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Water Security in Peri-Urban South Asia
Adapting to Climate Change & Urbanization

Groundwater Extraction: Implications on Local Water Security of Peri-urban Kathmandu

Anushiya Shrestha,* Rajesh Sada, Kanchan Karki and Ashutosh Shukla

The rapid and haphazard urbanization in Kathmandu valley and expansion of built-up area to the peripheral rural landscapes has resulted to formation of Peri-urban areas which are now themselves transforming into urban form. This paper examines how the increasing urban water demand has put unprecedented pressure on groundwater resources in the peri-urban areas of Kathmandu valley. Based on the semi-structured interviews with local people, focus group discussions and key informants interviews, the study found that water security at Jhaukhel is closely associated with groundwater and the dependency of local people on groundwater has increased over the years. The implications of the groundwater extraction coupled with sand mining in the area have been manifested in form of declining groundwater table and drying of traditional water sources. Despite the growing awareness among the local people on the consequences of depleting groundwater table, in absence of strict regulatory mechanism, the exploitation of groundwater has been adding threat to the local eco-hydrology of the area and subjecting the local community to water insecurity.

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This is one of a series of Discussion Papers from the Peri Urban Project of SaciWATERs.

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Groundwater Extraction: Implications on Local Water Security of Peri-urban Kathmandu

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1. INTRODUCTION

Kathmandu valley is the most urbanized area in the country. The built-up area in the valley expanded from 3,330 ha in 1955 to 16,472 ha in 2000 (Pradhan and Parera, 2005) and over the last decade the population increased by 61.23 per cent. (CBS, 2012). This process of urbanization and subsequent expansion of the built-up area to the peripheral rural landscape has resulted in the emergence of rural-urban intermediary, differentiated by a mixed rural-urban economy and livelihood, differently called, as, rural-urban fringe, peri-urban interface and Desakota by different researchers (Allen, 2003; Brook et al., 2003; Narain and Nischal, 2007).

As identified by ICIMOD (2007), population growth, expansion in the urban areas, agricultural intensification, growth in the tourism and other infrastructure and services in Kathmandu valley are the anthropogenic activities and processes that have been responsible for increase in the water demand for municipal, commercial and industrial uses. At present Kathmandu Upatyaka Khanepani Limited (KUKL), the water service providing agency in Kathmandu, is capable of supplying only 155 and 100 million litres of water per day (MLD) during wet and dry seasons respectively against a demand of 320 MLD; a deficit of 165 and 220 MLD in the wet and dry seasons being apparent (KUKL, 2010). This acute short supply in municipal water supply coupled with ever increasing demand of water forced people to look for other reliable sources of water supply. Moench and Janakarajan (2006) argue that the emergence of different modes of water transfer from rural and peri-urban areas in Kathmandu has been the result of increasing demand and availability of a convenient water source, in a situation wherea gap has been created even after the combined services of traditional sources and piped water supply system being available in the valley. As per the estimation made by Shrestha (2011) more than 90 per cent of the water supplied by tankers was extracted from groundwater resources available from the peri-urban areas.

As the surface water sources in Kathmandu are already constraint, increasing urban water demand has put unprecedented pressure on groundwater resources. In the peri-urban areas, increasing groundwater extraction for local and urban water supply has posed serious implications for water security. In this context, this paper examines this linkage with regard to the peri-urban study village of Jhaukhel and describes the current status of various modes of groundwater extraction in the area highlighting upon the impending implications on the local water security.

2. MATERIALS AND METHODS

2.1 Study site

The study was conducted in Jhaukhel Village Development Committee (VDC) which is located at 27°41'54"N and 85°25'47"E North and lies about 2 km north of the city core of Bhaktapur Municipality. Located at the northern flange of Bhaktapur Municipality, this VDC covers an area of 5.41 km2. The VDC is inhabited by a population of 7,721 people (Male- 3,908 and Female- 3,813) in 1,631 households (CBS, 2012). In the last decade, the population in the VDC increased by 1.56 per cent with the addition of 435 (3.68 per cent) households. This VDC lies in the northern ground water recharge zone among the three distinct groundwater zones in Kathmandu Valley identified by JICA (1990).

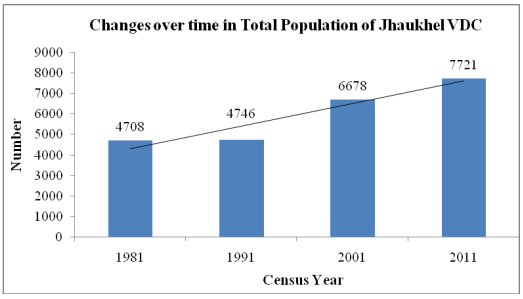

Figure 1: Changing trend in total population at Jhaukhel

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2.2 Methods

The study is based on qualitative research design involving direct field observation and semi-structured interviews with local residents, government and non-governmental officials, commercial water entrepreneurs and brick kiln operators to capture the information on groundwater extraction at Jhaukhel. Similarly, series of focus group discussions were conducted in the study area to understand the perceptions on positive and negative implications of the increasing competition over the extraction of groundwater resources in terms of local water security. Secondary sources of data have been reviewed to substantiate the findings from the formal and informal interactions.

3. RESULTS AND DISCUSSION

3.1 Groundwater extraction

3.1.1 Groundwater extraction for local water use

There are around 11 community drinking water supply schemes in Jhaukhel. Among all these, Changu-Duwakot-Jhaukhel Drinking Water Supply System (CDJ DWSS) that has been in operation since 1998 A.D. is the largest community drinking water supply scheme. It is based on the groundwater extracted from two infiltration galleries that are constructed near the bank of Manohara river in Changunarayan VDC. Apart from this system, all the other systems are dependent upon groundwater sources of Jhaukhel itself. Households that do not have piped water supply within households, are dependent on other public as well as private groundwater sources and even the households who do have a tap connection also use the existing community groundwater sources for other domestic purposes, because the tap water supply is not adequate to meet all the domestic water requirements. According to the VDC profile (2006), majority of the households are dependent upon piped water supply connection followed by dug well/ tube well, springs, stone spouts and other sources (Figure 2).

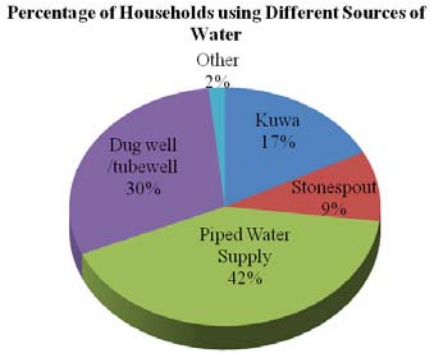
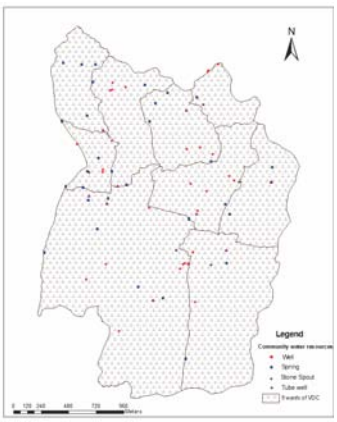


Figure 2: Distribution of households using different sources of water
(Source: VDC profile, 2006)



ENPHO (2011) recorded 70 community groundwater sources in the study area (29 springs, 11 stone spouts, 26 dug wells and 4 tube wells). Among those 70 sources, 51 were recorded to be in use as domestic and drinking water sources while the remaining 19 were used for irrigation and other purposes. The spatial distribution of these community groundwater sources are given in figure 3. Besides these community water sources, people also own private groundwater sources like dug wells and tube wells, however, their exact numbers were not known. Lately, an increasing trend has been observed in constructing private dug wells and tube wells, for both domestic and irrigation uses. This clearly reveals the increasing dependency of the local people on groundwater extraction in the area to meet the domestic and irrigation water needs.

Figure 3: Location of community groundwater resources in the study area
(ENPHO, 2011)

3.1.2 Groundwater extraction for brick production

Brick industries have been in operation in Jhaukhel since 1990 and at present there are 12 brick industries in this VDC. This is a high water consuming industry and in Jhaukhel, the only reliable water source is groundwater. According to the field survey conducted in the village, production of each brick requires on an average 0.75 litres of water. Based on the data obtained from Department of Small Scale and Cottage Industries (DSSCI) of Bhaktapur, all the brick industries in Jhaukhel annually produce 31.8 million bricks. Considering the water required per brick production, the estimated volume of annual groundwater extraction by these brick industries comes to be 23.85 million litres. However, based on the interviews with key functionaries of brick factories operating in the VDC, the annual average brick production per industry is 7 million which makes a total of 84 million bricks production per year in Jhaukhel. Considering this data, these industries annually extract 63 million litres of groundwater. Apart from the water consumption for brick production, large number of labourers who are engaged in the brick factories also dependent on the same groundwater sources for their domestic needs. According to DSSCI official record, there are 2,890 employees in these brick industries. Most of labourers are involved in these brick industries only for about seven months in a year. Considering 45 litres of water consumption per capita per day, the quantity of water for domestic use as specified by Rural Water Supply and Sanitation Strategy 2004, the annual average water consumption by the labourers would be 27.3 million litres. Thus, the total annual groundwater exraction due to the brick industries in Jhaukhel is around 90 million litres. More importantly, the inference elicited that brick production consumes huge volumes of water and a large volume of groundwater resource in the study area is being annually extracted for the brick production.

3.1.3 Groundwater extraction for commercial purpose

Groundwater exploitation for commercial purposes in Jhaukhel started in 2002 in the form of water bottling industries targeting the market in adjacent Bhaktapur city. This water business further flourished with increasing gap in urban water demand and supply, in the form of tanker and tractor water supply by 2008 and has been mushrooming ever since. The withdrawal of groundwater for commercial supply in Jhaukhel occurs from shallow tube wells with depth ranging from 60 to 120 feet. Currently, 12 privately owned commercial water extractors have been operating to supply water to water bottling industries and the tankers and tractors vending water from the VDC. Seven water bottling industries and five tanker operators of three different sizes (1,000, 5,000 and 7,000 litres) have been found to be in operation in Jhaukhel. The exact number of tractors could not be estimated as the owners are individuals transferring water from varying areas based on the convenience of hauling distance. Four of the bottling industries in the VDC are owned by the local people from the same VDC, the remaining three are operated by outsiders while two new are in the process of initiation. The water intermediaries existing in the form of tanker and tractor water suppliers in the VDC were charged NPR. 50, 150 and 200 for 1,000, 5,000 and 7,000 litres respectively at the extraction points whereas the consumers at the urban areas were charged NPR. 400, 1,000 and 1,200 for 1,000, 5,000 and 7,000 litres respectively.

Water market for the tanker water supply from Jhaukhel is primarily concentrated in and around Bhaktapur city, while the processed water, in bottles or jars has its market expanded in all three cities of Kathmandu valley viz., Kathmandu, Bhaktapur and Lalitpur. The study estimated that the volume of groundwater extracted at the twelve commercial wells during fiscal year 2010-11 was more than 90 million litres. Large amounts of groundwater are being extracted every year in Jhaukhel VDC for quenching the thirst of growing urban water needs. While this has been an attractive income source for the water business operators in the VDC, the implication of the massive ground water extraction has started to be apparent thereby raising serious concerns for local water security.

3.2 Haphazard sand mining and declining groundwater resources

Terrace sand mining in Jhaukhel started since 1978 when sand required for construction of bridges and other infrastructure during construction of Araniko Highway, was extracted from sand deposited on the hillock located at ward number 8. Thereafter trend of terrace sand mining was initiated at the local level and is currently widespread in ward numbers 8, 7 and 6 of Jhaukhel. Currently, three sand mines are in operation from hillocks at three different sites viz., Tajale, Devdole and Sundarthali area in Jhaukhel. Among these sites, sand mining in Sarkigaun, a part of mine site in Devdole was prohibited by District Development Committee (DDC) since 2009. Large scale sand mining from approximately 26,000 m^2 area has been extracting from Tajale area, with a permission from Bhaktapur DDC since 2011 whereas small scale terrace sand mining operated in Sundarthali area began from 2012 at an approximate area of 1,400 m^2.

Sand mining has had adverse impact on groundwater recharge (Rao, 2006; Chandrakanth et al., n.d. and Rodrigo, 2004). Sand layers serve as sponge and helps in recharge of groundwater through percolation of water through different layers of sand (Nagaraj, 1968). When sand is quarried, the vertical and lateral movement of water is checked and affects the recharge of groundwater (Hemalatha et al., 2005). As Jhaukhel lies in the northern district of Kathmandu Valley which is rich in groundwater resources, continued sand mining in the area is likely to yield negative consequences on groundwater reserves in the longer term.

Estimations by Sayami and Tamrakar (2007) shows that excessive growth of infrastructure has resulted in demand for about 3,100 m^3 of sand per day in the Kathmandu Valley. At the current rate of urbanization in Kathmandu valley, sand mining activity in Jhaukhel VDC is expected to continue, resulting in adverse impacts on groundwater of the area.

3.3 Implications on local water security

Groundwater extraction in Jhaukhel has grown extensively over the years. While limited influential groups relish the advantage, local community has been apprehensive about the growing negative implications of increasing groundwater extraction. Lowering of the water table has been an increasing concern in the area and the consequence of declining groundwater level has been the increasing needs of deepening of the wells and bores. The study showed that the average annual groundwater drawdown in the area is 3.38 feet (Table 1). The depletion of groundwater is taken as the first indicator of water scarcity (Shah and Indu, 2004). The depletion also indicates unsustainable extraction and lack of proper management (Shrestha et al., 2012). Three commercial wells in the VDC, two operated by bottling industries and one by tanker operator lowered down their submersible pumps by 10 to 25 ft due to the lowering of groundwater level. Those who are capable of bearing the cost for deepening the wells and bores adapt to the situation but the major victims of the competitive deepening of wells are the poor, who are incapable of deepening their wells due to the cost implication.

Local residents noted depletion of groundwater table after terrace sand mining started in the area. They recall the presence of a traditional stone spout known as Khujocha Hiti (Newari term for stone spout) which was located at ward number 8 with a discharge of almost 2,000 litres per minute. This has disappeared in late 1980s as an impact of sand mining for construction of the Araniko Highway. The stone spout used to be a reliable source of domestic water requirement for the local residents. It also served large number of households from Bhaktapur Municipality to carry out washing activities. Additionally, the discharge from the stone spout used to contribute in irrigating large areas of land. The stone spout and a spring in Nabala area had been a reliable source of irrigation for the farms located at Lukhondole area. Sand mining at Lakhaju tole since 1991 and unauthorized extraction of sand from underground upto the water table has decreased discharge from the Nabala spring. Farmers in this area have experienced a decrease in the discharge from Nabala spring by 95 per cent during dry season since 2010.

Similarly, after a spring located in ward no. 7 of Jhaukhel that served around 20 households for their domestic water needs, dried 3-4 years ago, the people previously have been compelled to depend upon the groundwater sources of neighbours to fulfill their daily water requirements. The spring was located between the commercial extraction points in the upland area and number of brick kilns in the low land within the ward. The decline in recharge zone due to haphazard sand mining, scraping out of the top soil by brick factories and over extraction of groundwater for commercial purpose, especially in the southern part of the VDC were considered as factors responsible for drying up of the spring.

Table 1: Commercial Groundwater Extraction and Groundwater Drawdown

S. N	Type of water business	Year of Construction	Initial Depth of Pump (ft bgl)*	Current Depth of Pump (ft bgl)*	Increase in Depth of Pumping (ft)**	Annual Drawdown (ft)**	Average Annual Drawdown (ft)**
1.	Bottling Plant I	2003/04	40	60	20	2.22	3.38
2.	Bottling Plant II	2007/ 08	50	60	10	1.67	
3.	Tanker	2008/09	50	75	25	6.25	

* Feet below ground level, ** Feet

While the groundwater extraction in the VDC has been increasing rapidly, the potential groundwater recharge zone in the VDC has been continuously declining due to massive sand mining activities followed by changing land use pattern. The local people in the VDC anticipate acute water shortage in Jhaukhel, if the situation continues unabated. Chai et al., (2004) mentioned that the most important mechanism causing land subsidence is excessive groundwater extraction, which causes drawdown of water table in the aquifer. Along with the increasing water insecurity, local people have additionally been stressed due to the threat of land subsidence that could result due to the excessive extraction of groundwater.

3.3 Regulatory attempts

The increasing opposition from local people compelled the Jhaukhel VDC office to step forward and regulate the commercial water extraction activities. All the water bottling industries in the VDC are registered as cottage industries under the Department of Small Scale and Cottage Industries under Industrial Enterprises Act, 1992 A.D which issues a license to run bottling plant with the consent of the local VDC office. Further, these industries are also registered in the Company Registration Office under the Company Act, 2006 A.D,

Department of Food Research Laboratories, Internal Revenue Department and Chamber of Commerce and Industries. The local VDC office has been charging an initial fee of NPR. 6,500 from the water bottling industries as the registration cost which is then required to be renewed annually through a payment of 33 per cent of the initial registration cost (NPR. 2,166/year). However, the VDC has not been able to collect the annual renewal charge from most of the industries. While licensing has come up as legalization mechanism for the bottling industries, the regulatory attempt has not put any restriction upon the volume of water extraction from these industries.

Furthermore, tractor and tanker water supply in the VDC has not come under any regulatory norms. The only tax paid by these water intermediaries is the road tax charged on the water tractors and tankers plying along the road which ranges from NPR. 25 to NPR. 80 per trip. For collection of road tax, the VDC annually calls for a tender and the tax collection contract is then awarded to the highest bidder.

The Local Self Governance Act 1999 empowers the local governments- Municipalities and VDCs as custodian of natural resources at the local level, and hence they are expected to ensure conservation and restoration of natural resources, including water bodies, within their jurisdiction. Contrary to this expected role, the existing situation at Jhaukhel shows that though the regulatory interventions has been a source of revenue for the VDC, it has remained insensitive towards the degradation of local resources and its possible consequence on the local environment. The voices of local people against unregulated extraction of natural resources in the VDC have nonetheless been suppressed due to the involvement of people in these activities who have the added advantage of money and muscle power to curb such protests. After the frequent delegations made by local people to the VDC office demanding immediate action through regulation of the commercial water extraction activities, VDC has issued a public notice declaring water tanker operations as illegal and considering it as a prohibitory act. However, local people are not satisfied with the decision, because of its weak implementation, that is unable to regulate such activities strongly.

Brick industries in the VDC are registered in the Department of Small and Cottage industries and the VDC has therefore no regulatory authority over these industries. Similarly, the ongoing sand mining in the VDC poses question on the sustainability of groundwater resources and the stability of the local physical and geological conditions. However, despite local resistance against mining activities, sand mines are still in operation with the involvement of influential groups, who have large stakes in such operations without following adequate monitoring mechanisms. This creates doubt on the efforts and hence the effectiveness of adopting such regulatory actions, which has merely taken any concrete shape in penalising the offenders.

4. Conclusions

Water security at Jhaukhel is closely associated with groundwater and the dependency of local people on groundwater has increased over the years. As the annual recharge of groundwater and hydro-geological settings of the study area is not known, it would not be possible to conclude whether the ongoing trend of groundwater extraction in the VDC is sustainable or not. However, the lowering of the groundwater table and drying up of traditional water sources indicate that the extraction of groundwater resources in the area is beyond the sustainable withdrawal rate and thus the stress on local environment and its implication for water security is increasing. Despite the growing awareness among the community about the probable consequences of depleting groundwater table, the absence of effective regulatory mechanism, has not been able to curb the rampant exploitation of groundwater; adding to the existing threat to eco-hydrology of the area and to water security of the local community. While the local resources are being overused, the emerging threats emphasize on the need to redefine the legal and institutional framework for groundwater management in the area.

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Adapting to Climate Change & Urbanization

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Working primarily on water security issues in Peri-Urban South Asia, across India, Bangladesh and Nepal, the project's main concerns are the rapidly changing peri-urban landscapes due to urbanisation and implications for water security in specific locations in the larger context of climate change. As an action research project, working across four locations in South Asia, it will serve as a basis for capacity-building at the grass roots level to address concerns of the poor, marginalised and other vulnerable communities to water security and seek to understand the dynamics of adaptation in the specific locations, for action and policy agenda at the regional level. It will build their capacities to cope with climate change induced water in-security.

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