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RAIN
Resilience, Adaptation and Inclusion in Nepal

SUMMARY REPORT

March 2026

Cost–Benefit Analysis of Nature-based Solutions for Climate Adaptation

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A EXECUTIVE SUMMARY

Nepal is acutely vulnerable to climate-induced hazards such as floods, droughts, erosion, and water scarcity, particularly in Madhesh and Lumbini provinces, where livelihoods depend heavily on rainfall, groundwater, and river systems. Even small climatic shifts can undermine agricultural productivity and food security. In response, the RAIN project has implemented a portfolio of NbS, including riverbank protection, pond restoration, recharge ponds, rajkulo rehabilitation, lake embankment measures, and Climate Resilient Village (CRV) approaches. These interventions aim to strengthen resilience by improving water management, safeguarding farmland, and supporting rural livelihoods.

The need for this research arose from the limited economic evidence available to local governments when justifying NbS investments. While communities value these interventions, municipalities often struggle to demonstrate their cost-effectiveness in planning and budgeting processes. This study, therefore, sought to combine field-based evidence with a simplified Cost–Benefit Analysis (CBA) to assess whether NbS represent economically viable adaptation strategies.

The methodology involved thirty-two Key Informant Interviews (KIIs) with ward officials, technical staff, farmer groups, and beneficiaries, alongside insights from ten Focus Group Discussions (FGDs). Ten case study sites were selected across Madhesh and Lumbini to represent major NbS types. The CBA applied a ten-year evaluation period with discount rates of ten and twelve per cent, monetising benefits such as avoided crop losses, labour and time savings, and additional agricultural production. Other benefits, including fish farming, tourism, land value appreciation, and ecosystem services, were noted but not monetised due to data limitations.

The scope of the study was deliberately focused on a representative sample of interventions rather than the full project portfolio. Limitations included the early stage of implementation, reliance on perception-based data rather than long-term monitoring, uncertainty in maintenance cost assumptions, and the exclusion of several intangible benefits from economic calculations. As a result, the findings should be interpreted as conservative estimates of the true value of NbS.

Key findings demonstrate that NbS interventions are widely perceived as multi-functional assets that deliver both tangible and intangible benefits. Communities reported improved water availability, protection of farmland, livelihood diversification, and reduced labour burdens, alongside ecosystem co-benefits such as groundwater recharge and vegetation growth. The economic analysis confirmed strong performance: across the portfolio, the present value of benefits was estimated at NPR 53.6 million compared to costs of NPR 25.8 million at a ten per cent discount rate, yielding net benefits of NPR 28.7 million. All interventions produced positive Net Present Values (NPVs) and Benefit Cost Ratios (BCRs) greater than one, with examples such as Yasodhara riverbank protection (NPV NPR 4.66 million, BCR 2.02) and Maharajgunj rajkulo irrigation (NPV NPR 3.2 million, BCR 1.9).

In conclusion, the study provides robust evidence that NbS under the RAIN project are cost-effective investments for climate adaptation and rural development. With strengthened community ownership, improved maintenance, and integration into municipal planning, NbS approaches hold strong potential for scaling across Nepal's climate-vulnerable landscapes.

B RATIONALE

Nepal is widely recognised as one of the most climate-vulnerable countries in South Asia, facing recurring hazards such as floods, droughts, riverbank erosion, and water scarcity. These risks are particularly acute in Madhesh and Lumbini provinces, where rural livelihoods depend heavily on rainfall, groundwater recharge, and the stability of river systems. Even minor shifts in climate patterns can directly affect agricultural productivity, food security, and household income. In this context, strengthening local resilience has become a pressing priority for communities and local governments.

The RAIN project introduced a portfolio of NbS to address these challenges. These interventions include riverbank protection, pond restoration and renovation, multipurpose and recharge ponds, rajkulo rehabilitation, lake embankment measures, and CRV approaches. Together, they aim to improve water management, enable groundwater recharge, protect farmland, enhance agricultural productivity, and support livelihoods. While communities recognise their benefits, local governments often face the question of whether such interventions are economically worthwhile. This study was designed to provide evidence by combining field-based insights with a simplified cost-benefit analysis of selected NbS interventions.

C SCOPE OF THE STUDY

The primary objective of the study was to assess the local performance and economic relevance of NbS interventions implemented under the RAIN project.

Specifically, the analysis sought to document how communities and local actors value these interventions, identify categories of benefits such as avoided losses, livelihood gains, and time savings, and translate these into measurable streams for cost-benefit analysis.

The scope covered ten sampled case study sites across Madhesh and Lumbini provinces, representing major NbS types. Data were collected through thirty-two Key KIIs with ward officials, technical staff, farmer groups, and beneficiaries, supplemented by insights from ten FGDs.

D METHODOLOGY

The study combined qualitative and semi-quantitative approaches. KIIs provided information on investment costs, maintenance, land protection, income changes, time savings, and broader co-benefits. These perceptions were triangulated with FGDs and field observations.

For the economic appraisal, the study followed a comparative analytical framework that evaluates the performance of the interventions against a baseline or BAU scenario. The purpose of this framework is to understand whether the NbS measures generate economic and livelihood benefits that justify their investment and maintenance costs over time.

Under the BAU scenario, communities continue to face existing climate and environmental risks without the NbS interventions introduced under the RAIN project. These risks include seasonal flooding, riverbank erosion, dry-season water shortages, and declining agricultural productivity. In such conditions, farmers often experience crop losses, reduced land productivity, and limited opportunities for livelihood diversification.

The NbS intervention scenario represents the situation in which nature-based measures such as riverbank stabilisation, pond restoration, recharge systems, rajkulo irrigation rehabilitation, lake embankment protection, and CRV initiatives are implemented and maintained. These measures aim to improve water management, protect farmland, strengthen agricultural productivity, and enhance resilience to climate variability.

The analysis compares the costs and benefits associated with these two scenarios over a defined period of time. The economic value of the NbS interventions is assessed by estimating the present value of their benefits and costs over the lifespan of the interventions. The cost includes initial capital investment, annual operation and maintenance costs (conservative estimation) and periodic maintenance costs. The benefits include considerations for increased agricultural production, especially off-season vegetable production due to water availability, avoided crop losses, labour and time savings and additional livelihood opportunities such as fish farming.

NPV, which measures overall economic value generated by intervention over time; BCR, which compares total discounted benefits with the total discounted costs; and Internal Rate of Return (IRR), which estimates the rate of return generated by the intervention.

The time horizon represents the period over which the costs and benefits of each intervention are evaluated. For this analysis, a 10-year time horizon was adopted. This period reflects the typical functional lifespan of many NbS interventions observed in the field, particularly pond restoration, irrigation ponds, and riverbank stabilisation structures, provided regular maintenance, for which annual maintenance cost is also considered while doing the analysis.

The sensitivity analysis, focusing on discount rates of 10% and 12% were applied to reduce dependency on a single set of assumptions. The evaluation period was set at ten years, with discount rates of ten and twelve per cent. Benefits monetised included avoided crop losses, labour and time savings, and additional agricultural production from off-season vegetable cultivation. Other benefits, such as fish farming, tourism, land value appreciation, and ecosystem services, were noted but not monetised due to limited data.

Table 1. Summary of the key assumptions used in the NbS Cost–Benefit Analysis.

Parameter	Assumption Used in Analysis
Analysis time horizon	10 years
Discount rates	10%, and 12%
Cost components	Capital investment, annual maintenance and major investment in 5th and 10th Year
Benefit categories	Agricultural income, avoided crop damage, labour savings
Sensitivity analysis	Variation in discount rate

E LIMITATIONS

Several limitations must be acknowledged in this study. Many interventions were still at an early stage of implementation, meaning that some benefits had not yet fully materialised.

The economic analysis focused only on benefits that could be reasonably estimated, leaving out important but less quantifiable outcomes such as ecosystem restoration, groundwater recharge, increased land value and tourism potential, leading to conservative estimation of benefits. Heavy reliance on KIIs introduced a degree of uncertainty, as estimates were based on perceptions rather than systematic measurements.

The sample of case study sites was not statistically representative of all RAIN interventions, and assumptions about maintenance costs may not reflect actual requirements.

Finally, results were sensitive to discount rates and benefit streams, meaning future outcomes could vary depending on climate conditions and agricultural markets.

F RESULTS

1. Qualitative Field Findings

Communities consistently described NbS interventions as multi-functional assets. Improved water availability was one of the most valued outcomes. Ponds and recharge systems allowed storage of monsoon water, enabling irrigation during dry seasons and supporting off-season vegetable farming.

This increased household income and improved food security. Riverbank stabilisation was another major benefit, protecting farmland from seasonal floods and erosion. Multipurpose ponds supported irrigation, livestock watering, and fish farming, while improved irrigation systems reduced labour burdens and saved time.

Beyond direct economic gains, respondents highlighted ecosystem and social co-benefits. These included groundwater recharge, improved soil moisture, vegetation growth, and better environmental conditions around restored water bodies. In some cases, interventions contributed to reduced conflict over water, improved food security, and stronger community cooperation and support for religious and cultural activities.

Owing to these benefits, the study also notes high interest and ownership of these NbS Interventions at the community and local government level. Respondents consistently described the interventions as useful for improving water security, protecting agricultural land, supporting livelihoods, and strengthening resilience to climate-related risks. These findings suggest that NbS approaches have strong potential for scaling within local development and climate adaptation planning. However, scaling such interventions will require clear evidence of their economic performance indicators, such as NPV, BCR and IRR.

Table 2. Summary of KII Findings by Intervention Type.

Intervention Type	Example Locations (Municipality/ Ward)	Key Functions	Benefits Reported by Respondents	Key Risks / Issues
Riverbank Protection / Stabilisation	Yasodhara-8, Buddhabhumi-9	Control river erosion and protect farmland	Protection of agricultural land, reduced flood damage, avoided crop loss, reduced repair costs	Requires periodic maintenance; extreme floods may damage structures
Multipurpose Pond	Siraha-12, Kamala-8, Balwa-6, Loharpatti-3	Water storage for irrigation and livestock	Improved irrigation, fish farming, livestock water, off-season vegetables, increased crop production	Siltation and maintenance required; water management needed
Recharge Pond / Integrated Pond System	Shivaraj-4, Maharajgunj-3	Water storage and groundwater recharge	Improved groundwater levels, irrigation water during dry season, reduced drought stress	Requires community management and periodic cleaning

Intervention Type	Example Locations (Municipality/ Ward)	Key Functions	Benefits Reported by Respondents	Key Risks / Issues
Lake Embankment / Recharge System	Lamahi-7	Water retention and landscape water regulation	Flood moderation, groundwater recharge, environmental improvement, and tourism potential	Needs long-term maintenance and watershed management
Climate Resilient Village (CRV)	Banaganga-9	Integrated climate adaptation practices	Improved agricultural productivity, reduced pesticide use, increased income, and better food security	Requires continued technical support and knowledge sharing

Table 3. Key Variables Extracted from KII Data for NbS Cost–Benefit Analysis

Variable Category	Information Collected from KIIs	Use in CBA Calculation
Capital Investment	Total project investment cost and funding sources	Initial project cost in CBA
Community Contribution	Labour or financial contribution from the community	Added to project cost or treated as an in-kind investment
Land Saved / Protected	Area of farmland protected from erosion or flooding	Value of avoided land loss
Estimated Land Value	Market value of protected land	Used to estimate avoided damage benefits
Household Income Before Intervention	Baseline livelihood income	Establish baseline scenario
Household Income After Intervention	Income change due to irrigation, fish farming, or agriculture	Annual benefit stream
Agricultural Income	Crop production or yield improvements	Direct economic benefit
Additional Benefits	Fish farming, livestock water, and vegetable production	Added to the benefit stream
Time Savings	Reduced time for irrigation, water collection, or repair	Monetised as labour savings
Co-Benefits	Groundwater recharge, ecosystem benefits, and tourism	Qualitative or secondary benefits
Annual Maintenance Cost	Maintenance or repair costs	Operating cost in CBA
Expected Lifespan	Estimated functional life of the infrastructure	Time horizon for CBA
Overall Value Perception	Respondents' assessment of usefulness	Used for qualitative validation

This table explains how the KII variables feed into the economic CBA model.

2. NbS relevance for Climate Adaptation and Disaster Risk Reduction (DRR)

NbS implemented under the RAIN project in Madhesh and Lumbini provinces are designed to strengthen both Climate Change Adaptation (CCA) and DRR. Rural livelihoods in these regions depend heavily on rainfall, river systems, and groundwater resources, yet increasing climate variability—such as irregular rainfall, seasonal flooding, and prolonged dry periods—has created mounting challenges for agriculture and water security. NbS interventions directly address these vulnerabilities by stabilising fragile landscapes and improving local water regulation, thereby enhancing the resilience of communities and ecosystems.

Riverbank protection measures reduce erosion and flood risks by safeguarding farmland and preventing the loss of productive land, while pond-based interventions—including conservation, recharge, and multipurpose ponds—capture monsoon rainfall and provide water during dry seasons. These systems support irrigation, livestock watering, and fish farming, while recharge ponds improve groundwater availability and stabilise water resources for long-term agricultural productivity. Multipurpose ponds also enable livelihood diversification, reducing dependence on rainfall-based farming. Collectively, these interventions help communities manage flood and drought risks more effectively, protect productive landscapes, and strengthen local resilience, thereby demonstrating how NbS approaches contribute simultaneously to climate adaptation and DRR in Nepal's vulnerable provinces.

Table 4. Summary of NbS Contributions to CCA and DRR

NbS Intervention	Main Climate / Disaster Risk Addressed	DRR Function	Contribution to Community Resilience
Riverbank Protection and Stabilisation	Riverbank erosion, monsoon flooding, and land degradation	Stabilises vulnerable riverbanks and reduces erosion during high-flow events	Protects agricultural land, reduces flood-related damage, and maintains the stability of farming areas near rivers
Conservation Ponds	Dry-season water shortages, irregular rainfall	Stores rainfall and provides water for irrigation during dry periods	Helps farmers maintain crop production and reduces drought-related agricultural losses
Recharge Ponds	Groundwater depletion, water stress during dry seasons	Captures rainwater and allows gradual infiltration into groundwater systems	Supports groundwater recharge and stabilises water availability in wells and irrigation sources
Multipurpose Ponds	Water scarcity, livelihood vulnerability	Provides water for irrigation, livestock, and other uses	Supports diversified livelihoods such as irrigation-based agriculture and fish farming, increasing resilience to climate variability
Lake Embankment / Landscape Water Regulation	Flood risks, water regulation challenges	Moderates water flows and supports local water retention	Improves local water regulation and strengthens landscape-level resilience

3. Cost-Benefit Analysis (CBA)

The portfolio investment across the ten case study sites amounted to approximately NPR 17.7 million, directly benefiting about 335 households. At a ten per cent discount rate, the present value of costs was estimated at NPR 25.8 million (including annual maintenance costs), while the present value of benefits reached NPR 53.6 million. At a twelve per cent discount rate, benefits were slightly lower at NPR 51.8 million. Net economic benefits were estimated at NPR 28.7 million and NPR 24.9 million, respectively, at 10 and 12 per cent discount rates.

At the individual intervention level, all projects produced positive NPVs and BCRs greater than one, indicating that benefits exceeded costs.

For example, the Yasodhara riverbank protection intervention generated an NPV of NPR 4.66 million with a BCR of 2.02, at 10% discount rate, protecting farmland and reducing recurring crop losses, while the Maharajgunj rajkulo irrigation system produced an NPV of NPR 3.2 million with a BCR of 1.9 at 10% discount rate, showing strong returns from improved irrigation and agriculture productivity.

The Banaganga CRV intervention generated an NPV of NPR 2.3 million and a BCR of 1.59 at 10% discount rate, reflecting improved farming practices and increased productivity.

Pond renovation and multipurpose pond systems also demonstrated positive returns, with BCR values ranging from 1.68 to over 2 at 10% discount rate, depending on water use and local agricultural productivity.

Even under conservative assumptions, NbS interventions provided strong economic value for communities.

Below is the summarised version of the 10 NbS interventions covered under this study:

3.1 Khoriya Riverbank protection, Ward no 8, Yasodhara, Lumbini

Community members reported that prior to the intervention, seasonal floods regularly damaged standing crops and eroded farmland. KIIs highlighted that the stabilisation structures now protect agricultural land and reduce recurring losses, while FGDs confirmed improved confidence among farmers to cultivate near the river. The intervention has generated significant avoided losses and strengthened local resilience. Economically, the cost–benefit analysis estimated a NPV of approximately NPR 4.66 million with a BCR of 2.02 at a 10 percent discount rate, demonstrating that the benefits are more than double the costs. Even under conservative assumptions, the intervention is considered highly viable and valued by the community.

Figure 1: Representative graphical view of CBA of river Bank Protection.

3.2 Buddhabhumi Riverbank protection, Ward number 9, Lumbini

Similar to Yasodhara, farmers in Buddhabhumi described frequent crop damage and gradual land loss before the intervention. KIIs noted that the protective structures have reduced erosion and safeguarded livelihoods, while FGDs emphasised the psychological security of farming without fear of losing land. The intervention has also contributed to reduced repair costs and stabilised local production. The economic analysis confirmed positive returns, with NPVs in the millions and BCRs consistently above one, indicating strong justification for investment. The findings suggest that riverbank protection is not only an environmental measure but also a livelihood safeguard with clear economic value.

3.3 Chanai Pond renovation, Shivaraj Ward No. 4, Lumbini

Respondents described the pond as a multi-functional resource, providing irrigation water, livestock watering, and opportunities for vegetable farming. KIIs highlighted improved water availability during dry seasons, while FGDs noted reduced labour burdens for women and increased household food security. The intervention has enabled off-season cultivation and diversified livelihoods. Economically, the CBA showed positive NPVs and BCRs ranging from 1.68 to above 2 at a 10 percent discount rate, confirming that the benefits outweigh the investment and maintenance costs. The recharge function also contributes to groundwater sustainability, which was valued by communities even though not fully monetised.

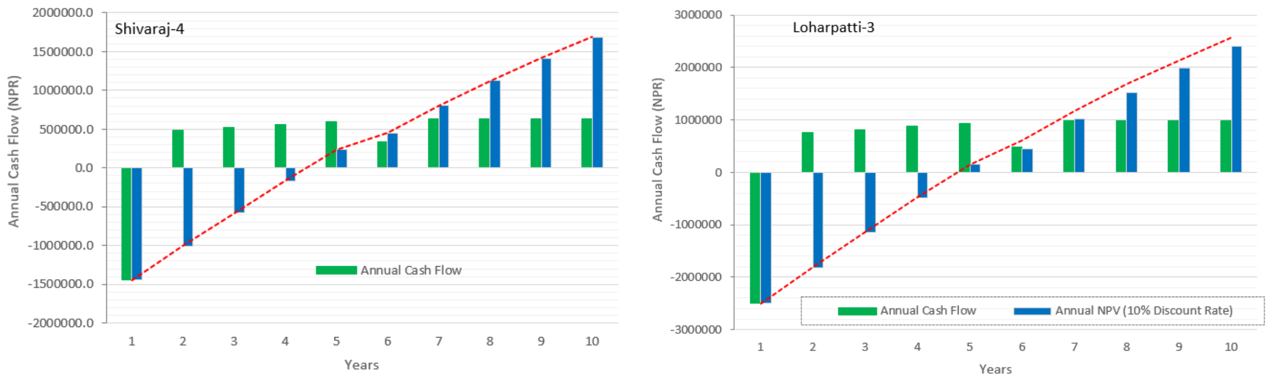

Figure 2: Representative graphical view of CBA of conservation Pond/recharge pond.

3.4 Rajkulo spillway channeling, Maharajgunj ward number 3, Lumbini

This intervention combined pond restoration with rajkulo rehabilitation, creating an integrated irrigation and recharge system. KIIs reported improved irrigation reliability, reduced crop losses, and enhanced productivity. FGDs emphasised that the system supports multiple households and strengthens cooperation among farmers. The intervention has enabled vegetable cultivation and reduced dependence on erratic rainfall. The CBA estimated an NPV of about NPR 3.2 million with a BCR of 1.9 at a 10 percent discount rate, reflecting strong returns. Communities valued the system as both a livelihood asset and a resilience measure, with broader ecosystem benefits noted but not monetised.

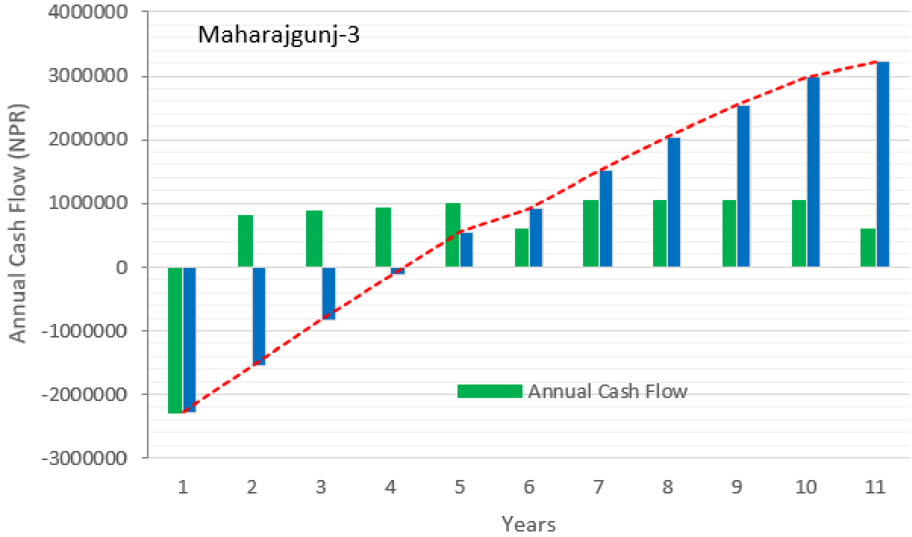

Figure 3: Representative graphical view of CBA of Rajkulo

3.5 Dhoreni Lake embankment protection, Lamahi, ward number 7, Dang, Lumbini

Respondents valued the intervention not only for land protection but also for groundwater recharge, flood moderation, and reduced heat stress. KIIs highlighted improved environmental conditions and potential tourism benefits, while FGDs noted enhanced local vegetation and reduced conflict over water. Although some benefits are intangible, the intervention is widely perceived as a landscape-level resilience measure. Economically, the CBA confirmed positive NPVs and BCRs above one, demonstrating viability. The recharge function was particularly appreciated, as it contributes to long-term water security, even though its full economic value was not captured in the calculations.

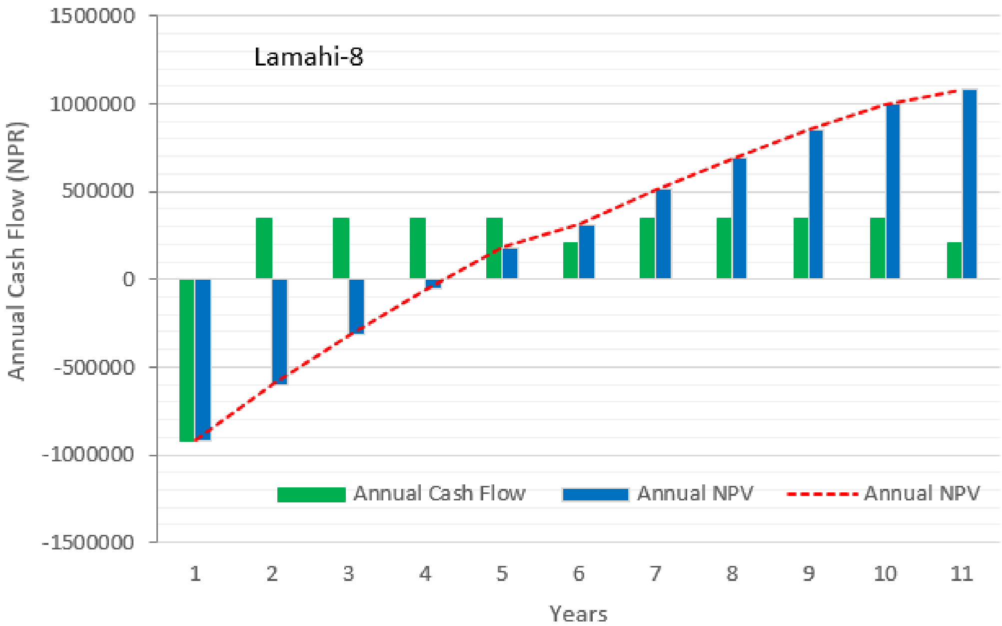

Figure 4:Representative graphical view of CBA of Lake Embankment.

3.6 Banganga Climate Resilient Village, Ward number 9, Kapilvastu, Lumbini

The CRV approach integrated farming practices, water management, and community participation. KIIs reported improved food security, reduced pesticide use, and better market access. FGDs emphasised that the intervention fostered local ownership and collective action, with households benefiting from diversified crops and reduced vulnerability. Economically, the CBA estimated an NPV of NPR 2.3 million and a BCR of 1.59 at a 10 percent discount rate. While the returns are slightly lower than other interventions, the CRV model provides broader social and institutional benefits, making it a valuable approach for scaling inclusive adaptation.

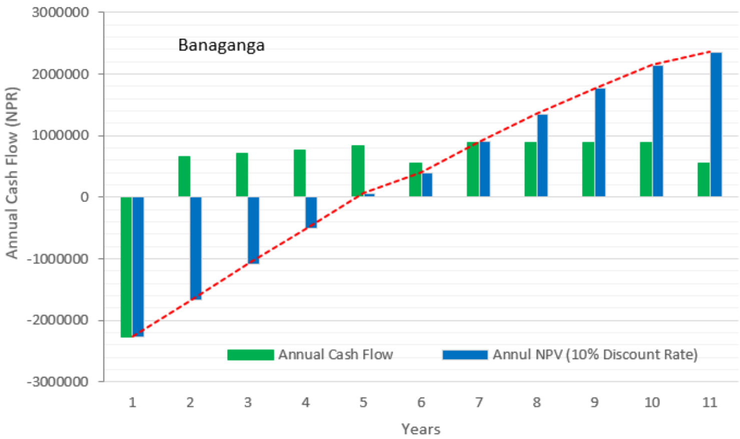

Figure 5: Representative graphical view of CBA of CRV.

3.7 Shrawangadh Pond Restoration, Loharpatti ward no 3, Madhesh

Community members described the pond as critical for irrigation and livestock use. KIIs noted that reconstruction improved water storage capacity, while FGDs highlighted reduced time spent collecting water and increased opportunities for vegetable farming. The intervention has supported household income and food security. Economically, the CBA confirmed positive NPVs and BCRs above one, indicating that the investment is justified. The pond also contributes to groundwater recharge, which was valued by communities but not fully monetised.

3.8 Saraswanath Pond restoration at Siraha, ward no 12, Madhesh

Respondents emphasised the pond's role in supporting irrigation, livestock, and fish farming. KIIs reported increased agricultural productivity and reduced crop losses, while FGDs highlighted improved household resilience and reduced labour burdens. The intervention has enabled off-season cultivation and diversified livelihoods. Economically, the CBA showed strong returns, with BCRs above 1.7 and NPVs in the millions. Communities valued the pond as a multi-functional asset that strengthens resilience and supports livelihoods.

3.9 Pond construction at Kamala, ward number 8, Madhesh

KIIs highlighted improved irrigation reliability and opportunities for vegetable farming, while FGDs noted reduced labour burdens and enhanced food security. The intervention has supported household income and reduced vulnerability to rainfall variability. Economically, the CBA confirmed positive NPVs and BCRs above one, demonstrating viability. Communities valued the pond for its multiple uses, including livestock watering and groundwater recharge, even though some benefits were not monetised.

3.10 Badkapokhari Pond Restoration, Balwa, ward number 6, Madhesh

Respondents described the pond as a critical resource for irrigation and livestock. KIIs reported increased agricultural productivity, while FGDs emphasised reduced labour burdens and improved household resilience. The intervention has enabled off-season cultivation and supported livelihoods. Economically, the CBA confirmed positive NPVs and BCRs above one, indicating strong justification for investment. Communities valued the pond as a multi-functional asset that contributes to resilience and sustainability.

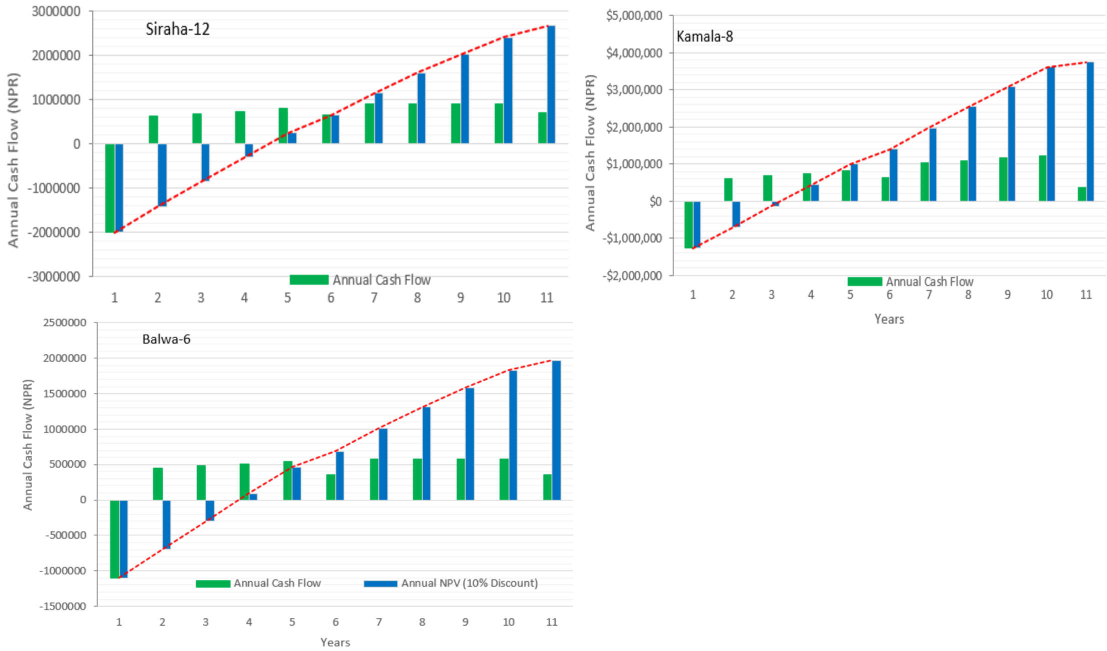

Figure 6: Representative graphical view of CB Analysis of Multipurpose Pond.

Table 5: Overall portfolio and indicators.

Indicator	Portfolio Result	Remarks
Initial Investment (NPR)	17.67 million	Total of 10 sampled NBS Intervention
PV investment at 10% Discount Rate	NPR 25.8 million	includes annual maintenance Cost of all 10 sites
PV investment at 12% Discount Rate	NPR 26.68 million	includes annual maintenance Cost of all 10 sites
PV benefits (10% Discount Rate)	NPR ~53 million	Total of all 10 sites
PV Benefit (12% Discount Rate)	NPR ~51 million	Total of all 10 sites
Net economic benefit (10% Discount Rate)	NPR ~28.7 million	NPV at 10% Discount Rate of all 10 sites
Net economic benefit (12% Discount Rate)	NPR ~24.9 million	NPV at 12% Discount Rate of all 10 sites
BCR (10% Discount Rate)	~1.88	Average of 10 sampled sites
BCR (12% Discount Rate)	~1.78	Average of 10 sampled sites
Payback period (10% Discount Rate)	~3.24 years	Average of 10 sampled sites
Payback period (12% Discount Rate)	~3.43 years	Average of 10 sampled sites

Table 6. Qualitative Score of NbS Interventions based on economic analysis.

NbS Intervention	Economic Benefit	Resilience Impact	Livelihood Impact	Environmental Benefit	Cost Efficiency	Sustainability (O&M)	Overall Performance
Riverbank Protection	Very High	Very High	High	High	High	Medium	Very High
Multipurpose Pond	Very High	Very High	Very High	Very High	Very High	High	Very High
Recharge Pond	High	Very High	High	Very High	High	High	Very High
Conservation Pond	High	High	Very High	High	Very High	High	Very High
Rajkulo System	Very High	Very High	Very High	High	Very High	High	Very High
Lake Embankment	High	Very High	Medium	Very High	Medium	Medium	High
Climate Resilient Village (CRV)	Very High	Very High	Very High	Very High	High	Very High	Very High

To complement the quantitative cost–benefit analysis, a qualitative performance assessment of the selected NbS interventions was undertaken to capture their multi-dimensional impacts across economic, resilience, livelihood, and environmental domains. While indicators such as NPV, BCR, and IRR provide important insights into economic viability, they do not fully reflect the broader range of benefits observed in the field, particularly those related to ecosystem services, social outcomes, and long-term sustainability. Drawing on evidence from KIIs, field observations, and the comparative CBA results, this sub-section presents a structured scorecard of NbS interventions. The assessment evaluates each intervention based on key performance dimensions, including economic returns, climate resilience, livelihood support, environmental benefits, cost efficiency, and sustainability considerations. This integrated perspective helps to better understand the relative strengths of different NbS approaches and supports more informed decision-making for scaling and investment prioritisation.

4. GEDSI inclusion

The study also considered GEDSI. NbS interventions reduced labour burdens for women and improved access to water, contributing to gender equity.

Inclusive participation in CRV planning strengthened local ownership. However, disability inclusion remained limited. Infrastructure accessibility and representation of persons with disabilities in decision-making were weak points. Future scaling of NbS should explicitly integrate disability-inclusive climate action, ensuring that persons with disabilities benefit equally from adaptation measures.

5. Comparison of BAU and NbS Scenarios

The cost–benefit analysis of NbS under the RAIN project compared two scenarios: a BAU situation where no interventions are implemented, and an NbS scenario where measures such as riverbank protection, pond restoration, recharge systems, rajkulo rehabilitation, lake embankments, and CRVs are introduced. In the BAU scenario, communities continue to face recurring environmental risks including erosion, flooding, water shortages, and limited irrigation, leaving agricultural productivity highly vulnerable and households exposed to repeated losses.

Table Conceptual Comparison of BAU and NbS Scenarios.

Dimension	BAU Scenario	NbS Intervention Scenario
Water availability	Limited dry-season water; reliance on rainfall	Improved water storage and recharge through ponds and irrigation systems
Flood and erosion risk	Continued riverbank erosion and flood damage	Riverbank protection reduces crop loss and land degradation
Agricultural production	Mostly seasonal cropping; limited irrigation	Increased crop productivity and off-season vegetable farming
Livelihood opportunities	Limited diversification; dependence on rainfall	Additional income from irrigation, diversified crops and fish farming in long terms
Labour and time burden	Higher time spent on water management and repair work	Reduced labour burden due to improved water access and infrastructure
Ecosystem services	Limited water regulation and landscape resilience	Improved groundwater recharge, soil moisture, and ecosystem health
Economic outcome	Recurring environmental losses and missed opportunities	Positive economic returns from improved productivity and avoided losses

G CONCLUSION AND WAY FORWARD

This study examined the performance and economic relevance of NbS implemented under the RAIN project in Madhesh and Lumbini provinces of Nepal. Using evidence from KIIs, FGD, and site observations, alongside a simplified CBA, the research assessed interventions such as riverbank protection, pond restoration, recharge systems, rajkulo rehabilitation, lake embankments, and CRV initiatives. Communities consistently described these measures as multi-functional assets that improve water availability, safeguard farmland, reduce disaster risks, and support diversified livelihoods. The findings highlight that NbS interventions contribute simultaneously to CCA and DRR by stabilising vulnerable landscapes and strengthening local resilience to climate variability.

The economic analysis confirmed that all sampled interventions produced positive NPVs and BCRs greater than one, even under conservative assumptions. Riverbank protection and integrated water management systems demonstrated particularly strong performance, preventing recurring crop losses while supporting agricultural productivity. Although the analysis focused on a limited set of measurable benefits—such as avoided crop losses, time savings, and off-season farming—other significant outcomes like groundwater recharge, ecosystem restoration, and tourism potential were not monetised, meaning the results represent lower-bound estimates of true value. Overall, the study shows that NbS approaches under the RAIN project are practical, economically viable, and socially beneficial strategies for climate-vulnerable communities, with long-term sustainability dependent on community ownership, regular maintenance, and integration into local planning processes.

H ANNEXES

Annexes 1: Summary Result of Cost-Benefit Analysis of Nature-based Solutions.

SN	Activity	Estimated Beneficiaries HH	PV Investment (10% Discount Rate) Including Annual Maintenance	Analysis Year	PV Benefit (NPR) at 10% Discount Rate	PV Benefit (NPR) at 12% Discount Rate	Scenario	NPV	BCR	IRR	Payback Period (Years)	Assumptions
1	Shivaraj-4, Chanai, Pond Renovation	15	2,041,628.22	10	3,725,643.94	3,434,377.53	Discount rate (10%) Discount Rate (12%)	1,814,556 1,548,374	1.82 1.72	12.85% 6.03%	3.28 3.36	1) Annual maintenance cost 10% of the total initial investment; 2) Expected annual Income/benefit is 800,000 NPR; 3) First Year Annual Income/benefit is estimated to be 70% and increased by 5-10% in the following years; 4) Annual Income of Time value and Off-season vegetable farming is considered;

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2	Maharajgunj-3, Karhawa, Rajkulo connecting to Pond	25	3,441,978.62	10	6,659,227.15	6,099,614.76	Discount rate (10%)	3,217,249	1.93	16%	3.13	1) Annual maintenance cost 5% of the total initial investment; 2) Expected annual Income/ benefit is 1,750,000 NPR; 3) First Year Annual Income/ benefit is estimated to be 50% and increased by 5-10% in the following years; 4) Annual Income of Time value and Off-season vegetable farming is considered;
							Discount Rate (12%)	2,767,454	1.83	13%	3.21	
3	Yasodhara- 8, Khoriya, River Bank Protection	50	4,557,940.46	10	9,216,850.66	8,475,334.54	Discount rate (10%)	4,658,910	2.02	60	2.59	1) Annual maintenance cost 10% of the total initial investment; 2) Expected annual Income/ benefit is 3,000,000 NPR from crop and time saving; 3) Annual Income/benefit is estimated to be 50% of the total expected annual savings; 4) Other co-benefits area not considered for this stage;
							Discount Rate (12%)	4,090,358	1.93	27%	2.68	

SN	Activity	Estimated Beneficiaries HH	PV Investment (10% Discount Rate) Including Annual Maintenance	Analysis Year	PV Benefit (NPR) at 10% Discount Rate	PV Benefit (NPR) at 12% Discount Rate	Scenario	NPV	BCR	IRR	Payback Period (Years)	Assumptions
4	Lamahi-9, Dhoreni, Lake Embankment	20	1,622,426.86	10	4,688,046.07	4,276,439.75	Discount rate (10%)	3,065,619	2.89	43%	2.02	1) Annual maintenance cost 10% of the total initial investment and major investment of 25% of initial investment in 5th and 10th Year is considered; 2) Expected annual Income/benefit is 1,100,000 NPR from off-season vegetable farming and time saving of the beneficiries families; 3) For this analysis only 50% of the expected income/benefits is considered throiughout the analysis period; 4) Annual Income of Time value and Off-season vegetable farming is considered;
							Discount Rate (12%)	2,715,580	2.74	40%	2.07	
5	Buddhabhumi-9, Dhmauli, River Bank Protection	50	1,978,413.78	10	4,608,425.33	4,237,667.27	Discount rate (10%)	2,630,012	2.33	32%	2.18	1) Annual maintenance cost 5% of the total initial investment and a major investment of 25% of the initial investment in the 5th and 10th year is considered; 2) Expected annual Income/benefit is 1,500,000 NPR; 3) For this analysis 50% of the expected annual benefits/income is considered; 4) Annual Income of Time value of the beneficiry family is considered;
							Discount Rate (12%)	2,322,376	2.21	29%	2.23	

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6	Banaganga, Bharlabas, CRV	30	1,978,413.78	10	4,006,834.68	6,364,391.14	Discount rate (10%)	2357556.46	1.59	7%	3.61	1) Annual maintenance cost 10% of the total initial investment; 2) Expected annual Income/benefit is 1,250,000 NPR; 3) First Year Annual Income/benefit is estimated to be 60% and increased by 5% in the following years but not 100% throughout the analysis period; 4) Annual Income of Time value and income from off-season vegetable farming is considered; other benefits such as savings from medication and nuteriants availability are not considered at this stage
							Discount Rate (12%)	1974771.45	1.51	4%	4.08	
7	Loharpatti 3, Shrawangadh, Renovation of Pond	30	3,530,338.64	10	5,934,486.28	5,470,535.20	Discount rate (10%)	2593087.95	1.68	7%	3.52	1) Annual maintenance cost 5% of the total initial investment and major investment of 15% of the initial investment is considered in 5th and 10years of the analysis period; 2) Expected annual Income/benefit is 1,200,000 NPR; 3) First Year Annual Income/benefit is estimated to be 70% and increased by 5% in the following years, but not 100%; 4) Annual Income of Time value and Off-season vegetable farming is considered;
							Discount Rate (12%)	2178577.56	1.59	4%	3.60	

SN	Activity	Estimated Beneficiaries HH	PV Investment (10% Discount Rate) Including Annual Maintenance	Analysis Year	PV Benefit (NPR) at 10% Discount Rate	PV Benefit (NPR) at 12% Discount Rate	Scenario	NPV	BCR	IRR	Payback Period (Years)	Assumptions
8	Kamala-8, Jamindar Pokhari, Multipurpsoe Pond	40	1,899,228.29	10	5,653,513.36	5,158,473.79	Discount rate (10%)	3754285.07	2.98	38%	2.17	1) Annual maintenance cost 7.5% of the total initial investment; 2) Expected annual Income/ benefit is 650,000 NPR; 3) First Year Annual Income/ benefit is estimated to be 70% and increased by 5% in the following years but not 100%; 4) Annual Income of Time value and Off-season vegetable farming is considered;
							Discount Rate (12%)	3319841.31	2.81	36%	2.21	
9	Balwa 6, Multipurpsoe Pond	35	1,659,373.41	10	3,629,532.97	3,324,522.85	Discount rate (10%)	1970159.56	2.19	24%	1.58	1) Annual maintenance cost 5% of the total initial investment; 2) Expected annual Income/ benefit is 455,000 NPR; 3) First Year Annual Income/ benefit is estimated to be 70% and increased by 5% in the following years but not 100%; 4) Annual Income of Time value and Off-season vegetable farming is considered;
							Discount Rate (12%)	1718092.57	2.07	21%	1.62	

SN	Activity	Estimated Beneficiaries HH	PV Investment (10% Discount Rate) Including Annual Maintenance	Analysis Year	PV Benefit (NPR) at 10% Discount Rate	PV Benefit (NPR) at 12% Discount Rate	Scenario	NPV	BCR	IRR	Payback Period (Years)	Assumptions
10	Siraha-12, Sarswadnath, Multipurpsoe Pond	30	2,815,749.63	10	5,494,368.74	5,025,687.06	Discount rate (10%)	2678619.11	1.95	13%	3.38	1) Annual maintenance cost 7.5% of the total initial investment and a major investment of 15% in the 5th and 10th years of the analsyis period; 2) Expected annual Income/ benefit is 1,050,000 NPR; 3) First Year Annual Income/benefit is estimated to be 70% and increased by 5% in the following years but not 100%; 4) Annual Income of Time value and Off-season vegetable farming is considered;
							Discount Rate (12%)	2282784.74	1.83	10%	3.45	
Total Protfolio		**325**	**25,525,492**		**53,616,929**	**51,867,044**		**28,740,054**				

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