Sustainable solutions for cost effective rainwater harvesting in Nepal *(pilot project STORAGE realised in Kathmandu valley – Patan)*

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Abstract

According to the official statistics more than a billion people in the world do not have access to water supply. Groundwater resources face to still increasing pressure induced by particular land use practices and demand for drinking water. In some areas, groundwater levels decreased, which consequently negatively impacted on quality of water. In the research work in Nepal, Kathmandu – Patan area, we focusing new methods of rainwater harvesting which are aimed to increase groundwater recharge. It is done in localities meeting two criteria - where abstraction rate of groundwater exceeds the one of natural infiltration, and where suitable hydrogeological conditions occur. The research strategy included socio-cultural aspect as well. In-depth understanding of local knowledge concerning historical practices of rainwater harvesting, as well as understanding of current community needs appear to be of crucial importance when trying to implement any new technology. Therefore, mapping of situation on particular (pre-selected) localities became the first step of our research strategy

The paper reports on preliminary outputs achieved by the EUREKA project STORAGE, namely on our research, technological strategy and in-situ work in particular pilot sites in Patan, Nepal.

Keywords: Rainwater Harvesting, Monitoring, Groundwater, Integrated Water Resources Management, Pilot Communities, Nepal.

1 Introduction

Intensive migration of the Nepalese population to Kathmandu valley began about 15 years ago, currently the number of inhabitants in Kathmandu valley is estimated to be around four million and the population growth rate in last decade is 61.23 % (1). Because of increasing immigrant rate, the Kathmandu valley suffers from a severe drinking water supply crisis, particularly in the dry seasons of every year. To mitigate the crisis, nearly all sources are continually under exploitation, including groundwater from various aquifer, shallow one of few meters to deep one of several hundred meters. In the beginning of last century, water was channelled to the centre of Kathmandu valley by an aqueduct from springs lying outside the city. Each inhabitant could take drinking water from some of the fountains. Besides this official source of drinking water almost every bigger house in Kathmandu had its own well, which provided service water. There was a minimal waste, organic waste was composted, and flushing toilet was unknown. Problems arose only when the Nepal capital started to approximate the West and from the civilization possibilities it chose just some development options. The king had the aqueduct built in Kathmandu, but only sparsely the sewage and sewage plants were constructed. Water mains brought the comfort of water to households and its consumption rose, the rising volume of wastewater started to endanger the quality of groundwater (2). Today, the water supply of Kathmandu is secured mainly (especially the North of the city) by the Water Sources Company (Kathmandu Upatyaka Khanepani Limited) who pumps water from rivers and springs in the detrital areas of the outer Himalaya chain. This supply is not sufficient for the city (it covers about 50% of the demand), and the majority of inhabitants (mainly from peripheries of the capital and Patan) depend on an individual pumping of groundwater (3). For example in the South of Kathmandu, in the centre of ancient Patan, local people depend on taking groundwater from wells or public fountains and gargoyles, because there is the water main in function only 1 - 2 times per week for 2-3 hours (4). The lack of groundwater here is solved by the system of infiltration wells; these wells serve to infiltration of precipitation water into underground collectors and in such way they are enhancing the sources of groundwater (shallow aquifer). By the way, they could raise not only the volume of available water artificially, but also its quality.

2 Hydrogeological situation in Patan

Shallow groundwater is the most important source of water for many residents in the core part of Patan. The area has benefitted from being located in the middle of south to north gentle sloping terrace with gravel deposits. Rainwater falling on the surface infiltrates to recharge the groundwater. Trend of surface sealing and

concretization due to increased urbanization, increasing water demand, disappearance of traditional recharge ponds have resulted in depletion/ lowering of shallow groundwater level in the area. Most of the traditional water sources have been dried out and artificial recharge appears to be the only solution available to revive these sources. Artificial recharge however tends to be case specific depending largely on local hydrogeology and rainfall. Past studies (5) have shown potential for rainwater recharge in Patan area. Difference in the water level in dry and wet season clearly indicates the sources for groundwater of shallow aquifer in the area is only rainwater recharge. Local geology, geomorphologic factors and rainfall variation testify strong influence in the groundwater recharge rates. Areas dominated by coarse sediments have high to moderate infiltration rate.

3 Possibilities of rainwater recharge sites in Patan

Project E!6731STORAGE: Tools and technologies for effective use and protection of groundwater selected Patan as the pilot area for rainwater harvesting technologies and related best practice training. The main goal of this project (in third countries as Nepal) is to select a typical pilot site / sites, where infiltration experiment will take place in order for the technology to meet the requirements of the local communities, respect legislation and legislative recommendations of the country and be effectively transferable to similar communities. For the project (which runs from 1 March 2012 till 31 December 2014), we have selected, on the basis of previous research and recommendations of the PÁNÍ project (2), seven typical sites in Patan, where it would be possible to perform the infiltration experiments. This selection was based on the fact that Patan inhabitants are forced to choose a strategy of combination of several sources of water – water mains, purchase of „bottled water“ and mainly return to original sources – wells, fountains and gargoyles. In the same time, the use of fountains, gargoyles and wells in Patan faces the following limits:

- More people means more consumption, which in turn leads to increased water abstraction from the aquifer without, however, sufficient saturation of this aquifer. This results in a gradual lowering of the groundwater level, which leads to the fact that some of the wells and fountains systems are drying (at least in periods of drought);
- Ponds designed to saturate the aquifer generally fell victim to the advancing urbanization – today a built-up area is there instead of ponds;
- The establishment of a central water supply system led to the destruction (or at least rudimentalization) of local knowledge (and institution) of management of a local water resource.

The Patan communities, that live there in the so-called „bahals“ (i.e. in the area that defines each community and its joint action and decision-making; bahal always consists of several families – between 10 and approx. 25, rarely even more), are solving the situation of water supply individually (though from the same shallow aquifer). Since 2006, there has been gradual use of wells (which may be even 100 years old, they are almost at all bahals and originally were used for religious purposes) as sources of drinking water and service water for the community. However, in the course of time, even these wells are not enough to supply the existing communities, due to advancing lowering of groundwater level, and so it is necessary to take the next step – build infiltration facilities/reservoirs/wells, where there is infiltration of rainwater (which originally drained away to sewers and the Bagmati River) into the upper groundwater aquifer.

After consultation with local experts and field reconnaissance, the set of sites was restricted to four typical locations, where field research was subsequently conducted and following possible pilot localities for STORAGE project implementation were selected:

Machhindra Bahal

It is in fact a „square“ with 26 households living there. They form a separate and clearly defined community. Currently, the households abstract water from two wells, one historical, one built in 2012 (within the Czech development assistance), from a depth of approx. 9 m below the ground level. The square serves as an infiltration area – there are two infiltration wells built in 2008. Bahal residents tend to extend this system, because the current system of abstraction and infiltration of rainwater for 26 families living there is not sufficient.

Fig. 1. Historical well at Machhindra Bahal

Fig. 2. Machhindra Bahal – overall view

Minnath Bahal

Same type locality, a "square"-defined community with 20 households. Similarly to the previous case, they abstract water from two wells; in the area of the square there is a simple but effective system of infiltration. The households aim to extend this system. For the time being, they solve the situation by themselves, with the assistance of UMES organization.

Fig. 3 and 4: Minnath Bahal – discussion on the topic "what next"

Both of the above mentioned communities are well organized, ready and willing to cooperate.

Prayag Pokhari

The site in question is the school premises, where in the past there was an infiltration pond (it is a hard surface today), which was used for religious purposes and also contributed to the saturation of one of the fountains cascades in Patan. Under the project, it would be possible to restore its original function due to infiltration of rainwater (collected from the school roofs) into the upper aquifer in the area of interest. Ownership relations are not a problem in this case, on the contrary, representatives of the school have expressed interest in cooperation. Now, there is not any source of water in the school area and the water must be supplied by the tanks. Thus the results of the project will be on the two levels: a) the new accumulation well for the school will be drilled and b) as well the spouts in the surrounding area will be supplied by the rainwater recharging to the shallow aquifer. Moreover, work at the site might also have an educational character by involving local schoolchildren, who during their lessons could assist the project in the form of playing games.

Fig. 5: Entrance to the school premises

Fig. 6: Hard surface – formerly infiltration pond

Kani Bahal (Nahity)

It is a location, which is "public space". It is a place where water collects, which then saturates one of the cascade lines of public fountains. Water for infiltration would also here be collected from the roofs of surrounding schools and recharged into the infiltration borehole near the storage well (source of water for fountains). The agreement with the users/owners of space in question would in principle be possible, but it is also necessary to resolve the source of water for schools, which will deliver water from the roofs.

Fig. 7 and 8: Source of water for fountains

The above mentioned examples of optimum sites may serve for the formation of two institutional models of infiltration of rainwater that would be transferable to similar sites not only in Patan, but also in Kathmandu itself, etc. From the

institutional point of view the two models differ by a degree of unambiguousness of the abstraction-saturation relationship.

Wells: From the urban point of view, the historical part of Patan consists of small or larger squares (bahal), with a temple and temple-related well located in their centres. Also the community living on the square and using its water resource is usually defined by the square. Should the infiltration system be implemented on the square in question, the abstraction-saturation relationship is quite clearly and simply defined both spatially (the square in question), and socially/institutionally (the community in question).

Fountains and gargoyles: Fountain is not an isolated source. In Patan, there are several „lines of cascades", where the water from one fountain is transferred to the next one; the entire line is saturated from a single source. In this model, the abstraction-saturation relationship is much more open, spatially and thus also socially. Simply put, those who abstract water, may not be aware of where and how the source they use is saturated. In these cases, it is possible within the site where water for fountains is collected to also meet the needs of those who deliver water for infiltration (e.g. from the roofs of schools) by building a local source.

Aforementioned two models represent two typical problem situations in the historical part of Patan. Both of them should be analysed and solutions should be found. Therefore, we recommend to choose two pilot sites for fieldwork in 2013:

Minnath Bahal: the community is ready to cooperate, there exists a functional institution that regulates water abstraction from the well, they prepared a plan how to use more water acquired, ownership relations are not a problem. In this respect, the situation does not differ from that at Machhindra Bahal. Giving priority to Minnath Bahal can be justified as follows:

- Research is inevitably linked with the practical construction of the appropriate infrastructure, i.e. it can be interpreted also as specific assistance to the community in question.
- This „assistance" should be „spread out" in order not to favour too much one community (where e.g. already in the past international development assistance was provided).
- From this perspective, Minnat Bahal seems to be more appropriate than Machhindra Bahal, where they have already „got accustomed" to external assistance and within donations a storage well (VODNÍ ZDROJE, a.s., 2012) and 2 infiltration wells (UMES, 2008) were installed there.

Prayag Pokhari: in this area there existed in the past a reservoir designed for infiltration, the project would thus help to restore the original situation. As mentioned above, the area concerned is school premises. This situation could be

used to promote the project and activities which it represents, to the „prospective“ target group – young generation.

4 Conclusions

Fieldwork in Patan (Kathmandu) will take place in the period August – September 2013 on the basis of discussions with local collaborators (UMES, CISD), the resulting number of selected pilot sites for the actual field survey will be given by financial scope of the project. At the selected pilot site(s), in situ project of rainwater recharge will take place within the following phases:

- Development of new technology (testing of „best practices“ and existing approaches to rainwater recharge, testing of the new technology of optimum rainwater recharge within the framework of selected pilot sites). The specific design of infiltration facility will be chosen in accordance with the local conditions in cooperation with communities.
- Analysis of end users for the needs of transfer of technology.

The principal objective of the research will be to study the rainwater recharge potential and its impact on the local groundwater system in Patan. Specific research objectives will be:

- Understand efficacy of the recharging methods in recharging shallow groundwater aquifer to enhance availability of water by verifying effectiveness of the various recharge methods identified by previous studies (by UEMS)
- Understand the recharge rate with different types of surfaces to augment shallow water aquifer by rainwater harvesting techniques.
- Study effect of rainwater in shallow groundwater aquifer in the locality in terms of quality.
- Evaluate open spaces like bahals for rainwater recharging compared to roof area.

Results of the STORAGE project will be not only the recharge of the aquifer and availability of water for the bahal/school area, but as well estimation of a preparedness of the pilot site (community) concerned to cooperate (institutional, socio-economic and possibly cultural preparedness), evaluation of the potential impact of the implementation of project activities (spatial, social, institutional and „educational“) and estimation of repeatability of the proposed solution in Patan – Lalitpur district and as well in the other similar areas.

5 Acknowledgements

This paper was developed thanks to the E!6731 EUREKA project STORAGE (*Sustainable TOols for gRoundwater manAGEment optimisation and water scarcity mitigation)*, financed by the Ministry of Education, Young and Sports, CR.

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