

Adaptation Beneficiary Analysis

Livable and Resilient Cities Project (LRCP)

Context

The Livable and Resilient Cities Project (LRCP) is a flagship urban climate resilience initiative designed to align closely with Bhutan's national planning priorities. The project represents a phased and integrated effort to address climate vulnerabilities in urban systems, particularly in Thimphu, through infrastructure investments and institutional strengthening.

The primary goal of the LRCP is to enhance climate resilience in Thimphu, Bhutan's capital and largest urban center. The project has two core components:

Component 1: Infrastructure Investments – Upgrading and climate-proofing critical water supply, drainage, and urban mobility infrastructure to improve resilience to flooding and drought and address rising emissions in the transport sector.

Component 2: Technical Assistance (TA) – Providing targeted support to strengthen institutional capacity, climate risk management, and service delivery, with the aim of ensuring long-term sustainability and replicability.

The LRCP adopts an integrated approach that combines low-carbon development with adaptation co-benefits, aligning with Bhutan's broader goals of carbon neutrality and sustainable urbanization.

1. Vulnerability Assessment

Climate Hazard Exposure: As described in the Feasibility Study, Thimphu faces multiple climate-related hazards that directly threaten urban water security and mobility:

Increased Drought Frequency and Severity: Climate projections indicate dry-season flows in the Wang Chhu basin will decline by 4.7-5.8% by mid-century. During the 2023 dry season, over 77% of Thimphu households resorted to water storage, reflecting widespread exposure to seasonal drought. The current water supply system serves only 3-9 hours per day in many areas, leaving most connected residents vulnerable to water scarcity. Climate-induced variability in flows places additional pressure on storage infrastructure, which provides only limited buffering against short-term fluctuations in supply. During prolonged dry periods, constrained operational flexibility reduces the ability to redistribute water between service zones or balance available storage and treatment capacity across the network. Intake structures are vulnerable to fluctuating flows and debris loads during intense rainfall and to severely reduced abstraction capacity during the increasingly prolonged dry seasons projected under climate change.

Flooding and Landslides/Erosion: Over the past 50 years, Thimphu has experienced six major riverine and flash flooding events affecting over 10,000 people. Flooding events have accelerated sharply in recent decades, with 65 of Bhutan's 116 recorded events occurring between 2012 and 2020.¹ In the transport sector, Thimphu's road network and bridges face growing exposure to flood and landslide damage, with many bridges built to 20- or 25-year design standards that are likely to be exceeded with increasing frequency as extreme events intensify. Roads are frequently disrupted by flooding, causing prolonged service interruptions affecting the entire population. Road drainage infrastructure is inadequate, with intense rainfall regularly overwhelming drainage capacity along key corridors, flooding road surfaces, and causing sewer overflow onto major routes, which poses a health risk and further constrains mobility, including for public transport users and pedestrians in low-lying areas and along the main north-south corridor. In the water supply system, transmission pipelines traversing hillside corridors are exposed to landslides and washouts during heavy rainfall events, leading to breakages and extended service disruptions. During periods of intense rainfall, pipe breakages caused by landslides or erosion have historically disrupted water supply for several days at a time, highlighting the growing exposure of transmission infrastructure to extreme weather events.

Extreme heat: Rising temperatures exacerbate Urban Heat Island (UHI) effects, disproportionately affecting non-motorized transport users. Limited tree cover and inadequate pedestrian infrastructure increase heat exposure and health risks.

Socio-Economic Vulnerability: Thimphu's most vulnerable populations experience disproportionate impacts from climate-related water and transport disruptions:

Low-Income Households in Poorly-Served Areas: While the poverty rate in Thimphu is low relative to the rest of Bhutan, around 6% of residents are considered multidimensionally poor. Low-income residents in areas receiving only 3-9 hours of water supply per day, such as Motithang and Chhubachhu, have limited adaptive capacity. These households cannot afford alternative water sources (water delivery services costing BTN 500-1,000 per truck, or large storage tanks), and experience health impacts (increased waterborne disease risk from inadequate storage and handling), economic impacts (lost productive time for water collection, reduced ability to maintain income-generating activities), and educational impacts (children, particularly girls, missing school to collect water).

Women and Children bear the primary burden of water collection during supply disruptions. Bhutan's 2017 Time Use Survey indicates women spend 2.5x more time than men on water collection in urban areas.

Elderly and Mobility-Impaired Populations face heightened vulnerability to:

- Heat stress during increased temperatures (inadequate pedestrian shade/cooling; limited accessibility to bus stops)
- Flooding due to limited mobility to evacuate or access alternative routes
- Water scarcity due to physical inability to collect/store water

Climate-Sensitive Livelihoods: Small businesses (restaurants, laundries, guesthouses) dependent on reliable water and transport access face economic losses during supply disruptions. The tourism sector, which provides employment for roughly 15% of Thimphu's workforce, is particularly vulnerable to infrastructure service disruptions.

Adaptive Capacity:

Extensive leakage, under-metering, and illegal connections place stress on water storage systems, posing a critical vulnerability during drought and dry-season periods.

¹ Tempa K (2022) District flood vulnerability assessment using analytic hierarchy process (AHP) with historical flood events in Bhutan. PLOS ONE 17(6): e0270467. <https://doi.org/10.1371/journal.pone.0270467>

Vulnerable populations have especially limited capacity to cope with climate-related water and transport disruptions. When municipal supply fails, residents have limited options:

- Water delivery services: Expensive and unreliable during peak demand
- Private wells/boreholes: Not accessible to all; limited groundwater availability
- Public standpipes: Overcrowded during shortages; may be contaminated

As no rail transport exists in Thimphu, the population is dependent on road-based mobility. Unsafe/inadequate pedestrian infrastructure is vulnerable to disruption during flooding events, and as the city grows to the north and south, walking becomes increasingly unfeasible particularly for the lower-income households who are least likely to own a vehicle. These households are also more likely to live in peripheral areas that are least served by public transit.

Adaptation needs

Considering the vulnerability context, the following key adaptation needs are identified:

Transport & public space:

- **Climate-resilient improvement of stormwater drainage**
- **Urban greening** (street trees, bioswales) to combat UHI and improve stormwater retention capacity

Water supply:

- **Reduction of NRW** (monitoring via SCADA; active leakage control; reduce illegal connections; metering) to ensure adequate storage capacity and build resilience to drought
- **Protect supply infrastructure** from damage due to climate hazards (e.g., flooding, landslides) to ensure the water supply is resilient through emergencies
- **Improve operations and monitoring** to optimize use of storage reservoirs and improve preparedness for drought events

2. Adaptation benefits of the project

Direct adaptation benefits

Transport and public space:

The project's investments in improved stormwater drainage, climate-resilient road and bridge upgrades, and urban greening in public spaces (under Components 1.2 and 1.3) are expected to produce the following key direct adaptation benefits:

- Reduced vulnerability to flooding and associated disruptions along Bus Priority Corridor and Norzin Lam area
 - *Key project activities:*
 - Climate-resilient improvement of roads and bridges (scour protection, pier and abutment works) → reduce the risk of structural failure or washouts during flood events, maintaining corridor access under the high-flow conditions that currently cause closures or restrictions.
 - Improved drainage in roads and sidewalks and connections to Sustainable Urban Drainage systems → reduce the frequency and duration of surface-water accumulation that currently disrupts pedestrian and vehicle movement during heavy rainfall events
- Strengthened resilience of public transport operations/management to flooding
 - *Key project activities:*
 - Improved ITS/information systems for City Bus Services → Real-time operational monitoring through improved ITS enables transit managers to redirect buses, alert passengers, and maintain service continuity during flooding and other climate events
- Reduced exposure to extreme heat through urban greening and infrastructure
 - *Key project activities:*
 - Street trees in Norzin Lam area → reduce ambient temperatures through shading and evapotranspiration, providing measurable heat stress relief for pedestrians during extreme heat events that are projected to intensify with climate change
 - 75 new bus shelters along BPC → protect passengers from heat and rain, also reducing the risk that adverse weather causes riders to abandon public transit

These are mapped to GCF ARA 3 (Infrastructure and built environment). Direct beneficiaries are defined as residents using the improved public transit and NMT infrastructure (see section 3). Resilience outcomes will be evaluated against a reduction of the average number of closures or restriction days to the Bus Priority Corridor per year due to flooding. Baselines will be established in the first project year using CBS operational records, ITS monitoring data, and MoIT maintenance logs.

Water supply:

In the water supply sector, the project's key direct adaptation benefits are:

- Improved access to treated water for core city residents
 - *Key project activities:*
 - Distribution line replacement & extension → reduces the frequency of pressure failures and bursts that are disproportionately triggered during drought periods when elevated household storage demand increases network stress; enables extensions to previously unconnected households eliminate dependence on informal supply alternatives that become unsafe or unaffordable when climate-induced disruptions occur
- Enhanced resilience of water supply to landslide/erosion and drought
 - *Key project activities:*

- SCADA systems → real-time detection of leaks and pressure anomalies → reduced stress on water demand during dry seasons; *and* allows operators to isolate faults and restore supply faster during climate-event disruptions, directly reducing outage duration
- Improved climate-resilient intakes → ensures adequate water capture capacity during the low dry-season river flows that climate projections indicate will worsen by mid-century
- Slope protection measures for hillside transmission pipelines → reduces likelihood of climate-triggered landslide damage that would otherwise cause extended supply interruptions

The project’s investments in Thimphu’s water supply network, including the upgrading of vulnerable transmission pipelines, slope stabilization measures protecting critical infrastructure, and the installation of monitoring systems (i.e., SCADA) for improved operation and monitoring of the water network (Component 1.1) will strengthen the resilience of the city’s water supply system to climate hazards including flooding, rainfall-triggered landslides, and increasing seasonal variability in water availability. Emergency preparedness will be strengthened through the development and implementation of protocols for responding to infrastructure failures and climate-related disasters such as GLOFs (Component 2). The project will support replacing and extending existing distribution lines, ensuring that all households in the project area are connected to the municipal treated water supply system. While the project’s water activities are focused on the city core, the interventions will yield adaptation benefits for all users of the city water supply system. Reduced NRW throughout the network is expected to result from the leakage reduction measures and SCADA systems; combined with measures to protect vulnerable critical water supply lines, upgrade intakes to function effectively under drought and flood conditions, and thus producing reductions in system downtime/underperformance during shocks, these interventions will enhance the resilience of the water supply network city-wide to climate change-exacerbated drought and landslides/slope erosion.

These are mapped to GCF ARA 2 (Health, well-being, food and water security). Results are quantified by percentage of the system covered by SCADA, reduction in NRW, and number of beneficiaries with access to at least 15 hours/day (12 hours/day during dry season) of clean, treated water (representing improved resilience to drought and climate-induced supply disruptions).

Indirect adaptation benefits

Transport/Public Space:

- Reduced urban heat island effect: tree planting and green corridors along BPC provide city-wide cooling effects, reducing heat island intensity exacerbated by climate change
- Enhanced economic productivity and livelihoods: Climate-resilient transport infrastructure reduces economic losses from weather-related disruptions; improved accessibility supports climate-resilient livelihoods

Water supply:

- Economic resilience through reliable water for tourism and businesses: Continuous water supply maintains tourism infrastructure functionality during dry seasons; reduces economic losses from climate-induced service disruptions

3. Identification and quantification of beneficiaries

Data and detailed calculations underlying the summary below are available in the attached .xlsx file. Annex 11 contains more information on the proposed M&E plan.

Transport and public space interventions

Direct: Direct beneficiaries from the project’s transport- and public space-focused adaptation benefits consist of citizens using the improved bus system and upgraded NMT infrastructure. An estimated 72,448 residents are expected to directly benefit by project end.

Public transit users: Estimates of bus ridership vary. The City Bus Service 2023 Annual Report reports 20,000 daily “commuters”², while smartcard data from the previous year indicates that this is an estimate of *trips* rather than unique users. This would represent approximately 7.9% of total trips (as estimated by traffic surveys conducted for the project’s traffic demand modelling) and is used as the 2023 baseline for bus trips in the EFA. This is projected to grow due to the project’s interventions, natural population growth, and complementary policies (see EFA), and projected trips are divided in half to estimate the number of unique users. However, the National Statistical Bureau reports that as of 2017, 28.2% of residents in Thimphu *dzongkhag* (which includes more rural areas) used public transport “every day or almost every day” while 41.4% used it “at least once a week”, which would imply higher ridership. Conservatively, the 20,000 reported by CBS is used as the baseline figure, and citywide modal shift projections from the project’s EFA are used to project this number for the mid-term and final estimates.

NMT: As per UNESCAP’s 2019 SUTI report, walking is the primary mode for 22% of the population. Absent more recent data, this is used as the baseline and is conservatively assumed to remain the same at project end, despite the project’s likely positive effect on NMT share.

- **Disaggregation by sex:** As no data on the male/female split of public transit and NMT users in Thimphu is available, the ratio for Thimphu’s urban population is used, i.e. 48.5% female, 51.5% male. At project end:
 - o Female: 35,137
 - o Male: 37,311

These represent the direct beneficiaries for transport interventions under Core Indicator 2. Resilience outcomes will also be monitored through the average number of flood-related closure or restriction days on the Bus Priority Corridor per year; (ii) average duration of surface-water accumulation on upgraded road and pedestrian surfaces following heavy rainfall events; and (iii) infrastructure restoration time following flood or landslide events affecting the corridor. Baselines for each indicator will be established in the first project year using CBS operational records, ITS monitoring data, and MoIT maintenance logs.

² <https://thimphucity.bt/wp-content/uploads/2025/03/AR-2023-for-WEB-1.pdf>

Indirect: All Thimphu residents — including private vehicle users and those who walk through the Norzin Lam area only occasionally — benefit indirectly from the enhanced climate resilience of the city's main north-south corridor and the core urban public space. For private vehicle users, this resilience benefit is most material during flood events: the BPC currently functions as the principal arterial link for road traffic, and flood-related closures or damage force all road users onto inadequate alternative routes, generating congestion, economic delay, and in some cases complete loss of access to parts of the city. A climate-resilient corridor that remains operational during design-storm events therefore preserves network redundancy that all road users depend on, not just bus passengers. City-wide urban heat reduction — through the cooling and stormwater retention effects of BPC and Norzin Lam greening — accrues to all residents and workers in these areas, including those who do not regularly use public transit, as urban heat island intensity is a function of city-wide land surface characteristics rather than individual travel behaviour. The aggregate economic benefit of these resilience improvements (reduced business interruption, maintained supply chains, and sustained workforce mobility during climate events) is therefore shared across the city's population, including the approximately 15% of Thimphu's workforce employed in tourism-related sectors whose livelihoods depend on the continued functioning of the urban transport and public space network during and after climate events. Visitors from other parts of the country and international tourists will benefit from these improvements as well, experiencing fewer disruptions to road-based travel from flooding and landslides, and less exposure to extreme heat while exploring on foot, during their stay in Thimphu. Therefore, the remaining urban population of Thimphu (112,232 non-PT/NMT users), plus the annual population of tourists (200,000), are considered as indirect beneficiaries by project end.

Water supply

Direct: Direct beneficiaries of the project's water supply improvements are residents of the targeted Core Area who have inadequate access (9 hours or less per day) to clean, treated water.

Based on the Thimphu Water Services Masterplan (2023), this population is conservatively estimated at 56,567 as of 2027, increasing to 61,473 by 2031 and 81,100 by 2047. Of these, approximately 83% currently are underserved, with access to water for 9 hours per day or less (see Feasibility Study section 4.1.2). By project end (2031), it is estimated that 100% of underserved residents (**52,046**) will have access to treated water for at least 15 hours per day (12 hours during the December-February dry season). These results stem from the project's interventions to strengthen the resilience of water transmission pipelines and water supply intakes (reducing drought- and landslide-induced disruptions) and reduce NRW through SCADA systems and distribution line replacement (ensuring adequate water availability even during dry periods.)

It should be noted that these figures are conservative and approximate estimates based on limited available baseline data; surveys will be conducted in the first project year to establish a precise baseline.

- **Disaggregation by sex:** The ratio for Thimphu's urban population is used, i.e. 48.5% female, 51.5% male.
 - o **Female:** 25,242
 - o **Male:** 26,804

These represent the direct beneficiaries for water interventions under Core Indicator 2. Verification will be achieved through surveys, data from the SCADA system, and records maintained by Thimphu Thromde's water division.

Indirect: All users of the city water supply, including residents outside the Core Area and visitors, benefit indirectly from the project's resilience investments through two distinct climate-contingent pathways. First, NRW reduction through SCADA monitoring and active leakage control preserves effective reservoir storage capacity — the system's primary buffer against drought. During extended dry-season low-flow periods, which are projected to become more frequent and severe, a high-NRW system draws down storage reserves faster than a low-NRW system, increasing the risk of system-wide supply rationing that affects all connected users regardless of their location within the network. By reducing NRW from approximately 50% to 25% across the distribution system, the project extends the resilience of the whole network — not only the Core Area — to drought-induced low-flow conditions. Second, slope stabilization and intake upgrades protect the transmission infrastructure on which the entire system depends: a landslide-triggered rupture of a hillside pipeline, or an intake failure during an extreme weather event, could cause supply interruptions across multiple service zones simultaneously, affecting all users connected downstream. For the tourism sector specifically, the benefit is climate-contingent rather than merely developmental: drought and flooding/landslide events can cause hospitality closures and reputational damage to Thimphu as a destination; the project addresses the underlying infrastructure vulnerability that makes the sector's continuity dependent on climate resilience.

Roughly 123,988 water users outside the Core Area, and 200,000 annual tourists (for whom reliable water supply in hotels, restaurants, and guesthouses is a prerequisite for a functioning visit) are expected to benefit from this strengthened system-level resilience by project end.

Avoiding double-counting

Many direct beneficiaries of water supply resilience improvements, tracked under IRMF Core Indicator 2, may also benefit from the transport and public-space resilience improvements. As both are reported under Core Indicator 2, the project will ensure that beneficiaries are not double-counted when reporting results.

Water supply beneficiaries will be tracked separately from transport/public space beneficiaries, as the former are mapped to ARA 2 and the latter ARA 3 (see logframe in FP). Baseline surveys will be conducted in the project area, establishing residents' water supply status and primary transport mode before, during, and after implementation. This will enable identification of direct beneficiaries of both water supply and transport improvements, who will only be counted once toward aggregate reporting for Core Indicator 2.

For the purposes of ex-ante beneficiary estimation, double counting is addressed by assuming that Core City residents benefitting from water supply improvements use public transport and NMT at the same rate as the city as a whole (absent more specific neighborhood-level data), and these are removed to report the total figures. (See associated Excel file for detailed calculations.)

Unique direct and indirect beneficiaries

Applying this adjustment yields the estimated **total unique direct beneficiaries:**

Midterm (2029): 77,957 (of which 37,809 female)

Final (2031): 104,162 (of which 50,519 female)

Total unique **indirect** beneficiaries:

Midterm (2029): 265,275 (of which 131,659 female)

Final (2031): 271,871 (of which 134,857 female)