Rainwater Harvesting and Groundwater Recharge for Water Storage in the Kathmandu Valley

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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. These were the words of Parakramabahu, a 13th century monarch from Sri Lanka, who constructed a massive rainwater harvesting reservoir which is used to irrigate vast stretches of paddy fields in the Gal Oya district of Sri Lanka to this day.

Rainwater is used all over the world for drinking, irrigation, aquaculture, groundwater recharge, and fire fighting. In South Australia, 42% of the population drinks rainwater. In Bangladesh, rainwater is a major alternative source of drinking water in arsenic-affected areas. At Singapore's Changi Airport, 63,500 tonnes of rainwater is used for flushing toilets and cooling the terminal buildings each month, about 33% of the total

Traditional stone spout in Patan Durbar Square

water used, saving approximately USD 390,000 a year. In China's Gansu Province, the annual precipitation of 300 mm caters to 2 million people and supplies supplementary irrigation for 236,400 hectares of land. In India, direct recharge of rainwater into the ground (Mahnot et al. 2003) resulted in groundwater level increases of up to 5 to 10 metres in just two years.

Given such successes around the world, it is clear that rainwater harvesting has great potential to address some of today's water crises in many of the world's urban areas.

Water demand and exploitation of groundwater in the Kathmandu Valley

Kathmandu Valley has been suffering from a shortage of drinking water since the 1980s, and the situation is getting worse. The Valley's current water demand is about 280 million litres per day (MLD), but the Kathmandu Valley Water Utility (KUKL) can only supply about 86 MLD during the dry season and 105 MLD during the wet season. To meet the supply-demand gap, groundwater from both shallow and deep aquifers (more than 200 metres) is being heavily extracted by small- to large-scale users, including KUKL itself. This unregulated extraction is depleting the aquifers; especially the deep aquifers are not easily rechargeable due to the Valley's impermeable black clay (JICA 1990). The overall groundwater extraction rate exceeds the natural recharge capacity by 6 times, resulting in a lowering of the groundwater table by approximately 2.5 metres per year (MPPW 2002). An immediate consequence of the depletion of shallow groundwater aquifers is that dug wells, hand pumps, and traditional stone spouts can no longer provide water as they once did. The groundwater quality is also a concern, chemical pollutants such as arsenic, ammonia, and nitrate have been detected in deep aquifers in many areas of the Valley.

Historical water management

The historical cities in the Kathmandu Valley were established over 2000 years ago. The Kirat regime constructed rainfed ponds and springs. Later, the Lichhavi kings linked the ponds to stone spouts and dug wells to provide water to the cities. These structures were expanded during the Malla regime, when elaborated networks of canals, ponds, and water conduits were constructed (Figure 1). This water supply and management system supplied adequate good quality water to the urban population throughout the year. Guthis (local community groups) were formed to maintain the overall supply system. Once a year, on the Sithi Nakha festival, the guthis worked together to clean up the ponds, wells, and water canals.

This historical system was neglected after the introduction of a piped water system to the Kathmandu Valley about a century ago. The stone spouts have been further affected by the recent uncontrolled exploitation of groundwater and the destruction of the former rainwater collection ponds and recharge areas. A recent study found that about 400 stone spouts and several hundred traditional dug wells in the Kathmandu Valley are now dry (NGOFUWS 2006).

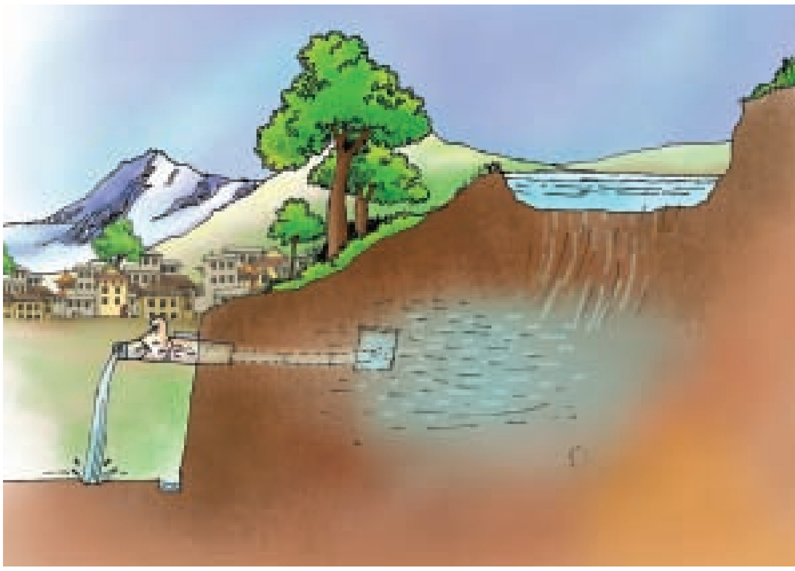


Figure 1: Schematic diagram of traditional water supply system (CIUD/UN-HABITAT 2009)

Rainwater harvesting potential

Rainwater harvesting and artificial recharge into shallow and deep aquifers offers a promising approach for reversing the trend of water resource exploitation and groundwater depletion. The average rainfall in the Kathmandu Valley is around 1900 mm: more than twice the world average. Approximately 1.2 billion cu.m/year or 3353 million litres per day (MLD) of rainwater falls in the 640 sq.km Valley. This is about 12 times the present water demand.

The author has been collecting rainfall data at one location in Kathmandu since January 2005. The average annual rainfall in this location over the last four years was about 2500 mm, higher than the estimated valley average. About 80% of total rainfall on a building can be collected easily (UN-HABITAT 2006), thus in theory a building with a roof area of 100 sq.m could collect up to 200 cu.m of rainwater per year, adequate for a family of five with a water demand of about 170 cu.m per year. But it is not practical to store all this water, thus artificial groundwater recharge to replenish the aquifers is likely to be one of the best options for the optimal use of rainwater. If just 10% of the Kathmandu Valley area was to be used for rainwater harvesting, 128 million cu.m per/year could be recharged. To implement such a plan, investigation is required to identify suitable recharge techniques and locations.

Artificial groundwater recharge in the Kathmandu Valley

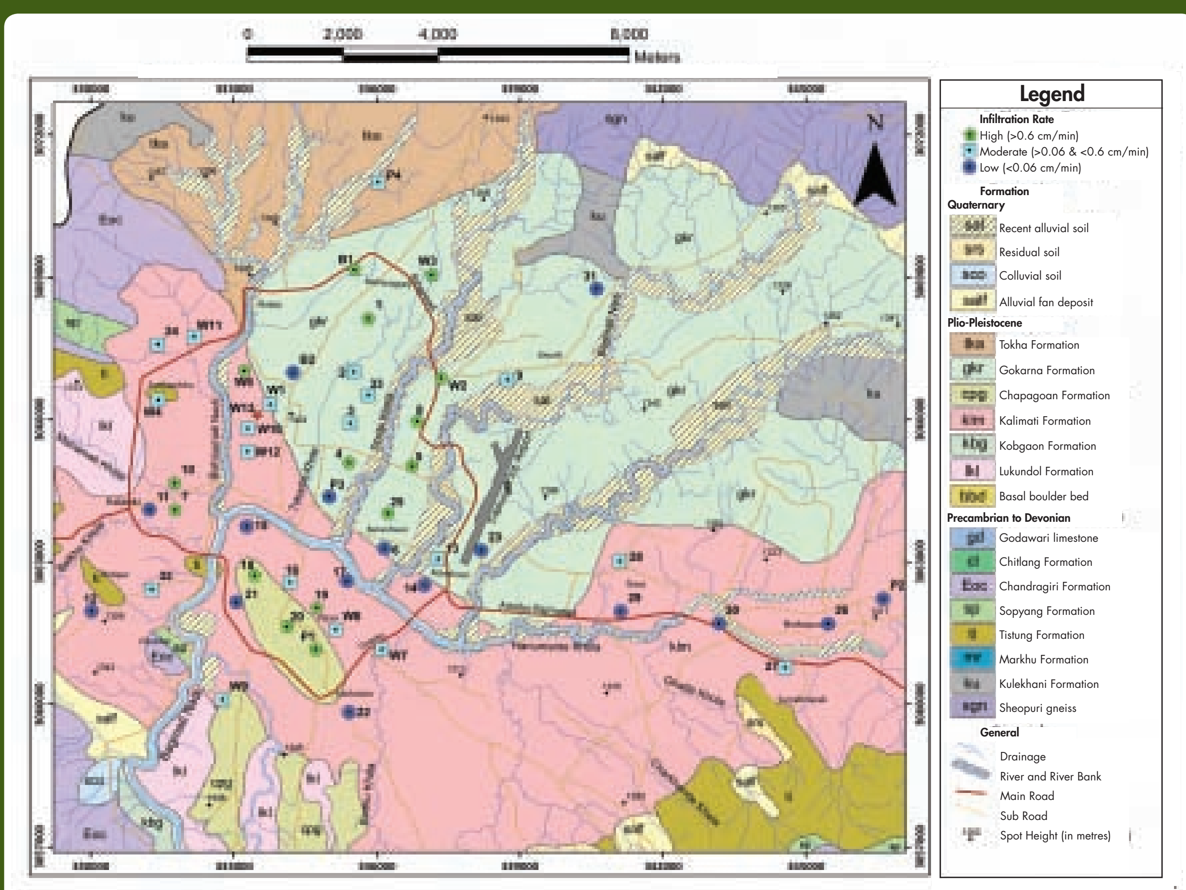
A recent study indicates that the Valley's sub-surface geology is favourable for assisted recharging of groundwater. Although several areas have high groundwater infiltration rates because of favourable geological formations, natural infiltration is generally ineffective due to the sealing of the ground's surface (NGOFUWS/ UNHABITAT 2008). Several methods are currently available for assisted groundwater recharge. These include recharge trenches and permeable pavements that promote the percolation of water through soil strata at shallower depths; and recharge wells that allow rainwater to seep to greater depths. Figure 2 shows the potential areas for shallow aquifer recharge. The north and northeastern parts of Kathmandu have great potential (Shrestha 2001) for deep aquifers. Past studies and research recommend dug wells, shallow tubewells, and recharge pits to recharge shallow aquifers. Pond restoration and channelling rainwater into the ponds also supports the recharging of shallow groundwater aquifers.

A recent groundwater recharge initiative of UN-Habitat and the Centre for Integrated Urban Development (CIUD) in a community in Patan resulted in increased flow from the stone spouts and increased water levels in dug wells in the area. Rainwater from roofs and surface runoff from houses, courtyards, and surrounding areas was collected and channelled to a recharge pit (Figure 3). With the success of this initiative, UN-Habitat has agreed to provide further financial and technical support for groundwater recharge, in partnership with Lalitpur Sub-Metropolitan City and Bottlers Nepal Limited, through a public-private community partnership model.

Time to start harvesting

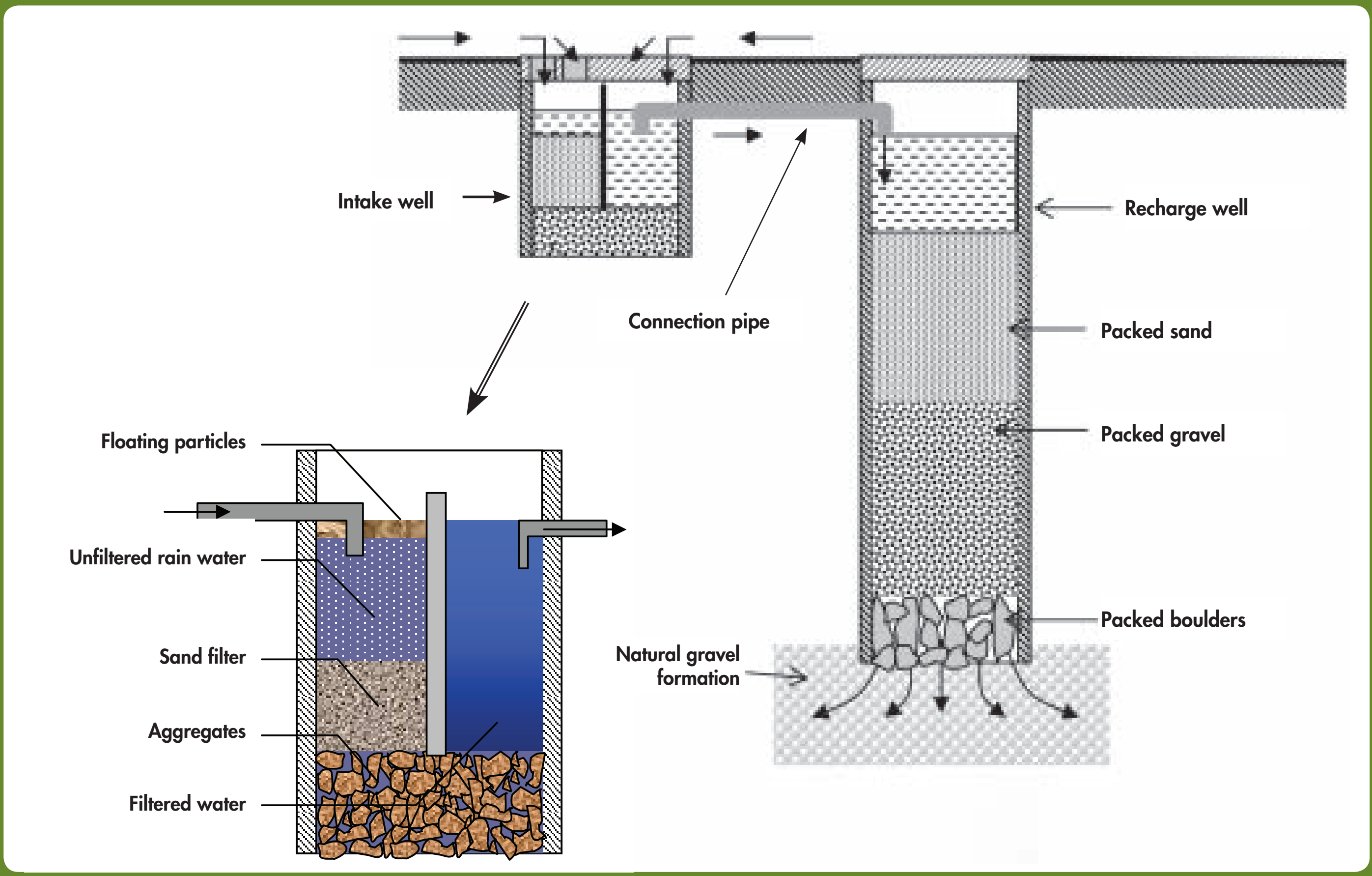
The water shortage in the Kathmandu Valley will not be solved in the near future. It is now time to tap alternative sources of water. Rainwater harvesting has been successfully practised in many parts of the world and was a major source of water in the Kathmandu

Figure 2: **Potential recharge zone in the Kathmandu Valley showing the infiltration rate during the monsoon season** (NGOFUWS/UN-HABITAT 2008)



Map source: based on engineering and environmental geological map published by DMG in cooperation with BGR

Figure 3: **Cross-section of recharge pit for shallow groundwater recharge in Lalitpur**



Valley before the introduction of the piped supply system. The abundance of rainwater in the Valley means that modern techniques of rainwater collection have enormous potential to fulfil the unmet water demand. However, storing rainwater in large reserve tanks is not always practical or economic for individual households. The introduction and wider implementation of artificial groundwater recharge could be one of the best options for storing and conserving rainwater.

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