Supplementary Materials: The Status of Domestic Water Demand: Supply Deficit in the Kathmandu Valley, Nepal

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1. Data

The Village Development Committee (VDC) and Ward level population for the year 2001 and 2011, and water supply sources and sanitation coverage data obtained from Central Bureau of Statistics, Nepal [1,2]. VDC wise data on households covered with piped water supply obtained from Central Bureau of Statistics, Nepal [3,4]. The households without piped water supply are considered to be using stand post water supply (*i.e.*, population fetching water from remote sources). Data on households covered with flushing toilet system in five municipalities (namely Kathmandu, Bhaktapur, Lalitpur, Kirtipur, and Madhyapur) considered as a proxy for households connected to the public sewage system [3,4] The other VDCs do not have public sewage collection system. The indicators used to estimate VDC/Municipality wise water demand are 1) population, 2) population with pipe water supply, 3) population using stand post (or other source) water supply, 4) households connected to public sewage (full flushing toilet) systems, and 5) households with septic/ordinary toilet facilities.

2. Population Growth

The Village Development Committee (VDC) level annual population 2011 onwards is predicted by using exponential growth formula as follows:

$$P_t = P_0 \times e^{rt} \quad \text{(S1)}$$

where, P_t-Population at time t, P_0-Population at time t_0,r-Growth rate, t-Time (number of periods).

Step 1: Estimate annual population growth rate over 2001–2011 (t = 10 years) using Equation (S1).

$$P_{2011} = P_{2001} \times e^{r \times 10} \quad \text{(S2)}$$

$$r = (\ln \frac{P2011}{P2001}) / 10 \quad \text{(S3)}$$

Step 2: Use (r) estimated in step 1 to predict the population for next year (t = 1) and so on.

$$P_{2012} = P_{2011} \times e^{r \times 1} \quad \text{(S4)}$$

$$P_{2013} = P_{2012} \times e^{r \times 1} \quad \text{(S5)}$$

Figure S1 shows the annual population growth rates at VDC levels. The VDC wise annual exponential population growth rates in the Kathmandu Valley were ranged from −0.26% to 13.05% over the period of 10 years (2001–2011). VDCs namely Bisankhunarayan, Gundu, Phukulacchi and Satikhel showed negative growth rates *i.e.*, 0.09%, 0.12%, 0.26% and 0.19%, respectively. However, the growth rates were negative and small in these VDCs, with population 4526, 5757, 2746 and 4328, respectively; which are unlikely to affect prediction of the total population of the valley. The population growth rates in most of the VDCs located near the edge of the valley were ranging from 0.1% to 2.3% (small) which may attribute to the less developed mountainous regions. The population growth rates were moderate (2.4% to 4.3%) in the Kathmandu Metropolitan City (KMC), Lalitpur Sub-Metropolitan City (LSMC) and other 17 VDCs. However, the population growth rates were highest (4.4% to 13.1%) in VDCs located near or in the vicinity of KMC and LSMC; those can be classified as rapidly urbanizing VDCs. The high population growth rates in these VDCs may have resulted from the migration of population (due to better education, health, and other facilities) from surrounding VDCs and other parts of Nepal. Also, convenience to commute to nearby metropolitan areas might have resulted in settlements of the population in these VDCs. By using the growth rates, VDC level population predicted for the year 2016 and 2021.

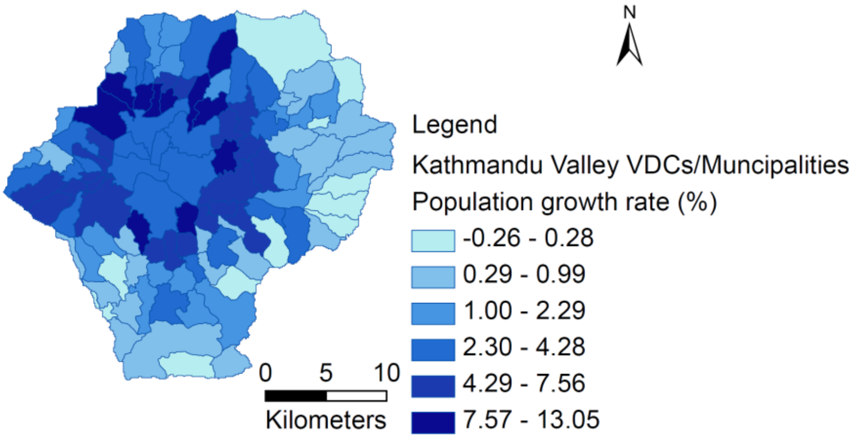

Figure S1. Annual population growth rates at VDC levels.

Figures S2 and S3 show annual population growth in the valley. The population has increased from 1.59 million in 2001 to 2.42 million in 2011. It is expected to rise to 4 million in 2021 (2.5 folds compared to 2001 population). The urbanizing and rapidly increasing population trend is expected to increase pressure on existing infrastructure of the valley like water supply and sanitation unless adequate planning is done in advance.

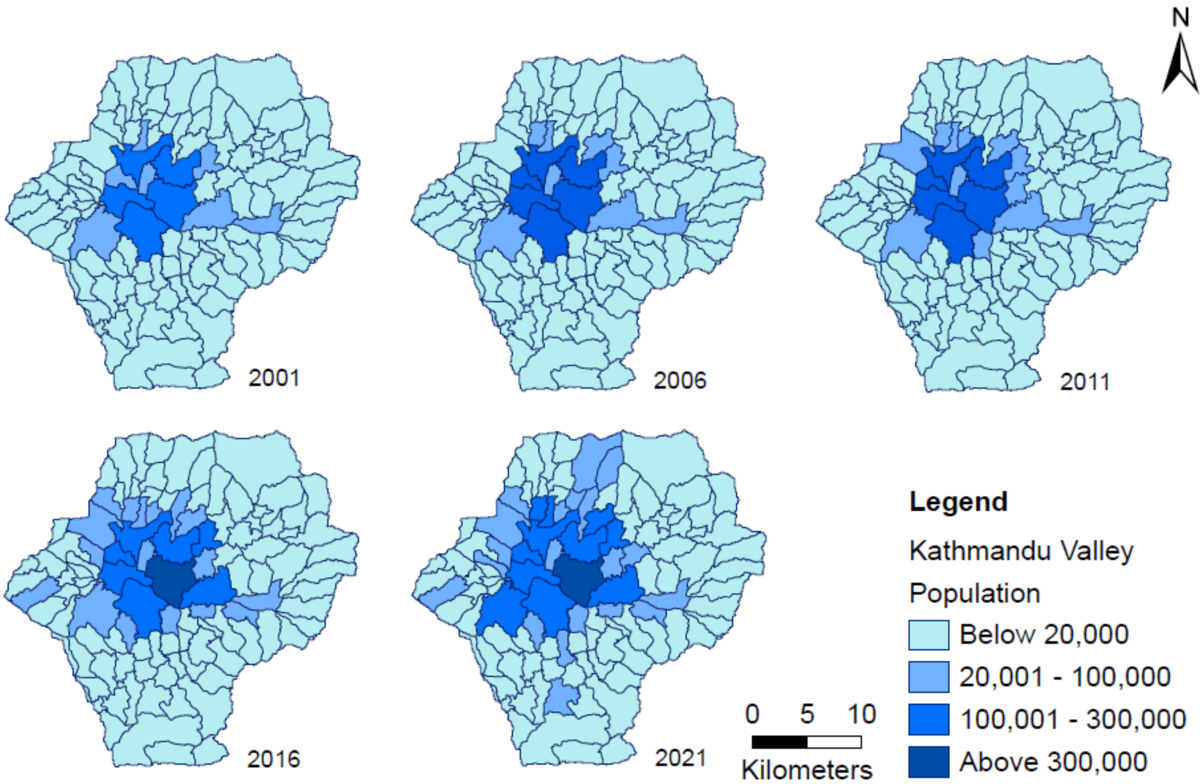

Figure S2. VDC/Municipality level population of the Kathmandu Valley (Note: 35 wards of the Kathmandu Metropolitan City are classified into six KUKL water supply service areas for population projection).

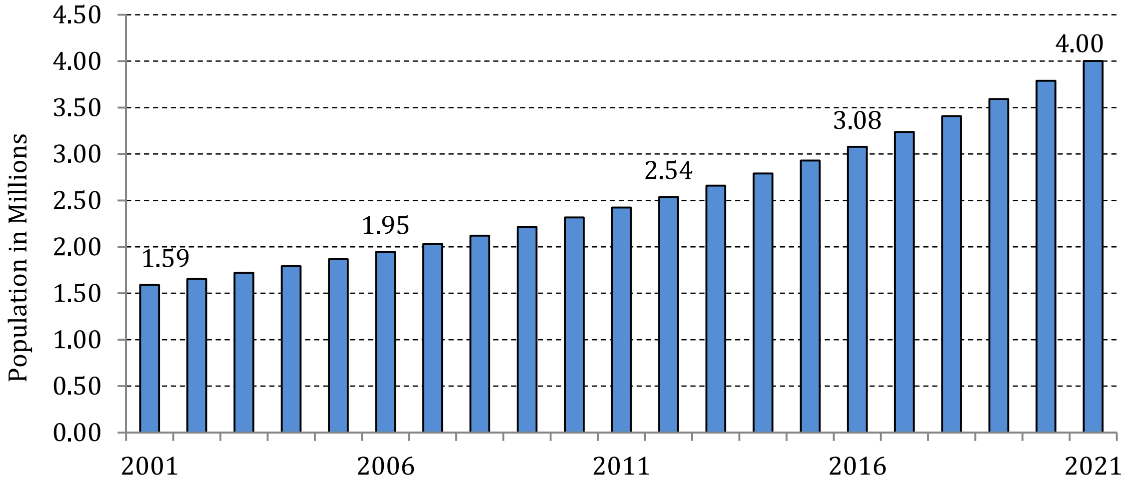

Figure S3. Annual population growths in Kathmandu Valley.

3. Literature on per Capita Water Demand

The definition of domestic water requirement or demand (in liters per capita per day, lpcd) may vary based on water supply infrastructure, climate, geography, and culture, *etc*. This section discusses the available literature on the per capita domestic water requirement. Various studies ranging from 1988 to 2002 [5] has estimated water consumption in the valley in the range of 43 to 145 lpcd based on different criteria. According to a report by Joshi *et al.* [5], the average domestic water consumption in the valley is about 94 lpcd (in 2003) and recommends considering rapid urbanizing trend while designing future water supply infrastructure. A recent study (2013) by Shrestha *et al.* [6], based on the field investigation in the Valley has recommended securing access to sufficient domestic water to 100 lpcd regardless of the source, rather than providing minimal access to improved water (20 lpcd). The KUKL estimated water demand for the population located in its service areas assuming water consumption equals to 135 lpcd [personal communication].

The World Health Organization (WHO) has estimated that the likely volume of water collected for basic (source within 1 km distance), intermediate (water provided through at least one tap), and optimal (supply of water through the multiple taps within the house) access as 20, 50 and 100 to 200 lpcd, respectively [7]. Of it, intermediate and optimal access to water supply poses a little risk to individual hygiene and also includes on-plot laundry. These guidelines could be useful to design water supply infrastructure in the valley.

The Bureau of Indian Standards (BIS) [8] considers a minimum of 70 to 100 lpcd as adequate for domestic needs (water supply for residences) of urban communities excluding flushing requirements (which is allocated as 45 lpcd). As a general rule (Figure S4), BIS considers minimum water requirement as:

(1) For communities with population up to 20,000 and without flushing system,

i) water supply through stand post −40 lpcd.
ii) water supply through house service connection, 70 to 100 lpcd.

(2) For communities with population 20,000 to 100,000 together with flushing system −100 to 150 lpcd.

(3) For communities with a population above 100,000 with full flushing system −150 to 200 lpcd.

In case (3), the minimum water requirement can be reduced to 135 lpcd for low-income groups and economically weaker section of society.

This study applied the BIS guidelines for estimating water demand (Figure S4). It is based on the population size of a local administrative unit (VDC/Municipality), the population having piped water supply and connections to the public sewage system. The study does not consider water demand for buildings other than residences (factories, hospitals, schools, offices, *etc*.) and other public places. The algorithm presented in Figure S4, in general, assumes that water demand for the population from larger administrative units (with piped water supply and connection to sewage) as 200 lpcd (maximum). The minimum water demand in the villages or rural areas with less population (without piped water supply and public sewage connections) assumed to be 40 lpcd (minimum). The water demand assumed in this study ranges from 40–200 lpcd depending on defined criteria.

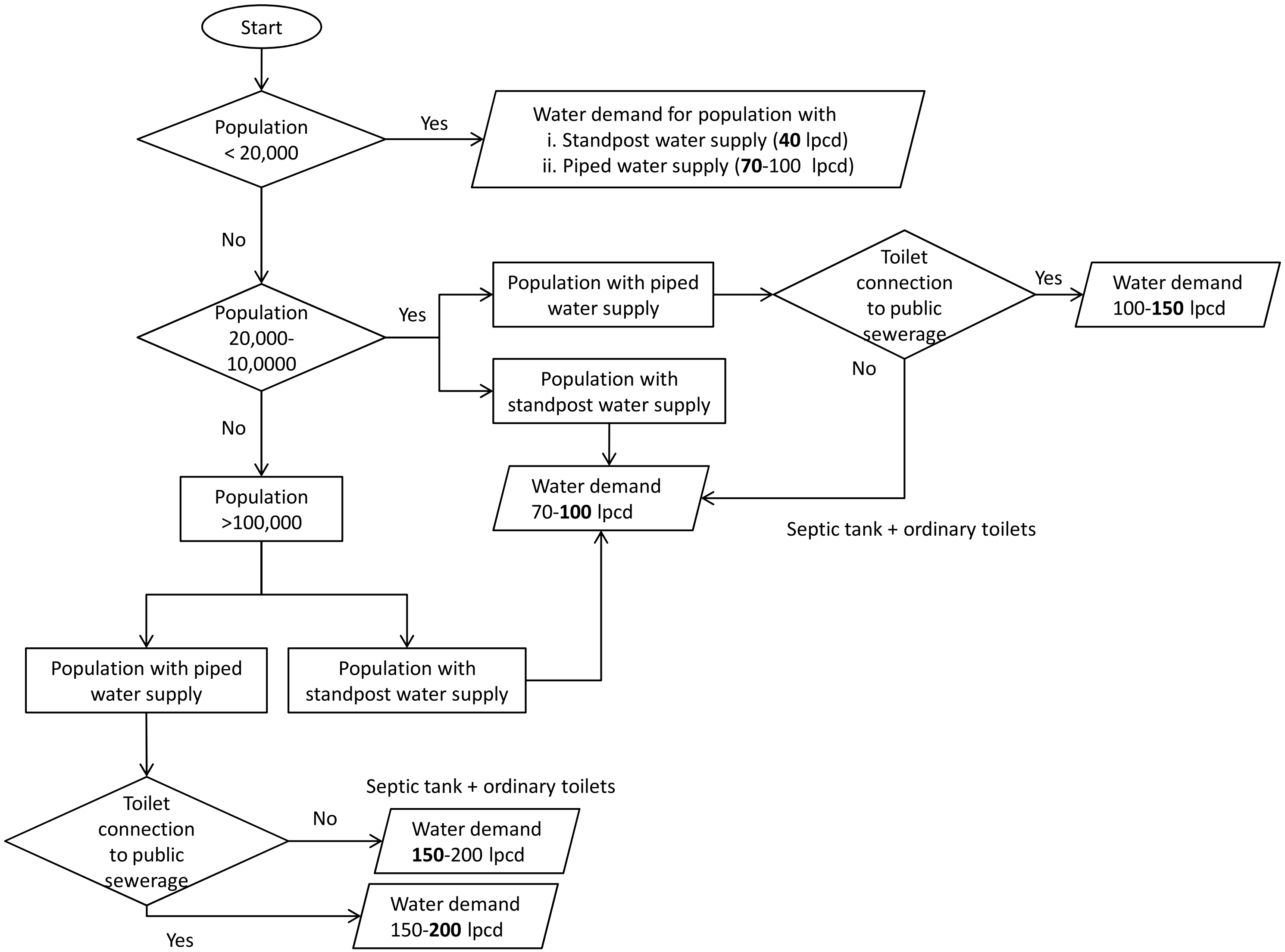

Figure S4. Algorithm for estimating water demand based on population size, water supply, and sanitation coverage (used values are in bold).

References

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