DOI: https://doi.org/10.3126/ejdi.v37i2.77469

Estimating Water Poverty in Small Cities in Nepal

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Abstract

Nepal is water rich climate prone country where small cities are facing escalating water scarcity and stress at household levels, this study estimates water poverty in these small cities across different elevations in the water basin in Nepal and households' imperative behaviors. Using cross-sectional data sets of water poverty collected from the 12 small cities of the water basin in Nepal in 2022, the study employs descriptive statistics and the water poverty estimation method. As a result, headcount poverty reveals extreme water poverty, with 63.7 percent of the population living below the minimum threshold of 20 liters per capita per day and 95.82 percent below the maximum threshold of 50 liters per capita per day, despite the purported availability of water. Ecologically, there is less water poverty in the hills in the Terai and Himalayas at the minimum threshold, while it is uniform across all regions at the maximum. The levels of water poverty in cities vary widely. The cities of Devighat, Dordi, Besishar, and Abhukharini have the lowest levels of water poverty, while all small cities have at least 50 percent water poverty. This highlights the significant disparity between the supply and demand of water. Physical infrastructure and the economic capacity of people and cities to afford and access safe drinking water have identified constraints. Otherwise, climate change has stressed water availability. These results reveal the negative implications of climate change, water stress, and water poverty. This study provides a predictability of future complications in water stress and poverty at the household level. Therefore, it would be a valuable input to the water management system and preparedness for water. Further, it would extend to point out infrastructure constraints and households' adaptation capacity and behavior.

Keywords: Water Stress, Water Poverty, Climate Change, Small Cities, Water Basin
JEL Code: I32, Q25, Q54, R23

1. INTRODUCTION

The study is motivated by the immediate need to address mounting threats of *extreme* water poverty at household levels in emerging small cities across Nepal complicating the existing poverty. This complicated issue comprehends various causal drivers, shortage of water supply, disappearance of water sources, seasonal water pollution, flood and landslides polluting rivers, the visible and invisible impact of climate change, leakages in the pipelines, etc. (Immerzeel, et al., 2010, Stitt, 2011, Bista, 2018 & Bista, 2022). This causes water borne diseases including typhoid, dysentery and cholera in Kathmandu (UN, 2019, Bista, 2021, & Bista 2022). In Eastern Development region, 32 percent children have suffered from it (MoF, 2024). As the fundamental right of citizen in the constitution and top priority to the distribution of drinking water in the 16th national plan, households are in the crisis of water deficit in the ineffective water distribution, management system and water governance of the public institution all over the country (Bista and Shahi, 2024). In this critical context, this study aims to estimates the level of water poverty at households' level in small cities in the water basin in Nepal unlocking the level of water poverty at households by ecology and cities and the existing issues and structural barriers in water supply and management system at household level and forward recommendations for policy implication to the policy makers and further research.

Clean water and sanitation are global agendas. UN has made it as a core focus of SDG as SDG 6: clean water and sanitation, along with SDG 3: Good health and wellbeing and SDG 15: life in land (WB, 2021 & WB, 2022). UN has partnered to implement it (UN, 2019). Nepal has nationalized it as social development goals, targets, programs and plan in the 14th national plan (2016-2018). Since then, the succeeding plans (the 15th plan (2019-2024) and the 16th plan (2024-2029) have mainstreamed in the path of national development (NPC, 2024). The 16th plan has a target to distribute clean water to all till the next 2029 (NPC, 2024). Over the last decade, the trend of clean water and sanitation is positive because the tendency of the state and non-state financing on clean water and sanitation is intensely consistent and a growing trend aiming to address water poverty at household level across the country. MoF (2024) points out 49.1 billion Rs of the federal and province budget in 2023. It is 1 percent of GDP and 2.3 percent of annual budget of Nepal. In the 1990s, the clean water and sanitation covered 36 percent of total population (MoF, 1990; B. K., et al., 2019). Thus, the progressive indicator and achievements in clean water and sanitation in the last 24 years reflects the tendency of the government.

IWMI (2000), Rijsberman, (2000), IPCC (2001), Krvsanova, et al. (2005), Sullivan, & Huntingford, (2009) and UNFCCC (2018) mentions declined availability of fresh water in the World. So far concerning Nepal, we can find its extreme reflection. Bista & Shahi (2024) claims the sedimentation of landslide and flood as major polluter to river water and other water sources and increasing drought events in hill and terai regions across the country. Furthermore, climatic instability in form of the erratic rainfall and precipitation has distorted water cycle in this climatic disaster-prone country. The declined water availability has constrained water supply and distribution to households to meet the standards of WHO (2024). Different types of water leakages in the distribution have limited water supply in the poor pipeline maintenances. Thus, *water availability* has become a critical issue to households to meet the international standards of water consumption in mega and small cities all over the country.

This study contributes substantially to the existing literatures on water poverty and water distribution in water supply and distribution system in the context of emerging small cities. Using the cross-sectional data sets of the survey 2024, the study has applied head count poverty method to measure water poverty to understand the relationship between water poverty, city and urbanization process to achieve better health and good sanitation for cleanliness, good environment and healthy. Firstly, the study extends the scope of analysis capturing water poverty by ecological belts. This method captures water deficit, the level of water poverty and alternative behaviors in three different landscapes. Secondly, the study deals quantitatively water poverty gap among cities within ecological belts and thirdly, the study measures water severity among these cities within ecological belts. Furthermore, the study influences stakeholders and policy makers for reducing water poverty, water poverty gap and water poverty severity for exploring appropriate policy interventions.

This remaining section of the paper includes a summary of the literature in section II, data and methods in section III, result and discussion in section IV and conclusions in section V.

2. LITERATURE REVIEW

Water poverty is a complex and multifaceted issue that has garnered attention from numerous scholars, particularly in relation to its economic, environmental, and social dimensions. Researchers have explored various conceptualizations and drivers of water poverty, emphasizing its significant impact on health, livelihoods, and overall well-being. The issues are highlighted in the literature review sections.

Yoon et al. (2021) and Ogwang and Cho (2023) considers water poverty as a multidimensional concept. A study of Feitelson and Chenoweth (2002) conceptualizes water poverty as a situation where a nation or region cannot afford the cost of sustainable clean water to all people at all times. Sylvester et al. (2023) briefly mentions it as the lived condition households experience when they are struggling, or unable, to afford their water bills. Similarly, CCW (2021) explains it households' unaffordability to water. UNICEF & WHO (2021) derives water affordability as the reference line of water poverty. Differently, Salameh (2000) describes it as the ratio of the amount of available water to the amount required to cover food production and the household uses of one person in one year under the prevailing climate conditions (p. 146). Sullivan (2001) notes it to the poverty notions as they are currently referred to and does not address.

Water poverty has many concerns. Feitelson, & Chenoweth (2002) mentions livelihood, environmental and economic dimensions. Yuan, et al (2023) identifies population growth, industrialization, the rapid development of urbanization and global warming. Out of these concerns, Garriga and Foguet, (2010), Mekonnen and Hoekstra, (2016), United Nations, (2017), Hussein (2018), Zhang et al., (2021b), and Yuan et al., (2022c) consider climate change as major one in many countries and regions.

Garriga and Foguet (2010), Mekonnen and Hoekstra (2016), and Zhang et al. (2021b) notes the growth of water poverty in the future, considering access to safe, clean and affordable water as a basic human right and climatic new threat of water scarcity on health and wellbeing of people and new inequalities. Satoh et al. (2022) has considered a similar argument. Further, Feitelson, & Chenoweth (2002) argues it due to water scarcity. Water scarcity is a function of demand and availability. The traditional neo-Malthusian view is that resources are fixed while demand rises as a function of population growth. This view underlies the most widely used indicator of water stress or scarcity, which is based upon renewable water resources per capita (or number of people depending on a unit of renewable freshwater) **(**Feitelson, & Chenoweth, 2002)**.** Similarly, Bista, et al. (2023) claims varying rainfall causing water scarcity and then water poverty.

Many literatures (Sullivan, 2002 and Molle and Mollinga, 2003) have extensively studied the relationship between poverty and access to water. Studies (Sullivan, 2002 and Molle and Mollinga, 2003) argue the water poverty as a driver of wider poverty. Further, the improvement of access to water may be out of extreme poverty (World Bank, 2017 and Molle and Mollinga, 2003). Differently**,** Bista et al. (2024) have examined the relationship between water deficit and water stress. Further, the study has argued water deficit as a driver of water poverty.

Ogwang and Cho (2023) states measurement of water poverty from both unidimensional and multidimensional perspectives. Yuan, et al. (2023) explains indicator-based index methods related to water resources including Water Sustainability Index (CWSI), Watershed Sustainability Index, and West Java Water Sustainability Index (JWSI).

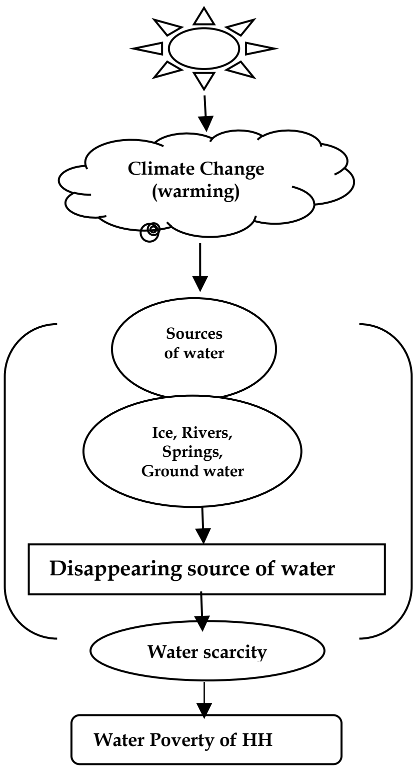
As seen and demonstrates in the literature, that water poverty is not only a result of insufficient water resources but is intricately linked to a variety of factors, including climate change, population growth, and socio-economic inequalities. Future research must continue to explore comprehensive solutions that address both the causes and consequences of water poverty, particularly in vulnerable regions, ensuring equitable access to water for all.

3. RESEARCH METHODS

Theoretical /Conceptual Framework

The traditional neo-Malthusian view is that resources are fixed while demand rises as a function of population growth. Then resource scarcity happens (Feitelson, & Chenoweth, 2002). In the context of water poverty, water scarcity is the function of demand and availability. Climate change badly hits to water availability (IPCC, 2001; Gleick, 2000; Solomon, et al., 2007; Adams and Peck, 2008; IPCC AR4, 2018, Bista, et al. 2023 & Bista, et al. 2024). Both facts are core concept of this study (Figure 1). UNFCCC (2018) projects global warming in the future by 0.18^0c per year, declining rainfall and disappearing water sources. As a consequence, water scarcity will be stressful to increase water poverty at household level (Figure 1).

Figure 1: Conceptual framework



This study adopts this conceptual framework aiming to measure water poverty at household and analyzes its severity and impacts at households in the small cities in Nepal. The study employs water poverty as the ratio of water availability and households for understanding its severity and livelihood effects.

Data and Data Collection Method

Addressing above objectives, the study employs explanatory research and descriptive methods under the conceptual framework and uses primary data sets collected from the study area, where 317 samples out of 47060 households were randomly selected by using the sampling technique of Daniel (2012) from the 12 cities of Marshyangdi river basin ((Chame, Nashong, Neshyang, Dordi, Marsyangdi, Anbukhaireni, Bandipur, Devighat (Rural Muncipality), Besishahar, Bhanu, Gaindakot (Municipality) and Bharatpur (Metropolitan City) by three ecological belts (himal, hill and terai). These cities were relevant to this study due to their climate vulnerability, the availability of snow fed river basin and emerging cities as municipalities.

Data collection method includes a household survey as a key tool to collect qualitative and quantitative data with respect to the specific objectives of the study. The survey used a questionnaire covering specifically water poverty in the KOBO tool after pre-testing in Kathmandu and orienting enumerators from June 22-24, 2022. The survey schedule was scheduled into two periods to catch up with favourable weather: a) the first schedule (15 days) from June 25-July 10, 2022; and b) the second schedule (15 days) from Nov 30-Dec 15, 2022. Thus, approximately 1-month of field work was administered to collect data through the KOBO tool.

In data analysis, the study adopts measures of poverty including Head Count Poverty (HCP) and Poverty Gap (PG) for applying to measure Head Count Water Poverty and Water Poverty Gap. Head Count Poverty is the ratio of have-not populations and total populations. Similarly, head count water poverty is directly related to the ratio between water use and water availability of a society as well as in a household. If water use grows at the same water availability, the water deficit will increase. If water use is constant but water availability decreases, a water deficit follows again. These poverty measures are widely used by, Ravallion (1996), Edeleman (2012) and the World Bank (2024). In the function, water poverty is $W_{\mathbf{p}}$, water use is W_U, and water availability is W_A. Mathematically,

i) Head count Water Poverty

$$W_p = W_U / W_A \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

ii) Water Poverty Gap (WPG)

$$WPG = 1/n^* \sum((z-c)/Z)^{\alpha} \ldots\ldots\ldots\ldots\ldots\ldots..(2)$$

Where,

n=total number of poor
z=water poverty line (threshold)
c= consumption of water

4. RESULTS AND DISCUSSIONS

Overview of Water Poverty

Being a critical issue in the world, the water poverty that is unable to access to safe drinking water is available at 2.2 billion population of total global populations (8 billion) including overe 700 million people without a basic water service. Approximately 25 percent live in the water poverty due to water scarcity (UNICEF, 2024). Similarly, 3.6 billion people lack access to safe sanitation (UNICEF, 2024). UNICEF(2024) worry about killing 1.4 million people every year because of unsafe water, sanitation and hygiene. Since water scarcity is a function of water demand and availability, the trade-off between declining water availability and inclining the growth of population led water consumption has driven water poverty in the world. The extremity of water poverty has made complicated poverty and vulnerability of the poor households. This is a big challenege to achieve SDG 6: clean water and sanitation by 2030.

Asia is one of the vulnerable regions. WHO (2024) has noted 500 million people not having access to safe water below the water poverty line. It is supplymented by 1.14 billion people lack access to sanitation. This is worst situation when we observe the density of population in this region. ADB (2024) reports in Asia and the Pacific region - home to nearly 900 million of the world's poorest people - one in three people does not have safe drinking water. UNCIEF(2024) discloses 347 million children are exposed to unsafe water and sanitation.

In Nepal, Every day, children die from preventable diseases caused by poor water, and a lack of sanitation and hygiene. 10.8 million people in Nepal do not have access to improved sanitation, and 3.5 million do not have access to basic water services (UNICEF, 2024). However, the 16th plan has targeted to alleviate these water poverty.

Water Poverty by Head Count

Water poverty is defined as a household's ability to afford clean drinking water at a minimum threshold of 20 liters per capita per day and maximum threshold of 50 liters per capita per day.

In case of region and location, the country cannot afford the cost of clean drinking water for all its people at all times at both thresholds. Table 1 presents the result of head count water poverty.

Table 1: Head count water poverty and rank by cities and ecological belt

Ecological Zone	Cities	water Poverty (min)	Rank	water Poverty (max)	Rank
Himal	Nasong	100	1	100	1
	Nishyang	100	1	100	1
	Chame	100	1	100	1
	Norphu	100	1	100	1
Hill	Bandipur	85.7	6	90.5	5
	Bhanu	60	4	100	1
	Dordi	9.1	7	100	1
	Devighat	0	8	100	1
	Abhukharini	34.2	5	94.7	3
	Beshishar	13.2	6	76.5	6
	Marshangdi	66.7	3	91.7	4
Terai	Chitwan	95.5	2	96.4	2
	Mean	63.70		95.82	

Table 1 presents the estimation of head count water poverty of 12 small cities across three ecological belts of Nepal, using minimum threshold and maximum threshold. The estimation of mean head count poverty is 63.7 percent of the population in the minimum threshold across these cities of these ecological belts and is 95.82 percent in the maximum threshold. These water poverties are so extreme values that about 63.7 percent population cannot afford water only for personal drinking and sanitation and about 95.8 percent cannot meet personal drinking, and sanitation, along with washing clothes, food preparation, and household hygiene. This is a critical scenario of water poverty explaining water scarcity and the constrained water consumption in the sufficient sources of water such as rivers, rivulets, ponds, springs etc. Out of these sources, the Marshangdi river basin (2150km) is major one, along with ground water sources in these cities, which is ridiculously paradox of the existing water sources. It unlocks the critical situation of human rights on water at households because of the ineffectiveness of water and sanitation development policy, governance and institutions and non-reflection the localization of SDG.

By ecological belts, the estimations of head count poverty are 100 percent in Himal, 95.5 percent in Terai and 35 percent in Hill in the minimum threshold and 100 percent in himal, 96.4 percent in Terai and 93.3 percent in Hill in the maximum threshold. The result in the minimum threshold indicates 35 percent water poverty in the Hill but relatively least in Terai and Himal. The result is extremely higher in the maximum threshold but Hill is slightly less than Terai and Himal. This result reveals water security in Hill higher than Terai and Himal at the minimum threshold. In contrast, majority households in all belts live with water insecurity with three times growth of water poverty. These results have complicated the crisis of poverty in these belts because of their unaffordability, along with insufficient investment on water infrastructures, ad hoc basis water distribution plan, poor maintenance of pipelines, rugged geography, technological constraints, inefficient institutions, and poor water governance.

Similarly, the density of water poverty is different across 12 small cities of these ecological belts. Using a reference line of less than 50 percent water poverty, only four cities have the least water poverty at 20 litres per capita per day minimum threshold. These Hill cities are Devighat, Dordi, Besishar, and Abhukharini among which water security is 100 percent in Devighat city for personal drinking and hygiene. About 67 percent cities (8 cities) contradicts water security of Hill, Himal and Terai. The result is complicated water security in all small cities in the maximum thresholds. The result manifests excessive demand of water and insufficient water supply because of poor water governance, management and system, the limited physical infrastructure of pipeline, storage, tanks and dams, poor engineering of small cities, social planning and resources constraints of local government (Municipality). Field observation (2023) opens up new discussion about small cities and their institutional capacity and performance to expand safe clean drinking water. In 2017, the government of Nepal restructured the country into 753 municipal cities (460 rural municipalities, 276 municipalities, 11 sub metropolitan cities and 6 metropolitan cities) based on the reference of 10000 population size. These small cities are rural municipalities which are not well prepared based on infrastructure and social and economic capacity with reference to theory of city building are just politically announced as the reengineering of local governments in the order of the federal system. These rural municipalities have new governance system in which there are insufficient human capitals (engineering, social engineers, planners and administrators) and resources as required to be functional for development planning and governance. In these varying landscapes, the construction of pipeline for safe water distribution that is costlier has been a key barrier against the functional budget. Further, exogeneous variables including seasonal factor and disasters have created water scarcity. Despite an indigenous knowledge and technology, freezing temperature in winter season in Himal is a key barrier for the availability of safe clean water and flood in rivers has polluted a fresh water in the Hill and Terai. As a result, a large inhabitant in these small cities is vulnerable to water borne diseases, health hazards, and high costs.

5. WATER POVERTY GAP AND SEVERITY

Water Poverty Gap

The poverty gap that is an indicator developed by the World Bank to measure poverty incidence far from the poverty line. This is main conceptual idea for this water poverty gap indicator. This approach of water poverty gap that measures how far below the water poverty line was developed by the World Bank to measure water poverty incidence. The study aims to measure water poverty intensity in the 12 small cities across three ecological belts (Himal, Hill, and Terai) for understanding an inequality of access and consumption to safe water. Table 2 presents different water poverty gaps in 12 small cities in three ecological belts (Himal, Hill, and Terai), where there are minimum and maximum thresholds. The result of poverty gap index shows the incidence of water poverty gap in Hill less than Terai and Himal in the minimum index, whereas the higher incidence of water poverty gap is in all ecological belts but Hills has less than Terai and Himal. The incidence of mean water poverty gap is 0.87 wider among cities at the minimum threshold, whereas the incidence of mean water poverty gap is -0.25 extremely wider at the maximum threshold. This result indicates that the extreme intensity of water poverty gap is higher at the minimum threshold than at the maximum threshold.

By cities, the estimation of mean water poverty gap in 12 small cities in these ecological belts are heterogeneous in both thresholds. The result shows the wider mean water poverty gap in the cities of Himal and Terai more than the cities of Hill at minimum threshold. Out of these mean water poverty gaps, chitwan (-0.06) and Nishyang (-0.07) are extremely wider. Further, the result reveals the extremely wider mean water poverty gap in all cities, except for Dordi, Devighat, Abhukharini and Beshishar at maximum threshold. Both results of cities and ecological belts provide a strong evidence of higher mean water poverty gap among cities and ecological belts for personal consumption and sanitation. Majority peoples who are facing the scarcity of safe water for their drinking are in the threat of water borne diseases and uncleanliness related diseases in all cities and ecological belts. However, himal and terai are critical in this regards.

Table 2: Water poverty gap by cities and ecological belt

Belts	Water Poverty gap (min)	Water Poverty gap (max)	Cities	water Poverty gap (min)	water Poverty gap (max)
Himal	-0.23	-0.68	Nasong	-0.34	-0.73
			Nishyang	-0.07	-0.62
			Chame	-0.23	-0.69
			Norphu	-0.28	-0.71
Hill	1.6	0.05	Bandipur	0.73	-0.31
			Bhanu	1.36	-0.05
			Dordi	1.86	0.14
			Devighat	1.95	0.18
			Abhukharini	1.59	0.03
			Beshishar	2.96	0.58
			Marshangdi	0.92	-0.22
Terai	-0.06	-0.62	Chitwan	-0.06	-0.62
			Mean	0.87	-0.25

Water Poverty Severity

This approach of water poverty severity that measures how severe water poverty was developed by the World Bank. The squared water poverty gap, also known as the poverty severity index measures water poverty severity. In the 12 small cities across three ecological belts (Himal, Hill, and Terai), water poverty intensity is a key curiosity. Table 3 presents the result of water poverty's severity in 12 small cities in three ecological belts (Himal, Hill, and Terai) in both thresholds: minimum and maximum. Ecologically, the result of water poverty serverity at the minimum threshold shows exterme severity of Himal (-0.23) and Terai (-0.06) and moderate severity of 1.6 in Hill. Out of three ecological belts, Himal has the highest severity of all belts. The degree of severity at the maximum threshold has increased in all ecological belts including Himal (-1.39), Terai (-1.25) and Hill (0.10), out of which Himal and Terai are extremes of water poverty gap severity. Ecologically, the result of water poverty gap severity indicate explicitly water inequality among three ecological belts in both thresholds.

Like ecological belts, these 12 small cities have comfortable water poverty gap severity with 1.7 in the minimum threshold but uncomfortable severity of water poverty gap of -0.5 in the maximum threshold. Out of 12 cities, five cities including Chitwan(-0.06), Nishyang(-0.07), Chame(-0.23), Norphu(-0.28), and Nasong(-0.34) of Terai and Himal are highly severity of water poverty gap but seven cities including Behishar (2.96), Devighat(1.95), Dordi(1.86), Abhukharini (1.59), Bhanu (1.36), Marshangdi (0.92), and Bandipur (0.73) have moderate severity in the minimum threshold. The degree of severity in the maximum threshold has increased in all cities including Behishar (0.58) Devighat (0.18), Dordi (0.14), Abhukharini (0.03), Bhanu (-0.05), Marshangdi (-0.22), Bandipur (-0.31), Chitwan (-0.62), Nishyang (-0.62), Chame (-0.69), Norphu (-0.71) and Nasong (-0.73).

Table 3: Water poverty severity by cities and ecological belt

Ecological Zone	Water Poverty Severity (min)	Water Poverty Severity (max)	Cities	water Poverty severity (min)	water Poverty severity (max)
Himal	-0.47	-1.39	Nasong	-0.68	-1.47
			Nishyang	-0.15	-1.26
			Chame	-0.48	-1.39
			Norphu	-0.56	-1.43
Hill	3.21	0.10	Bandipur	1.45	-0.62
			Bhanu	2.56	-0.10
			Dordi	3.52	0.29
			Devighat	3.90	0.36
			Abhukharini	3.20	0.08
			Beshishar	5.93	1.17
			Marshangdi	1.86	-0.46
Terai	-0.13	-1.25	Chitwan	-0.13	-1.25
			Mean	1.7	-0.5

6. DISCUSSION

Considering that water deficit issue is one of major social issue deriving three complicated social issues related to water including water poverty, water poverty gap and severity in three ecological belts (Himal, Hill and Terai) and 12 small cities including Beshishar, Devighat, Dordi, Abhukharini, Bhanu, Marshangdi, Bandipur, Chitwan, Nasong, Nishyang, Chame, and Norphu in Marshangdi River Basin in the central Nepal in minimum and maximum thresholds, these indicators have directly and indirectly related to poverty and inequality, along with the indicators of SDGs and local governance of muncipalities. Water-related issues contribute to health problems like waterborne diseases, malnutrition, and poor sanitation, which, in turn, drive conflicts, migration, and economic stagnation within communities.

The estimation of mean head count poverty is 63.7 percent of the population in the minimum threshold across these cities of these ecological belts and is 95.82 percent in the maximum threshold. Both are extremely critical water poverty, although the water basin areas is rich for water sources. It is triple times more than 20 percent national poverty. This is a critical human right of individual citizen on safe water and no good result in SDG. Ecologically, Hill has water security three times more than Himal and Terai in the minimum threshold but all are insecure in safe water in the maximum threshold. Water poverty is a common issue across three elevations, except for Hill. Himal is ecologically complicated, geologically rugged, highly elevated and demographically scattered to safe water. In contrast, Terai is ecologically plain, physically accessible and demographically dense to distribute safe water. Surprisingly, both ecological belts have critical water poverty for different reasons: highly costlier and seasonally tough to construct water project in Himal and insufficient investment on water infrastructures, ad hoc basis water distribution plan, poor maintenance of pipelines, rugged geography, technological constraints, inefficient institutions, and poor water governance in Terai.

Similarly, the density of water poverty is different across 12 small cities of these ecological belts. Out of 12 cities, it is dense in 8 cities (67 %) more than 4 cities (33%) at the minimum threshold. The cities in Hill including Devighat, Dordi, Besishar, and Abhukharini have least water poverty. Devighat is exceptionally zero poverty among these 4 small cities. Further, the density of water poverty is unexpectedly higher in all cities at the maximum threshold. The result of water poverty manifests thirsty with excessive demand of water to maintain urban life but the municipalities have not governed it sufficiently by investing water infrastructure by spatial planning. Further, the building of political structure and institutions of municipalities are unfriendly to these issues in the absence of their capacity and performance because the gradual process is highly relevant. Furthermore, the varying elevated landscape and seasonal exogeneous shocks are also barriers.

The status and distribution of water poverty is uneven within these ecological belts and cities in the different elevations, the capacity of institutions and structures. In this regard, the depth of water gap is relevant. The result of water poverty gap of the Hill is 1.6, which is greater than Himal (-0.23) and Terai (-0.06) at the minimum threshold whereas at the maximum threshold, the mean water poverty gap in the Hills is 0.05 higher than in the Himal (-0.68) and in the Terai (-0.62). It indicates that the extreme intensity of water poverty is greater in the Hill, Himal and Terai at the minimum threshold than at the maximum threshold. Similarly, the water poverty gap is heterogeneous across 12 small cities in minimum and maximum thresholds. In minimum threhold, Beshishar(2.96), Devighat(1.95), Dordi(1.86), Abhukharini(1.59), Bhanu (1.36), Marshangdi(0.92), Bandipur (0.73) have higher water inequality than Chitwan(-0.06), Nasong(-0.34), Nishyang(-0.07), Chame(-0.23), and Norphu(-0.28). However at the maximum threshold, water poverty gap exists, unlike at the minimum threshold. However, Beshishar(0.58), Devighat(0.18), Dordi(0.14), and Abhukharini(0.03) have declined. It indicates that the extreme intensity of water poverty is higher in 12 small cities at the minimum threshold than a the maximum threshold. Further, the correlation between water poverty and water poverty gap is negative. In Himal and Terai, water poverty is higher but water poverty gap is not intense. Differently, in Hill, water poverty is less but water poverty gap is intense.

Similarly, the degree of severity at the maximum threshold has increased in all ecological belts including Himal (-1.39), Terai (-1.25) and Hill (0.10), out of which Himal and Terai are extremes of water poverty gap severity. Ecologically, the result of water poverty gap severity indicate explicitly water inequality among three ecological belts in both thresholds. By cities, all cities are in severity at the minimum and maximum thresholds in which cities of Himal and Terai have higher severity than Hill. Despite a water basin, these cities of three ecological belts have water deficit threating the quality of life with water poverty gap and severity to eradicate poverty and improving their living standards in these small cities.

7. CONCLUSION

This study examines an economic analysis of water stress, and the adaptation of households in 12 small cities across three ecological belts: Himal, Hill, and Terai of the Marshyangadi River Basin based on a household survey under an explorative cum descriptive design. The study has found two major findings. Firstly, water poverty is a proxy for water stress. Water poverty is low at water poverty minimum threshold, but is accounted for 23.5 percent at the maximum threshold. Both thresholds are themselves less than South Asian and US water consumption for clean drinking water, and sanitation, and other utilities for higher living standard and quality of life. Water poverty in Terai and Himal is more than Hill at minimum and maximum threshold. The magnitude of water poverty is heterogeneous in the small cities. Water stress is not more significant in the community in Himal and Terai than Hill. Secondly, the water poverty gap indicates that explicit inequality between water poors in the 12 small cities is greater in Hill, Himal and Terai at the minimum threshold than at maximum threshold because of poor water distribution, and availability. However, households of Himal and Terai are more vulnerable than Hill. Therefore, water deficit-induced water stress in the 12 small cities across three ecological belts due to climatic variables as well as lower water infrastructure is a big threat creating physical and economic complexity in poverty, inequality, and the welfare of the vulnerable community at present and may be a further complicating factor in the vulnerable community in future if temperature rises and declining rainfall are consistent as before if everything is constant. Thus, it makes it complicated to achieve SDG 3 and SDG 6. In future, the climate change induced water deficit may be extreme. Therefore, the sustainable development approach should be made a foundation of the development paradigm to increase more investment in the tree approach: plantation, conservation, management, governance, and utilization integrating with the water approach: conservation, utilization, and governance, investment in research and technology; and investment in the adaptation capacity of the local community, and environmentally friendly livelihood activities and development for addressing water deficit induced water stress and poverty.

References

Adams, R. M., & Peck, D. E. (2008). Effects of climate change on drought frequency: Impacts and mitigation opportunities. In A. Dinar & A. Garrido (Eds.), *Mountains, valleys, and flood plains: Managing water resources in a time of climate change* (Chapter 7). Routledge Publishing. https://www.choicesmagazine.org/2008-1/theme/2008-1-04.htm

Asian Development Bank (ADB). (2024). *Press release*. Philippines: ADB.

Bista, R. B. (2011). *Economics of Nepal*. Kathmandu: New Hira Books.

Bista, R. B. (2018). Determinants of flood disaster households' vulnerability in Nepal. *Economic Journal of Development Issues, 25 & 26*(1–2), 47–59.

Bista, R. B. (2021). *Economics of Nepal*. Kathmandu: New Hira Books.

Bista, R. B. (2022). Examining determinants of household vulnerability in Nepal: Descriptive statistics analysis of flood disasters. *Patan Pragya, 11*(2), 139–159. https://doi.org/10.3126/pragta.vqqi02.52111

Bista, R. B., Thakuri, S., Koirala, P., & Bhattari. (2023). Examining varying rainfall in the different elevations of Nepal and water scarcity. *Economic Journal of Development Issues, 35–36*(1–2).

Bista, R. B., Thakuri, S., Koirala, P., & Bhattari. (2024). Assessing water deficit induced water stress of households and their welfare in small cities of Nepal. *Economic Journal of Development Issues, 37*(1).

Bista, R. B., & Shahi, P. B. (2024). Estimating the fixed effect of climate friendly low-cost technology in wheat crop in the rural Nepal. *Journal of Ecohumanism, 3*(8), 493–505.

B.K., A., Devkota, N., Gautam, N., Paija, N. (2019). Industry willingness to pay for adequate electricity supply: A discourse on sustainable industrial development. *Quest Journal of Management and Social Sciences, 1*(2), 251-259.

Consumer Council for Water. (2021). *Independent review of water affordability*. Consumer Council for Water, Birmingham, UK.

Daniel, J. (2012). *Sampling essentials: Practical guidelines for making sampling choices* (p. 103). Sage Publications. https://doi.org/10.4135/9781452272047

Edelman, P. (2012, July 28). Poverty in America: Why can't we end it? *The New York Times*. Retrieved November 20, 2020.

Feitelson, E., & Chenoweth, J. (2002). Water poverty: Towards a meaningful indicator. *Water Policy, 4*(3), 263–281.

Gleick, P. H. (Lead author). (2000). *Water: The potential consequences of climate variability and change for the water resources of the United States*. Pacific Institute for Studies in Development, Environment, and Security.

Immerzeel, W., Van Beek, L. P., & Bierkens, M. F. (2010). Climate change will affect the Asian water towers. *Science, 328*(5984), 1382–1385.

IPCC. (2001). *Climate Change 2001*. UN: Washington. https://www.ipcc.ch/report/ar3/wg1/

IPCC. (2001a). *Climate change 2001: Impacts, adaptation and vulnerability. Summary for policymakers*. Cambridge University Press.

IPCC. (2007). *Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. UN: Washington.

IPCC. (2008). *Climate change and water*. UN: Washington.

IPCC AR4. (2018). *Special report on global warming 2018*. https://www.ipcc.ch/sr15/

International Water Management Institute (IWMI). (2000). *World water supply and demand: 1995–2025*. Draft report.

Krysanova, V., Hattermann, F., & Habeck, A. (2005). Expected changes in water resources availability and water quality with respect to climate change in the Elbe River basin (Germany). *Hydrology Research, 36*(4–5), 321–333.

Mitlin, D., & Satterthwaite, D. (2013). *Urban poverty in the global south: Scale and nature*. London and New York: Routledge.

Ministry of Finance (MoF). (1990). *Economic survey*. Kathmandu: MoF.

Ministry of Finance (MoF). (2024). *Nepal Budget 2023*. Kathmandu: MoF.

Ministry of Law (MoL). (2015). *Nepal Constitution 2015*. Kathmandu: MoL.

Ministry of Population and Environment (MoPE). (2004). *Initial National Communication to the Conference of Parties of the United Nations Framework Convention on Climate Change*. Kathmandu: MoPE.

National Planning Commission (NPC). (2024). *The 16th plan*. Kathmandu: NPC.

Ogwang, T., & Cho, D. I. (2023). Water poverty. In *Research handbook on measuring poverty and deprivation* (pp. 243–251). Edward Elgar Publishing.

Ravallion, M. (1996, June). Issues in measuring and modeling poverty. *Policy Research Working Paper, 1615*. World Bank. Retrieved November 20, 2020.

Rijsberman, F. R. (Ed.). (2000). *World water scenarios: Analyses*. London, UK: Earthscan.

Salameh, E. (2000). Redefining the water poverty index. *Water International, 25*(3), 469–473.

Singh, R., Pandey, V. P., & Kayastha, S. P. (2021). Hydro-climatic extremes in the Himalayan watersheds: A case of the Marshyangdi watershed, Nepal. *Theoretical and Applied Climatology*. https://doi.org/10.1007/s00704-020-03401-2

Singh, R. B., & Mal, S. (2014). Trends and variability of monsoon and other rainfall seasons in western Himalaya, India. *Atmospheric Science Letters, 15*, 218–226.

Solomon, S., Qin, D., Manning, M., Chen, Z., Marquis, M., Averyt, K. B., Tignor, M., & Miller, H. L. (Eds.). (2007). *Climate change 2007: The physical science basis*. Cambridge University Press.

Stitt, M. (2011). The interdependence of mechanisms underlying climate-driven drought. *Forest Ecology and Management, 429*, 18–27. https://doi.org/10.1016/j.foreco.2018.06.036

Sullivan, C. (2001). The potential for calculating a meaningful water poverty index. *Water International, 26*(4), 471–480.

Sullivan, C., & Huntingford, C. (2009). Water resources, climate change and human vulnerability. *Environmental Science, 18th World IMACS / MODSIM Congress*, Cairns, Australia, 13–17 July. http://mssanz.org.au/modsim09

Sullivan, C., & Meigh, J. (2005). Targeting attention on local vulnerabilities using an integrated index approach: The example of the climate vulnerability index. *Journal of Water Science and Technology*. https://doi.org/10.2166/WST.2005.0111

Sylvester, R., Hutchings, P., & Mdee, A. (2023). Defining and acting on water poverty in England and Wales. *Water Policy, 25*(5), 492–508.

United Nations (UN). (2019). *World Water Development Report 2019*. https://www.unwater.org/publications/un-world-water-development-report-2019

UNFCCC. (2018). *UN Climate Change Annual Report 2018*. UN: Washington.

UNICEF. (2024). *10 things you did not know about water*. https://www.unicef.org/stories/10-things-you-didnt-know-about-water

World Health Organization (WHO). (2024). *World health statistics 2024*. Switzerland: WHO.

World Bank. (2021). *Press release*. Washington: World Bank. https://www.worldbank.org/en/news/press-release/2021/08/23/lack-of-water-linked-to-10-percent-of-the-rise-in-global-migration

World Bank. (2022). *Resilience to water scarcity and commodity price shocks are critical for Moroccan economic growth and stability*. https://www.worldbank.org/en/news/press-release/2022/07/20/moroccan-economy-slows-in-wake-of-drought-and-commodity-price-rises

World Bank. (2024). *Poverty, prosperity and planet*. https://www.worldbank.org/en/publication/poverty-prosperity-and-planet

Yechieli, Y., Shalev, E., Wollman, S., Kiro, Y., & Kafri, U. (2010). Response of the Mediterranean and Dead Sea coastal aquifers to sea level variations. *Water Resources Research, 46*(12550), 1–11.

Yoon, H., Domene, E., & Sauri, D. (2021). Assessing affordability as water poverty in Metropolitan Barcelona. *Local Environment, 26*(11), 1330–1345.

Yuan, L., Yang, D., Wu, X., He, W., Kong, Y., Ramsey, T. S., & Degefu, D. M. (2023). Development of multidimensional water poverty in the Yangtze River Economic Belt, China. *Journal of Environmental Management, 325*, 116608.

Zhu, R., Fang, Y., Neupane, N., Koirala, S., & Zhang, C. (2020). Drought stress and livelihood response based on evidence from the Koshi River Basin in Nepal: Modeling and applications. *Water, 12*(6), 1610. https://doi.org/10.3390/w12061610