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A Sustainable Asset Valuation Assessment of Nature-Based Solutions in the Dechatu River Catchment in Dire Dawa, Ethiopia

SUNCASA REPORT

Michail Kapetanakis

November 2025

Project partners

IISD International Institute for Sustainable Development

World Resources Institute

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Written by Michail Kapetanakis

Photo: Cesar Henrique Arrais/IISD

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About SUNCASA

The SUNCASA initiative—Scaling Urban Nature-based Solutions for Climate Adaptation in Sub-Saharan Africa—is a 3-year project led by the International Institute for Sustainable Development and the World Resources Institute, with funding from Global Affairs Canada. It aims to enhance climate resilience, gender equality, social inclusion, and biodiversity protection in urban communities across Dire Dawa (Ethiopia), Kigali (Rwanda), and Johannesburg (South Africa).

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The Nature-Based Infrastructure (NBI) Global Resource Centre aims to improve the track record of NBI to deliver infrastructure services and adapt to climate change while delivering other environmental, social, and economic benefits. We provide data, training, and customized valuations of NBI projects, based on the latest innovations in systems thinking and financial modelling.

The Centre is an initiative led by the International Institute for Sustainable Development, with the financial support of the Global Environment Facility and the MAVA Foundation, in partnership with the United Nations Industrial Development Organization.

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Executive Summary

Dire Dawa, Ethiopia's second most populous urban centre, faces increasing vulnerability to flash floods and water scarcity. Seasonal flooding from the Dechatu River, driven by intense summer rains and exacerbated by rapid urban expansion, threatens infrastructure and communities. At the same time, the interconnected impacts of climate change, groundwater depletion, and declining soil fertility are undermining agricultural productivity and rural livelihoods in the surrounding catchment area, highlighting the need for the formulation and implementation of integrated urban and environmental resilience strategies.

The Scaling Urban Nature-based Solutions (NbS) for Climate Adaptation in sub-Saharan Africa (SUNCASA) project was designed to address these challenges. Through the implementation of NbS, the project aims to enhance climate adaptation, gender equality and biodiversity protection in urban communities in Ethiopia, Rwanda, and South Africa by responding directly to locally identified needs and priorities in three cities: Dire Dawa (Ethiopia), Kigali (Rwanda), and Johannesburg (South Africa). The project's main objective is to support municipal governments, local communities, and other urban stakeholders to increase their resilience to climate-induced risks such as flooding, droughts, and other water-related risks by adopting and implementing gender-responsive NbS.

The SUNCASA initiative is being implemented by the International Institute for Sustainable Development in collaboration with the World Resources Institute and local partners, with funding support from Global Affairs Canada. Local partners include organizations and communities in the three cities, including traditionally marginalized groups, women, and local and national authorities.

Through the use of the Sustainable Asset Valuation (SAVi) methodology, the International Institute for Sustainable Development developed an integrated cost-benefit analysis (CBA) to identify, value, and quantify the wider economic, social, and environmental impacts that the NbS implementations are projected to have in Dire Dawa. The NbS interventions that are considered in this assessment include a combination of afforestation, agroforestry, watershed restoration, and urban tree planting activities. These activities aim to create natural flood protection buffer zones that reduce soil erosion, enhance groundwater recharge, and increase opportunities for agroforestry, reducing the impacts of flooding and heat in the city, and improving land productivity in the long term. Further, the CBA assesses the multidimensional impacts of these and estimates their value in economic terms.

Key Results

The results in Table ES1 show that the NbS interventions in Dire Dawa generate a wide range of economic, social, and environmental benefits, most of which are typically not considered in traditional infrastructure assessments. Overall, results show that the NbS interventions are projected to save costs related to flood damages to infrastructure, health costs from floods, water pollution and heat, and result in new value creation from carbon sequestration and employment benefits.

Table ES1. Integrated CBA of SUNCASA-implemented NbS interventions in Dire Dawa (discounted at 10%)

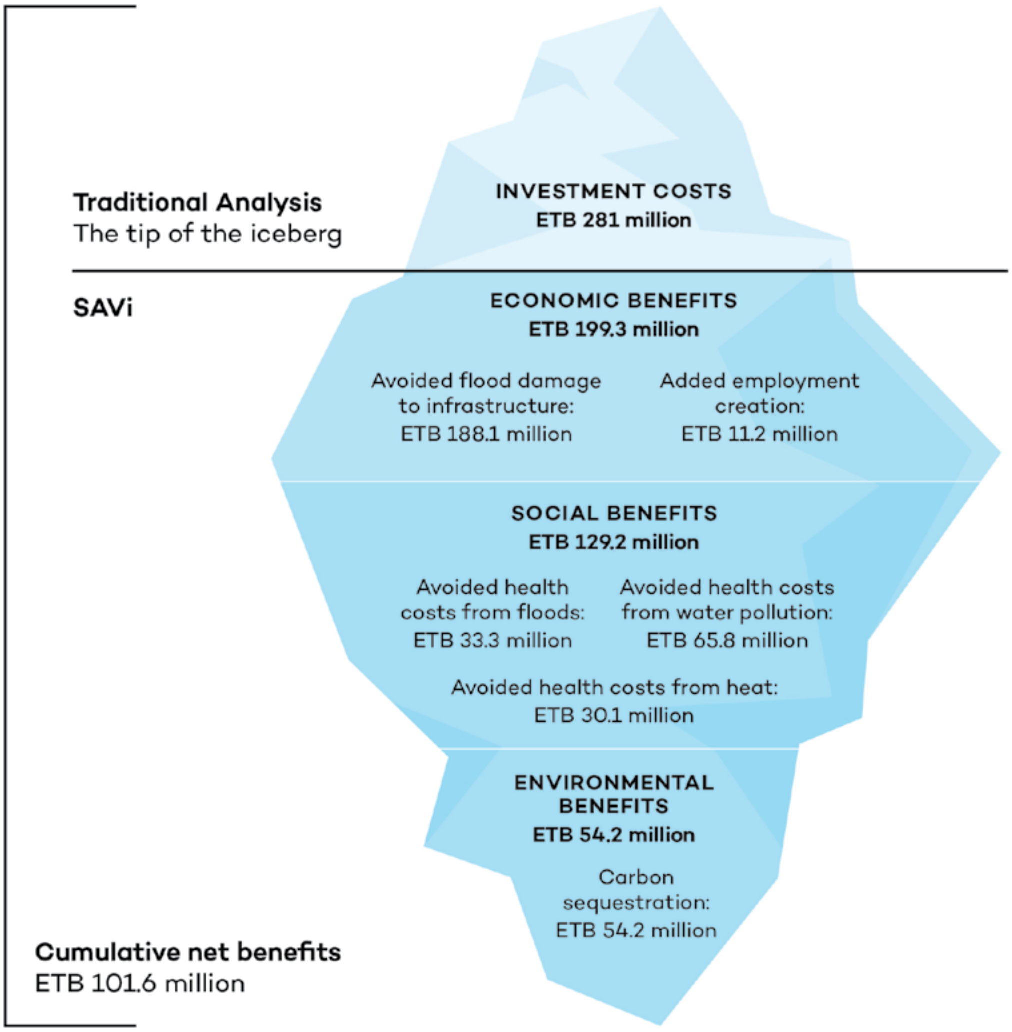
Integrated CBA 2025–2050 (discounted at 10%)	**NbS scenario** (ETB million)	**Sensitivity analysis** (ETB million)		
		Tree survival 94%	**High cost of carbon**	**Tree survival 94% & high cost of carbon**
Total direct costs	**281.2**	**281.2**	**281.2**	**281.2**
Implementation cost	65.9	65.9	65.9	65.9
Operation and maintenance cost	215.4	215.4	215.4	215.4
Total added benefit	**382.8**	**359.8**	**641.0**	**602.5**
Avoided flood damage to infrastructure	188.1	176.9	188.1	176.9
Avoided health costs: floods	33.3	31.3	33.3	31.3
Avoided health costs: water pollution	65.8	61.9	65.8	61.9
Avoided health cost: heat	30.1	28.3	30.1	28.3
Added employment creation	11.2	10.5	11.2	10.5
Carbon sequestration	54.2	50.9	312.4	293.6
Total net benefits (undiscounted)	**775.3**	**662.9**	**1,512**	**1,355**
Total net benefits (discounted)	**101.6**	**78.6**	**359.7**	**321.3**
Benefit-cost ratio	**1.36**	**1.28**	**2.28**	**2.14**

Source: Authors.

The NbS scenario will generate a cumulative net benefit of ETB 101.6 million (discounted at 10%), considering a project period of 25 years (2025 to 2050). The results of the project, when considering all economic, social, and environmental benefits, show an integrated benefit-to-cost ratio (BCR) of 1.36. Undiscounted values of the NbS scenario amount to a cumulative net benefit of ETB 775.3 million and a BCR of 1.71. These results highlight the economic viability of the project, which generates a considerable amount of avoided costs (ETB 317.4 million), of which 60% are tangible, avoided infrastructure damage costs. The total added benefits reach ETB 65.4 million, 24% of which relate to employment and income creation. The intangible societal value of the project is considerable, representing 48% of the total value generated via cost reductions and value creation. Further, the avoided costs and added benefits are shared across a large number of beneficiaries, as opposed to being accumulated by a few entities.

The largest impact of the NbS scenario is the avoided cost of flood damage to infrastructure, valued at a cumulative, discounted ETB 188.1 million. This is a tangible avoided cost that affects people in the city and surrounding areas. The second largest impact is instead intangible and relates to avoided health costs of water pollution, amounting to a cumulative ETB 65.8 million over 25 years. In addition, added benefits related to carbon sequestration amount to ETB 54.2 million. The avoided costs of human health from floods are valued at ETB 33.3 million. This is another example of benefits that are shared across a large number of beneficiaries.

Figure ES1. Economic, social, and environmental benefits of the NbS interventions in Dire Dawa



Source: Authors.

When considering the sensitivity analysis scenarios, the economic value of carbon sequestration benefits increases substantially when applying a higher shadow price for carbon, set at USD 40/ton, in line with World Bank's (2024) guidance. Under this higher carbon price assumption, cumulative carbon sequestration benefits are valued at ETB 312.4 million. Overall, the scenario yields cumulative net benefits of ETB 359.7 million and a BCR of 2.28, indicating stronger economic viability with a higher valuation of carbon.

In addition, the SAVi assessment found that the project is still economically viable under a 94% tree survival rate, reflecting recent trends in Dire Dawa, with net benefits of

ETB 78.6 million and a BCR of 1.28. When accounting for the higher shadow price of carbon, net benefits reach ETB 321.3 million, and the BCR improves to 2.14, indicating that all scenarios show economic viability.

Integrated valuations, such as this SAVi assessment, provide a fuller picture of the medium to long-term societal impacts of NbS projects and complement and enhance traditional CBA analysis. This SAVi assessment demonstrates that implementing NbS investments in Dire Dawa will generate both avoided costs and added benefits across a variety of indicators. This type of analysis enables government actors, planners, and developers to better assess the impacts of NbS implementation and to better plan financing strategies based on expected tangible and intangible impacts. This information is crucial to help policy-makers develop and implement policies and processes that turn the intangible value of externalities into tangible revenues for the municipality and its citizens.

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Acronyms and Abbreviations

BCR benefit-to-cost ratio

CBA cost-benefit analysis

CLD causal loop diagrams

InVEST Integrated Valuation of Ecosystem Services and Tradeoffs

LULC land-use/land-cover

NBI nature-based infrastructure

SUNCASA Scaling Urban NbS for Climate Adaptation in sub-Saharan Africa

Glossary

Discounting	A financial process to determine the present value of a future cash value.
Indicator	Parameters of interest to one or several stakeholders that provide information about the development of key variables in the system over time and trends that unfold under specific conditions (United Nations Environment Programme [UNEP], 2014).
Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST)	"A suite of models used to map and value the goods and services from nature that sustain and fulfill human life. It helps explore how changes in ecosystems can lead to changes in the flows of many different benefits to people" (Natural Capital Project, 2019).
Methodology	The theoretical approach(es) used for the development of different types of analysis tools and simulation models. This body of knowledge describes both the underlying assumptions used as well as qualitative and quantitative instruments for data collection and parameter estimation (UNEP, 2014).
Net benefits	The cumulative amount of monetary benefits accrued across all sectors and actors over the lifetime of investments compared to the baseline, reported by the intervention scenario.
Nature-based solutions (NbS)	Actions to address societal challenges through the protection, sustainable management, and restoration of ecosystems, benefiting both biodiversity and human well-being (International Union for Conservation of Nature and Natural Resources, n.d.)
Scenarios	Expectations about possible future events used to analyze potential responses to these new and upcoming developments. Consequently, scenario analysis is a speculative exercise in which several future development alternatives are identified, explained, and analyzed for discussion on what may cause them and the consequences these future paths may have on our system (e.g., a country or a business).
Simulation model	Models can be regarded as systemic maps in that they are simplifications of reality that help to reduce complexity and describe, at their core, how the system works. Simulation models mimic a system's operation over time to analyze its behaviour and predict its performance. They are quantitative by nature and can be built using one or several methodologies (UNEP, 2014).

1.0 Introduction

Dire Dawa, Ethiopia's third most populous city, is a rapidly urbanizing centre facing multiple development challenges (World Population Review, 2025). While agriculture remains a primary livelihood in the city, the sector has been significantly weakened by poor soil quality, recurrent droughts exacerbated by climate change, and insufficient political commitment to rural development. The city's swift population growth has intensified existing pressures, including high unemployment, water scarcity, inadequate housing, and environmental degradation (Dire Dawa Administration Environmental Protection Agency [DDAEPA], 2011).

In rural areas surrounding Dire Dawa, extensive deforestation and land conversion for agriculture and settlement have severely diminished natural woodland and plantation forests, further increasing ecological vulnerability. The Dechatu River, a seasonal and ephemeral watercourse, typifies the region's hydrological volatility (DDAEPA, 2011). Although typically dry, it is prone to sudden and severe flooding during intense summer rainfall, driven in part by the degraded land cover across its catchment, which now comprises largely scrubland, open woodland, and bare soil (Billi et al., 2014).

As a result, Dire Dawa faces increasing vulnerability to flash floods, driven by rapid urban expansion, unplanned land-use changes, and upstream landscape degradation. These events have resulted in recurring loss of life, infrastructure damage, and disruption to economic activity. In addition, Dire Dawa is experiencing a worsening water crisis (Haramaya University, 2025b). The city depends entirely on groundwater for its water supply, but overextraction, reduced infiltration due to deforestation, and degradation of upper catchment areas have led to a steady decline in groundwater levels. Population growth, rising per capita demand, aging infrastructure, and the impacts of climate change are further intensifying water stress. Inadequate wastewater and solid waste management exacerbate environmental and public health risks. The Dechatu River, which plays a key role in urban drainage, is increasingly used as a dumping ground for solid waste and untreated wastewater. In parallel, poorly managed septic systems pose serious contamination risks to the city's already stressed groundwater resources (DDAEPA, 2011).

Addressing these interconnected challenges requires coordinated, cross-sectoral policy responses that integrate sustainable land management, urban planning, water security, and environmental protection. Without urgent intervention, these impacts threaten to undermine Dire Dawa's long-term resilience, public health, and socio-economic development. The city's susceptibility highlights the urgent need for integrated water resource and landscape management, including investment in gender-responsive nature-based approaches to build resilience, protect ecosystems, and support sustainable livelihoods in both urban and peri-urban Dire Dawa (Haramaya University, 2025b).

Gender-responsive NbS are approaches that aim to strengthen environmental resilience while empowering marginalized groups by embedding gender equality and inclusion into climate adaptation efforts. These approaches actively address and integrate gender considerations, ensuring that women and other underrepresented groups have equitable access to resources, meaningful participation, and fair distribution of benefits. Such groups are often more vulnerable to the negative impacts mentioned above, including land degradation and water-related challenges, adverse effects on human health, and the consequences of floods. Addressing these disparities and empowering women and vulnerable communities is a critical component of this initiative.

The Scaling Urban NbS for Climate Adaptation in sub-Saharan Africa (SUNCASA) initiative was developed to tackle these challenges. SUNCASA is a 3-year project that aims to enhance climate adaptation, gender equality, and biodiversity protection in urban communities in Ethiopia, Rwanda, and South Africa by responding directly to locally identified needs and priorities in three cities: Dire Dawa (Ethiopia), Kigali (Rwanda), and Johannesburg (South Africa). The project is funded by Global Affairs Canada for the implementation of gender-responsive NbS in the three cities.

In Dire Dawa, SUNCASA seeks to increase the climate resilience of approximately 827 hectares of land through the following interventions:

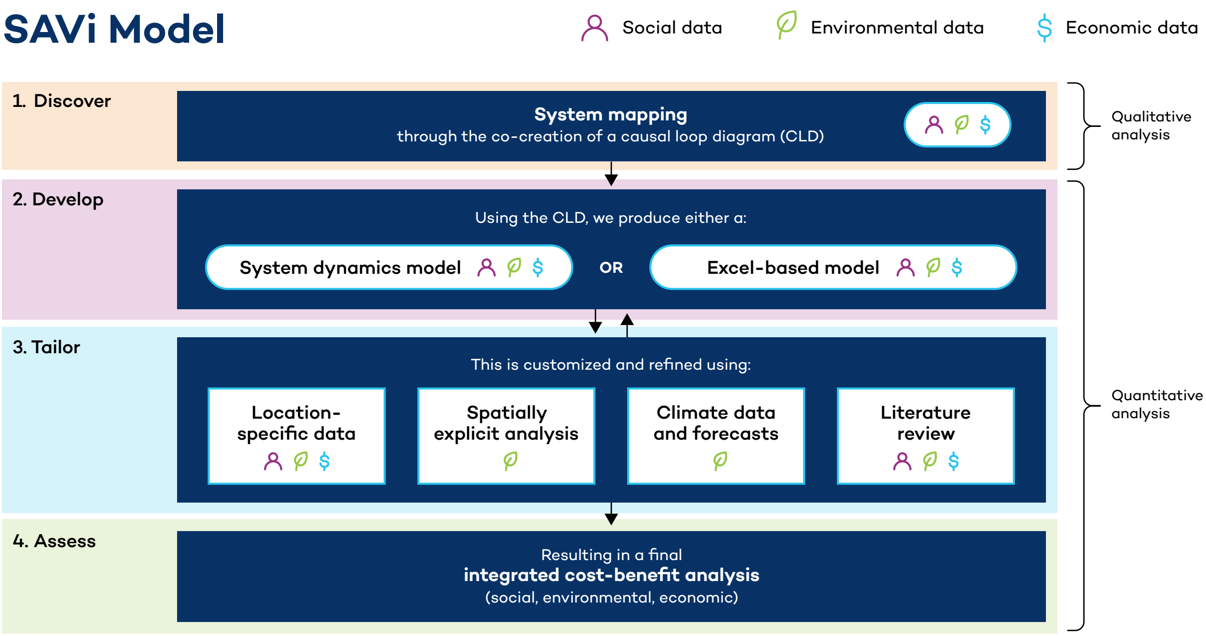
- **developing natural flood protection buffer zones** through afforestation and reforestation to control floods, reduce erosion, and promote infiltration.
- **developing agroforestry systems** to slow and absorb runoff and generate livelihood activities.
- **restoring degraded areas** by enclosing sites for small-scale forests using selected tree species with proven ecological and economic benefits, while allowing the existing native tree species to regenerate, improve vegetative cover in the catchment, stabilize soils, promote infiltration, and attenuate floodwaters.
- **building urban green infrastructure**, including the planting of 12,500 trees and open space improvements, to reduce the impacts of flooding and heat in settlements.

To promote a better understanding of the economic and financial viability of the SUNCASA project and to support efforts for sustained funding and financing mechanisms for the NbS interventions, the International Institute for Sustainable Development developed an integrated cost-benefit analysis (CBA) using the Sustainable Asset Valuation (SAVi) methodology. SAVi allows for the identification, valuation, and quantification of the broad and often indirect socio-economic, environmental, and disaster risk reduction benefits of NbS implementations. This report presents the methodology and results of the SAVi assessment of the NbS interventions in Dire Dawa and concludes with recommendations on their use by key stakeholders in the development, implementation, and financing of NbS.

2.0 Sustainable Asset Valuation

SAVi is an assessment methodology that provides policy-makers and investors with a comprehensive life-cycle analysis of infrastructure projects, considering often-overlooked impacts. Combining systems thinking and project finance modelling, SAVi captures the full costs and benefits, including environmental, social, and economic risks. It calculates the monetary value of externalities, offering a nuanced evaluation. Integrated valuations, such as SAVi assessments, basically provide a fuller picture of the long-term effects of infrastructure projects by integrating these externalities into traditional calculations of benefit-to-cost ratios (BCRs). This holistic approach enables investment decisions that align with regional development priorities, climate change adaptation, and the UN Sustainable Development Goals, ensuring a financially sound and sustainable outcome.

Figure 1. Steps of the SAVi model



Source: International Institute for Sustainable Development.

2.1 Importance of Systems Thinking

The SAVi methodology is based on systems thinking. The methodology considers the intricate connections among various factors within a system and forms the first step of the SAVi methodology (see Figure 1). By employing this approach, our study explores how different indicators and variables within the system interact. It delves into the complex relationships and interdependencies among key indicators, including rainfall patterns, agricultural practices, infrastructure, and socio-economic aspects. Understanding these interconnections provides a more nuanced perspective, enabling us to identify the fundamental drivers and dynamics influencing the livelihoods of local communities. These drivers might include deforestation, population growth, urbanization, and policy frameworks, while dynamics encompass interactions and feedback loops shaping the system's behaviours or outcomes.

By identifying these key drivers and dynamics, our study gains insights into the underlying causes and mechanisms shaping the current situation in Dire Dawa. This method offers a more comprehensive view of how NbS projects interact within a wider context, recognizing that changes in one aspect of the system can trigger cascading effects on others. This improved understanding facilitates a more accurate assessment of potential impacts and the overall effectiveness and efficiency of NbS interventions.

Systems thinking also helps identify project or policy entry points—specific areas or aspects within the system where interventions or policies can yield the greatest impact. Policy-makers and project developers, armed with knowledge about these entry points, can prioritize and target their efforts, thereby maximizing the efficiency and effectiveness of investments.

In summary, by applying systems thinking, our study achieves several key objectives: gaining a comprehensive understanding of the system in which the SUNCASA NbS interventions operate, recognizing the interconnectedness of key indicators, uncovering key drivers and dynamics, and discerning the most impactful policy entry points.

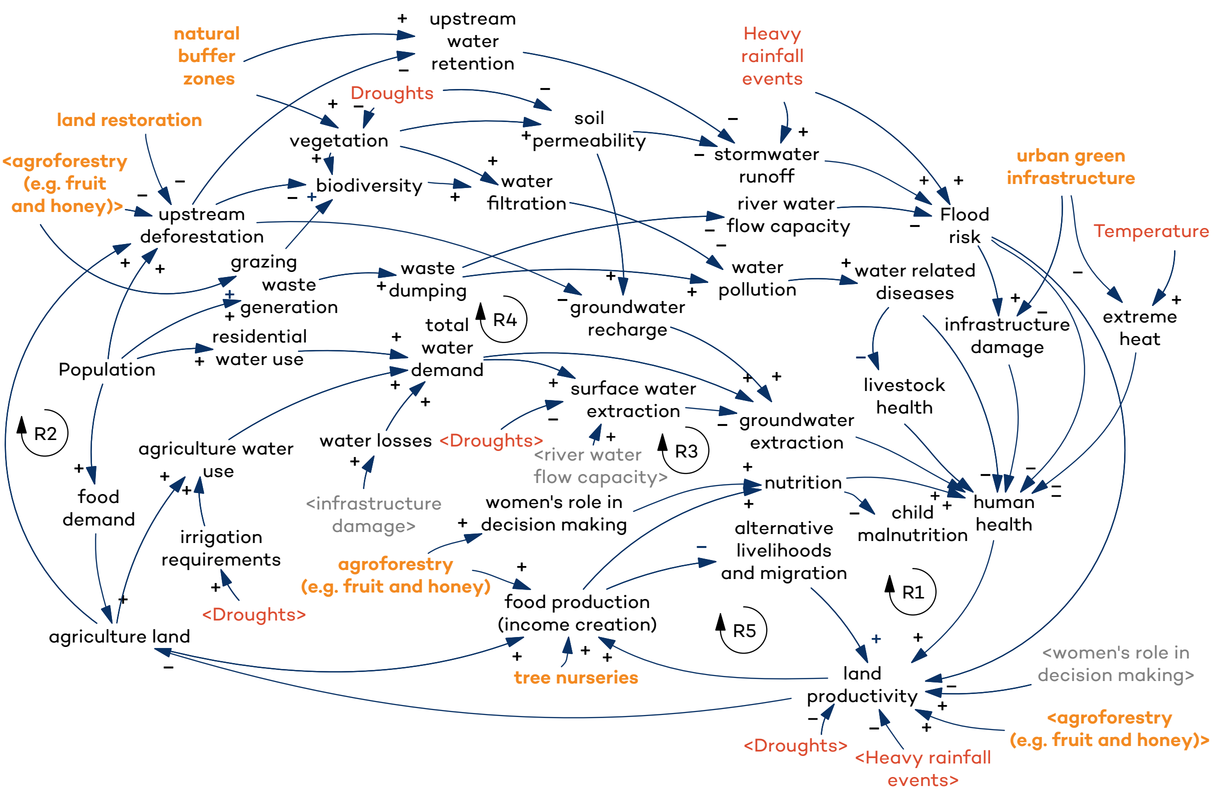
2.2 Causal Loop Diagram

The first step in the SAVi assessment is to identify the impacts and underlying dynamics of a project, including driving forces and key indicators, summarizing them in causal loop diagrams (CLDs). CLDs show the interconnections of the social, economic, and environmental components of the system, highlighting key dynamics and potential trade-offs emerging from the different scenarios considered in the SAVi assessment. The CLD is the starting point for the development of the mathematical stock and flow model that will simulate the NbS scenario. The CLD was validated through engagement with local stakeholders in Dire Dawa during a workshop held in June 2024. Feedback from the local stakeholders was incorporated into the CLD.

Box 1. Reading a CLD

A CLD is a tool that supports systems thinking. It shows relations between components of a system. Arrows indicate causality, and plus and minus signs are used to show the direction of causality. A plus sign means that two variables change in the same direction (a positive correlation), while a negative sign means that they change in opposite directions (a negative correlation). Feedback loops are labelled as either reinforcing (R) or balancing (B). A reinforcing loop indicates that a change in one variable will lead to further change in the same direction, whereas a balancing loop dampens change.

Figure 2. CLD representing the dynamics of the NbS interventions in Dire Dawa



Source: Authors.

Over recent decades, the city of Dire Dawa has experienced a significant increase in upstream deforestation primarily driven by population growth and urban expansion. Upstream deforestation and environmental degradation have compromised the region's hydrological functions, particularly its capacity for water retention. The resulting increase in surface runoff has amplified the frequency and severity of flooding events, especially during periods of intense precipitation, leading to significant infrastructure damage and elevated public health risks. Moreover, rising temperatures, exacerbated by global climate change, have further intensified environmental stressors. These conditions, in conjunction with more frequent and severe extreme weather events, such as droughts and heavy rainfall, have led to a marked decline in land productivity.

The reduction in land productivity directly undermines food security and agricultural income generation. These outcomes have cascading socio-economic effects, including deteriorating nutritional outcomes, particularly among vulnerable populations. In addition, the erosion of agricultural livelihoods disproportionately affects women’s decision-making power and contributes to heightened child malnutrition rates, collectively placing additional pressure on both public health systems and ecosystem resilience (R1) and often leading to alternative livelihoods and migration (R5). Declining land productivity intensifies pressure on available agricultural land, further accelerating upstream deforestation (R2). At the same time, population growth and escalating food demand exacerbate this pressure, driving the expansion of cultivation into marginal and ecologically sensitive areas. The expansion of agricultural land, coupled with increasing agricultural water demand and rising residential water consumption due to urbanization, has led to a substantial increase in total water demand. This surge in demand promotes excessive surface water extraction, contributing to ecosystem degradation and adversely impacting public health through reduced water availability and quality (R3).

Moreover, upstream deforestation diminishes watershed functionality by reducing biodiversity and impairing natural water filtration processes. This degradation elevates the risk of water pollution and increases the prevalence of waterborne diseases, posing significant threats to human health and undermining regional water security. Dire Dawa is also increasingly experiencing intensified urban heat stress relative to previous decades. This trend, coupled with prolonged drought conditions, has led to significant vegetation loss and reduced soil permeability. These changes have diminished the land's capacity to absorb rainfall, resulting in increased stormwater runoff and heightened flood risk. The loss of vegetative cover has also impaired natural water filtration processes, further contributing to water pollution and negatively affecting public health.

Furthermore, rapid population growth in Dire Dawa has led to a substantial rise in solid waste generation and waste disposal. Waste dumping reduces river water flow capacity, increasing the likelihood of urban flooding. Simultaneously, unmanaged waste contributes to the deterioration of water quality, adding to the burden on public health systems—directly, through increased exposure to waterborne contaminants and disease vectors or indirectly, through declining livestock health.

The application of NbS presents a strategic approach to mitigating key environmental pressures and addressing underlying drivers of land degradation in Dire Dawa, illustrated in Figure 2. Land restoration and the promotion of agroforestry practices have the potential to significantly reduce deforestation in and around the city. These measures would contribute to enhanced biodiversity through increased grazing, improved water filtration, and increased soil permeability, ultimately reducing the adverse health effects of flood events and associated water pollution, with direct benefits to public health. Furthermore, advancing agroforestry systems is expected to improve land productivity and agricultural output, thereby supporting food security, reducing malnutrition, and strengthening women's participation in decision-making processes within the agricultural sector. The establishment of natural buffer zones would further enhance vegetative cover and upstream water retention, reducing stormwater runoff and improving hydrological regulation. These outcomes would mitigate both flood and water contamination risks. Lastly, the integration of urban green infrastructure would reduce flood-related damage to infrastructure and help moderate urban heat island effects, thus lowering heat-related health risks in vulnerable populations.

2.3 Spatially Explicit Analysis

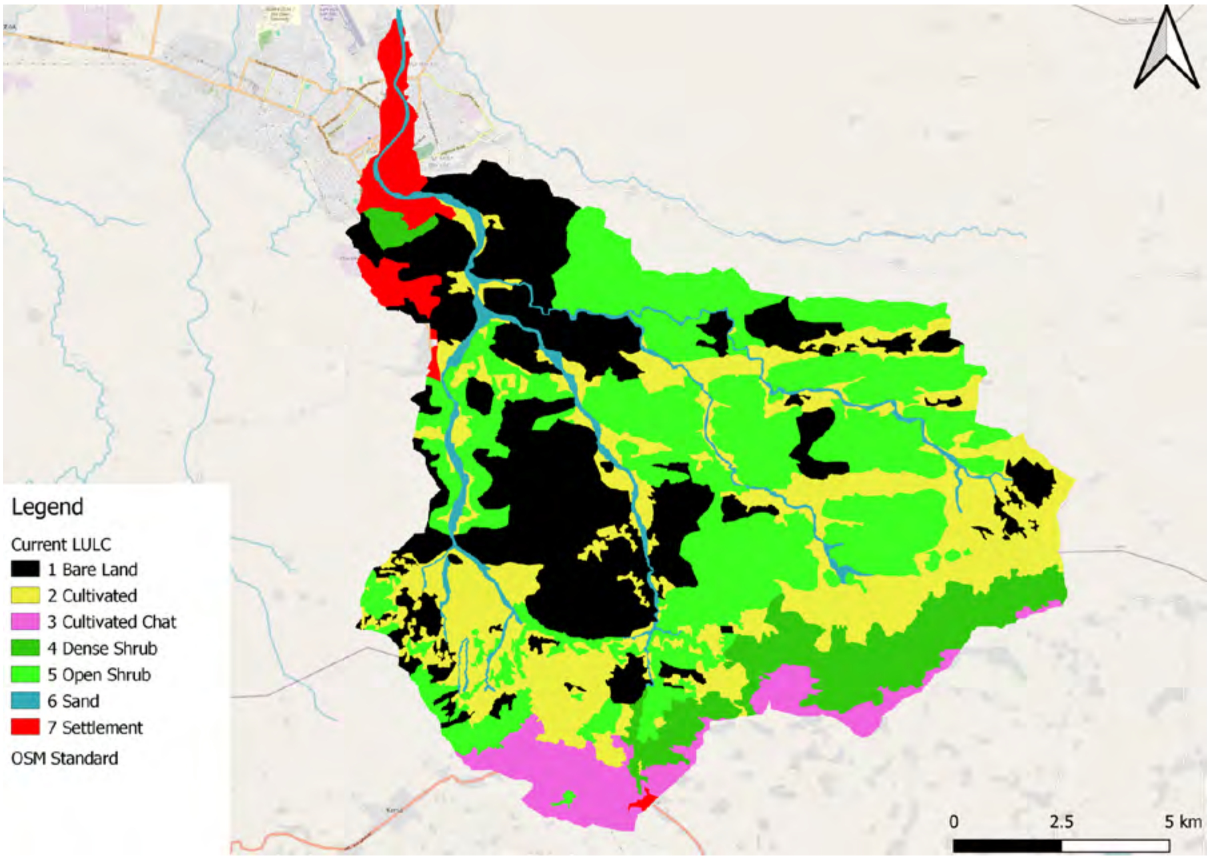
Two land-use/land-cover (LULC) maps were developed in support of this assessment: the Current LULC scenario (showing the land use of Dire Dawa and surrounding areas prior to the beginning of the project) and the Restored LULC scenario (which considered the same study area but also with the additional hectares (ha) of the NbS interventions, including restored areas, tree planting, etc.). Table 1 shows the total number of ha of the additional land classes under the Restored LULC scenario (calculations made with QGIS). Figure 3 shows the specific location of the interventions.

Table 1. Total hectares of interventions

Activity	ha
Agroforestry	385
Afforestation	350
Riparian zone restoration	83
Urban tree planting	8 (or 12,500 trees)
Green spaces	1

Source: Authors.

Figure 3. Location of the interventions



Note: OSM standard is that of the OpenStreetMap project.
Source: Authors.

The spatially explicit analysis performed for this assessment relies on the Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) suite of models. These models, developed by the Natural Capital Project, use LULC maps as input and quantify a wide range of ecosystem services.

Four InVEST models, used to map and quantify specific ecosystem services based on LULC data, were used. First, the Carbon Storage model calculates the amount of carbon stored in the landscape. The results, illustrated in Figure 4, demonstrate that relative to the Current LULC scenario, carbon storage is expected to increase by around 25.12% (approximately 175,000 tons). Second, the habitat quality model estimates changes in habitat disturbance, defined using a unitless index ranging from 0 to 1, where 0 represents no habitat and 1 represents the highest-quality habitat. The results indicate that the mean of habitat quality in the study area will increase by 16%. This is because trees and other interventions replace land classes with lower potential for habitat quality. Third, the Urban Cooling model estimates the temperature reduction by vegetation based on shade, evapotranspiration, and albedo, as well as distance from cooling islands (e.g., parks). The results indicate that the temperature in Dire Dawa will decrease by 0.77% in the whole study area as a result of the NbS interventions, with potentially larger benefits at the local level. Fourth, the Urban Flood Risk mitigation calculates the runoff reduction, which is the amount of runoff retained per pixel compared to the storm volume, when land-cover changes (i.e., in this case, when trees are planted) during a precipitation event of 100 mm. The results, illustrated in Figure 5, indicate that retention volume will increase by roughly 4% (or around 278,000 m^3). If vegetated land cover increases, then the runoff retention is higher than in the areas covered by other land classes because trees and other plants can retain larger volumes of water in the soil.

Compared to the Current LULC scenario, carbon storage, habitat quality, and runoff retention are estimated to be higher in the Restored LULC scenario, as shown in Table 2, while the average temperature is expected to decrease. Overall, the results of the InVEST analysis show an increase in benefits from selected ecosystem services thanks to the implementation of SUNCASA's NbS activities in Dire Dawa.

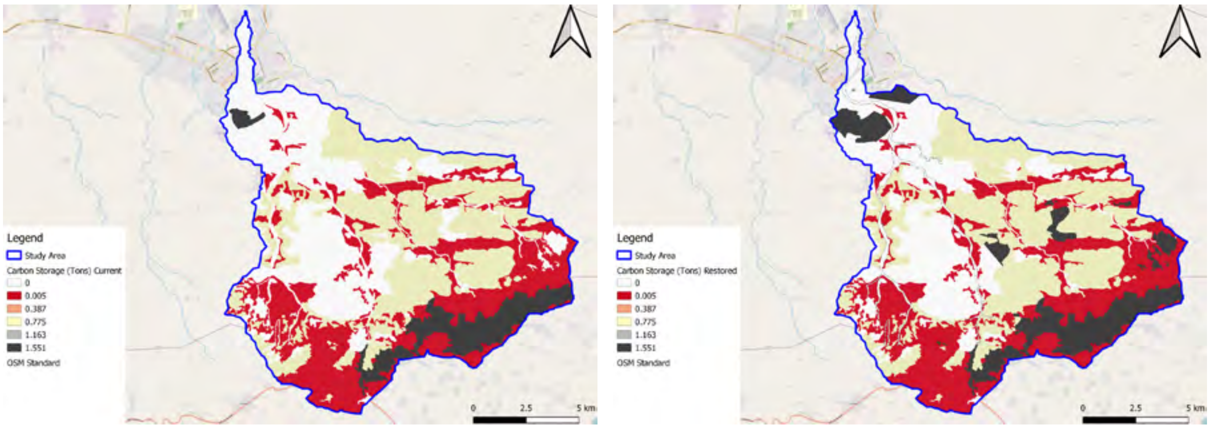
Table 2. Spatial analysis results summary

LULC scenario	**Carbon storage** (tons)	**Habitat quality** (mean)	**Average temperature value** (°C)	**Runoff retention** (m^3)
BAU (current)	696,916	0.097	31.915	6,972,343
Restored	872,003	0.113	31.669	7,250,831
Change from the current scenario	25.12%	16.49%	-0.77%	3.99%

Source: Authors.

Figure 4. Carbon storage in tons: Current and Restored LULC scenarios

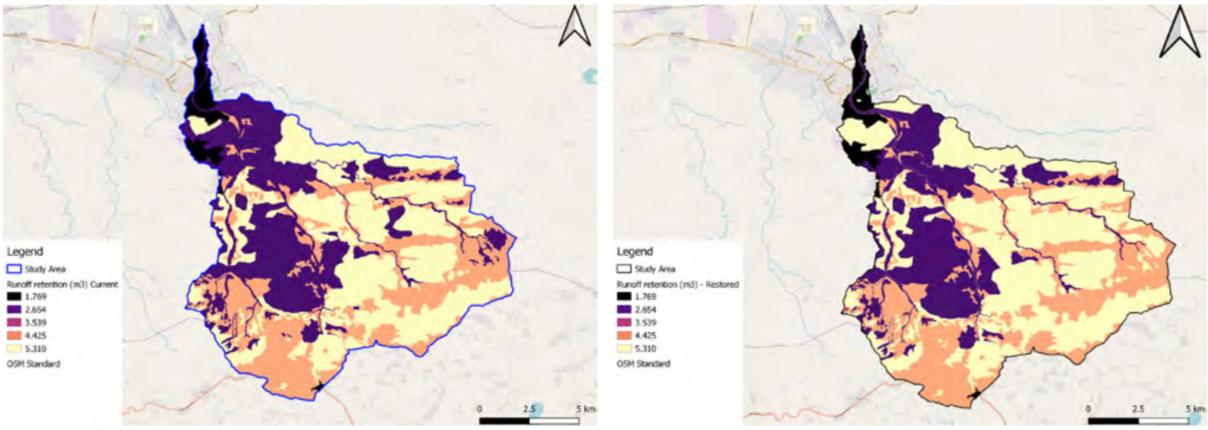
Current Scenario **Restored Scenario**



Source: Authors.

Figure 5. Runoff retention in m^3: Current and Restored LULC scenarios

Current Scenario **Restored Scenario**



Source: Authors.

3.0 Integrated CBA

3.1 Methodology

The integrated CBA builds upon all elements of the SAVi methodology that were detailed previously: CLD, systems thinking, and spatial analysis. For example, the CLD identified carbon sequestration as an important outcome of the NbS, the spatial analysis quantified how many additional tons of carbon will be stored, and the CBA assigns a monetary value to this carbon storage.

The CBA is the outcome of a customized Excel-based model that integrates the results of these assessments. This user-friendly tool is designed to enhance accessibility and facilitate comprehensive assessments. Our Excel-based model considers not only the financial implications of NbS measures but also their broader ecological and socio-economic impacts. Through the inclusion of key indicators such as investment costs, ecosystem service valuation, and employment/income generation, the model provides a nuanced understanding of the overall effectiveness and sustainability of NbS strategies.

The model's initial structure benefits from the cumulative and collective knowledge that the NBI Centre has built over the years. We tailored the model to the specific needs of the project and its partners through an iterative process involving data collection, equation formulation, and results validation. In the case of data gaps in the development of the model simulations, informed assumptions are applied to ensure continuity and coherence in the analysis. Specific values, sources and assumptions that were used for this assessment are included in Appendix A. Following the last iteration, we finalized the use of the following key indicators.

1. **Construction/Implementation and Maintenance Costs**

   The model incorporates a detailed assessment of the investment and maintenance costs associated with the various NbS interventions considered. This includes expenses related to tree planting and restoration, along with operation management.

2. **Value of Ecosystem Services**

   An integral component of the model involves a robust evaluation of the value of ecosystem services (expressed in monetary terms). This encompasses a thorough analysis of avoided infrastructure damage costs, avoided human health costs from floods, water pollution, and heat, as well as the quantification of carbon sequestration within the ecosystem.

3. **Employment and Income Generation**

   To capture the socio-economic benefits of the NbS project, the model accounts for employment opportunities generated by implementing interventions. Furthermore, it assesses the additional income generation stemming from the operation and management activities needed.

3.2 Scenarios

In addition to the BAU scenario, one NbS scenario was simulated for the SAVi assessment using a timeline from 2025 to 2050. The NbS scenario considers the proposed NbS interventions and the restoration of the Dechatu River catchment in Dire Dawa. As part of the same scenario, three sensitivity analysis scenarios are included:

NbS Scenario

This scenario proposes the introduction of NbS measures, including afforestation, agroforestry for runoff management and generating livelihoods, and urban tree planting to reduce flooding and heat impacts. These measures aim to reduce soil erosion, enhance groundwater recharge, buffer zone development, and expand opportunities for agroforestry, improving land and productivity, crop yields, and access
to technology.

- **1.1 Tree survival 94%:** This sensitivity analysis scenario assumes a 94% tree survival rate, based on tree survival data from recent years.
- **1.2 High cost of carbon:** This sensitivity analysis scenario assumes a higher cost of carbon value (USD 40/ton), based on the World Bank (2024) shadow price of carbon.
- **1.3 Tree survival 94% & high cost of carbon:** This sensitivity analysis scenario assumes both a 94% tree survival rate and a higher cost of carbon.

4.0 Results

The integrated CBA is shown in Table 3, showing discounted values at 10%. The analysis shows that the NbS scenario is economically viable and that the SUNCASA-implemented NbS interventions in Dire Dawa would have a wide range of economic, social, and environmental benefits beyond the initial infrastructure costs. The NbS interventions will have benefits in terms of avoided costs related to flood damages to infrastructure, avoided health costs from floods, water pollution, and heat, along with carbon sequestration and employment benefits.

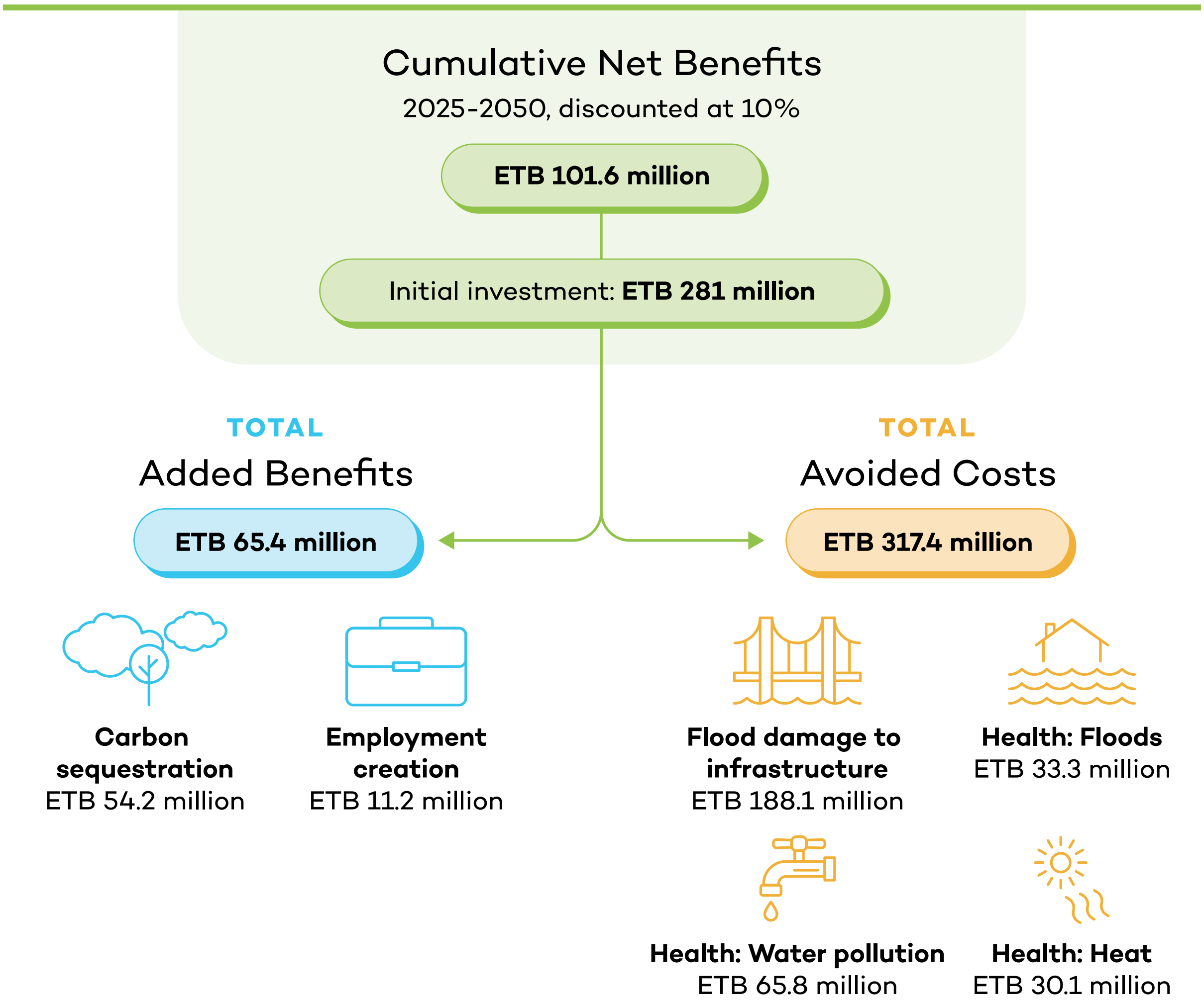
Table 3. Integrated CBA of SUNCASA-implemented NbS interventions in Dire Dawa (discounted at 10%)[1]

Integrated CBA 2025–2050 (discounted at 10%)	NbS scenario (ETB million)	Sensitivity analysis (ETB million)		
		Tree survival 94%	High cost of carbon	Tree survival 94% & high cost of carbon
Total direct costs	**281.2**	**281.2**	**281.2**	**281.2**
Implementation cost	65.9	65.9	65.9	65.9
Operation and maintenance cost	215.4	215.4	215.4	215.4
Total added benefit	**382.8**	**359.8**	**641.0**	**602.5**
Avoided flood damage to infrastructure	188.1	176.9	188.1	176.9
Avoided health costs: floods	33.3	31.3	33.3	31.3
Avoided health costs: water pollution	65.8	61.9	65.8	61.9
Avoided health cost: heat	30.1	28.3	30.1	28.3
Added employment creation	11.2	10.5	11.2	10.5
Carbon sequestration	54.2	50.9	312.4	293.6
Total net benefits (undiscounted)	**775.3**	**662.9**	**1,512**	**1,355**
Total net benefits (discounted)	**101.6**	**78.6**	**359.7**	**321.3**
BCR	**1.36**	**1.28**	**2.28**	**2.14**

Source: Authors.

[1] Disaggregated data by gender or social group was not available. It is recommended to track benefits by gender and vulnerability in future assessments.

Figure 6. Added benefits and avoided costs of the NbS interventions in Dire Dawa

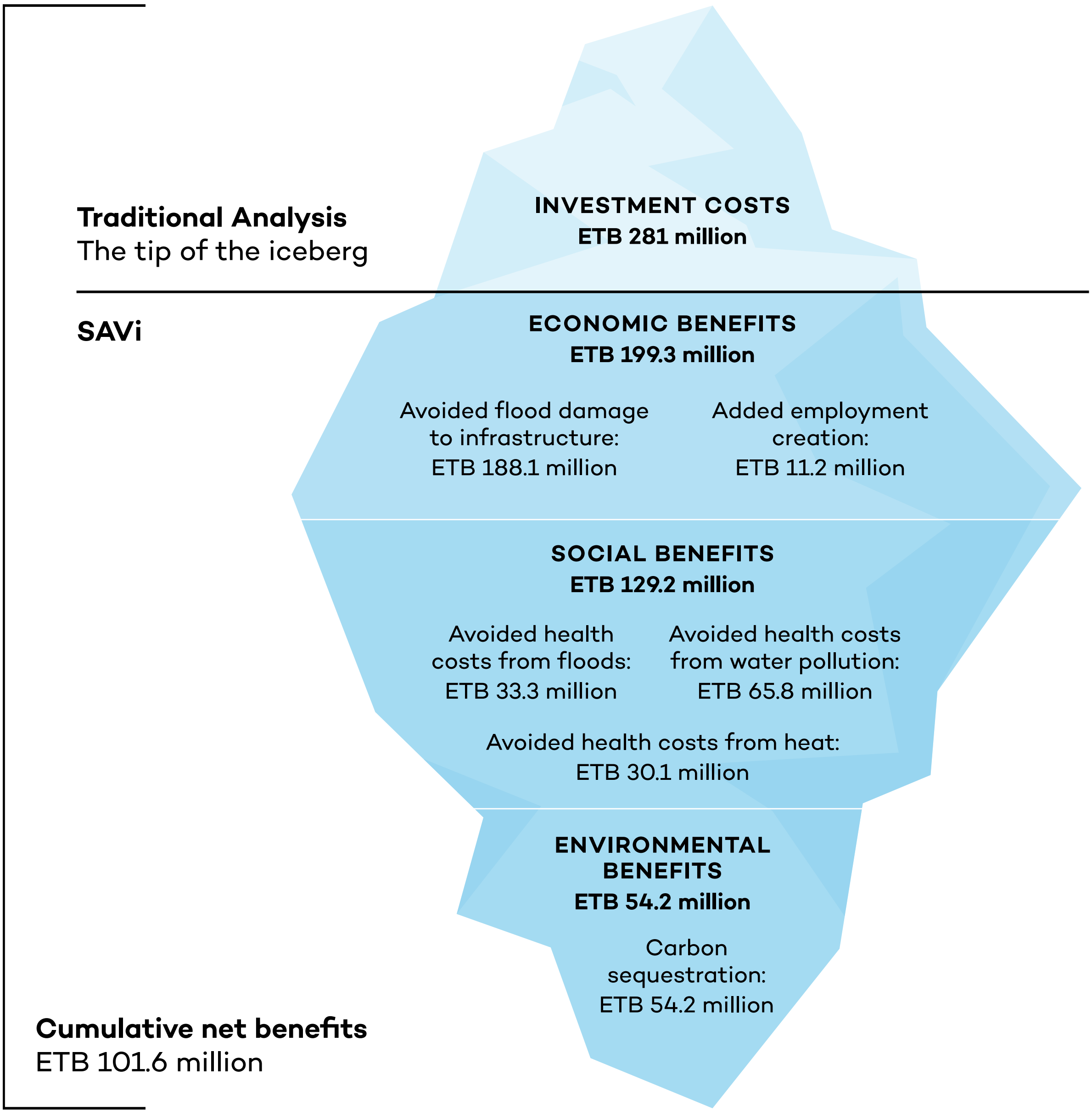


Source: Authors.

The NbS scenario will generate a cumulative (discounted at 10%)[2] net benefit of ETB 101.6 million, considering a project period of 25 years from 2025 to 2050. The results of the assessment, which consider all economic, social, and environmental benefits, also show that SUNCASA's gender-responsive NbS interventions in Dire Dawa will lead to a discounted integrated BCR of 1.36, highlighting the societal returns on investment. As a reminder, the BCR determines the overall value for money of a project and illustrates the return for every unit (ETB invested) by comparing the project's total benefits with the total costs. Importantly, inclusive approaches that target women and other underrepresented groups and communities can further increase the societal return on investment. Lastly, undiscounted values of the NbS scenario amount to a cumulative net benefit of ETB 775.3 million and a BCR of 1.71.

[2] A 10% discount rate was considered for the assessment for the following reasons: (i) the central bank lending rate for Ethiopia is currently set at 15%. This is an all-time high for Ethiopia, and the average is 5.83% from 1995 until 2025 (National Bank of Ethiopia); (ii) the central bank rate may well decline in the future, especially when considering the 25-year timeframe for the analysis (the central bank interest rate was 3% up to 2022); (iii) we assume that projects that support climate adaptation and mitigation can be eligible for conditional loans, either via preferential rates or risk reduction related to the provision of collateral or a grant portion for the project. As a result, a rate of 10% as chosen for the analysis (Trading Economics, 2025).

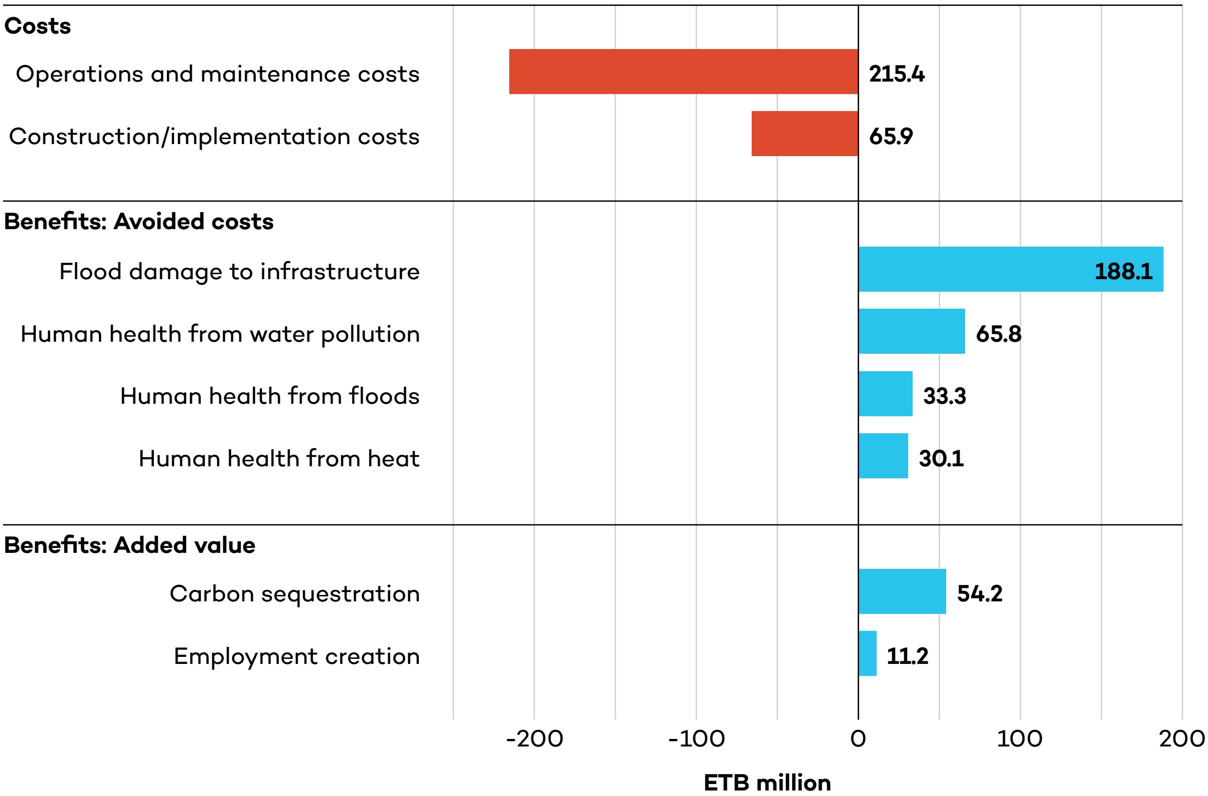
Figure 7. Economic, social, and environmental benefits of the NbS interventions in Dire Dawa



Source: Authors.

The greatest impact of the NbS scenario is the avoided cost of flood damages to infrastructure, valued at a cumulative, discounted ETB 188.1 million. This is a tangible avoided cost that affects people in the city and surrounding areas. This is followed by the avoided costs of human health from water pollution, amounting to a cumulative ETB 65.8 million. In addition, benefits from carbon sequestration amount to a cumulative ETB 54.2 million and avoided costs of human health from floods are valued at ETB 33.3 million. These impacts are shown in Figure 8.

Figure 8. Monetary values of the NbS scenario (discounted at 10%, cumulative 2025–2050)



Source: Authors.

When considering the sensitivity analysis scenarios, the economic value of carbon sequestration benefits increases substantially when applying a higher social cost of carbon, set at USD 40/ton in line with the World Bank's (2024) shadow price of carbon. Under this high social cost of carbon sensitivity scenario, cumulative carbon sequestration benefits are valued at ETB 312.4 million. Overall, the scenario yields cumulative net benefits of ETB 359.7 million and a BCR of 2.28, indicating strong economic viability.

In addition, the SAVi assessment found that under a 94% tree survival rate, reflecting recent trends in Dire Dawa, the NbS interventions are still economically viable, with net benefits of ETB 78.6 million and a BCR of 1.28. When accounting for a high social cost of carbon, net benefits increase considerably (ETB 321.3 million) and the BCR improves to 2.14, indicating that all sensitivity analysis scenarios show economic viability.

Table 4. Net benefits and BCRs of the NbS interventions in Dire Dawa across scenarios

	NbS scenario	Tree survival 94% scenario	High cost of carbon	Tree survival 94%+ high cost of carbon
Undiscounted net benefits (ETB million)	775.2	662.9	1,512	1,355
Discounted (at 10%) net benefits (ETB million)	101.6	78.6	359.7	321.3
BCR (discounted) (ETB million)	1.36	1.28	2.28	2.14

Source: Authors.

5.0 Conclusions

The NbS interventions in Dire Dawa are a multifaceted solution with strong potential to advance climate adaptation efforts across the city and surrounding areas. The results of the SAVi assessment shed light not only on implementation costs but also demonstrate that a range of economic, social, and environmental added benefits and avoided costs can be generated over time. SUNCASA's extensive agroforestry, afforestation, riparian restoration, and urban tree planting efforts have the potential to reduce risks related to floods, water pollution, and extreme heat while creating jobs and providing multiple economic, social, and environmental benefits for the city's wider population.

Integrated valuations using the SAVi methodology provide a more complete picture of the long-term effects of infrastructure projects by integrating these values into the traditional calculations of BCRs. BCRs determine the overall value for money of a project. In this case, they illustrate the return for every unit (ETB invested) by comparing the SUNCASA project's total benefits with the total costs. The analysis demonstrates that SUNCASA's NbS interventions in Dire Dawa will lead to a discounted (at 10%) BCR of 1.36, highlighting the societal returns on investment. In addition, the NbS interventions will lead to estimated discounted net benefits of ETB 101.6 million for the population of Dire Dawa and its surroundings, cumulatively, from 2025 to 2050. Importantly, inclusive approaches that target women and other underrepresented groups can further increase the societal return on investment.

The greatest impacts over the timeline considered in the analysis (2025–2050) are the avoided cost of flood damages to infrastructure (ETB 188.1 million), the avoided costs of human health from water pollution (ETB 65.8 million), the benefits from carbon sequestration (ETB 54.2 million), and the avoided costs of human health issues resulting from floods (ETB 33.3 million). Lastly, according to one sensitivity analysis scenario that is based on current tree survival rates in Dire Dawa as part of the SUNCASA initiative (Haramaya University, 2025c), even with a 94% tree survival rate, the NbS interventions are still economically viable, leading to cumulative, discounted, net benefits of ETB 78.6 million, with a BCR of 1.28.

The SAVi assessment also demonstrates that advancing NbS investments, such as the activities in Dire Dawa, delivers strong economic, social, and environmental outcomes that outweigh the upfront implementation and operation and maintenance costs in the long term. To truly understand and extract the value of NbS activities, it is important that these additional avoided costs and added benefits are identified, assessed, valued, and incorporated into the analysis so that government actors, city planners, and project developers can advocate for their implementation and financing. It is critical that policy-makers design and implement processes to recognize and account for these wider values so that decisions are made that deliver nature-based investments that provide the greatest benefits to society while minimizing their environmental impacts.

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Appendix A. Key Data Sources

Table A1. Data sources used in the SAVi assessment of the NbS interventions in Dire Dawa

	Indicator	Value	Data source
Construction/implementation costs			
	Area and number of trees for NbS interventions	Agroforestry: 385 ha, afforestation: 350 ha, Riparian zone: 83 ha, urban tree planting: 12,500 trees, green spaces: 1 ha	Internal SUNCASA project documents
	Rate of tree survival	94%	Haramaya University (2025a, 2025c)
	Planting costs per tree	0.65 USD/tree	Internal SUNCASA project documents: Reviewed from various sources, including SUNCASA Dire Dawa seedling procurement
	Trees per hectare	1,500	Assumption
	Time of construction/ implementation in years	5 years	Assumption
Operation and maintenance (O&M) costs			
	Area for NbS interventions	Agroforestry: 385 ha, afforestation: 350 ha, Riparian zone: 83 ha, urban tree planting: 12,500 trees, green spaces: 1 ha	Internal SUNCASA project documents
	O&M costs per tree	0.30 per tree	Reviewed – Internal SUNCASA Dire Dawa project management documents
	Trees per hectare	1,500	Assumption
	Time of O&M costs in years	21 years	Assumption
Avoided flood damage to infrastructure (starting after 5 years of initial NbS implementation)			
	Cost of house/building reconstruction per sq m	2,500 ETB/m^2	Ethiopian Roads Administration (2025)

	Indicator	Value	Data source
	Average size per house in Ethiopia	24 m^2	The British Academy (2021)
	Total number of damaged houses per flood	2,685 houses/flood	Dire Dawa Administration Program of Adaptation to Climate Change (2019)
	Estimated damage to roads – 2006 flood disaster	ETB 7,197,100/flood	Dire Dawa Administration Program of Adaptation to Climate Change (2019)
	Future frequency of floods	Every 2 years	Assumption
	Percentage increase in water retention (as a result of the NbS interventions)	40%	Assumption
	Time for NbS to mature	8 years	Assumption
Avoided human health costs from floods (starting after 5 years of initial NbS implementation)			
	The number of people impacted per flood	12,897 persons (including dead, displaced, and homeless)	Dire Dawa Administration Program of Adaptation to Climate Change (2019)
	Average cost per capita of health care treatment in Ethiopia	USD 36/person	Zarepour et al. (2023)
	Future frequency of floods	Every 2 years	Assumption
	Percentage of people impacted needing health care	50%	Assumption
	Percentage increase in water retention (as a result of the NbS interventions)	40%	Assumption
	Time for NbS to mature	8 years	Assumption
Avoided human health costs from water pollution (starting after 5 years of initial NbS implementation)			
	Nitrogen uptake per ha	126 kg/ha/year	Kim & Isaac (2022)

	Indicator	**Value**	**Data source**
	Phosphorus update per ha	14 kg/ha/year	European Soil Data Centre (2022)
	Price per kg of nitrogen removed	USD 50/kg	Plauborg et al. (2023)
	Price per kg of phosphorus removed	177 USD/kg	Dunne et al. (2013)
	Percentage reduction in nitrogen and phosphorus uptake per ha and price per kg based on size of trees and country source	50%	Assumption
	Percentage of water pollution budget avoided (as a result of the NbS interventions)	50%	Assumption
	Time for NbS to mature	8 years	Assumption
Avoided human health costs from heat (starting after 5 years of initial NbS implementation)			
	Reduction in energy use (air conditioning) and air pollution from urban shade trees	200	Akbari (2022)
	Duration of tree benefits	30 years	Assumption
	Percentage of heat mitigation budget avoided (as a result of the NbS interventions)	50%	Assumption
	Time for NbS to mature	8 years	Assumption
Employment creation (construction/implementation employment in the first 5 years, O&M employment after 5 years and until 2050)			
	Total number of Jobs (Pitting, plantation, seedling mobilization, transportation and management, site clearance and site preparation, watering, weeding and mulching, beekeeping, compost preparation)	1,436 jobs for 2024, 2,745 jobs for 2025, 2,545 jobs for 2026	Internal SUNCASA Green Jobs forecasting document

	Indicator	Value	Data source
	Gender disaggregation in employment created	Various percentages for different activities	Photograph from SUNCASA workshop in Dire Dawa, December 17, 2024
	Average monthly salary	ETB 3,000/month	Internal SUNCASA project documents
	Average number of working months per year	4 working months	Internal SUNCASA project documents
	Percentage of discretionary spending	20%	Assumption
	Time of construction/ implementation employment and O&M employment	3 years and 21 years	Internal SUNCASA project documents
Carbon sequestration (starting after 5 years of initial NbS implementation)			
	Price of carbon in Ethiopia	EUR 6.66/tCO_2	Organisation for Economic Co-operation and Development (2023)
	Shadow price of carbon	40/tCO_2	World Bank (2024)
	Carbon stored	696,916 tCO_2 in current scenario, 872,003 tCO_2 in restored scenario	Dire Dawa Spatial Analysis (International Institute for Sustainable Development, 2024).
	Time for NBI to mature	8 years	Assumption

All assumptions and data sources were validated by stakeholders during the June 2025 workshop in Dire Dawa.

Source: Authors.

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