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

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Abstract

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 transforming into urban form. This paper examines how the increasing urban water demand has put unprecedented pressure on groundwater sources 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 it has increased over the years. The implications of the groundwater extraction coupled with sand mining in the area have been manifested in the 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.

Key words: groundwater extraction, impacts, peri-urban, urbanization, water security

Introduction

Kathmandu valley is the most urbanized area in the country. The built-up area in the valley expanded from 33.3 km^2 in 1955 to 164.72 km^2 in 2000 (Pradhan & Parera 2005) and over the last decade the population increased by 61.23% (Central Bureau of Statistics (CBS) 2012). This process of urbanization and subsequent expansion of the built-up area to the peripheral rural landscape has resulted to 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 & Nischal 2007).

As identified by International Center for Integrated Mountain Development (ICIMOD) in 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 the increase in the water demand for municipal, commercial and industrial uses. At present, Kathmandu Upatyaka Khanepani Limited (KUKL) is capable of supplying only 155 and 100 million liters per day (MLD) of water during wet and dry seasons respectively against the demand of 320 MLD. Thus shortages of 165 and 220 MLD in the wet and dry seasons are apparent (KUKL 2010). This acute short supply in municipal level 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 demand for convenient water supply, created by the gap left by the combined services of traditional sources and piped water supply system in Kathmandu valley. As per the estimation made by Shrestha (2011) more than 90% of the water supplied by tankers was extracted from groundwater resources mostly 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 been stressing local water security. In this context, this paper examined how the local water security at Jhaukhel is linked to groundwater and describes the current status of various modes of groundwater extraction in the area highlighting upon the impending implications on the local water security.

Methodology

Study area

The study was conducted at Jhaukhel Village Development Committee (VDC) which is located at longitudes 85° 24' 56" and 85° 26' 15" East and latitudes 27° 40' 39" and 27° 42' 17" North (VDC, 2006). It lies about 2 km north of the city core of Bhaktapur Municipality (Figure 1). Located at the northern flange of Bhaktapur Municipality, this VDC covers an area of 5.41 km^2.

Fig. 1. Location map of the study area

The VDC is inhabited by a total of 7721 people (Male-3908 and Female- 3813) in 1631 households (CBS 2012) as shown in Figure 2. In the last decade the population in the VDC increased by 1.56% with the addition of 435 (3.68%) households. This VDC lies in the northern groundwater recharge zone among the three distinct groundwater zones in Kathmandu valley identified by Japan International Corporation Agency (JICA) in 1990.

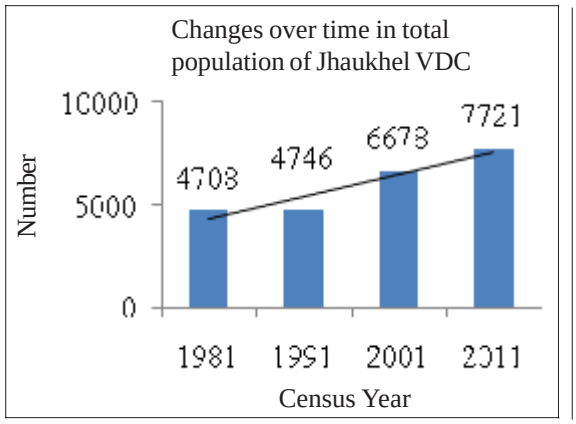

Fig. 2. Changing trend in total population at Jhaukhel (Source: CBS 1981; CBS 1991; CBS 2001; CBS 2012)

Data collection

This 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.

Results and Discussion

Groundwater extraction

Groundwater extraction for local use

There are around 11 community drinking water supply schemes in Jhaukhel. Among them, 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. Beside this system, all the other systems are dependent upon groundwater sources of Jhaukhel itself. Those households which do not have piped water supply connection within households are dependent on other public as well as private groundwater sources and even the households who have 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 3).

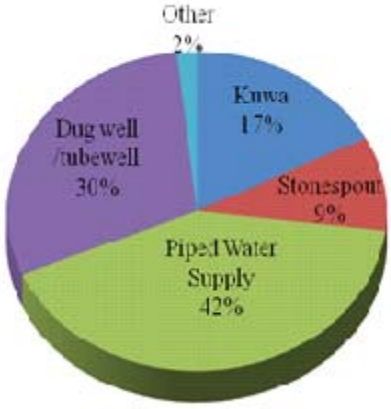

Fig.3. Distribution of households using different sources of water (Source: VDC 2006)

Environment and Public Health organization (ENPHO) recorded 70 community groundwater sources in the study area (29 springs, 11 stone spouts, 26 dug wells and 4 tube wells) in 2011. 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 4. Beside these community water sources, people also own private dug wells and tube wells to extract groundwater, 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.

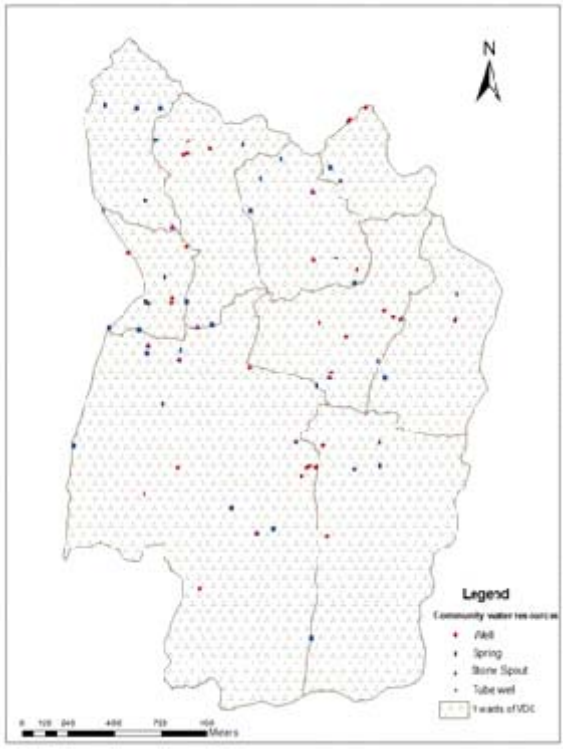

Fig.4. Location of community groundwater resources in the study area (Source ENPHO 2011)

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 highly water demanding industry and in Jhaukhel, the only reliable water source has been groundwater. As per the field information, production of each brick requires on an average 0.75 liters 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 industries comes to be 23.85 million liters. 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 extracts 63 million liters of groundwater. Beside water consumption for brick production, large numbers of labors who are engaged

in the brick factories are also dependent on the same groundwater sources for their domestic needs. According to DSSCI official record, there are 2890 employees in these brick industries. Most of labors are involved in these brick industries only for around seven months a year. Considering 45 liters 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 labors would be 27.3 million liters. Thus, the total annual groundwater extraction due to the brick industries in Jhaukhel is around 90 million liters. More importantly, inference elicited is that brick production consumes huge volume of water and a large volume of groundwater resource in the study area is being annually extracted for the brick production.

Groundwater extraction for commercial purpose

Groundwater exploitation for commercial purpose 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 around 2008 and has been mushrooming in every passing year. The withdrawal of groundwater for commercial supply in Jhaukhel occurs from shallow tube wells with depth ranging from 18 to 37 meters. 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 (1000, 5000 & 7000 liters) have been recorded to be in operation in Jhaukhel. The exact number of tractor could not be estimated as the tractor owners are individual owners 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 form of tanker and tractor water suppliers in the VDC were charged NPR. 50, 150 and 200 for 1000, 5000 and 7000 liters respectively at the extraction points whereas the consumers at the urban areas were charged NPR. 400, 1000 and 1200 for 1000, 5,000 and 7000 liters 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 volume of groundwater extracted at the 12 commercial wells during fiscal year 2010/11 was more than 90 million liters. The large amount of groundwater is 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 groundwater extraction has started to be apparent thereby raising serious concerns for local water security.

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. Sand was extracted from sand deposited on the hillock located at ward number 8. Thereafter trend of extracting terrace sand mining initiated in local level and is currently widespread in ward No. 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 as the local people of Sarkigaun registered an application letter at Bhaktapur DDC requesting to prohibit sand mining in their settlement for protecting their settlement from the potential landslides emerging with unchecked sand mining. Large scale sand mining from approximately an area of 26000 m^2 has been ongoing from Tajale area, with permission from Bhaktapur DDC since 2011 whereas small scale terrace sand mining operated in Sundarthali area began from 2012, from an approximate area of 1400 m^2.

Sand mining has adverse impact on groundwater recharge (Rao 2006, Rodrigo 2004). Sand layers serves as spongy layer 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 the Jhaukhel lies in the northern groundwater district of Kathmandu Valley which is rich in groundwater resources, continued sand mining in the

area is likely to produce negative consequence on groundwater reserve in the longer term. Sayami and Tamrakar (2007) estimation shows excessive growth of infrastructure demanded about 3100 m^3 of sand per day in the Kathmandu Valley. At the current urbanization trend in Kathmandu valley, the sand mining in Jhaukhel VDC can be expected to continue, resulting adverse impacts on groundwater of the area.

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 1.03 meters (Table 1). The depletion of groundwater is taken as the first indicator of water scarcity (Shah & 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 3.05 to 7.62 meters due to the lowering of groundwater level. Those who are capable of bearing the cost for deepening the wells and bores adopt to the situation but the major victims of the competitive deepening of wells become the poor who are not capable enough to affording deepening of their wells.

Table 1. Commercial groundwater extraction and groundwater drawdown

S. N	Type of water business	Year of construction	Initial depth of pump (m bgl)*	Current depth of pump (m bgl)*	Increase in depth of pumping (m)**	Annual drawdown (m)**	Average annual drawdown (m)**
1.	Bottling Plant I	2003/04	12.2	18.3	6.1	0.68	
2.	Bottling Plant II	2007/ 08	15.2	18.3	3.05	0.51	1.03
3.	Tanker	2008/09	15.2	22.86	7.62	1.91	

* meter below ground level ** meter

Local residents noted depletion of groundwater table after terrace sand mining started in the area. They recalled a traditional stone spout known as Khujocha *Hiti* (Newari term for stone spout) located at ward number 8 with discharge of almost 2000 liters per minute disappeared in late 1980s as an impact of mining the sand required for construction of Araniko Highway. The stone spout used to be reliable source of domestic water requirement for the local residents. It also served large number of households from Bhaktapur Municipality to carry out washing of their clothes. Additionally the discharge from the stone spout used to contribute in irrigating a large area 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 to the level of water table has decreased discharge in Nabala spring. Farmers in this area have experienced decrease in discharge from Nabala spring to 95% 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 depending upon the spring for their water needs have been compelled to depend upon the groundwater sources of neighbors 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 responsible factors for drying of the spring.

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 and changing land use pattern. The local people in the VDC anticipate

acute water shortage in Jhaukhel, if the situation continues in the same way. 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.

Regulatory attempts

The increasing opposition of local people compelled Jhaukhel VDC office to step forward to regulate the commercial water extraction. 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 at the payment of 33% of the initial registration cost (NRs. 2,166/year). However, the VDC has not been able to collect annual renewal charge from most of these industries. While the 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 Rs. 25 to NRs. 80 per trip. For the collection of the road tax, the VDC annually calls for a tender and the tax collection contract which 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 the regulatory interventions though has been a source of revenue for the VDC, it has remained insensitive towards the degradation of local resources and the possible consequence on the local environment. The voices of local people, growing against the unregulated extraction of natural resources in the VDC have been suppressed over time and again due to the involvement of those with money and muscle power in the extraction activities. After the frequent delegations made by local people to VDC office asking for immediate regulation of the commercial water extraction, VDC issued a public notice on prohibiting private water tankers declaring it as an illegal activity but local people have not been satisfied with the regulatory mechanism and its weak implementation.

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 local environment. However, despite the local resistance at mining activities, sand mines are being operated under the involvement of influential groups and with inadequate monitoring mechanisms. This creates doubt on the efforts and hence effectiveness of regulatory actions. However, the local government has merely taken any concrete effort towards its monitoring and regulatory mechanisms.

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. As the annual recharge of groundwater and hydro-geological settings of the study area is not known, it would not be possible to comment whether the ongoing trend of groundwater extraction in the VDC is sustainable. However, the lowering of the groundwater table and drying of water sources indicate the extraction of groundwater resources in the area is beyond the sustainable withdrawal rate and thus increasing the stresses on local environment and local water security. Despite the growing awareness among the local people on the likely consequences of depleting groundwater table, in absence of 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. While the local resources are being overused, the emerging threats emphasize on the need of redefining the legal and institutional framework addressing the groundwater management in the area.

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