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Measuring Water Deficit and Stress Level of Household in Nepal

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Abstract
In the context of Nepal's emerging small cities, where most households have faced the growth of water deficit and stress, this study delve the nexus between water deficit and water stress and adaptation capacity of households and lesson learnt. Surveying 317 sample households in 12 small cities for cross sectional data sets of households across three different elevations and ecological belts (Himal, Hill and Terai) under explorative and descriptive research design, the study has used economic analysis and index method to achieve above key objectives. Our findings are presented here. Firstly, we found water deficit for one month long in these small cities relative to excessive water demand of households with reference to 20 liters and 50 liters water thresholds for basic utilities and more than basic utilities. The distribution of water deficit is uneven across three elevations and ecological belts. In the higher elevation (Himal), water deficit is higher than moderate elevation (Hill) and lower elevation (Terai). Lower water availability below average 0.9 liters water in the higher elevation causes water deficit. Secondly, we observed uneven water stress in all small cities across the different elevations (Himal, Hill and Terai) relative to water demand of 20 liters and 50 litres. The level of water stress is extremely higher in Himal and Terai but is comfortable in Hills. At a per capita daily water availability of 20 liters, household water stress is unevenly distributed across the small cities. Five cities in the Himal and Terai regions experience extreme stress, while seven cities in the Hill region remain largely unstressed, except for Bandipur and Marsyangdi, which face moderate stress. Overall, water deficits in the Hill region are lower than in the Himal and Terai. Although 20 liters per capita per day may suffice for basic household needs, most cities still experience high water stress, with the Hill region showing relatively lower stress compared to the Himal and Terai. When assessed against WHO standards (50–100 liters per capita per day), all cities exhibit extreme water deficits and critical water stress, highlighting a severe gap between water availability and the level required for an adequate standard of living. Thus, lower water availability is a key determinant to water deficit and stress at household in these cities. Therefore, additional avoidance cost to water deficit and stress that is economic cost to households increases vulnerability to the low-income groups more than the high-income groups and redistribute income and welfare of households in these cities for fostering poverty, inequality and health hazards. In this insight, this study argues saving water and efficient use of water for reducing water deficit and stress and their socio-economic impacts in the form of poverty, inequality and vulnerability. Therefore, the study advocates to use indigenous water-saving knowledge and technology for harvesting rainfall during the monsoon period, conserving fresh water and purifying polluted water for welfare and prosperity of these small cities in Nepal.

Keywords
water deficit, household stress, adaptative capacity, small towns

1. Background
Water is essential for human survival and plays a critical role in global socio-economic and ecological systems. It is a key indicator for assessing water deficits, as variations in availability and demand influence the frequency and severity of deficits across seasons. Monitoring water deficits helps evaluate household water use, water security, and overall well-being.

According to UNICEF (2023), approximately 4 billion people—around two-thirds of the global population—live under extreme water deficits due to limited water availability and increasing demand. The study also projects that by 2025, half of the world's population will encounter water scarcity. The Global Water Institute (2023) estimates that 700 million people could be displaced by 2030 due to this scarcity, with water stress intensifying to extreme levels by 2040.The United Nations reports that roughly 2.3 billion people currently reside in countries experiencing significant water stress.

Water deficits are primarily driven by two factors: climate change and disasters that reduce water availability, and urban-driven water demand. Research by IPCC (2001), Stern (2006), and UNFCCC (2018) highlights that declining and erratic rainfall, along with rising temperatures, are key contributors to water scarcity. On the demand side, higher literacy, health awareness, and rapid urbanization increase water consumption. For instance, World Resources Institute (2023) projects a 163% rise in water demand in Sub-Saharan Africa by 2050—almost four times the 43% increase forecasted for Latin America during the same period.

Global analyses indicate that urban populations face more severe water deficits than rural areas. In developed countries, water stress is moderate due to consumption often exceeding WHO standards. In contrast, developing countries experience critical water stress because freshwater resources, though available, are poorly distributed, limiting access for drinking and hygiene. Thus, water deficits depend not only on resource availability but also on effective distribution and management.

WHO (2023) indicates that 884 million people globally are without access to safe drinking water, while 3.2 billion depend on water for agriculture. In Asia, 73% of the population is affected by water stress (Majumdhar, 2015). ConcernUSA (2022) classifies Nepal alongside countries like Lebanon, Pakistan, Afghanistan, Syria, Turkey, Burkina Faso, and Niger as water-deficit nations. Water stress is particularly severe in the Middle East and North Africa (83%) and South Asia (74%). Economically, water deficits result in substantial losses, equivalent to roughly 31% of global GDP, or about 70 trillion USD (WRI, 2024).

2. Literature Review

World Resources Institute (2024) highlights the severe water deficit in Nepal, yet Bista (2025) reports an annual water availability of 225 billion cubic meters, sourced from over 6,000 rivers and rivulets totaling 45,000 km. Despite this abundance, water deficits are reflected in economic losses across agriculture, industry, and households. DWSSM (2019) and MoF (2019) indicate that only 51.69% of the population has access to piped water, while 48.31% depends on non-piped sources, demonstrating that partial infrastructure coverage does not eliminate water scarcity. Such deficits pose risks to safety, hygiene, and health, particularly among vulnerable populations, as confirmed by Maskey, Pandey, and Giri (2023) in their municipal-level study on water equity, quality, and affordability. However, being qualitative and based on 40 key informants, questions remain regarding its reliability and validity.

Pandey (2021) identifies both supply- and demand-side drivers of water stress. On the supply side, climate change and unplanned urbanization reduce water availability; on the demand side, population growth, lifestyle changes, and socioeconomic practices increase pressure on urban water resources. Their analysis is based on cross-sectional data from eight Nepali cities. Conversely, Mishra et al. (2021) emphasizes water stress from deficits and quality issues, focusing on water security through literature review at the city level.

In Dhulikhel, Maskey et al. (2020) examines disparities in water distribution and quality between central and peripheral wards, identifying socioeconomic, environmental, technological, and governance factors as underlying drivers of unequal access and resultant water stress. Their approach is mixed-method but largely descriptive.

Studies by Dahal et al. (2019, 2020) underscore the impact of erratic and reduced rainfall on water scarcity and stress in Nepal, highlighting effects on agriculture, hydropower, ecosystems, and human use, particularly in the Karnali River Basin and downstream areas.

From an institutional perspective, Saraswoti, Mishra, and Kumar (2017) stress that governance reforms are essential for mitigating water deficit and household stress in the Capital City. Similarly, Singh et al. (2020) link household stress to poor governance, inadequate urban planning (including neglect of transient populations), and climate change, noting that short-term coping mechanisms, such as groundwater extraction, often create long-term problems. Some long-term strategies show promise, but results remain mixed.

McManus (2021) argues that inadequate local-level water management is a primary driver of water scarcity, directly affecting adaptation and availability. Ojha et al. (2019) highlights the value of combining indigenous and scientific knowledge to strengthen local adaptive capacity. Pradhan (2012) notes that households often adopt autonomous, unplanned strategies to cope with water stress, building resilience independently of formal policies.

Rai et al. (2019), emphasize the importance of context-specific approaches to tackle urban water shortages effectively in their study in in Dhulikhel Municipality and Dharan Sub-metropolitan City.

In summary, prior studies document the status, causes, and adaptive responses to water deficit-induced stress, demonstrating clear links to climate change. However, research remains limited regarding emerging small cities in the Marshyangdi River Basin, highlighting a knowledge gap. This gap justifies further study, particularly for climate adaptation planning and Sustainable Development Goal (SDG) implementation, which this study seeks to address.

3. Objectives and Methods

The main objective of this study is to examine the water deficit-induced water stress levels in Nepal. Its specific objectives are to study water deficit in the water basin, to rank cities household stress levels by index, and to present key issues and provide recommendations for policy development and future research.

The paper is structured as follows: Section 1 covers the Background, Section 2 outlines the Objectives and Methods, Section 3 describes the Methodology and Data, Section 4 presents the Results and Discussion, and Section 5 provides the Conclusion.

4. Methods and Data

4.1 Theoretical/Conceptual Framework

The theoretical framework is on Sun–Earth association as described by Milankovitch Theory, which suggests that long-term shifts in the Earth's position relative to the Sun are key drivers of climate change and play a crucial role in the beginning and end of glacial periods (Ice Ages) (Buis, 2020).

The theory asserts that solar variations influence climate, affecting temperature and rainfall patterns. Changes in solar temperature can alter precipitation and global temperature distributions, thereby contributing to climatic fluctuations. Higher rainfall may result in flooding, whereas reduced rainfall can cause drought, water scarcity, and stress, both of which lead to economic losses. These impacts compel communities to adopt adaptation strategies to reduce vulnerability and safeguard livelihoods (Figure 1).

These processes are well-documented by scientific research (IPCC, 2001; Gleick, 2000; Solomon et al., 2007; Adams & Peck, 2008; IPCC, 2018). Consequently, societies implement short-term adaptation and long-term mitigation measures to stabilize climate impacts and ensure a safer, more secure, and sustainable future.

4.2 Study Areas

This study focuses on the Marshyangdi River Basin, located in Gandaki Province, Nepal. The basin covers an area of 4,787 sq. km and extends approximately 150 km in length, lying between 27°50′42″N to 28°54′11″N latitudes and 83°47′24″E to 84°48′04″E longitudes (Figure 1). Originating in the Annapurna trans-Himalayan range, the basin stretches southward to the lowlands of Chitwan.

The basin is largely rain-fed, with water availability dependent on both the monsoon (wet season) and winter (dry season) flows. It covers a variety of ecological zones**,** from cold high-alpine regions to hot and humid tropical areas, with an average slope of about 29.42°**.** These geographical and ecological characteristics make the basin highly sensitive to climatic factors, especially rainfall. The clustering of small, densely populated cities heightens the area's susceptibility to flooding, landslides, and drought, and rainfall distribution differs widely across its landscapes (Figure 1).

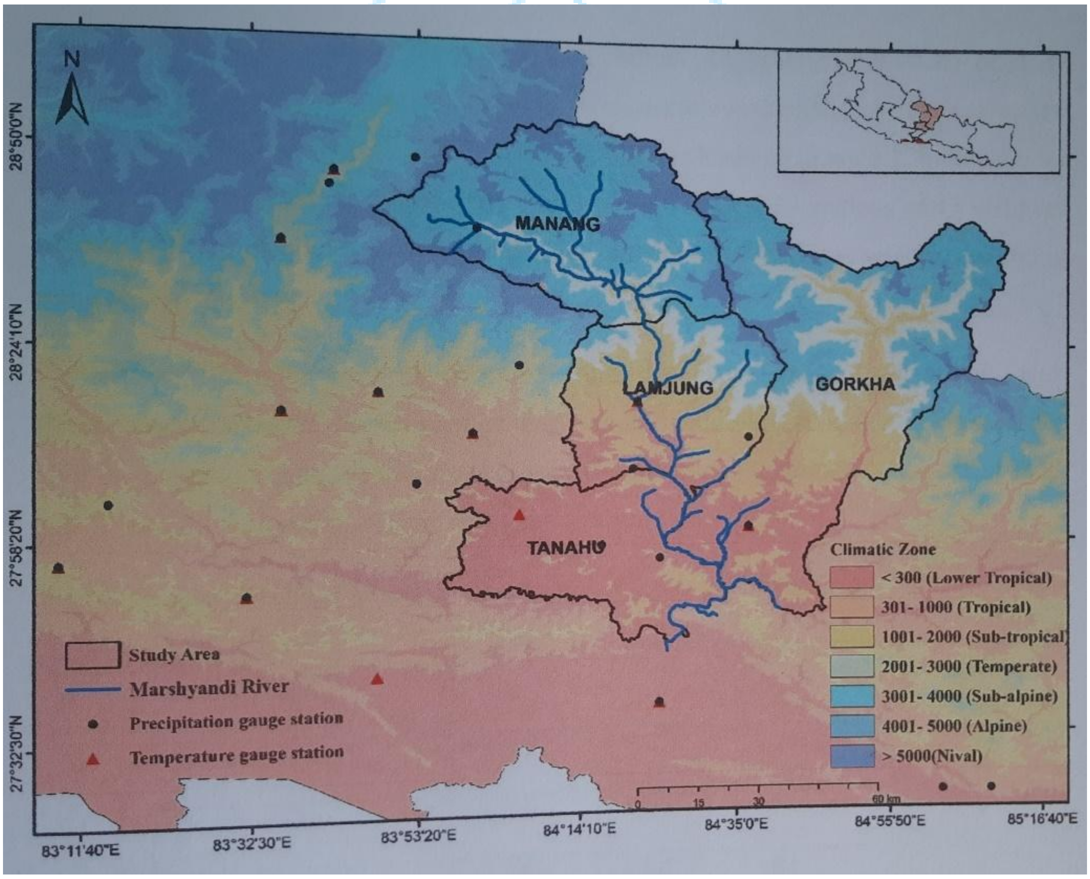

Figure 1 The Study Area- Marshyangdi River Basin
Source: Koirala, 2022

Figure 1 illustrates the study area, which is significant for two main reasons. First, the Marshyangdi River Basin experiences erratic rainfall and substantial impacts on its catchment areas (DHM, 2022). Second, the basin covers a broad elevation range, from 200 meters to 7,800 meters**,** spanning multiple ecological zones. The study area includes four districts across three ecological belts**:** Manang in the **Himal** (high altitude), Lamjung and Tanahu in the Hills (mid-altitude), and Chitwan in the **Terai** (low altitude). Within these districts, there are twelve emerging small cities classified as municipalities.

4.3 Data and Method

This study employed an explorative–descriptive research design in the River Basin districts of Manang, Lamjung, Tanahu, and Chitwan. The basin covers three ecological zones—Himal, Hill, and Terai—with elevations ranging from 415 to 3,600 meters. Within this area, the research focused on 12 small cities comprising 9 rural municipalities, 2 municipalities, and 1 metropolitan city. Based on the CBS (2011) census, these areas contained approximately 47,060 households and a population of 254,124, which served as the study population.

From this population, a sample of 317 households was calculated using Daniel's (1999) formula, with a 95% confidence level and a 4% margin of error. Sampling followed a two-stage clustering approach. In the first stage, samples were proportionally allocated across the four districts. In the second stage, they were further distributed among the twelve small cities—Chame, Nashong, Neshyang, Dordi, Marsyangdi, Anbukhaireni, Bandipur, Devighat (Rural Municipality), Besishahar, Bhanu, Gaidakot (Municipality), and Bharatpur (Metropolitan City). Within these cities, selected wards were identified as the study sites. Households were then chosen using random sampling to ensure representativeness and reduce bias.

In addition to primary data, secondary rainfall datasets were collected through a desk review conducted between June 1 and June 20, 2024. Sources included:

a) *The 15th Five-Year Development Plan (2018/19–2022/23)*;
b) *Sustainable Development Goals Roadmap (2016–2030)*;
c) *Statistical Pocket Book* (CBS);
d) *Nepal Living Standards Survey III* (CBS); and
e) *Economic Survey* (Ministry of Finance, MoF).

4.4 Water Deficit Model

Water scarcity imposes stress on communities in various ways, including uneasiness, discomfort, long waiting times, hours spent collecting water, physical effort, and extra financial costs for drinking water. In urban areas, these effects significantly constrain household life, especially for small families where both partners have professional commitments and limited time. In contrast, in rural areas, women—whose time is often undervalued—tend to accept these burdens as a normal part of daily life. Nevertheless, such circumstances create negative externalities, as households incur additional costs to obtain water from alternative sources. The magnitude of these external costs depends on the level of household stress, meaning water shortages generate both noticeable and unseen household stress at these towns' levels.

While water deficit undeniably leads to water stress, the degree of stress also depends on the adaptation capacity of households. In cases where adaptation capacity is high, stress levels may be lower than expected; conversely, households with limited adaptive capacity face greater stress. Adaptation capacity is influenced by several factors, including literacy, awareness, training, group membership, age, poverty status, employment, income, and geographic location. Therefore, household adaptive capacity is an important determinant in shaping water stress outcomes.

In the literature, water deficit is generally defined as the ratio between water use (WU) and water availability (WA) at both household and community levels. A deficit emerges when water use increases while availability remains constant, or when availability declines while use remains unchanged. Formally, the water deficit (WD) can be expressed as:

$$W_D = W_U / W_A \quad \text{......................................(1)}$$

5. Results and Discussions

This section presents the study results on water deficit and household stress levels in the towns of the Marshyangdi River Basin. In addition, it discusses the associated economic inferences and potential resolutions.

5.1 Water Deficit and Household Water Stress in the Small Cities

Water deficit-induced household stress has become a significant challenge in developing countries like Nepal, affecting cities of all sizes, including small, emerging, and large urban centers. The question of how urban residents meet their daily water needs—for drinking, cooking, bathing, sanitation, and household chores—is critical. Bista (2016), and Bista (2021) note that in the Kathmandu Valley, asymmetrical water distribution and frequent leaks exemplify the stress caused by urban water deficits. Similarly, Smartphone (2024) reports an acute shortage, with a daily deficit of 120 million liters against a total demand of 360 million liters and a supply of only 90–140 million liters per day. These data highlight that water shortages and related stress are common across both small and large cities.

Nepal's national budget has focused on water supply projects to guarantee clean, reliable, and sustainable drinking water, as highlighted in the Fifteenth National Plan (Bista, 2021; NPC, 2022). The plan prioritizes the improvement of water services, enhancement of climate resilience, development of disaster-resilient infrastructure, and promotion of water conservation. Likewise, the 20-Year Long-Term Perspective Plan (2002) sought to secure water quality, availability, accessibility, reliability, and timely delivery (Bista, 2016). Nonetheless, water deficit-induced stress remains a persistent and significant challenge.

In urban areas, this problem stems from unplanned and haphazard urban growth, people-centered housing and infrastructure development, inadequate urban planning, and weak enforcement of regulations (Pandey, 2021; Mishra et al., 2021). Many residents prioritize constructing large, visually appealing concrete houses, assuming that such investments will address broader urban challenges. This often comes at the expense of essential services such as roads, water supply, electricity, health, and education, concentrating resources on personal property rather than on comprehensive urban development.

5.2 Water Deficit and Stress Level of Small Cities

The consequences of water deficits are apparent in the uncoordinated use of water, land, and other resources. Such scarcity creates negative externalities, resulting in higher costs and increased household stress. This study measures and quantifies household stress levels in these emerging towns through a household survey. Table 1 presents the calculated water deficits along with their corresponding household stress levels in these towns.

Table 1 Water Deficit and Water Stress

Ecological zones	Cities	Water Deficit	Range	Water Stress Level
Himal	Nasong	-0.3	<0	Extremely Stress
	Nishyang	-0.1	<0	Extremely Stress
	Chame	-0.2	<0	Extremely Stress
	Norphu	-0.3	<0	Extremely Stress
Hill	Bandipur	0.7	0.5-1	Moderate Stress
	Bhanu	1.4	>1	No stress
	Dordi	1.9	>1	No stress
	Devighat	2.0	>1	No stress
	Abhukharini	1.6	>1	No stress
	Beshishar	3.0	>1	No stress
	Marshangdi	0.9	0.5-1	Moderate Stress
Terai	Chitwan	-0.1	<0	Extremely Stress
	Mean	0.9	0.5-1	Moderate Stress

Source: Field Survey, 2024

Table 1 illustrates the water deficit and household stress levels in above towns within the Marshyangdi River watershed, across Himal, Hill, and Terai ecological zones. Although the watershed is naturally water-rich, this abundance is not equally experienced by all cities or income groups.

According to the table, the Himal region experiences the greatest water deficit, with water availability falling below the average threshold of 0.9, while the Hill and Terai regions exhibit comparatively better conditions. Consequently, the deficit is classified as water stress. Residents in the Himal and Terai zones face extremely high stress, whereas those in the Hill region generally experience minimal stress, with the exception of Bandipur.

In the Himal, low winter temperatures reduce water availability, though conditions improve in summer. Conversely, in the Terai, summer flooding contaminates water quality, and water scarcity occurs in winter (Micro-Workshop and KII, 2024). Despite geographical challenges in the Hill region, natural water sources significantly enhance water availability during the summer months.

5.3 Water Deficit and Stress (Min and Max)

Water deficit is measured based on per capita daily water availability**.** According to WHO (2021)**,** a minimum of 20 liters per person per day is necessary to meet basic drinking and sanitation needs, while 50 liters per person per day serves as the upper limit for basic requirements. For this study, these two values are used as reference points**.** Table 2 shows the calculated water deficits and the corresponding levels of water stress for this range.

Table 2 Water Deficit and Water Stress in the threshold between 20 liters(min) and 50 liters(max)

Ecological Belt	Cities	Water deficit (min)	Water deficit (max)	Range (min)	Water Stress Level (min)	Range (max)	Water Stress Level (max)
Himal	Nasong	-0.3	-0.7	<0	Extremely Stress	<0	Extremely Stress
	Nishyang	-0.1	-0.6	<0	Extremely Stress	<0	Extremely Stress
	Chame	-0.2	-0.7	<0	Extremely Stress	<0	Extremely Stress
	Norphu	-0.3	-0.7	<0	Extremely Stress	<0	Extremely Stress
Hill	Bandipur	0.7	-0.31	0.5-1	Moderate Stress	<0	Extremely Stress
	Bhanu	1.4	-0.05	>1	No stress	<0	Moderate stress
	Dordi	1.9	0.14	>1	No stress	<1	Moderate stress
	Devighat	2.0	0.2	>1	No stress	<1	Moderate stress
	Abhukharini	1.6	0.0	>1	No stress	<1	Moderate stress
	Beshishar	3.0	0.6	>1	No stress	<1	Moderate stress
	Marshangdi	0.9	-0.2	0.5-1	Moderate Stress	<0	Extremely Stress
Terai	Chitwan	-0.1	-0.6	<0	Extremely Stress	<0	Extremely Stress
	Mean	0.9	-0.3	0.5-1	Moderate Stress	<0	Extremely Stress

Source: Field Survey, 2024

Table 2 shows water deficit and household stress levels for twelve small towns across the three ecological zones—Himal, Hill, and Terai—based on per capita daily water availability ranging from 20 liters (minimum) to 50 liters (maximum), which corresponds to the basic requirement for drinking and personal sanitation. At the minimum level of 20 liters per person per day, the average water deficit across the 12 cities falls between 0.5 and 1, indicating moderate stress. In this scenario, five cities in the Himal and Terai zones experience extreme stress, while seven cities in the Hill region remain largely unstressed, except for Bandipur and Marsyangdi, which face moderate stress. Overall, the Hill region is relatively less affected by water deficits than the Himal and Terai.

At the higher reference level of 50 liters per capita per day, water availability is generally more adequate, with the average deficit across the 12 cities below zero. Nonetheless, five cities in the Himal and Terai continue to face extreme stress, while two cities in the Hill zone also experience extreme stress. The remaining five cities in the Hill region exhibit moderate stress, showing that water stress in the Hill remains lower compared to the Himal and Terai.

Meeting only basic water needs, however, is insufficient for ensuring an adequate standard of living, which includes drinking, personal sanitation, washing, cooking, and household hygiene. According to WHO (2021), a more sufficient per capita daily water requirement ranges between 50 liters (minimum) and 100 liters (maximum). Table 3 presents the water deficit and household stress levels corresponding to this expanded range.

Table 3 Water Deficit, Water Threshold & Water Stress

Ecological Belt	Cities	Water deficit (min)	Range (min)	Water Stress Level (min)	Water deficit (max)	Range (max)	Water Stress Level (max)
Himal	Nasong	-0.7	<0	Extremely Stress	-0.9	<0	Extremely Stress
	Nishyang	-0.6	<0	Extremely Stress	-0.8	<0	Extremely Stress
	Chame	-0.7	<0	Extremely Stress	-0.8	<0	Extremely Stress
	Norphu	-0.7	<0	Extremely Stress	-0.9	<0	Extremely Stress
Hill	Bandipur	-0.31	<0	Moderate Stress	-0.7	<0	Extremely Stress
	Bhanu	-0.05	<0	Extremely Stress	-0.5	<0	Extremely Stress
	Dordi	0.14	<1	Moderate stress	-0.5	<0	Extremely Stress
	Devighat	0.2	<1	Moderate stress	-0.4	<0	Extremely Stress
	Abhukharini	0.0	<1	Moderate stress	-0.5	<0	Extremely Stress
	Beshishar	0.6	<1	Moderate stress	-0.2	<0	Extremely Stress
	Marshangdi	-0.2	<0	Extremely Stress	-0.6	<0	Extremely Stress
Terai	Chitwan	-0.6	<0	Extremely Stress	-0.8	<0	Extremely Stress
	Mean	-0.24	<0	Extremely Stress	-0.63	<0	Extremely Stress

***Source*:** Field Survey, 2024

Table 3 presents water deficit and water stress levels for 12 small cities across the three ecological zones—Himal, Hill, and Terai—based on a per capita daily water range of 50 liters (minimum) to 100 liters (maximum). This range accounts not only for drinking and personal sanitation but also for household needs such as washing clothes, food preparation, and hygiene.

At the 50 liters per capita per day minimum**,** water typically meets drinking and sanitation needs**,** yet it is still inadequate for additional household uses**.** Across the 12 cities, the average water deficit is below zero (<0), with a mean value of -0.24, indicating extreme water stress, though not at the highest intensity. Notably, four Hill-region cities—Dordi, Devighat, Anbukhaireni, and Marsyangdi—experience moderate stress, whereas the remaining cities across all three ecological zones face extreme deficits and stress in meeting both drinking and broader household water needs.

At the upper reference of 100 liters per capita per day, the situation remains critical, with average water deficits still below zero and residents experiencing extremely high levels of stress and discomfort. While the severity of stress varies slightly among the 12 cities, all populations are confronted with significant challenges in meeting their water needs. This scenario illustrates the impact of water poverty on poor living conditions and its role in limiting productive activities. Despite the presence of water resources in the Marshyangdi River and its tributaries**,** ineffective extraction and distribution systems remain major obstacles. These conditions have direct implications for the cleanliness, hygiene, and overall quality of life of residents in these 12 small cities.

5.4 Discussions

This segment outlines the results of the study on water deficits and household stress in Nepal. The two phenomena are unidirectionally linked, with water deficits leading to water stress, but not the other way around. The analysis considers three water-use scenarios:

1. Drinking water only (survival),
2. Drinking and sanitation (survival and hygiene), and
3. Drinking, sanitation, laundry, food preparation, and household hygiene (ensuring a basic living standard).

In the first situation, average water deficits and stress levels are moderate across the cities. Nonetheless, towns in the Himal and Terai regions experience severe deficits and heightened stress, whereas Hill towns remain largely stable, indicating that residents there can typically access sufficient drinking water.

The second scenario examines water availability from 20 liters per capita per day (minimum) to 50 liters per capita per day (maximum). At the minimum level, results are similar to the first scenario. At the maximum level, all cities experience deficits and stress, with Hill cities at moderate levels and Himal and Terai cities remaining at extreme levels.

Under the third scenario, aligned with WHO standards (50–100 liters per capita per day) to support a basic standard of living, all cities across the three ecological zones show extreme water deficits and stress. Consequently, nearly all households in the Marshyangdi River Basin face severely stressful living conditions, reflecting critically poor standards of living. This situation presents a major barrier to achieving the Sustainable Development Goals (SDGs) and improving overall quality of life.

These findings are supported by wider regional analyses**.** WHO (2023) reports that 73% of South Asia's population is under water stress, a pattern also noted by UNICEF (2023) and the World Resources Institute (2023)**.** Concern USA (2022) similarly identifies Nepal as a water-stressed nation. Further confirmation comes from national research, including studies by Pandey (2021), Mishra et al. (2021), Maskey et al. (2020), Dahal et al. (2019, 2020), Saraswoti, Mishra, and Kumar (2017), McManus (2021), Ojha et al. (2019), Pradhan (2012), and Rai et al. (2019)**.**

These results contradict assumptions of adequate water availability in the Marshyangdi River Basin and highlight deficiencies in water governance, institutional frameworks, and policy implementation. Despite the presence of the river and related water resources, local municipalities, as well as provincial and federal authorities, have not implemented planned measures to mitigate deficits and stress. This shortfall may drive migration to Dhading and Kathmandu where water deficits and stress are minimal, impacting not only household livelihoods quality but also farming and non-farming productivity, income generation, and overall welfare.

6. Conclusions

This study explores water deficits and stress in Nepal across three water-use scenarios: (a) drinking only, (b) drinking and sanitation, and (c) drinking, sanitation, laundry, cooking, and family hygiene to achieve an adequate standard of living. It indicates notable deficits in drinking, sanitation, and hygiene, leading to moderate stress on average. Ecologically, cities in the Himal and Terai regions face severe water deficits and household stress, with potential health risks, while Hill region cities generally experience minimal deficits and low stress**.** At the 50 liters per capita per day standard, all cities across the Himal, Hill, and Terai show severe deficits**,** leading to extreme water stress**,** reduced living standards, and increased health hazards.

These findings indicate that mere water availability does not guarantee reduced water stress or improved health outcomes unless water management is efficient. The magnitude of water deficit constrains higher living standards, exacerbates stress and health hazards, and imposes additional economic costs on households. These costs disproportionately affect low-income groups, redistributing income and welfare, and reinforcing poverty, inequality, and vulnerability.

In light of these challenges, the study emphasizes the importance of water conservation and efficient usage to mitigate water deficits, reduce stress, and limit associated socio-economic impacts. It advocates employing indigenous water-saving practices and technologies, including rainfall harvesting during the monsoon, freshwater conservation, and purification of polluted water, to enhance the welfare and resilience of small cities in Nepal. Addressing these issues is critical for achieving Sustainable Development Goals (SDGs) and ensuring the well-being and happiness of urban populations. Prioritizing water management in the plans, policies, and programs of all three tiers of government is therefore essential.

Competing Interests

The author confirms that no financial or non-financial conflicts of interest exist in connection with this study.

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Author's Contribution

The author undertook the entire research process independently, including designing the methodology, collecting and analyzing data, and writing the manuscript, thus contributing fully to this work.

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