

## Status of Groundwater Condition in Kathmandu Valley and its Potential Impacts

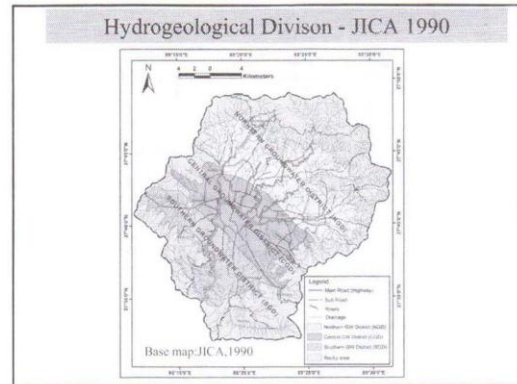
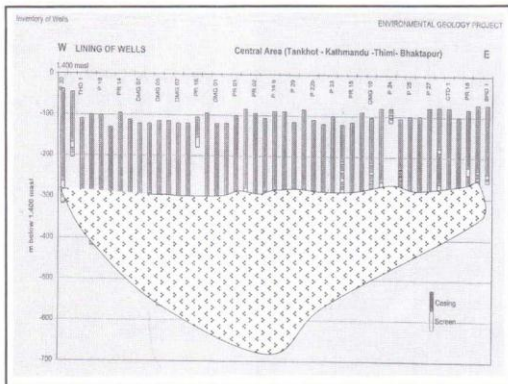
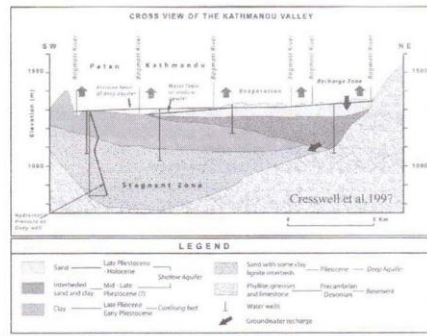
Naba Raj Shrestha  
Senior Divisional Hydrogeologist  
Department of Irrigation  
28<sup>th</sup> December, 2009



### Study Programmes

- 1960 Geological survey of India: Ground water Resources of Kathmandu Valley
- 1973 WHO/UNDP/ Binnie & Partner: Master Plan for Water Supply & Sewerage for Greater Kathmandu & Bhaktapur
- 1990 JICA: Ground water Management Project in
- 1992 NWSC/CES: Urban Water Supply & Sanitation Rehabilitation Project
- 1994 DMG/BGR: Engineering & Environmental Geology
- 1996 DMG/Silt Consult: Detailed Feasibility Study on Kathmandu Natural Gas
- 1997 AGSO/DO: Assessment of Ground water Pollution
- Others (Optimization of Groundwater , Melamchi Project, ICIMOD, AMEC etc.)

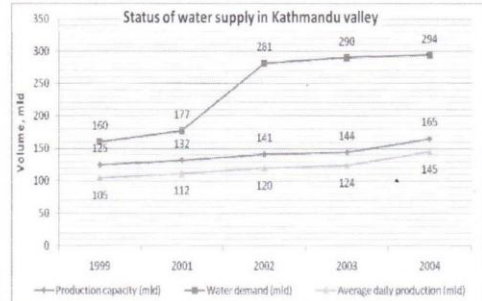
### Hydrogeological cross-section of Kathmandu Valley



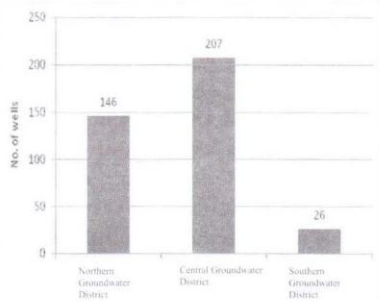
### Groundwater use in Kathmandu Valley

- Phase I: Ancient times – 1960 No impact  
*Dug wells and stone spouts (dhunge dharas)*
- Phase II: 1961 to 1973 Initial Investigation  
No impact, Investigation deep tube wells
- Phase III: 1974 to 1983 Insignificant impact  
Few production deep tube wells
- Phase IV: 1984 to 1990 Visible impact  
NWSC developed well fields. Private tube wells also increases
- Phase V: 1990 to 2000 increasing impact  
More NWSC & private tube wells
- Phase VI: 2000 onwards sharp increase in impact  
NWSC & private tube wells increased sharply

### Water supply status - NWSC, 2004



### Deep Tube Well Distribution



### Deep Wells in Central Groundwater District



### Summary of groundwater production Melamchi DB, 2000

User	Deep tube wells MLD	Shallow tube wells MLD	Dug wells MLD	Total MLD	Percent of Total
NWSC	23.8	2.05	3.31	29.17	63
Plastic ,textile, bottle, Ind.	2.47	1.30	0.71	4.46	10%
Dyeing ,carpet industries	0.07	0.32	0.19	0.58	1%
Hotels	5.51	0.90	0.12	6.53	14%
Embassies	0.43	0.00	0.00	0.43	1%
Institutions	5.23	0.41	0.03	5.67	12%
Total from wells	37.51	4.99	4.36	46.86	100%
estimate from springs				1300	
Total groundwater supply				59.86	

- Total water demand (2004) -294 MLD,
- Maximum daily KUKL Production-145 MLD

### Groundwater Recharge

- Binnie and partners (1989) & MPPW-2002- 30 – 40 MLD
- JICA (1990)- 15 MLD
- Gautam and Rao (1991) – 12.6 MLD
- (Maximum Recharge 40 MLD but Extraction is 60 MLD, giving daily overdraft of about 20 MLD )

## Population growth in KTM Valley

Population growth prediction in 1994

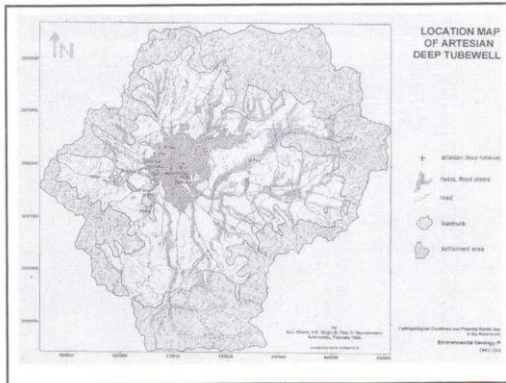
Area	1991	% growth		2011		% growth	
		rate	rate	rate	rate	rate	rate
Municipal	598,528	5.0	975,000	4.0	1,446,000	2.0	1,759,000
Rural	466,371	2.0	571,000	-1.2	506,000	-2.0	414,000
Total Valley	1,064,899	3.8	1,546,000	2.3	1,949,000	1.1	2,173,000

Source: GOV, 1994

## Household increase from 1971-2001

Year Location	1971	1981	1991	2001
Kathmandu	59,507	67,933	127,196	235,387
Lalitpur	26,578	29,943	45,682	68,922
Bhaktapur	18,908	25,047	28,160	41,253
<b>Kathmandu Valley</b>	<b>104,993</b>	<b>122,923</b>	<b>201,038</b>	<b>345,562</b>

Source: Urban Growth and Its Impact on Livelihood on the Kathmandu Valley  
Pravakar Pradhan and Ranjit Parera, February 2005 UMP - Asia Occasional Paper No. 63



## Static Water Level - Fluctuations & its impact

- Water Table has fallen down in Manohara, Gokarna, Bansbari and Bhaktapur wells
- Water table unchanged since '84 in Duwakot, Phutung, Danchi & Dhobi Khola
- NGD - Average decline 1.7m/year
- CGD - Average decline-1.5m/year
- SGD - Average decline 0.3m/year
- **Possible impact is the land subsidence**

## Water level decline & Land subsidence

- Lucknow: groundwater level is declining by an average of 73 cm per year
- Six lakh litres of groundwater extraction daily
- There is threat of massive land subsidence in next 15 years
- Bangkok: facing serious problems of land subsidence due to over-exploitation of groundwater
- Land subsidence has reached almost 2 m at some places (KÜHN Friedrich et al)
- Land subsidence cases observed in many mega cities & will be in Kathmandu as well !!!!

## Age of Ground Water

- 9,000 to 29,000 year (JICA, 1990)
- 200,000 year (Australian Geological Survey Organization, 1997)
- Mining of ground water

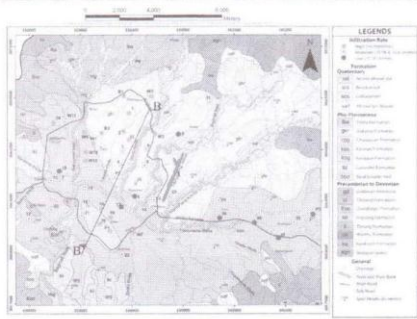
### Groundwater recharge

- Rain Water Harvesting
- Infiltration Dams
- Artificial recharge

### Potential locations for infiltration dams



### Fluvial and lacustrine sediments in Kathmandu Valley

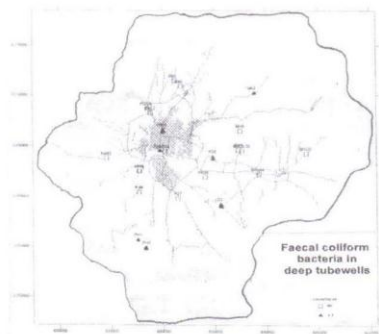


### Groundwater Pollution n Kathmandu Valley

Presence of Coliform					
WHO, 1972		JICA, 1990		AGSO, 1995	
Location	Depth	Location	Depth	Location	Depth
Lagan		GK 3		New Road	
Bir H	274	BB 6		Tripuresor	
Bode	135	BB 8		Balaju	
Okalgaon	56.4	Pepsi cola		Balaju	
Bansbari	112	Everest		Tripuresor	
Sundarjal	167	Sheraton		Balaju	
				Balaju	

### Groundwater Pollution

Presence of Coliform				Presence of Arsenic	
EGP 1997		Melamchi P, 2000		NWSC, 2004	
Location	Depth	Location	Depth	Location	Depth
Tripuresor		Herb P	230	Anam nagar	
BHD 5		Teku H	300	Lagan	
Gokarna		Balaju	153	Tripureswor	
Imadol		Bansbari	238	Sipradi	
Lubhu		Gongabun	100	Kuleswor	
Pepsi C		"	234		
Pharping					
Anapurna H					



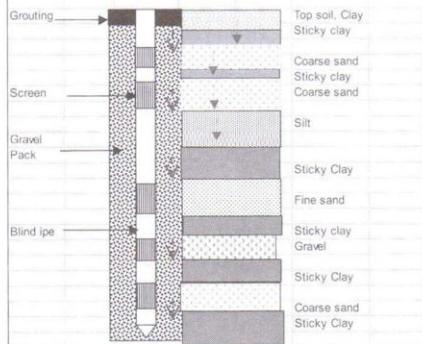
### Ground Water Pollution cases

- Apache Nitrogen Products (ANP) began operations near St. David, Arizona since 1922 manufacturing industrial chemicals and explosives
- ANP Inc. agrees to \$5 million groundwater and soil cleanup work at its production Site
- Union Carbide (pesticide) Factory has been contaminating land and water of Bhopal for more than 25 years
- Groundwater in areas even three km away from the factory contains almost 40 times more pesticides than Indian standards.
- No such serious case reported in Kathmandu Valley

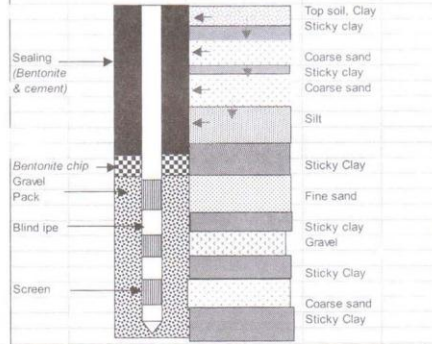
### Tube Well Construction

- The process of "well development" is critical to optimizing well performance, yet too often it is not given proper priority in the overall well construction, Said Mike H. Mehmert, director of sales and marketing Johnson Screens, Weatherford company

Schematic Diagram of Well Design in normal practice



Schematic Diagram of proposed Well Design



Details of Grouting/Sealing of Deep tubewells

Tubewell Location	Total Dpth	Drilling Company	Grouting Depth	Depth to First Screen	Remarks
Kalanki	160	NISSAKU	48	123	Cement
Yak & Yeti H	292	"	30	190	"
Shankar H	260	"	30	203	"
Scaltee H	312	"	30	216	"
Parasi	80	"	73	75	Cement
TI Airport	225	NADCO	133	183	Clay Chips 0-55m Cement
Nursing C.	75	"	15	49	55-133 Clay balls Cement

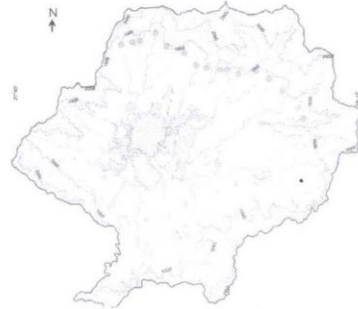
### What next to do?

1. Effective use of water
  - Personal Habit
  - Bottled water, other industries
2. Recharge
  - Identification and protection of recharge area
  - Rain water harvesting
  - Infiltration dams
  - Artificial Recharge
3. Regular Monitoring
  - Groundwater table
  - Groundwater Quality
  - Land subsidence
4. Explore for other water sources
  - Hard rock aquifers
  - Karst aquifers
5. Full fledge Institution for investigation, monitoring, licensing and regulating groundwater
6. National guidelines for well construction and completion
7. Act, Policy, rules & regulations about all aspects of Groundwater resource

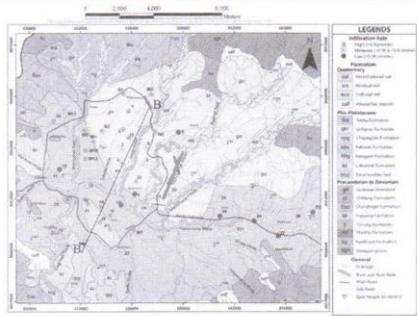
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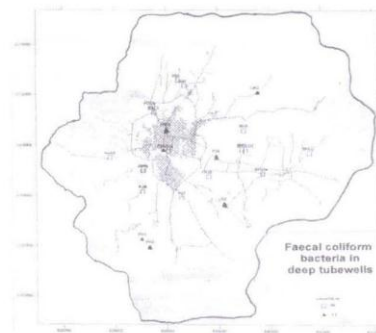




### Groundwater Pollution in Kathmandu Valley

Presence of Coliform					
WHO, 1972		JICA, 1990		AGSO, 1995	
Location	Depth	Location	Depth	Location	Depth
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Okalgaon	56.4	Pepsi cola		Balaju	
Bansbari	112	Everest		Tripuresor	
Sundarijal	167	Sheraton		Balaju	
				Balaju	

### Groundwater Pollution

Presence of Coliform				Presence of Arsenic	
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BHD 5		Teku H	300	Lagan	
Gokarna		Balaju	153	Tripureswor	
Imadol		Bansbari	238	Sipradi	
Lubhu		Gongabun	100	Kuleswor	
Pepsi C		"	234		
Pharping					
Anapurna H					



## Concluding Remarks

**National Symposium on  
Challenges and Opportunities for  
Sustainable Management of Groundwater  
Resources of the Kathmandu Valley, Nepal**

Monday, 28th December 2009, Kathmandu, Nepal

CREEW & SEN

National Symposium on  
Challenges and Opportunities for Sustainable Management of  
Groundwater Resources of the Kathmandu Valley, Nepal

Monday, 28th December 2009, Kathmandu, Nepal

Jointly Organized by:


- Center of Research for Environment Energy and Water (CREEW)
- The Small Earth Nepal (SEN)

Parallel Program:  
Exhibition and prize distribution of **Nationwide Open Photography Competition** on the theme **"Groundwater: today's matter, manage it sustainably for better future"**

National Symposium on  
Challenges and Opportunities for Sustainable Management of  
Groundwater Resources of the Kathmandu Valley, Nepal

Objectives:

- To identify quantitative, qualitative and legislative issues of groundwater use in the Kathmandu Valley
- To identify remedial measures to improve quality of groundwater in the Valley
- To identify groundwater recharge potential and prospects of artificial recharge in the Valley
- To raise awareness on significance of groundwater and its current status in the Valley




National Symposium on  
Challenges and Opportunities for Sustainable Management of  
Groundwater Resources of the Kathmandu Valley, Nepal

Opening Session

Prize Distribution to the Winners of the  
Nationwide Open Photography Competition

First:	Mr. Subhadin Gautam
Second:	Mr. Sisan Baniya
Third:	Mr. Darpan Adhikari
Consolations:	Mr. Prajwal Bhattacharai and Mr. Milan Budathoki

Prize and Certificate distributed by:  
Prof. Futaba Kazama,  
Dr. Roshan Shrestha,  
Dr. Sangam Shrestha  
Mr. Sharad Rai



National Symposium on  
Challenges and Opportunities for Sustainable  
Management of Groundwater Resources of the Kathmandu  
Valley, Nepal

Opening Session (Keynote  
Speeches)

**Dr. Roshan Raj Shrestha**  
"Rainwater harvesting for groundwater recharge in the Kathmandu Valley"

**Dr. Sangam Shrestha**  
Groundwater and climate change: No longer the hidden resource




### Keynote Speeches

#### Dr. Roshan R. Shrestha

- High extraction of deep and shallow groundwater extraction
- Arsenic and ammonia contamination is very high
- Only small area (10%) is sufficient to increase the groundwater table in the Valley
- Focused on challenge about the storing rainwater harvesting
- Need to identify recharge zone, need to monitor groundwater quality and quantity along with research development

## Keynote Speeches

Dr. Sangam Shrestha

- Degradation of groundwater quality by sea level raise.
- Focused about the adaptation strategies to manage groundwater.
- Need to promote water harvesting technologies since climate change will add to existing pressure on groundwater resources.

## Technical Session 1

Chairs: Dr. Khada Nanda Dulal and Mr. Jagadishwor Karmacharya

- Dr. Saroj K. Chapagain (University of Yamanashi, Japan): Groundwater quality
- Ms. Pramita Maharjan (NGO Forum): Enumerator, mapping and water quality analysis of traditional stone spouts in Kathmandu Metropolitan Area
- Mr. Basanta Adhikari (Pro-Public, Nepal): Regulatory framework on groundwater extraction in Nepal
- Dr. Bhoj Raj Panta (NAST): Groundwater quality in the Kathmandu Valley
- Mr. Madhukar Upadhyaya (SchEMS): Groundwater sustainability and future food supply



## Technical Session : 1 Key Conclusions

- The isotopic analysis shows that there is heterogeneous recharge sources of the Kathmandu Valley
- Most stone spouts are drying out and the water are contaminated
- Water users are to be categorized on the basis of level of extraction/mode of use
- Quality parameters of most of the area of Kathmandu valley's groundwater are found to be within the limit of WHO standard
- The time has come to think about the Green water along with the Blue one as we have to be serious about future food supply

## Technical Session : 1 Key Recommendations

- There is a need of further collaborative research to understand the groundwater sources of the Valley
- Preservation and protection of stone spouts are essential and awareness & motivation on quality assessment is necessary

## Technical Session : 1 Key Recommendations

- Regulatory mechanism of groundwater should be implemented or should have license
- Better treatment, effective maintenance of water reservoirs and proper management of waste water should be necessary.

## Technical Session : 2

Chairs: Mr. Dhiraj Pradhananga and Mr. Sanjeev Kumar Dhungana

- Prof. Futaba Kazama (University of Yamanashi, Japan): Research work in groundwater in Kofu and Kathmandu.
- Dr. Suresh Das Shrestha (Central Department of Geology, TU): Potential for shallow groundwater recharge from rainwater in Kathmandu Valley under the perceived impacts of climate change.
- Mr. Prakash Amatya (NGO Forum): Policy framework for rainwater harvesting in the urban Nepal
- Mr. Naba Raj Shrestha (Department of Irrigation, Nepal): Groundwater status in the Kathmandu Valley



## Technical Session : 2 Key Conclusions

- Recharge of shallow and deep aquifers are important to recharge groundwater in Kathmandu Valley.
- Ammonia of groundwater can be reduced by cheaper technology.
- Identification of infiltration ponds, rainwater harvesting specially in the northern part of Kathmandu Valley might be useful due to its geological formation.

## Technical Session 2 Key Recommendations

- Policy framework of rainwater harvesting should be essential to recharge groundwater specially in Kathmandu Valley
- There is an urgent need to follow act, policy, rules and regulation about the all aspect of groundwater resources

## Panel Discussion Moderator: Dr. Sangam Shrestha Rapporteurs: Mr. Shakti P.C. and Ms. Maneesha Shakya

### Panelists:

- Prof. Futaba Kazama, University of Yamanashi, Japan
- Mr. Basanta Adhikari, Pro-Public, Nepal
- Mr. Naba Raj Shrestha, Department of Irrigation, Nepal
- Dr. Suresh Das Shrestha, Central Department of Geology, Tribhuvan University, Nepal
- Dr. Narayan Upadhyaya, ENPHO, Nepal
- Mr. Indra Kumar Maharjan, KUKL, Nepal



## Panel Discussion Key Questions

1. How to preserve the groundwater recharge areas for the Kathmandu Valley?  
Agreed to preserve the recharge areas
2. How to enforce tariff and/or tax for groundwater extractors?  
Commercial users need to be taxed
1. How to promote and implement groundwater treatment techniques?  
Simple technologies should be promoted and expanded.

## Panel Discussion Key Responses

- Conservation areas as well as regulation on monitoring system should be better option to preserve gw
- Kits might be useful for quality of gw
- Commercial organizations shall have monitored for charging tax
- Should not be allowed to permit to extract water everywhere
- Proper management of waste water is needed

## Panel Discussion Key Responses (contd.)

- Should promote rainwater harvesting including governmental organizations
- Private companies and governmental organizations both should

## Annex II: Program Agenda

### *National Symposium on Challenges and Opportunities for Sustainable Management of Groundwater Resources of the Kathmandu Valley, Nepal*

Monday, 28 December 2009, Kathmandu, Nepal

MC: Ms. Kanchan Shrestha

8:30	Arrival
8:30-9:00	Registration

#### **Opening Session**

9:00-9:10	Welcome speech (Mr. Sanjeev Kumar Dhungana, CREEW)	
9:10-9:20	Introduction of the symposium (Ms. Isha Manandhar, SEN)	
9:20-9:35	Prize distribution to the winners of the nationwide open photography competition on 'Groundwater: Today's matter, manage it sustainably for better future'	
9:35-10:05	Keynote speech	Dr. Roshan Raj Shrestha (Water for Asian Cities Programme, UN-HABITAT): Rainwater Harvesting for Groundwater Recharge in the Kathmandu Valley Dr. Sangam Shrestha (Asian Institute of Technology (AIT), Thailand): Groundwater and Climate Change: No longer the Hidden Resource

*Coffee Break (10:05-10:20)*

#### **Technical Session I: Presentation (10:20 – 12:00)**

**Chairs: Dr. Khada Nanda Dulal and Mr. Jagadishwor Karmacharya**

10:20-10:40	Dr. Saroj K. Chapagain (University of Yamanashi, Japan): Application of Stable Isotopes (D and <sup>18</sup> O) to Evaluate Groundwater Recharge Characteristics of Kathmandu Valley.
10:40-11:00	Ms. Pramita Maharjan (NGO Forum): Enumeration, Mapping and Water Quality Analysis of Traditional Stone Spouts in Kathmandu Metropolitan Area
11:00-11:20	Mr. Basanta Adhikari (Pro-Public, Nepal): Regulatory Framework on Groundwater Extraction in Nepal
11:20-11:40	Dr. Bhoj Raj Panta (NAST): Groundwater Quality in the Kathmandu Valley
11:40-12:00	Mr. Madhukar Upadhyaya (Institute for Social and Environmental Transition- Nepal): Groundwater and Food Security

*Lunch Break 12:00 – 13:00*

**Technical Session II: Presentation (13:00 – 14:20)****Chairs: Mr. Dhiraj Pradhananga and Mr. Sanjeev Kumar Dhungana**

13:00-13:20	Prof. Futaba Kazama (University of Yamanashi, Japan): Research Work for Groundwater in Kofu and Kathmandu
13:20-13:40	Dr. Suresh Das Shrestha (UEMS, Central Department of Geology, TU): Potential for Shallow Groundwater Recharge from Rainwater in Kathmandu Valley under the perceived impacts of Climate Change
13:40-14:00	Mr. Prakash Amatya (NGO Forum, National Steering Committee on Rainwater Harvesting): Policy Framework for Rainwater Harvesting in the Urban Nepal
14:00-14:20	Mr. Naba Raj Shrestha (Department of Irrigation, Nepal): Groundwater Status in the Kathmandu Valley

***Coffee Break (14:20-14:50)*****Panel Discussion on Challenges and Opportunities for Sustainable Management of Groundwater Resources of the Kathmandu Valley (14:50 – 16:25)****Moderator:** Dr. Sangam Shrestha**Rapporteurs:** Ms. Maneesha Shakya and Mr. Shakti P.C.**Panelists:**

Prof. Futaba Kazama, University of Yamanashi, Japan

Mr. Basanta Adhikari, Pro-Public, Nepal

Mr. Naba Raj Shrestha, Department of Irrigation, Nepal

Dr. Suresh Das Shrestha, UEMS, Central Department of Geology, Tribhuvan University, Nepal

Dr. Narayan Upadhyaya, ENPHO

Mr. Indra Kumar Maharjan, KUKL

16:25 – 16:40 Concluding Remarks (Mr. Dhiraj Pradhananga, SEN)

16:40-17:00 Vote of Thanks (Ms. Kanchan Shrestha, SEN)

***Closing (17:00)***

### Annexes III: List of Participants

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24	Dr. Suresh Das Shrestha	TU	9851084659	<a href="mailto:suresh1958@hotmail.com">suresh1958@hotmail.com</a>
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69	Sudharsan Rajbhandari	SEN	9841236755	<a href="mailto:sudharshanraz@hotmail.com">sudharshanraz@hotmail.com</a>
70	Sujan Shrestha	University of Yamanashi	9841266851	<a href="mailto:sujan-353619@yahoo.com">sujan-353619@yahoo.com</a>
71	Sundar Layalu	ICC-BC/SEN	9851096572	<a href="mailto:sundar.layalu@gmail.com">sundar.layalu@gmail.com</a>
72	Sunil Acharya	CREEW	9841528699	<a href="mailto:sunilacharya@gmail.com">sunilacharya@gmail.com</a>
73	Sunita Khatiwoda	SEN	974110254	<a href="mailto:sunitakhatiwoda@gmail.com">sunitakhatiwoda@gmail.com</a>
74	Sunita Lohani	Rastriya Path	9849153814	<a href="mailto:sisonulonu30@gmail.com">sisonulonu30@gmail.com</a>
75	Suraj Bishanka	TU(micro)	9841448319	<a href="mailto:suraj.apple@gmail.com">suraj.apple@gmail.com</a>
76	Sushma Acharya	EYES Nepal	9841465984	<a href="mailto:sugav123@hotmail.com">sugav123@hotmail.com</a>
77	Tripti Kharel	CREEW	9841367337	<a href="mailto:khareltripti@gmail.com">khareltripti@gmail.com</a>
78	Umesh Tiwari	Solidarity	9808119727	

Annex IV: Top Twenty Photos



Photo by Subhadin Gautam (1<sup>st</sup> Prize)



Photo by Sisan Baniya (2<sup>nd</sup> Prize)

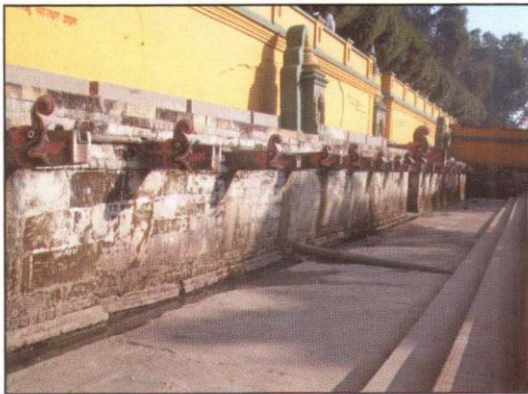


Photo by Darpan Adhikari (3<sup>rd</sup> Prize)

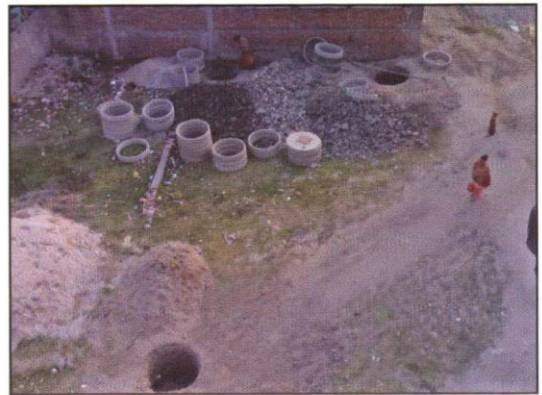


Photo by Milan Budhathoki (Consolation)



Photo by Prajwal Bhattarai (Consolation)



Photo by Mandira Maharjan

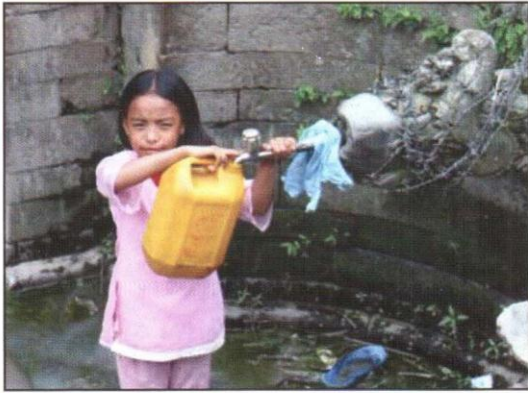


Photo by Gaurav Dhvaj Khadka

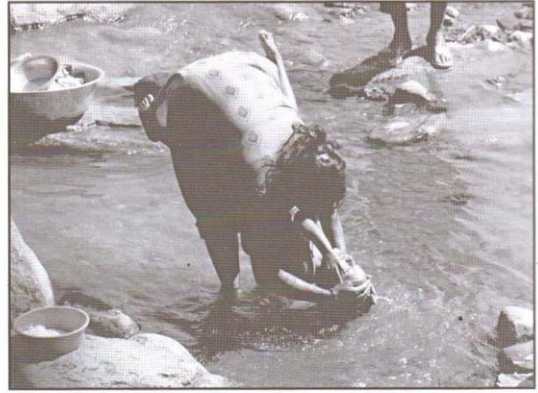


Photo by Narendra Mainali

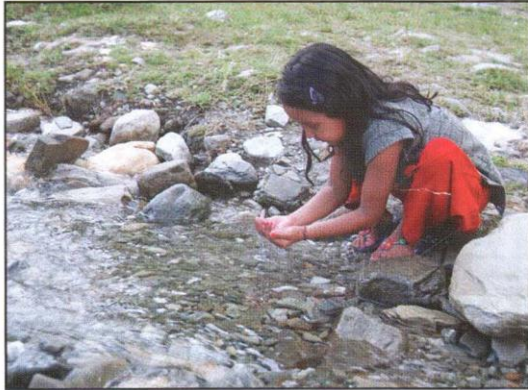


Photo by Mahesh Shrestha



Photo by Krishna Maharjan



Photo by Prakash Gaudel



Photo by Madhu Chhetri



Photo by Niraj Yogi Shrestha

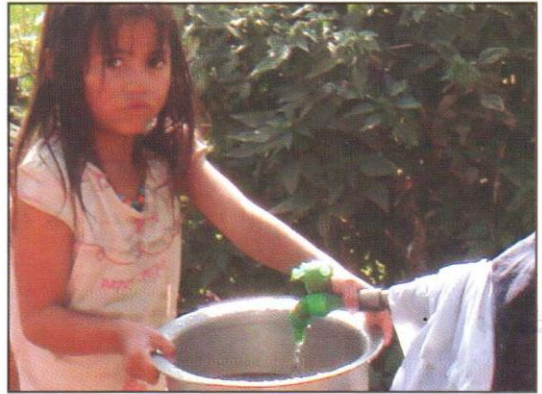


Photo by Niru Gurung



Photo by Achyut Dahal



Photo by Dr. Nidhi Nagabhatla



Photo by Kiran Adhikari



Photo by Susheel Shrestha

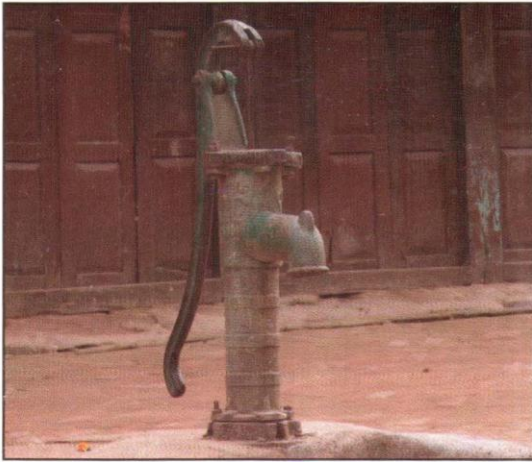


Photo by Niraj Yogal Shrestha



Photo by Nijan Yogal

The winners







Center of Research for Environment Energy and Water (CREEW) is a non-governmental organization, which brings together experts and students in different disciplines of environment to conduct researches and developmental activities related to environment, energy and water.

The Small Earth Nepal (SEN) is a non-governmental organization developing students-teachers-scientists (STS) networks to promote sustainable lifestyles through education and knowledge sharing. SEN supports activities that reduce our adverse impact on the environment.

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