Cost-benefit Analysis

of Climate Adaptive Infrastructures of Local Government Initiative on Climate Change (LoGIC) Project.

Co-funded by the European Union

Sweden
Sverige

UNCDF
Impact Capital for Development

UNDP

Cost-benefit Analysis of Climate Adaptive Infrastructures of Local Government Initiative on Climate Change (LoGIC) Project.

Bazlul Khondker, PhD

October 27, 2022

Muhammad Ibrahim
Secretary
Local Government Division
Ministry of Local Government, Rural Development and Cooperatives

Message

I am happy to find that Local Government Initiative on Climate Change (LoGIC) Project has done a cost-benefit analysis of investments made in climate resilient infrastructures. The finding of the analysis is encouraging because the benefit is more than the investment cost. For sustainability of the schemes funded by Performance-based Climate Resilience Grant (PBCRG), operation and management committees have been set up and beneficiaries are paying user fees.

This is even more important in the sense that the climate adaptive infrastructures that have been financed by LoGIC were planned with climate change adaptation/ resilience goal. So, the findings of this cost-benefit analysis are not typical economic return, it has strong climate resilience return as well, which is very important for policy direction in seeking global climate finance.

Climate change adaptation has become an important strategy for Bangladesh's development trajectory. Findings of the cost-benefit analysis will help Bangladesh in attracting more external support for Bangladesh's efforts in adaptation.

I am also happy to find that LoGIC Project is going to be extended for two more years. This will be helpful in establishing LoGIC as a successful model for scaling up nationwide.

Muhammad Ibrahim

Table of Contents

Abbreviation and Acronyms

LOGIC	:	Local Government Initiative on Climate Change
LGD	:	Local Government Division
UNDP	:	United Nation Development Program
UNCDF	:	United Nations Capital Development Fund
GoB	:	Government of Bangladesh
NGOs	:	Non-Government Organizations
EU	:	European Union
SIDA	:	Swedish International Development Agency
LGIs	:	Local Government Institutions
CSOs	:	Civil Society Organizations
CBA	:	Cost-Benefit Analysis
PBCRG	:	Performance Based Climate Resilient Grants
NPV	:	Net Present Value
IRR	:	Internal Rate of Return
MARR	:	Minimum attractive rate of return
BCR	:	Benefit Cost Ratio
SAM	:	Social Accounting Matrix
IOM	:	Input-output matrix
CGE	:	Computable general equilibrium
GDP	:	Gross Domestic Product
BAEC	:	Bangladesh Atomic Energy Commission
SLQ	:	Simple location quotients
APS	:	Average Propensities to Spend
DDLG	:	Deputy Director of Local Government
UNO	:	Upazila Nirbahi Officer
DCFC	:	District Climate Finance Coordinator

Executive Summary

The problems of climate change are now being discussed worldwide. Nowadays, these problems are more critical in developing or less developing countries like Bangladesh. To cope with these problems several climate change adaptation schemes or categories were implemented by the Local Government Division (LGD) in partnership with the United Nation Development Program (UNDP) and the United Nations Capital Development Fund (UNCDF) in vulnerable areas of Bangladesh. This study aims to evaluate the profitability analysis with the perception assessment of these climate change adaptation categories. In doing so, a multistage sampling technique was followed to conduct 84 focus group discussions (FGD) and 76 key informant interviews (KII). In the case of FGD, both quantitative (i.e., BCR) and qualitative (i.e., perception score index) analysis were used whereas KII only used qualitative analysis (i.e., perception score index and SWOT). The key findings of this study are as follows:

Quantitative analysis

- ✓ The estimated overall direct benefit and co-benefit are 62% and 38% respectively in terms of all implemented climate change adaptation categories;
- ✓ The calculated BCR is 3.91 for the total benefit consisting of direct (2.41) and co-benefit (1.50) in terms of the project;
- ✓ Adaptive water and sanitation solutions get the highest rank considering the total BCR among all adaptation categories and
- ✓ The highest percentage share is found for the category namely 'reduce impacts of flood and waterlogging' based on the direct benefit whereas based on the co-benefit, 'adaptive water and sanitation solutions' get the highest percentage share.

Qualitative analysis

- ✓ The study reveals social and environmental benefits as well;
- ✓ The estimated overall social benefit of the project is 81.51% indicating a very satisfactory level whereas a satisfactory level of benefit is found for overall environmental benefit;
- ✓ From KII, the study reveals a very satisfactory level for the overall performance of the project; and
- ✓ SWOT analysis reveals the strong backward and forward linkage as a strength, inefficient funding as a weakness, skill development programs as opportunities, and higher cost of supplies as a threat.

Based on the findings, the study recommends the implementation of more climate change adaptation plans so that residents of climate-vulnerable areas can easily maintain their way of life. The infrastructures must, however, be periodically monitored and, if necessary, maintained if they are to be used more widely and sustainably, given that they are located in relatively climate-vulnerable areas and regions.

1. Introduction and Background

Bangladesh is one of the world's most disaster-prone countries where the impact of climate change exacerbates the governing factor of disasters. Given the current trends, it is anticipated to be the country most affected by climate change. The risk of a major hydro-meteorological disaster is also increasing. The country's geographical location makes it more vulnerable to frequent natural disasters such as floods, cyclones, earthquakes, etc. Flooding and cyclones are recurring phenomena that are likely to result in massive loss of life, property damage, and loss of livelihood (Islam, 2013). To cope with these climate-induced vulnerabilities, a project titled 'Local Government Initiative on Climate Change (LoGIC)' was implemented by the Local Government Division (LGD) in partnership with UNDP and UNCDF (i.e. technical and management support) which was funded by the multi-donor collaborative initiative of GoB, UNDP, UNCDF, EU, and government of Sweden. The Project provided US$ 7.91 million as additional funding to 72 union Parishads through government-to-local fiscal transfer channels. This funding is earmarked to fill gaps in existing union Parishad plan financing for the public service and infrastructure priorities identified in the Risk Reduction Action Plan, i.e., ensuring that local infrastructures meet climate change-related national technical standards. The project is designed to enhance the capacity of vulnerable communities, Local Government Institutions (LGIs), and Civil Society Organizations (CSOs) for planning and financing climate change adaptation solutions in selected climate-vulnerable areas. This study aims to assess the impacts of climate change adaptation measures among vulnerable people throughout the prominent areas of Bangladesh.

1.1. Objective of the study

Overall, the project is expected to raise perceptions on the importance of adapting climate change-related strategies by analyzing the project implementation costs and benefits. The specific objective is as follows:

i. To evaluate the profitability analysis of climate change adaptation measures/and categories and
ii. To assess the perception on climate change adaptation category and/or measures

1.2. Key issues for evaluation

LoGIC PBCRG has been invested in a wide range of potential investments in the following key intervention areas in seven districts, each with its own set of socioeconomic, environmental, and climate-related challenges. The following key investment areas are provided below:

- Climate-resilient safe water and sanitation solutions;
- Promotion of climate-adaptive and environment-friendly irrigation systems and agricultural practices (canal re-excavation, solar-powered irrigation system, etc.);
- Nature-based solutions (including plantations and plant nurseries);
- Improving WASH and other facilities in cyclone and flood shelters in climate-vulnerable areas with a special focus on women's needs;
- Improving access to cyclone shelters, flood shelters, and kellas in climate-vulnerable areas (Roads and bridges);
- Reduce the impacts of climate change-induced floods and waterlogging (e.g., culvert, drain, flood protection walls, guide walls, and roads);
- Improving absorptive, adaptive, and transformative capacity
- Enhance the safety of vulnerable people from climate change-related extreme weather events (providing safety equipment to sea-going fishing boats and lightening/flood shelter).

2. Benefit-Cost of Climate Investment: Review of Literature

Arfanuzzaman et al. (2021) conducted an extended cost-benefit analysis in the lower Teesta basin (LTB) of Bangladesh. According to the study, shallow tube-well (STW) irrigation practices in both sandy and loamy soil have the highest marginal adaptation cost (MAC) but the lowest benefit-cost ratio (BCR). Due to the high cost of the government's initial establishment, deep tube-well (DTW) irrigation generates superior benefits for farmers compared to STW irrigation. Though the MAC for short-duration variety (SDV) rice is relatively low among the promising adaptations, its economic profitability is 62 percent lower than that of maize cultivation. However, maize cultivation generates US$86 more welfare to farmers than SDV rice, which may strengthen farmers' preference for maize cultivation over SDV rice. Strategic adaptation planning, soft credit, technological advancement, and subsidized agricultural inputs will encourage farmers to implement adaptation options that may reduce climate-induced loss and damages for farmers and build socioeconomic resilience in other similar areas of South Asia.

Williams et al. (2020) undertook a cost-benefit analysis (CBA) of adopting climate adaptation practices among Ghanaian smallholders. In two horticultural crop-growing municipalities, 180 smallholder households that had implemented the identified practices were surveyed. Profitability indicators, as well as an assessment of environmental and social externalities, were used to estimate the cost-effectiveness of the practices. The findings indicated that implementing any of the five adaptation practices would yield positive results from both the private and public sectors. However, given the capital required, the payback period for investments made, and the risks associated with implementation, two of the five practices are particularly suitable for smallholders. If all of the Institutional and policy support is required if all of the practices are to be implemented proposes integrating localized climate vulnerability and economic assessments for enhanced climate adaptation actions to broaden information on the potential of climate adaptation.

Akinola et al. (2019) conducted a study on the potential economic impacts of climate adaptation research in Nigeria. As a result, Nigeria's Baseline Study was launched in order to serve as a reference point for targeted agricultural investments. Stress-resistant varieties, improved management techniques, and irrigation techniques are likely the research options for maize and rice. This study documented empirical research on the returns to climate change adaptation strategies using a combination of primary data from a survey of 3600 crop farming households and secondary data from the FAO database. In the case of maize, improved management techniques had the lowest internal rates of return (IRR) (32%), while stress-resistant varieties had the highest (84%). Irrigation methods had the highest cost-benefit ratio of 12.4. The estimated number of people who benefited from the technologies ranges from 23 million to 36 million. Economic indicators for Rice follow the same pattern. The values, however, are lower. Changes in adoption rate are more responsive to the technologies than changes in costs. The potential economic gains are substantial. However, effective dissemination strategies are required because the realization of these gains is dependent on deployment and dissemination approaches.

Mtimuni and Campus (2018) pursued to identify the various adaptation strategies, factors influencing adaptation choice, and the costs and benefits of the most cost-effective identified adaptation strategy. Under World Vision, the study was carried out in the Chitethekwere, Nkhoma, and Lilongwe districts. To model, the relationships between the polytomous response variables and a set of variables, a multinomial logit model (MNL) was used. According to the study's findings, six of the seven discovered adaptation strategies were cost-effective, with an NPV greater than one. The traditional adaptation strategy (katutu) was not profitable because its NPV was less than one, indicating that the overall benefit accrued was less than the cost. According to the findings of the study, conservation agriculture had the greatest impact.

Devkota et al. (2017) estimated the cost and benefit of rural rice farmers in Nepal adopting climate change adaptation options. The study followed a multi-stage sampling technique and then collected data from 773 households using a structured questionnaire. In doing so, the study covered seven

districts, three in the Terai and four in the Hilly region of Nepal. The study revealed that rice farmers use 13 major adaptation strategies to protect themselves from climatic risk. The first three most expensive adaptation options are alternative irrigation practices, which cost an average of US $ 69.95 (US$ 1 = 102.84 Nepalese Rupees), denser plantation of local seeds ($ 20.69), and using climate-smart varieties ($ 18.06). Almost 88 percent of farmers used more than one adaptation strategy on the same farm to reduce the impact of extreme climatic conditions. Total cost and revenue revealed that the total cost per unit ranges from $ 28.34 to $ 32.79, while the total revenue per unit ranges from $ 33.4 to $ 49.02. Surprisingly, farmers who do not use any adaptation strategies are able to earn the highest per unit production income.

Shongwe et al. (2013) carried out a study to identify private adaptation strategies to climate change, as well as a cost-benefit analysis of the identified adaptation strategies in Lowveld of Swaziland. To select 350 households, a stratified random sampling technique was used, and all households were interviewed directly using a structured questionnaire. The data were analyzed using descriptive statistics and cost-benefit analysis, with net present value (NPV) and internal rate of return (IRR) serving as decision rules. Drought-resistant varieties, crop rotation, mulching, minimum tillage, early planting, late planting, and intercropping were all used as adaptation strategies. Switching crops had the highest NPV, with maize (E14.40) being replaced by drought-tolerant crops such as cotton (E1864.40), sorghum (E283.30), and dry beans (E292.20). Instead of maize, the study suggests that households grow drought-tolerant crops such as cotton, sorghum, and dry beans. In order to improve crop production, the government should build irrigation infrastructure such as dams, strengthen extension services, and subsidize farm inputs.

Kalame et al. (2011) conducted research on a win-win practice for forestry and climate change adaptation in the case of a modified taungya system (MTS) in Ghana. The findings show that MTS considers the majority of adaptation strategy activities, is a profitable venture (BCR > 1), and has a high potential to reduce vulnerability due to short-term food production and long-term plantation establishment. In the short term, resource management in MTS appears promising, but challenges remain in meeting livelihood and adaptation needs in the medium and long term. We conclude that MTS has the potential to be a win-win practice in terms of forestry and adaptation. The legalization of all contractual agreements, combined with ongoing monitoring, evaluation, and improvement, may propel MTS to become a long-term activity.

3. Methodology and Approach

3.1. Sample Size, Study Area, and Sampling Technique

Review of the Annual Progress Review (APR) and Mid-Term Evaluation (MTE) approaches envisaged that it is challenging to consider all climate change adaptation categories and or measures for impact evaluation implemented by LoGIC. The Annual Progress Review (APR), 2021 focused on agriculture and irrigation, water supply, health and sanitation, and adaptive infrastructure schemes by addressing awareness, plantation, solar-powered irrigation systems, sanitation, salinity, flood-resistant tube well for drinking water, river erosion, floods, tidal surges, dams, roads, smart boats, bridges, and culverts as climate change adaptation strategies. Furthermore, the socioeconomic characteristics covering 320 sample size were analyzed through the direct interview method from four locations – flashflood-prone haor area (Sunamganj), flood-prone char area (Kurigram), south-west coastal area (Bagerhat), and south-central area (Barguna). On the other hand, agriculture and innovation, water supply, health and sanitation, adaptive infrastructure, plantation, fisheries, and other schemes were focused by emphasizing solar power irrigation, rainwater harvesting structures, integrated drinking water plants, toilet, drainage, culvert, emergency center, guide walls, tree plantation, and smart boat as climate change adaptation strategies in the Mid-Term Evaluation (MTE), 2022. KIIs with Deputy Director of Local Government (DDLGs), Upazila Nirbahi Officers (UNOs), Union Parishad (UP) Chairmen, FGDs, and PRAs with beneficiaries were conducted in 19 Upazila MTE

2022. No household surveys were conducted in MTE, 2022.

In this impact evaluation, we conducted a Benefit Cost Ratio (BCR) analysis based on the climate change adaptation category and climate change adaptation measures. In doing so, following the approval of the UNCDF officials, twenty-nine (29) climate change adaptation measures were selected from eight (8) climate change adaptation categories (out of 11 categories) based on the prominence and the amount of PBCRG investment of the LoGIC project (see Column A and B in Table 1). Thus, we selected five hundred and seventy-eight (578) schemes (out of 645) under twenty-nine (29) climate change adaptation measures. Later, by using a standard formula for determining sample size for finite populations supported by Singh and Masuku (2014), we found eighty-one (81) schemes among 578. The following formula (I) was applied at a 95% confidence level by considering a 10% margin of error. Here, we considered a 10% margin of error instead of ≤5% due to the small size finite population.

If we assume ≤5%, the calculated sample size will be large and vice-versa (Singh and Masuku, 2014). The equation is given below:

Where,

SS=Sample size, z-score=1.96, p=0.50, e=0.10 and N=578.

Based on this calculated number of selected schemes, we used weight to see the distribution for each of the climate change adaptation measures (see Column D in Table 1). The weighted values which were smaller than 1, have been considered as 1. For instance, 3 weighted values for 3 climate change adaptation measures (water desalination plant, hydroponics, and swamp plantation) were considered as 1. Thus we get 84 (81+3) schemes for all the climate change adaptation measures (see Column D in Table 1) which is showing only the number of schemes but does not represent the specific study areas i.e., the name of the areas in which the schemes were implemented. Therefore, the number of weighted values of each climate change adaptation measure was used as a top scheme (based on investment and prominence) in order to identify the study areas where these were implemented. In such a way, we designated 44 unions, 18 Upazilas, and 7 districts (see Columns E, F, and G in Table 1). The technique of sampling is presented in Figure 1.

$$SS = \frac{\frac{Z^2 p(1-p)}{e^2}}{1+\frac{Z^2\, p(1-p)}{e^2 N}}$$

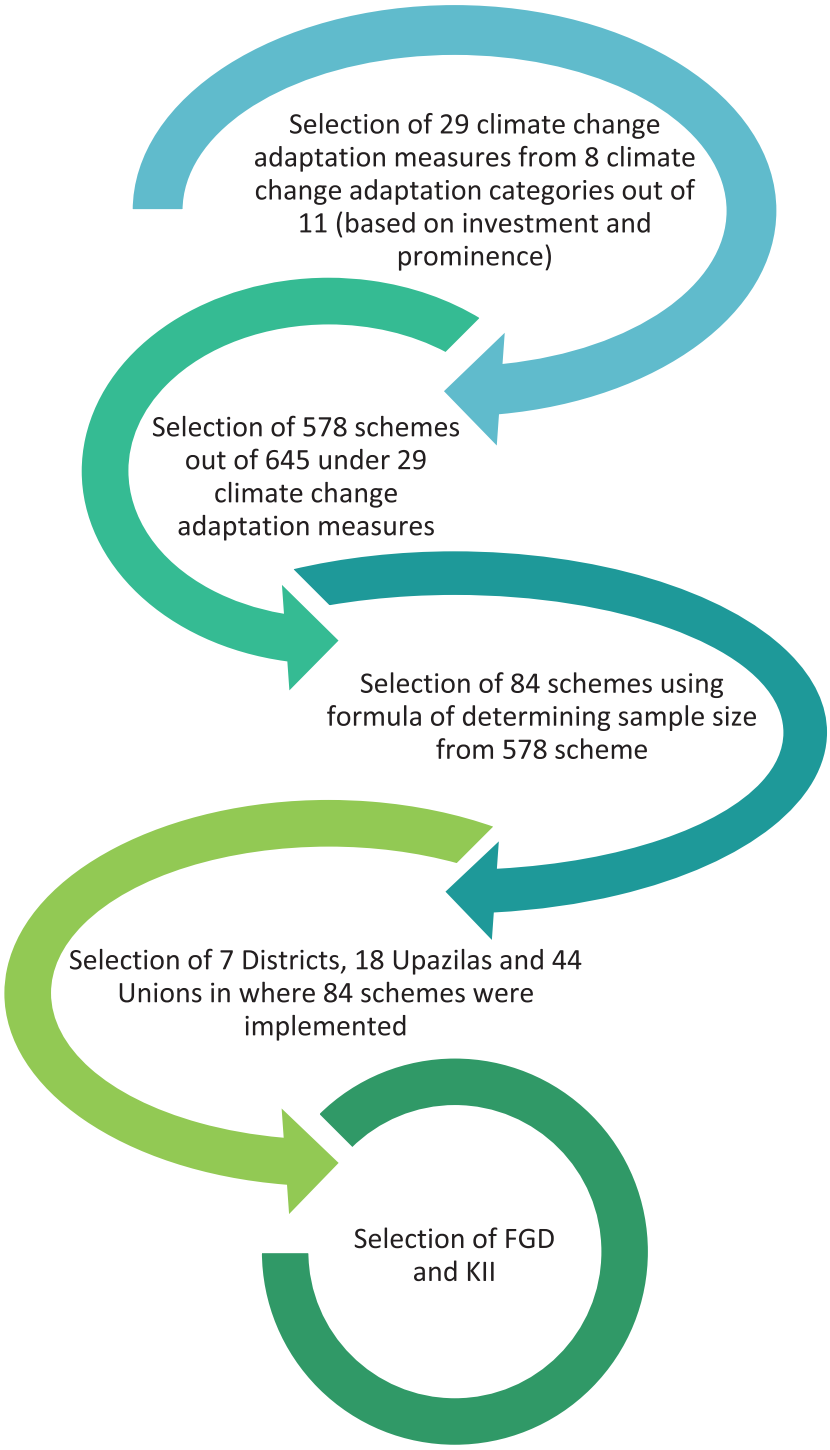

Figure 1. Flow chart of sampling

Table 1. Distribution of sample based on categories and sub-categories

A	B	C	D	E	F	G	*H
Climate change adaptation categories	Climate change adaptation measures	**Total scheme	Selected schemes	District	Upazila	Union	FGD
	Selected schemes						
Adaptive Water and Sanitation Solutions	Rainwater Harvesting System (Community Level)	70	10	Khulna	Koyra	koheshwaripur, Maharajpur, Koyra, Uttar Bedkashi, Dakkhin Bedkashi	10
				Bagerhat	Mongla	Chandpai	
					Sarankhola	Rayenda	
	Combined Rainwater Harvesting and Pond water Treatment Plan	24	3	Bagerhat	Morelganj	Nishanbaria	3
					Mongla	Sundarban	
					Sarankhola	Khontakata	
	Flood Proof Tube-well	38	5	Kurigram	Chilmari	Raniganj, Ashtamirchar	5
					Rowmari	Rowmari	
					Char Rajibpur	Rajibpur	
				Sunamganj	Derai	Charnarchar	
	Solar Powered Ground Water Treatment Plan	8	1	Kurigram	Rowmari	Bondober	1
	Pond Water Treatment Plant	5	1	Bagerhat	Morelganj	Nishanbaria	1
	Improve WASH Facility in Flood Shelter	15	2	Kurigram	Char Rajibpur	Rajibpur	2
					Rowmari	Rowmari	
	Solar Powered Pond Water Treatment Plant	15	2	Khulna	Dacope	Sutarkhali	2
	Water Desalination Plant (Reverse Osmosis)	3	1	Khulna	Koyra	Koyra	1
Reduce Loss and Damage of Life and Property	Provide Safety Equipment to Fishing Boats	31	4	Bhola	Bhola Sadar	Rajapur	4
					Borhanuddin	Bara Manika	
	Lightening Shed	8	1	Sunamganj	Derai	Rafinagar	1
	Provide Safety Equipment to Passenger Boats, Provide Safety Equipment to Fishing Boats	18	3	Sunamganj	Shalla	Habibpur, Atgaon	3

					Tahirpur	Dakkhin Baradal	
Reduce Impacts of Flood and Waterlogging	Culvert	69	10	Barguna	Barguna Sadar	Dhalua, Naltona, Badarkhali	10
				Bhola	Bhola Sadar	Rajapur, Dakkhin Digholdi	
				Kurigram	Char Rajibpur	Mohanganj	
					Chilmari	Thanahat	
				Bagerhat	Sarankhola	Rayenda	
				Sunamganj	Tahirpur	Uttar Sreepur	
	Drain	26	4	Bhola	Daulatkhan	Uttar Joynagar, Sayedpur	4
					Bhola Sadar	Dhania, Dakkhin Digholdi	
	Drain and Culvert	4	1	Bhola	Bhola Sadar	Dhania	
	Village Protection Wall	16	2	Sunamganj	Derai	Charnarchar	2
					Tahirpur	Dakkhin Baradal	
	Guide Wall	15	2	Bagerhat	Mongla	Sundarban	2
				Kurigram	Rowmari	Bondober	
	Flood Protection Wall	9	1	Patuakhali	Rangabali	Char Montaaj	1
Improve Accessibility Flood Shelter, Cyclone Shelter, Kella and Water Source	Road Construction/ Repair/	78	11	Khulna	Koyra	Moheshwaripur, Uttar Bedkashi,Koyra, Maharajpur	11
					Dacope	Tildanga, Kamarkhola, Sutarkhali	
				Bhola	Bhola Sadar	Rajapur	
					Daulatkhan	Char Khalifa	
	Bridge	11	2	Bagerhat	Morelganj	Baraikhali	2
Promote Climate Resilient Agriculture	Canal Re-excavation	17	2	Barguna	Barguna Sadar	Badarkhali	2
					Taltoli	Barabagi	
	Agricultural Demonstration	12	2	Bhola	Daulatkhan	Uttar Joynagar	2
					Borhanuddin	Bara Manika	
	Solar Powered Surface Water Irrigation	22	3	Bhola	Daulatkhan	Uttar Joynagar	3
					Bhola Sadar	Rajapur	
				Bagerhat	Sarankhola	Rayenda	
	Solar Powered Ground Water Irrigation	21	3	Bagerhat	Sarankhola	Khontakata	3
				Kurigram	Rowmari	Rowmari	

Improve Adaptive, Absorptive and Anticipatory Capacity	Shuhashni Sales Center	13	2	Sunamganj	Tahirpur	Uttar Sreepur	2
				Barguna	Pathorghata	Nachnapara	
	Solar Panel Distribution						
(at Household Level)	5	1	Kurigram	Chilmari	Ashtamirchar	1	
	Awareness Raising Billboard	12	2	Sunamganj	Shalla	Atgaon	2
					Derai	Bhatipara	
	Provide instrument support to PCSBA and Community Clinics	9	1	Sunamganj	Shalla	Bahara	1
Nature-based Solutions	Swamp Plantation	2	1	Sunamganj	Tahirpur	Dakkhin Sreepur	1
Climate Resilient Livestock Solution	Hydroponics	2	1	Bagerhat	Morelganj	Jiudhara	1
Total		578	84				84

Note: *H shows the number of FGD which is equal to the number of schemes; **Total scheme calculated based on climate change adaptation measures

For the costing exercise, two types of data are needed – costs (i.e. investment and maintenance) and benefits.

Cost (Investment) data, has two sources. One is PBCRG investment and the other is co-finance investment (co-finance means the finance received from other sources/institutions/organizations) for each of the climate change adaptation measures provided by the project. The cost data were compiled according to the identified climate change adaptation measures which were verified by the LoGIC project team.

Benefits and avoided cost/co-benefits data were collected through focus group discussion (FGD) with the local communities (such as crop farmers, poultry/livestock farmers, fish farmers/ fishermen, day laborers, small businessmen, salaried job holders, housewives, and so on). The number of FGD is equal to the number of selected schemes (see Column H Table 1). About 10 to 13 beneficiaries were included in each FGD. In addition, LoGIC's field team members provided the necessary information and guidance (e.g., identification of scheme, key people, locations, etc.) to facilitate the FGDs. The FGD was conducted using a well-structured questionnaire through a direct discussion with the beneficiaries. Before, starting FGD the note-takers (enumerators) delivered a short brief to the participants about the LoGIC project. They sought the participant's feedback (i.e., benefits) based on the schemes implemented by the LoGIC project. Thus the study differentiated the LoGIC benefits from other's interventions.

Finally, Key Informant Interviews (KIIs) were performed to identify the benefits, along with evaluating the project's performance. Besides, the study assessed the strength, weaknesses, opportunities, and threats of the project by KIIs. Since we selected 44 unions from 18 Upazilas under 7 districts, we carried out seventy-six (76) KIIs which consists of 44 union chairmen, 18 Upazila Nirbahi Officers (UNOs), 7 District Climate Finance Coordinator (DCFCs), and 7 Deputy Director of Local Government (DDLGs) in where the respective sub-categories were implemented.

3.2. Analytical Technique for Impact Assessment

The study followed two types of impact assessment. The first one is quantitative impact assessment and the other one is qualitative impact assessment. In the case of the quantitative approach, the study used financial assessment methods to examine the LoGIC interventions. Besides, the perception index method was used in the case of qualitative impact assessment.

In line with the well-accepted practices, the study applied the Benefit-Cost Ratio (BCR) in the case of the financial assessment. Investors use these quantitative measures to help them decide whether to undertake investment or not, based on their return requirements. The benefit-cost method is often used for public projects. The method compares project benefits to the cost of the project, and for the project to be viable, the benefits have to be greater than the cost. By definition, project benefits are the favorable consequences of the project to the public, and project cost is the monetary disbursement required of the government (Sullivan et al., 2006).

Park (2002) describes benefit-cost analysis as "a decision-making tool used to systematically develop useful information about the desirable and undesirable effects of public projects". He defines three types of benefit-cost analysis problems:

1. Maximizing the benefits for any given set of costs
2. Maximizing the net benefits when both benefits and costs vary;
3. Minimizing cost to achieve any given level of benefits.

The worthiness of a public project can be expressed by comparing the benefits (B) of the project to the investment/cost (C) of the project by taking the ratio B/C, i.e. the Benefit-Cost ratio (BCR). The ratio is calculated as:

$$BCR = \frac{\sum B}{\sum C}$$

The worthiness of a public project can be expressed by comparing the benefits (B) of the project to the investment/cost (C) of the project by taking the ratio B/C, i.e. the Benefit-Cost ratio (BCR). The ratio is calculated as:

BOX 1

Decision rules (BCR)

1. Based on direct and total benefit: if BCR > 1, accept the project; If BCR = 1, remain indifferent; and If BCR < 1, reject the project.

2. Based on co-benefit: in the case of measuring co-benefit, the study considered the cost/investment which was used also for measuring direct and total benefits. Because, there was no cost/investment allocated separately for measuring co-benefits. So any positive BCR (>0) indicates the project selection is right.

Furthermore, a qualitative impact assessment was performed for the indicators (benefit and co-benefit items) which were not measurable in monetary form. In such case, the study developed the extent of participants' perception in the case of benefit and co-benefit by following the five (5) points of the Likert scale (Very much=5, Much=4, Neutral=3, Less=2, Very less=1) technique (Likert, 1932). The perception extent of the beneficiary and stakeholder was measured by the following formula:

$$\text{Perception score index} = \frac{\sum \text{Total score gained}}{\text{Maximum score}} \times 100$$

Based on the index score, the study ranged the values by adopting the study of Polemi (2018). Values that were lies ≥80% of any climate change adaptation action were considered to be in very good (satisfactory) condition. The climate change adaptation action was considered as good (satisfactory) if the index values lie between ≥60% and <80%, medium (neutral) if index values were ≥40% and <60%, less satisfaction if were between ≥20% and <40%, and very less satisfaction if the values were between 1% to <20%.

Finally, the study performed a SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis to see the project's status.

4. Results: A quantitative Assessment (Based on FGD participants)

4.1. Overall Scenario of Benefit-Cost Ratio (BCR) Analysis of the Study

Investment/cost scenario

According to the Terms of Reference (ToR) and UNCDF sources, it is evident that about BDT 553 million (consisting of BDT 460 million from PBCRG investment/cost, and 93 million from other sources (i.e., co-finance)) was injected into the most vulnerable communities throughout the seven districts of Bangladesh to cope with climate change adaptation. However, a total of BDT 131.58 million (i.e., 24%) consists of BDT 97.92 million (74.42%) from PBCRG and BDT 33.66 million (25.58%) from other sources have taken into account as cost/investment to assess BCR in this study (Figure 2).

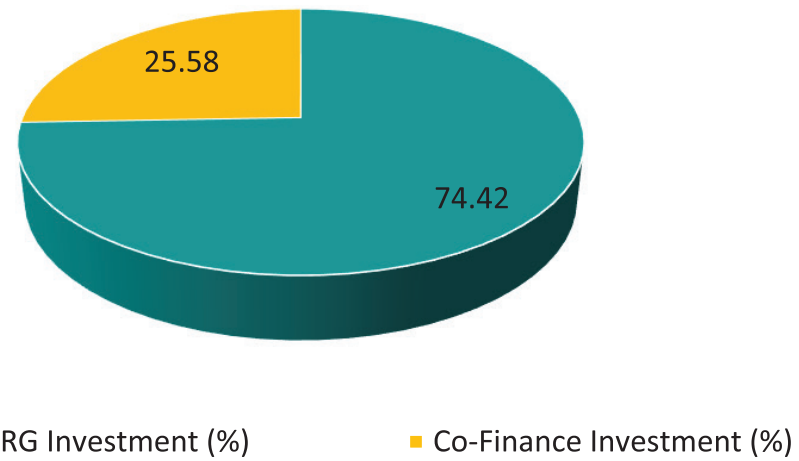

Figure 2. Percentage distribution of PBCRG and Co-finance investment

The estimated cost (%) was then distributed among the adaptation category to see the highest contribution

(i.e., higher rank) in the case of mitigating climate impacts among the vulnerable communities which are presented in Table 2. Considering the total investment (%), the study found a higher rank for the category of 'adaptation water and sanitation solution' among all. The highest grant was provided to implement this climate change adaptation category because the most climate-vulnerable people particularly in Khulna, Bagerhat, Sunamganj, and Kurigram face this issue mostly during different types of natural hazards such flush floods, cyclones, and so on.

Table 2. Investment distribution among the selected climate change adaptation category (in %)

Climate change adaptation category	PBCRG Investment (%)	Rank of PBCRG investment	Co-finance Investment (%)	Rank of co-finance investment	Total Investment (%)	Rank of total investment
Adaptive Water and Sanitation Solutions	29.26	I	2.44	IV	31.70	I
Reduce Loss and Damage of Life and Property	4.87	V	17.22	I	22.09	II
Reduce Impacts of Flood and Waterlogging	14.60	II	2.92	II	17.52	III
Improve Accessibility to Flood Shelter, Cyclone Shelter, Kella, and Water Source	11.81	III	0.48	V	12.30	IV
Promote Climate Resilient Agriculture	9.54	IV	2.45	III	11.99	V
Improve Adaptive, Absorptive, and Anticipatory Capacity	3.18	VI	0.06	VI	3.24	VI
Nature-based Solutions	0.76	VII	0.02	VII	0.78	VII
Climate Resilient Livestock Solution	0.39	VIII	0.00	VIII	0.39	VIII
Total	74.42		25.58		100	

Note: The percentages (%) were calculated based on the total investment incurred for the selected category of schemes, and a higher percentage indicates a higher rank.

Overall benefit-cost (BCR) scenario

It is promising that the implemented project provided direct benefits (the main purpose of implementation) and co-benefit (indirect benefit or additional benefit) among the vulnerable communities. The study finds 62% direct benefit and 38% co-benefit (i.e. Figure) 3. Considering the direct benefit and the co-benefit, estimated both of the BCRs are greater than 1. Besides, as the overall BCR of the project is greater than 1, therefore the project delivers a positive net present value to a firm and its investors (Table 3).

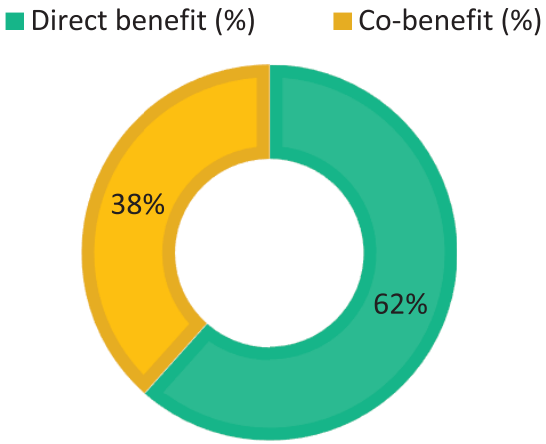

Figure 3. Percentage distribution of direct benefit and co-benefit

Table 3. Overall benefit-cost ratio (BCR) of the study

Items	Value
PBCRG investment (Tk. in million)	96.02
Co-finance investment (Tk. in million)	33.64
Total investment (Tk. in million)	129.66
Direct benefit (Tk. in million)	312.29
Co-benefit (Tk. in million)	195.11
Total benefit (Tk. in million)	507.40
BCR based on direct benefit	2.41
BCR based on co-benefit	1.50
BCR based on total benefit	3.91

Note: Investment in swamp plantations and billboards has not been considered to estimate BCR since the financial benefit has not been explored for both cases.

Ranks of the climate change adaptation categories based on benefits

From Table 4, it is noted that the BCR is higher for 'adaptive water and sanitation solution' and therefore it attaches higher rank considering the total benefit. Although, this scheme scores a higher rank while considering the total co-benefit while it scores 3rd rank in the case of direct benefit. This means that vulnerable people enjoy more additional benefits than direct benefits from the scheme. Surprisingly, improving accessibility to flood and cyclone shelter scores 2nd and 1st rank in the case of total and direct benefit respectively, though a lower investment was provided to it as discussed earlier in Table 2. This means the community people enjoy many more direct benefits such as easy access to flood and cyclone shelters during emergency cases due to the establishment of bridges and construction of roads.

Table 4. Ranks of the climate change adaptation category

Climate change adaptation category	BCR					
	Direct benefit	Rank (Direct benefit)	Co-Benefit	Rank (Co-Benefit)	Total benefit	Rank (Total benefit)
Adaptive water and sanitation solutions	2.41	III	3.19	I	5.60	I
Reduce loss and damage of life and property	1.58	V	1.16	III	2.74	V
Reduce impacts of flood and waterlogging	3.25	II	0.17	VII	3.42	III
Improve accessibility to flood shelter, cyclone shelter, kella, and water source	3.82	I	0.25	VI	4.07	II
Promote climate-resilient agriculture	1.41	VI	0.99	V	2.40	VII
Improve adaptive, absorptive, and anticipatory capacity	1.82	IV	1.13	IV	2.96	IV
Nature-based solutions*	-	-	-	-	-	-
Climate resilient livestock solution	1.16	VII	1.36	II	2.52	VI

Note: * Indicates the financial benefit has not been identified therefore the study did not calculate BCR on it.

Distribution of direct and co-benefit

The distribution of direct and co-benefit of each of the climate change adaptation categories are presented in Table 5. The study finds higher co-benefit than the benefit for adaptive water and sanitation solutions and climate resilient livestock solutions. The people who quested pure drinking water can save time now due to the implementation of water and sanitation scheme which helps to increase their income through involvement in income-generating activities. On the other hand, due to the adaptation of climate-resilient livestock solutions the availability of feed such as grass increases which reduces their feed cost.

Table 5. Percentage distribution of direct and co-benefit

Climate change adaptation category	BCR			Share (%)	
	Direct benefit	Co-Benefit	Total benefit	Direct benefit (%)	Co-Benefit (%)
Adaptive water and sanitation solutions	2.41	3.19	5.6	43.04	56.96
Reduce loss and damage of life and property	1.58	1.16	2.74	57.66	42.34
Reduce impacts of flood and waterlogging	3.25	0.17	3.42	95.03	4.97
Improve accessibility to flood shelter, cyclone shelter, kella, and water source	3.82	0.25	4.07	93.86	6.14
Promote climate-resilient agriculture	1.41	0.99	2.4	58.75	41.25
Improve adaptive, absorptive, and anticipatory capacity	1.82	1.13	2.96	61.49	38.18
Nature-based solutions*	-	-	-	-	-
Climate resilient livestock solution	1.16	1.36	2.52	46.03	53.97

4.2. Climate Change Adaptation Category-Wise BCR Calculation

Adaptive water and sanitation solutions

It is reported that the project provides different climate change adaptation actions such as the rainwater harvesting system, combined rainwater harvesting, and pond water treatment plan, flood-proof tube-well, solar powered groundwater treatment plan, pond water treatment plant, improve wash facility in flood shelter, solar powered pond water treatment plant, and water desalination plant (reverse osmosis) which implemented as adaptive water and sanitation solutions for the climate vulnerable people. However, from Table 6, it is evident that the cumulative BCR is 5.60 consisting of 2.41 for direct benefit and 3.19 for co-benefit indicating a tremendous positive implication of investment in the project areas. This remarkable output has been possible due to the generating direct benefit and co-benefit as well (see BOX 2). The community people are now completely able to reduce expenditure on searching for pure water and it also reduces the health cost than before. On the other hand, due to the establishment of climate change adaptation measures, the people of the community can increase their income as a result of saving time.

Table 6. Adaptive water and sanitation solutions

Items	Value
PBCRG investment (Tk. in million)	38.51
Co-finance investment (Tk. in million)	3.21
Total investment (Tk. in million)	41.72
Direct benefit (Tk. in million)	100.52
Co-benefit (Tk. in million)	133.22
Total benefit (Tk. in million)	233.75
BCR based on direct benefit	2.41
BCR based on co-benefit	3.19
BCR based on total benefit	5.60

BOX 2

Benefit and Co-Benefit List: Adaptive Water and Sanitation Solutions

Direct benefit item

- Reduce expenditure for searching pure water
- Reduce expenditure on health treatment

Co-benefit item

- Increase income due to saving time

Reduce loss and damage of life and property

Reducing loss and damage of life and property is another scheme that covers the climate change adaptation measures such as safety equipment for fishing boats, lightening sheds, and safety equipment for passenger and fishing boats. The result presented in Table 7. shows a positive BCR indicating that the community people are benefiting directly or indirectly from the actions. Due to getting safety equipment

like a life jacket, smart boat, etc. now fishermen can catch fish safely for a longer duration, and thus their income is increased to the pre-intervention period (see in BOX 3). In addition, some of the people earned money during the construction period of the lightening shed. The community people use this shed to protect themselves from the lightning. Not only that but also, the poor people who rear cattle, goats, sheep, etc. in the open field can save their livestock using this shed during bad weather. Now, this shed is also used as a shelter center during the flush flood.

Table 7. Reduce loss and damage of life and property

Items	Value
PBCRG investment (Tk. in million)	6.41
Co-finance investment (Tk. in million)	22.66
Total investment (Tk. in million)	29.07
Direct benefit (Tk. in million)	45.95
Co-benefit (Tk. in million)	33.82
Total benefit (Tk. in million)	79.77
BCR based on direct benefit	1.58
BCR based on co-benefit	1.16
BCR based on total benefit	2.74

BOX 3

Benefit and Co-Benefit List: Reduce Loss and Damage of Life and Property

Direct benefit item

- Reduce expenditure on safety equipment
- Reduce financial loss by protecting the livestock during lightening

Co-benefit item

- Increase income by fishing more with safety
- *Increase income by wage earning*

Reduce impacts of flood and waterlogging

It is evident that to reduce the impacts of flood and waterlogging, the project implemented culvert, drain, village protection walls, guide wall, and flood protection wall as climate change adaptation measures. From Table 8, the study finds an overall BCR which is 3.42 including the BCR of total direct benefit (3.25) and total co-benefit (0.17) indicating the satisfactory level of the measures taken. The taken climate change adaptation measures are beneficial to vulnerable peoples, particularly crop farmers and fish farmers. For instance, on the one hand, as crops are protected from damage, crop production is also increasing due to the implementation of these which accelerated the income of the farmers (see BOX 4). Besides, the fish farmers are benefited by protecting their ponds from flooding.

Table 8. Reduce impacts of flood and waterlogging

Items	Value
PBCRG investment (Tk. in million)	19.21
Co-finance investment (Tk. in million)	3.84
Total investment (Tk. in million)	23.05
Direct benefit (Tk. in million)	74.96
Co-benefit (Tk. in million)	3.95
Total benefit (Tk. in million)	78.91
BCR based on direct benefit	3.25
BCR based on co-benefit	0.17
BCR based on total benefit	3.42

BOX 4

Benefit and Co-Benefit List: Reduce Impacts of Flood and Waterlogging

Direct benefit item

- Reduce financial loss from crop damage
- Reduce financial loss by protecting household wealth damage
- Income increase due to higher crops production
- Reduce financial loss from aquaculture damage
- Reduce transportation cost

Co-benefit item

- Increase income by wage earning

Improve accessibility to flood shelter, cyclone shelter, kella, and water source

The two climate change adaptation measures such as bridge and road construction both are implemented such as citizens can move to flood and cyclone shelters easily when needed. Another aim of this intervention is to prevent waterlogging during floods and cyclones. However, the study finds the positive impacts as identified BCR is greater than 1 (Table 9). The common people especially crop farmers, fish farmers, and day laborers have benefited a lot financially from its establishment. Apart from the ease of communication, the cost of transportation for the general public has also been reduced to a great extent (see Box 5).

Table 9. Improve accessibility to flood shelter, cyclone shelter, kella, and water source

Items	Value
PBCRG investment (Tk. in million)	15.55
Co-finance investment (Tk. in million)	0.64
Total investment (Tk. in million)	16.18
Direct benefit (Tk. in million)	61.86
Co-benefit (Tk. in million)	4.05
Total benefit (Tk. in million)	65.91
BCR based on direct benefit	3.82
BCR based on co-benefit	0.25
BCR based on total benefit	4.07

BOX 5

Benefit and Co-Benefit List: Improve Accessibility to Flood Shelter, Cyclone Shelter, Kella, and Water Source

Direct benefit item

- Income increase due to higher crops production
- Reduce financial loss from crop damage
- Reduce financial loss from aquaculture damage
- Reduce transportation cost

Co-benefit item

- Increase income by wage earning

Promote climate-resilient agriculture

The project has taken action to promote climate-resilient agriculture through the implementation of canal re-excavation, agricultural demonstration, solar-powered groundwater irrigation, and solar-powered surface water irrigation in vulnerable climate-prone areas. The results in Table 10 show positive BCR which means the monetary value for the identified benefits outweighs the cost (investment) of this study. Income increase from crops, fishing, wage, and pond aquaculture and expenditure reduction on fuel/diesel for irrigation has been reduced remarkably which is reported by the beneficiaries (see BOX 6).

Table 10. Promote climate resilient agriculture

Items	Value
PBCRG investment (Tk. in million)	12.56
Co-finance investment (Tk. in million)	3.22
Total investment (Tk. in million)	15.77
Direct benefit (Tk. in million)	22.27
Co-benefit (Tk. in million)	15.56
Total benefit (Tk. in million)	37.83
BCR based on direct benefit	1.41
BCR based on co-benefit	0.99
BCR based on total benefit	2.40

BOX 6

Benefit and Co-Benefit List: Promote Climate Resilient Agriculture

Direct benefit item

- Increase income from crops
- Reduced expenditure on diesel cost

Co-benefit item

- Increase income by fishing
- Increase income by wage earning
- Reduce financial loss by participation in training program
- Income increases by exchanging water from pond for aquaculture

Improve adaptive, absorptive, and anticipatory capacity

Improve adaptive, absorptive, and anticipatory capacity covers the climate change adaptation measures such as Shuhashni Sales centers, solar panel distribution, awareness-raising billboards, and providing instrument support to PCSBA and community clinics. Table 11 presents favorable BCR in the case of direct benefit (1.82), co-benefit (1.13), and total benefit (2.96). This is because of the extraction of direct and co-benefits (see BOX 7) from the climate change adaptation measures. According to the field observation, the people particularly the farmers are now able to increase their income by selling higher quantities of agricultural products easily in the Shuhasini sales center. In addition, a decrease in expenditure for fuel/diesel/kerosene, increase their savings due to the solar panel installation at the household level. Not only that but also, the other income-generating activities (IGAs) like handicrafts are performed by the women of the household due to getting time at night.

Table 11. Improve adaptive, absorptive, and anticipatory capacity

Items	Value
PBCRG investment (Tk. in million)	3.28
Co-finance investment (Tk. in million)	0.08
Total investment (Tk. in million)	3.36
Direct benefit (Tk. in million)	6.13
Co-benefit (Tk. in million)	3.81
Total benefit (Tk. in million)	9.94
BCR based on direct benefit	1.82
BCR based on co-benefit	1.13
BCR based on total benefit	2.96

BOX 7

Benefit and Co-Benefit List: Improve Adaptive, Absorptive, and Anticipatory Capacity

Direct benefit item

- Increase income by selling agricultural crops
- Decrease expenditure on fuel such as diesel, kerosine, and etc.
- Reduced expenditure on childbirth

Co-benefit item

- Decrease financial loss from crops
- Increase income (such as handicrafts and other IGAs)
- Decrease expenditure on other health costs

Climate resilient livestock solution

Another climate change adaptation category is climate resilient livestock solution, which consists of a climate change adaptation measure, hydroponics, implemented for climate-vulnerable people in the Bagerhat district. Table 12 presents that the cumulative BCR is 2.52, with 1.16 for direct benefit and 1.36 for co-benefit, indicating a positive and satisfactory implication of project investment. This was made possible by receiving both direct and co-benefits (see BOX 8). For example, an increase in income for livestock farmers on the one hand, and a decrease in feed costs on the other, are identified as direct and co-benefits in this study.

Table 12. Climate resilient livestock solution

Items	Value
PBCRG investment (Tk. in million)	0.52
Co-finance investment (Tk. in million)	0.00
Total investment (Tk. in million)	0.52
Direct benefit (Tk. in million)	0.60
Co-benefit (Tk. in million)	0.70
Total benefit (Tk. in million)	1.30
BCR based on direct benefit	1.16
BCR based on co-benefit	1.36
BCR based on total benefit	2.52

BOX 8

Benefit and Co-Benefit List: Climate Resilient Livestock Solution

Direct benefit item

- Increase milk production

Co-benefit item

- Decrease feed cost

5. A Qualitative Assessment (Based on FGD participants)

The study also evaluates a qualitative analysis along with the quantitative one. For qualitative assessment, the study has taken responses from the participants based on the 5-point of Likert scale which is a worldwide familiar and acceptable method (Likert, 1932). After indexing, the study ranges the values to define the scenario of the project based on Polemi (2018) which is presented in BOX 9.

5.1. Overall Benefit of Climate Change Adaptation Categories

The study reports the overall direct and indirect (co-benefit) benefits from the social and environmental aspects which are presented in Figure 4. The estimated perception score is 84% (lies between the points of 80% to 100%) for direct social benefit indicating a very satisfactory level of benefit extracted from the implemented climate change adaptation categories. Also, indirect social benefit (79%) implies a satisfactory level of the climate change adaptation categories. On the other hand, direct and indirect environmental benefits both are lies between 60% to 80% which indicates a pleasant level of benefits that are provided by the implemented adaptation categories.

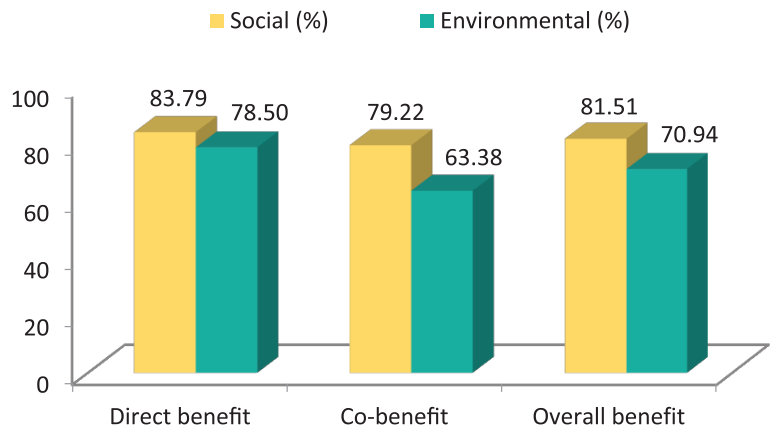

Figure 4. Overall benefit of climate change adaptation categories

Fi

5.2. Climate Change Adaptation Categories

Adaptive water and sanitation solutions

The study reveals the overall benefit consists of direct and indirect benefits from the environmental and social aspects presented in Figure 5 and Table 13. The estimated direct and indirect (co-benefit) social benefit is 77% and 70% indicates the satisfactory level of benefits from the implemented adaptive water and sanitation solutions. This is because enjoying available pure drinking water is a direct social benefit and getting more time for household take care is an indirect social benefit. On the other hand, due to the establishment of a rainwater harvesting plant as adaptive water and sanitation solution, the level of groundwater increases in the vulnerable areas, and this was reported by the FGD's participants.

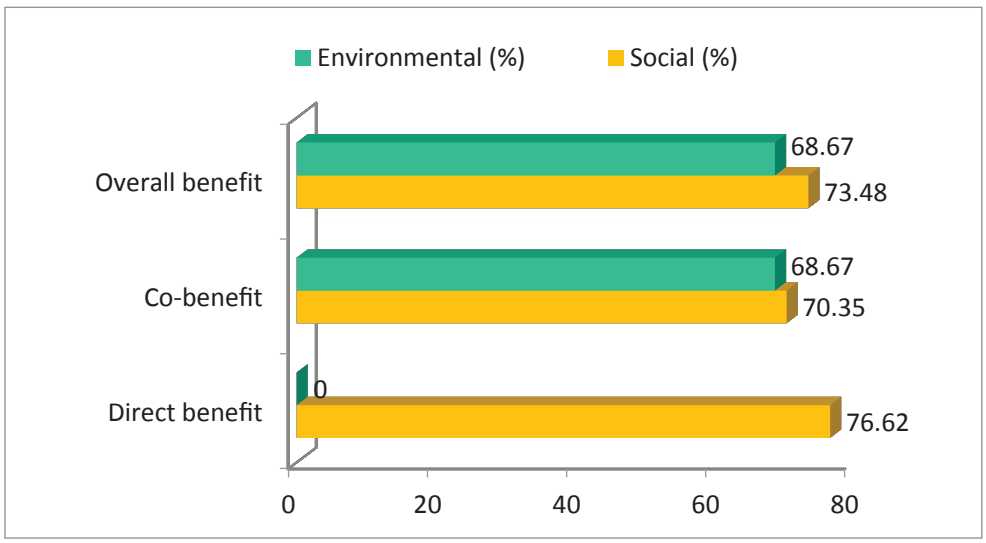

Figure 5. Percentage of the benefit of adaptive water and sanitation solutions

Table 13. Benefits of adaptive water and sanitation solutions

Direct benefit		Co-benefit benefit	
Social	**Environmental**	**Social**	**Environmental**
Decreased scarcity of pure drinking water	-	Can spend more time on housework due to save time	Increased sustainability of groundwater reservation
Decreased water-borne disease	-	Can spend more time for children education due to saving time	
	-	Children, adult and disabled person get more care from their household members	

Reduce loss and damage of life and property

In Figure 6 the study reveals the percentage distribution and in Table 14 the study reveals the items of benefit for the climate change adaptation category of reducing loss and damage of life and property. The estimated overall social benefit (91%) which covers the direct and indirect social benefits indicates a very satisfactory level of benefits. It is reported by the FGD participants that, due to providing safety equipment such as life jackets life risks become much more reduced for fishermen and passengers. Besides due to the implementation of lightening shed the death rate reduced tremendously than before. Now the community people use the lightening shed as flood and cyclone shelter. Therefore, their mental satisfaction is enriched than before.

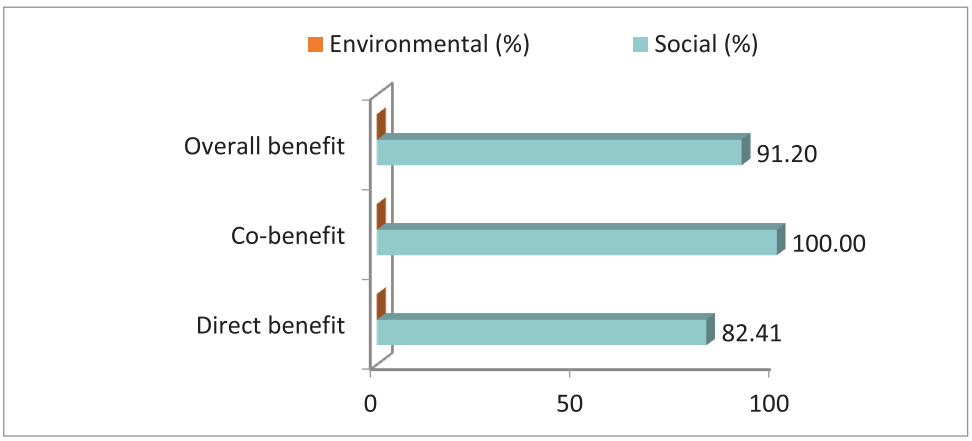

Figure 6. Percentage of the benefit of reduce loss and damage of life and property

Table 14. Benefits of reduce loss and damage of life and property

Direct benefit		Co-benefit benefit	
Social	**Environmental**	**Social**	**Environmental**
Decreased life risk during fishing in bad weather	-	Can do agricultural work without fear	-
Increased mental satisfaction	-	Used as flood shelter	-
Women, children and the disabled can move without fear during bad weather	-		-
Decreased death rate from lightening	-		-

Reduce impacts of flood and waterlogging

It is evident from Figure 7 that the indirect social benefit is higher than the direct social benefit. Due to the climate change adaptation measures such as a culvert, drain, village protection walls, guide wall, and flood protection the community people are now able to protect their houses and livestock from damage during the flush flood which is identified as a direct social benefit (Table 15). Also, students, children, adults, women, and the disabled enjoy an indirect social benefit from these climate change adaptation measures. On the other hand, the direct environmental benefit is higher than the indirect environmental benefit. Reducing waterlogging from agricultural land was identified as a direct environmental benefit whereas washing away garbage and reducing soil erosion was identified as an indirect environmental benefit in this study.

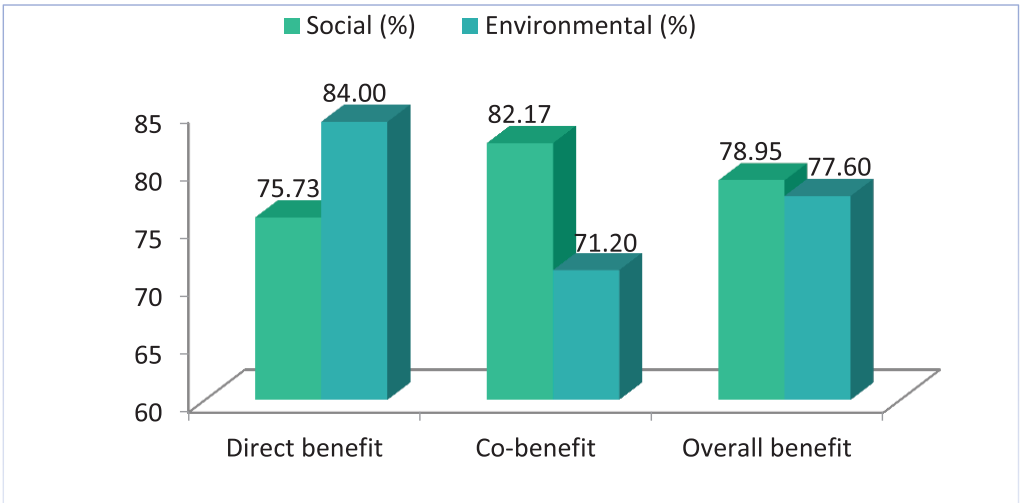

Figure 7. Percentage of the benefit of reduce impacts of flood and waterlogging

Table 15. Benefits of reduce impacts of flood and waterlogging

Direct benefit		Co-benefit benefit	
Social	**Environmental**	**Social**	**Environmental**
Protected houses	Reduced waterlogging of agricultural land	Local people can easily go to the local market	Washed away garbage during excessive rain
Reduced crops damage		Easier for pregnancy women to go to local community clinic local community clinic	Reduce soil erosion
Reduced livestock damage		Students can easily go to school	
		Children, disabled, and old age safety is ensured	
		The drain is also used for irrigation in dry season	

Improve accessibility to flood shelter, cyclone shelter, kella, and water source

The study finds social and environmental benefits in the case of direct and indirect benefits for improving accessibility to flood shelter, cyclone shelter, and water sources (Figure 8 and Table 16). The study reveals a satisfactory level of direct social benefit and a very satisfactory level of indirect social benefit. The FGD participants said that it is easier and safe to go to cyclone shelters than before and identified this as a direct social benefit of bridge and road construction. Also, the construction of bridges and roads makes it easier to go to the local community clinic in the case of pregnant women which is identified as an indirect social benefit. Furthermore, the study finds reducing waterlogging and reducing soil erosion as direct environmental and indirect environmental benefits respectively.

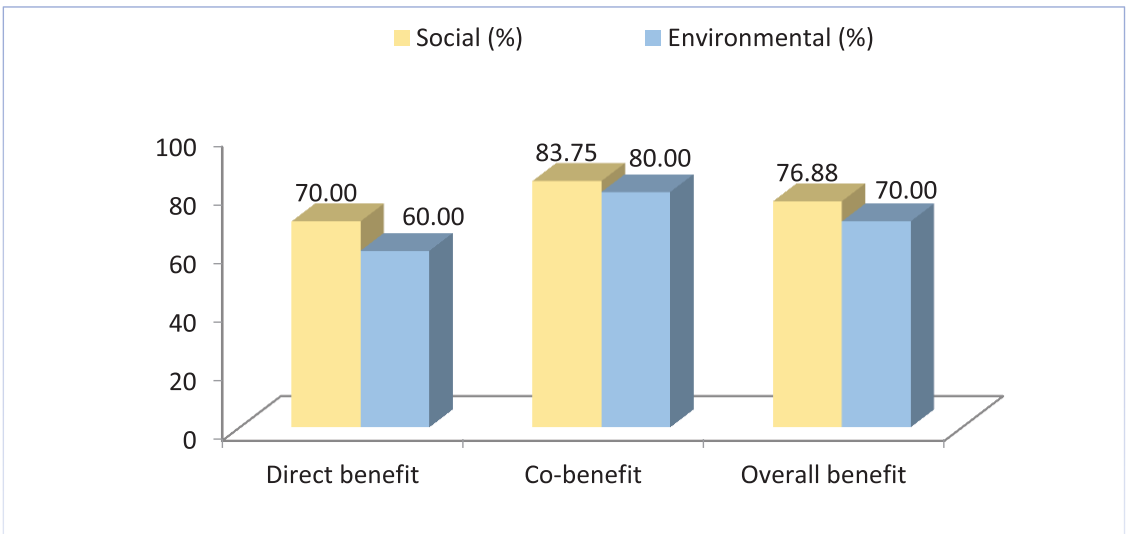

Figure 8. Percentage of the benefit of Improve accessibility to flood shelter, cyclone shelter, k ella, and water source

Table 16. Benefits of Improve accessibility to flood shelter, cyclone shelter, kella, and water source

Direct benefit		Co-benefit benefit	
Social	**Environmental**	**Social**	**Environmental**
Easier and safe to go to cyclone shelter during cyclone	Reduced waterlogging of agricultural land	Students can easily go to school	Reduced soil erosion
		Local people can easily go to the local market	
		Easier for pregnancy women to go to local community clinic local community clinic	
		Easier to move for children and disabled person	

Promote climate-resilient agriculture

The percentage distributions of benefits are presented in Figure 9 whereas the benefits items are presented in Table 17. From Figure 8, it is seen that both direct and indirect social benefit is good while the both direct and indirect environmental benefit is sufficiently good. The benefits of solar-powered ground-water and surface-water irrigation systems are comparatively higher than diesel-powered irrigation systems which indicates the direct social benefit. On the other hand, the sustainability of groundwater reservations which is identified as an indirect environmental benefit has enhanced due to the implication of solar-powered surface water irrigation systems.

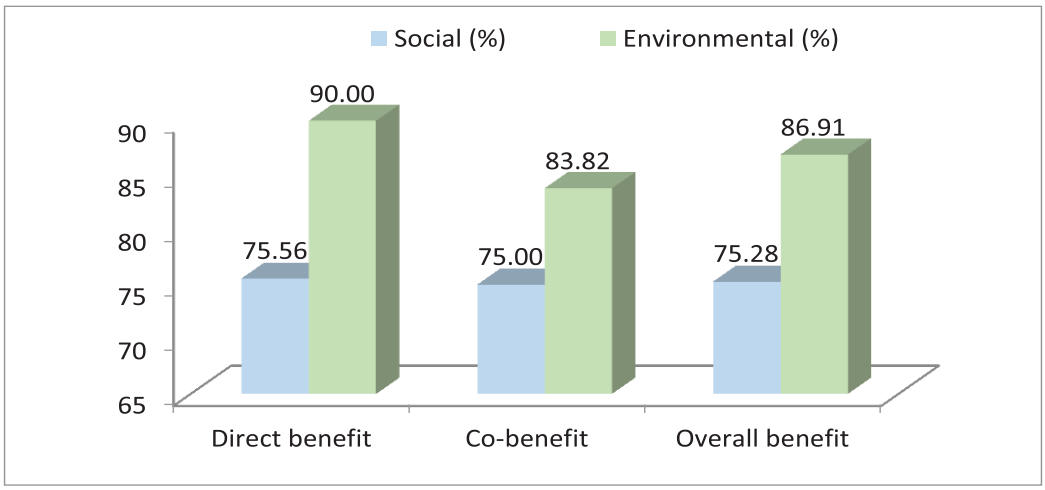

Figure 9. Percentage of the benefit of promote climate-resilient agriculture

Table 17. Benefits of promote climate-resilient agriculture

Direct benefit		Co-benefit benefit	
Social	**Environmental**	**Social**	**Environmental**
Enhanced knowledge on agriculture farming	Re-digging of canals has alleviated the shortage of water for plant & agriculture	Women use canals water for bath	Reduced carbon emission
The benefits of solar-powered ground-water irrigation systems are comparatively higher than diesel-powered irrigation systems		Flush floodwaters move quickly through canals	Increased sustainability of groundwater reservation
Increased cropping pattern			
The benefits of solar-powered surface-water irrigation systems are comparatively higher than diesel-powered irrigation systems			

Improve adaptive, absorptive, and anticipatory capacity

The study finds only direct and indirect social benefits which are presented in Figure 10 and Table 18. A higher perception score is found for direct social benefit than indirect social benefit. The estimated perception score indicates the sufficiently good status of direct social benefits such as medical equipment and regular check-up for pregnant women and sufficiently good also for indirect social benefits such as getting information through radio and television due to the solar-power distribution.

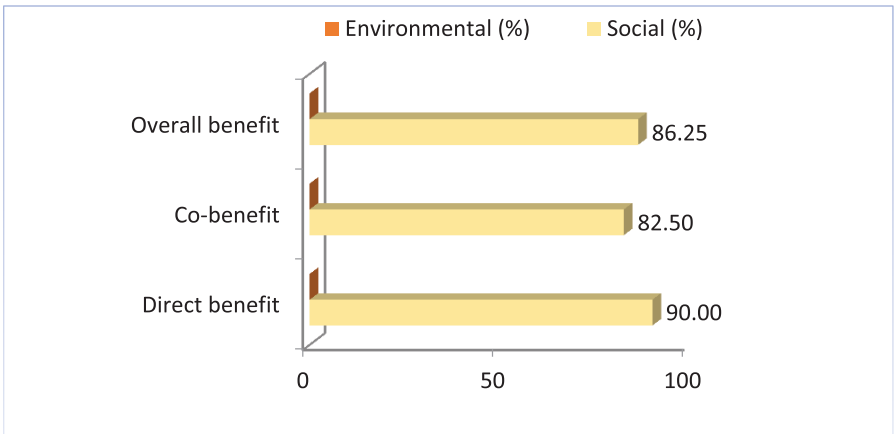

Figure 10. Percentage of the benefit of improve adaptive, absorptive, and anticipatory capacity

Table 18. Benefits of improve adaptive, absorptive, and anticipatory capacity

Direct benefit		Co-benefit benefit	
Social	**Environmental**	**Social**	**Environmental**
Community people can sell their agricultural products easily during flush flood	-	Due to the provision of night lighting due to solar electricity, women's interest in handicrafts	-
Medical supplies are very effective for pregnant women	-	Children of the family have increased interest in education	-
Easy to regular checkups for a pregnant woman	-	Due to solar power, the tendency to use radio, television or mobile has increased.	-
Women can buy and sell freely in Shuhashini sales center	-	Due to solar power, one can easily get information about the disaster forecast through the use of radio or television	-

Nature-based Solutions

A climate change adaptation measure namely swamp plantation was implemented under the nature-based solution category. Due to the implementation of such adaptation measures the vulnerable community enjoys not only social benefits but also enjoy environmental benefits in the case of direct and indirect benefits (Figure 11 and Table 19). It is promising that the direct social benefit such as protecting life, house, and livestock during cyclones and flush floods indicates the more pleasing level of benefit. On the other hand, the perception score from the aspect of direct and indirect environmental benefits reflects a very satisfactory level of benefits.

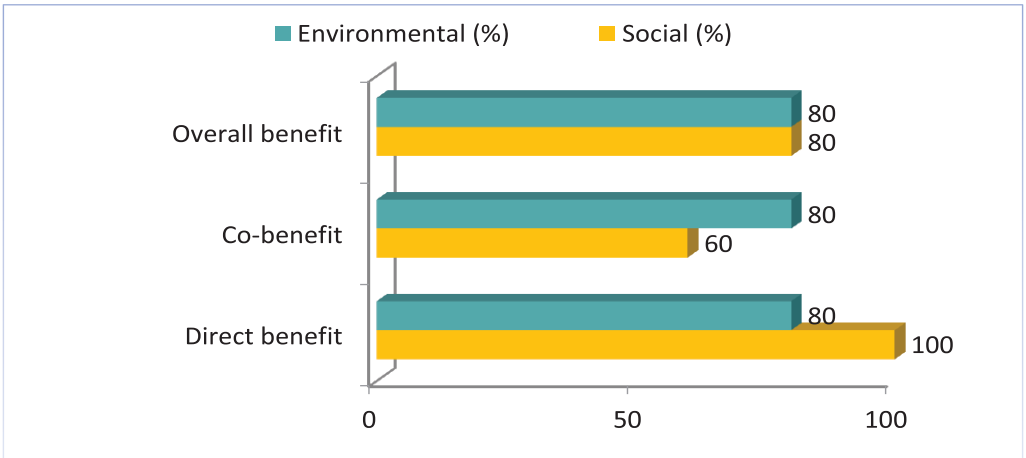

Figure 11. Percentage of the benefit of nature-based Solutions

Table 19. Benefits of nature-based solutionsbased

Direct benefit		Co-benefit benefit	
Social	**Environmental**	**Social**	**Environmental**
Protects life, house, and goods during cyclones and flush flood	Reduce soil erosion	Can be used as fuel wood	Increase ecological balance

Climate resilient livestock solution

Climate resilient livestock solution that covers hydroponics which was implemented as a climate change adaptation measure provides direct and indirect benefits from the point of social and environmental aspects (Figure 12 and Table 20). The study reveals a higher pleasant level for direct and indirect social benefit and reveals a pleasant level for indirect benefit. The people of the vulnerable area cultivate hydroponics to ensure the availability of grass during the flush flood which is identified as a direct social benefit. Besides, such adaptation measure provides balance in the ecosystem by reducing carbon emission from the environment which is identified as an indirect environmental benefit.

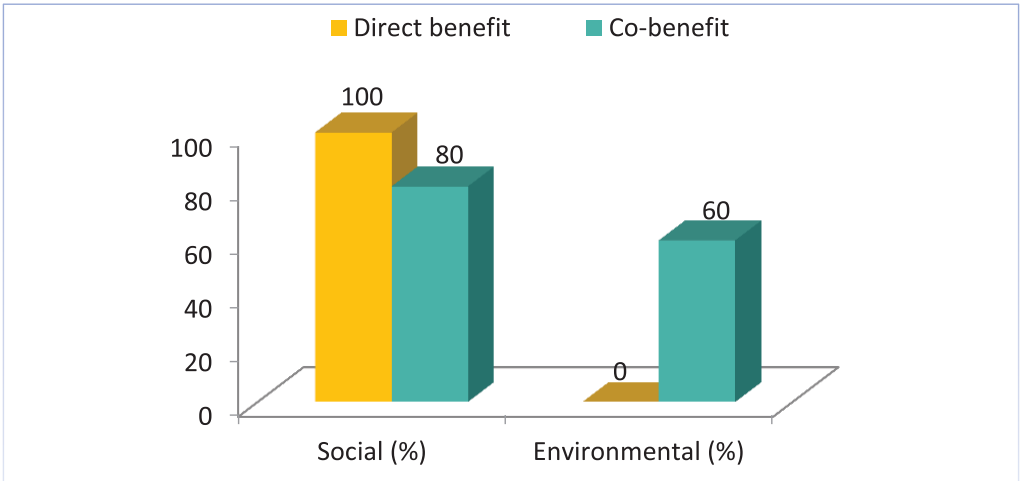

Figure 12. Percentage of the benefit of climate resilient livestock solution

Table 20. Benefits of climate resilient livestock solution

Direct benefit		Co-benefit benefit	
Social	**Environmental**	**Social**	**Environmental**
Increased availability of livestock fodder during floods	Balanced ecosystem	Women and disabled cultivate hydroponics at their homestead area for other purpose	-

6. KII participant's perception on the performance assessment of the project

Level of perception index on project's performance

To evaluate the performance of the project the study team has obtained the perception of DCFC, DDLG, UNO, and the Union chairman which is shown in Figure 13 and Table 21. The estimated score (82.9%) implies the project is at a very satisfactory level to meet the climate change issues which is reported by DCFC. Besides, a satisfactory level is identified in the case of DDLG, UNO, and Union chairman. On the other hand, all estimated perception scores are higher than 80% indicating a higher satisfaction level for the benefits which are extracted from the project's implemented climate change adaptation schemes. Furthermore, the overall perception score is 82.72% which lies between the threshold points of 80% to 100% implying a sufficiently good status of the project. Therefore, it can be said that the overall performance of the project is at a very satisfactory level.

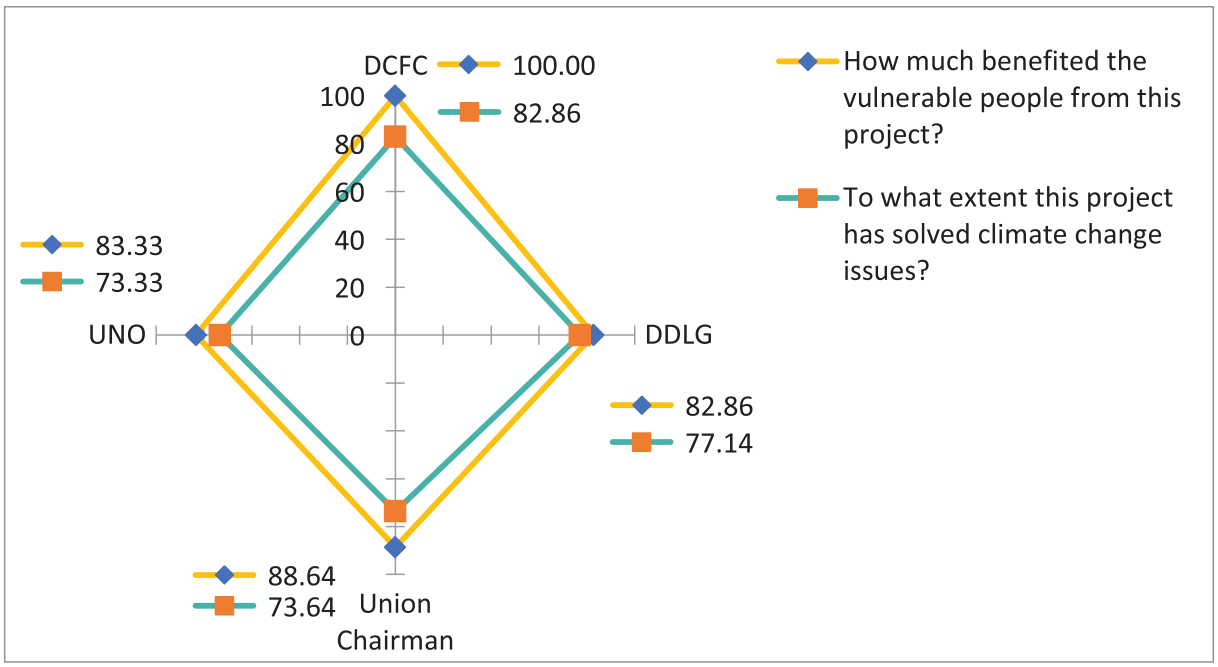

Figure 13. Stakeholders' perception (%) on the project performance

Table 21. Overall performance perception of stakeholders' regarding the project

Perception items	DCFC	DDLG	Union Chairman	UNO	Overall performance
How much benefited the vulnerable people from this project?	Very satisfactory	Very satisfactory	Very satisfactory	Very satisfactory	Very satisfactory
To what extent this project has solved climate change issues?	Very satisfactory	Satisfactory	Satisfactory	Satisfactory	Satisfactory
Overall performance	Very satisfactory	Very satisfactory	Very satisfactory	Satisfactory	Very satisfactory

SWOT analysis of the project (Based on KII participant's perceptions)

The study also performed the SWOT (Figure 14) analysis to see the strengths, weaknesses, opportunities, and threats of the project which are given as follows:

Strength:

The study identifies several strengths of the project. Strong coordination among the project's staff and local government bodies is identified as the main strength which is reported by the KII participants. The Upazila facilitator, Upazila line department, District Climate Risk & Adaptation monitor (DCRAM), District Climate Finance coordinator, Deputy Director-Local Government (DDLG), Upazila Nirbahi Officer (UNO), Community Mobilization Facilitators (CMF), Union chairman, Ward member, and others are involved intimately in the project. Further, the KII participant reports a strong backward linkage in receiving co-finance from other sources. The study also found a good communication system between the local staff to the local community where the climate change adaptation measures were taken.

Weakness:

The study identifies some weaknesses along with strengths. Most of the KII participants mentioned the budget limitation of the project for some vulnerable areas like flush flood-prone zone namely Sunamganj. Besides, the participants think a long-term project is very effective than a short-term project for the climate-vulnerable community to mitigate and adapt the climate issues.

Opportunities:

The success of any project also depends on its opportunities. In the case of this impact evaluation, the study finds some opportunities which are identified by the DCFC, DDLG, UNO, and Union chairman. Environment awareness-raising program, building a 'Quick Response Team' in the local vulnerable areas so that they can help in the emergency case, skill development program for quick adaptation to natural disasters, providing a GPRS tracking system for fishermen, and providing salt and flood-tolerant agricultural seeds can be implemented by the project further to cope with the climate vulnerable issues.

Threats:

The study also finds some threats that may hamper the project's smoothness in the case of success. Hostile or harsh weather, higher cost of supplies or materials, and local leader can reduce the sustainability of the project.

Since the infrastructures are operating in relatively climate-vulnerable areas/regions periodic monitoring of them is required and if needed periodic maintenance should also be ensured for wider and sustainable use of these infrastructures.

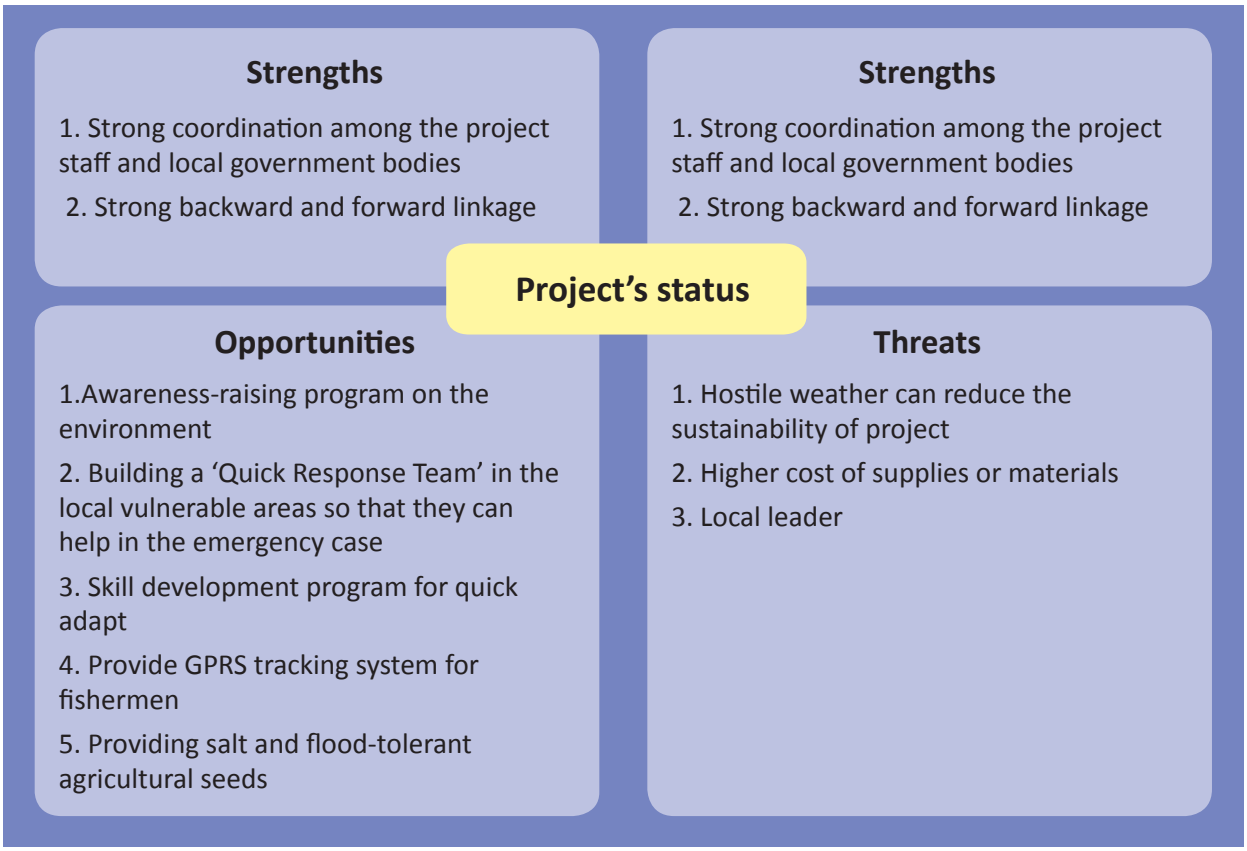

Figure 14. SWOT analysis of the Project

7. Conclusion and Policy Recommendation

Climate change is a global concern that has negative consequences, particularly in developing/emerging countries like Bangladesh. To mitigate the negative consequence of changing climate several initiatives were taken for the vulnerable community in different vulnerable areas of Bangladesh by the multi-donor collaborative of GoB, UNDP, UNCDF, EU, and SIDA. Therefore, this study aims to assess the impact of such initiatives on the local vulnerable people in 44 unions of 18 Upazila under 7 districts in Bangladesh. The study identified several types of co-benefit along with the direct benefits from each of the implemented climate change adaptation categories. From the aspect of quantitative assessment, it is found that the overall benefit is 62% while the overall co-benefit is 38%. The overall BCR is positive indicating better investment in the project. Considering total benefit, the highest BCR is found for adaptive water and sanitation solutions and improved accessibility to flood shelter, cyclone shelter, kella, and water source among all climate change adaptation categories. The study also finds higher co-benefit than the benefit for adaptive water and sanitation solutions and climate-resilient livestock solutions.

On the other hand, in the case of qualitative assessment, the study finds a highly pleasant level of satisfaction for social benefits and a pleasant level of satisfaction for environmental benefits which were extracted from the implemented climate change adaptation measures. Furthermore, the study finds a highly satisfactory level of performance in solving climate-related issues in the climate-vulnerable areas of Bangladesh that are reported by the KII participants of this study. Therefore, the study advocates for the implementation of more climate change adaptation schemes so that the people of climate-vulnerable areas can easily maintain their way of life.

Responses to the comments of LoGIC PMU

Comment: What are the overall results of LoGIC based on the BCR analysis? Need some narratives in bullets.
Response: The narrative results are now added to the executive summary

Comment: Is it BDT in million (Table 2)?
Response: This is the percentage

Comment: Need more analysis/elaboration on the benefits i.e. economic, social, environmental, gender, capacity, etc.
Response: We performed qualitative analysis for social and environmental benefits. Whereas, social benefits include women empowerment, child care, adult and disabled care, and so on. The environmental benefit includes keeping ground and surface water at a sustainable level, etc.

Comment: Need adaptation category-wise cost and benefit comparison in a single table. In addition, need elaboration on the lowest and highest case of benefit and cost ratio with what were the reasons?
Response: We already compared cost and benefit by estimating the BCR in Table 4 and Table 5. According to your suggestion, we've added discussions whenever necessary.

Comment: Need to re-write this section. Please add key analysis, lessons learned along with specific recommendations (E.g. adaptation category-wise) for policy and strategic changes.
Response: Thanks for your suggestion. We think category-wise policy implication is not the right way for this study. Since this study aims to evaluate the impact of the project therefore we focused on overall key findings and have given the policy accordingly.

Responses to the questions/comments from stakeholders

1. How are the different climate adaptive schemes separated into categories? What was the basis? It's not clear in the report.
   Response: Thanks for your query here. Following the approval of the UNCDF officials, twenty-nine (29) climate change adaptation measures were selected from eight (8) climate change adaptation categories (out of 11 categories) based on the prominence and the amount of PBCRG investment of the LoGIC project. This is mentioned in the report.
2. Why the KII was needed for this study? An explanation needs to mention in the methodology section of the report.
   Response: According to your suggestion we added an explanation to do KII in the method section.
3. How was the co-benefit of the schemes calculated? What is the definition of the co-finance considered in this study?
   Response: The calculation process of co-benefit is mentioned in the method section. The meaning of co-finance is added in the method section.
4. What are the beneficiary selection criteria for the LoGIC scheme? How are the beneficiaries selected?
   Response: Since the climate change adaptation categories were implemented at the community level therefore we tried to cover all types of people such as crop farmers, poultry/livestock farmers, fish farmers/ fishermen, day laborers, small businessmen, salaried job holders, housewives, and so on. These are already mentioned in the method section.
5. Have you measured other co-benefits like education, child's health, child protection, crop resilience, gender etc? These are very interesting findings and other UN agencies can use those for their planning and implementation.
   Response: Yes, we measured these as social direct benefit and co-benefit in the report.
6. How did you minimize the sampling errors? Were there any treatment and control groups? How did you differentiate the LoGIC benefits from the other's interventions? Details should be mentioned in the report.
   Response: We minimized the errors of sampling by covering a large data set. In this study, we conducted

84 FGDs by covering above 850 beneficiaries which ensured the minimization of sampling errors. No, there was a non-existence of treatment and control groups. Before, starting FGD we delivered a short brief to the participants about the LoGIC project. We sought their feedback (i.e., benefits) based on the schemes implemented by the LoGIC project. Thus we differentiated the LoGIC benefits from other's interventions.

7. How are the LoGIC schemes clubbed together as some benefits are overlapping? How the problem of double counting of benefits were avoided?

   Response: During conducting FGD, the note-takers (enumerators) were aware of the double-counting of benefits. Besides, the note-takers recorded (audio) the discussion as well. After completion of each FGD, the note-takers minimized the double counting by hearing the audio record.

8. In some cases, using of the bar chart is not effective to present the results, it can be replaced with the distribution chart.

   Response: This is difficult to do a distribution chart due to the nature of the data. Instead, we reformatted some bar diagrams in some cases to understand them easily.

9. What liker card was used for presenting the perception score index? Need to elaborate in the report.

   Response: We've mentioned this in the report.

10. There are many non-market methods to assess the benefits of public goods. In case of such study, the ToR should be shared with this group.

    Response: This could be assessed in future studies.

11. Long-term benefits need to be captured in future similar studies.

    Response: Of course.

12. The benefits ratio should be **at least**

    Response: Addressed in a footnote

References

Akinola, A. A., Ogunleye, A. S., Bamire, A. S., Abdoulaye, T., Reed, H., Adeyeye, V., ... & Ogundele, O. (2019). Potential Economics Impacts of Research on Climate Adaptation Strategies in Nigeria.

Arfanuzzaman, M., Hassan, S. T., & Syed, M. A. (2021). Cost-benefit of promising adaptations for resilient development in climate hotspots: evidence from lower Teesta basin in Bangladesh. Journal of Water and Climate Change, 12 (1), 44-59.

Devkota, N., Phuyal, R. K., & Shrestha, D. L. (2017). Cost and benefit analysis of adoption of climate change adaptation options among rural rice farmers in Nepal. Asian Journal of Agriculture and Rural Development, 7(7), 136-148.

Islam, S. M. D. (2013). Evaluation of environmental and socio-economic impact due to cyclone Aila, present condition and adaptation practices in Shyamnagar, Satkhira of Bangladesh. Unpublished Undergraduate Thesis, Department of Environmental Sciences, Jahangirnagar University, Dhaka.

Kalame, F. B., Aidoo, R., Nkem, J., Ajayie, O. C., Kanninen, M., Luukkanen, O., & Idinoba, M. (2011). Modified taungya system in Ghana: a win–win practice for forestry and adaptation to climate change? Environmental Science & Policy, 14(5), 519-530.

Likert, R. (1932). A technique for the measurement of attitude. Archives of Psychology,

Vol. 22 No. 140, pp. 1–55.

Mtimuni, M., & Campus, B. (2018). Adaptation to climate change: a cost benefit analysis of adaptation strategies practiced by smallholder farmers in Lilongwe district.

Shongwe, P. (2013). Cost benefit analysis of climate change adaption strategies on crop production systems: a case of Mpolonjeni Area Development Programme (ADP) in Swaziland (No. 634-2016-41455).

Singh, A. S., & Masuku, M. B. (2014). Sampling techniques & determination of sample size in applied statistics research: An overview. International Journal of economics, commerce and management, 2(11), 1-22.

Williams, P. A., Karanja Ng'ang'a, S., Crespo, O., & Abu, M. (2020). Cost and benefit analysis of adopting climate adaptation practices among smallholders: the case of five selected practices in Ghana. Climate Services, 20, 100198.

Zou, X., Cremades, R., Gao, Q., Wan, Y., & Qin, X. (2013). Cost-effectiveness analysis of water-saving irrigation technologies based on climate change response: A case study of China. Agricultural water management, 129, 9-20.

Annexes

Annex A. Adaptive Water and Sanitation Solutions

A1. Rainwater Harvesting System (Community Level)

Items	Value
Cost/Investment (Tk. in million)	
PBCRG investment	17.37
Co-finance investment	1.66
Total investment	19.03
Direct benefit (Tk. in million)	
Reduced expenditure for searching pure water	17.27
Reduced expenditure on health treatment	5.15
Total direct benefit	22.42
Co-benefit (Tk. in million)	
Increased income due to saving time	68.26
Total co-benefit	68.26
Total benefit	90.68
BCR based on direct benefit	1.18
BCR based on co-benefit	3.59
BCR based on total benefit	4.76

A2. Combined Rainwater Harvesting and Pond-water Treatment Plant

Items	Value
Cost/Investment (Tk. in million)	
PBCRG investment	5.84
Co-finance investment	0.30
Total investment	6.14
Direct benefit (Tk. in million)	
Reduced expenditure for searching pure water	11.47
Reduced expenditure on health treatment	25.10
Total direct benefit	36.57
Co-benefit (Tk. in million)	
Increased income due to saving time	39.20
Total co-benefit	39.20
Total benefit	75.77
BCR based on direct benefit	5.95
BCR based on co-benefit	6.38
BCR based on total benefit	12.34

A3. Flood Proof Tube-well

Items	Value
Cost/Investment (Tk. in million)	
PBCRG investment	5.53
Co-finance investment	0.51
Total investment	6.04
Direct benefit (Tk. in million)	
Reduced expenditure for searching pure water	8.22
Reduced expenditure on health treatment	2.57
Total direct benefit	10.79
Co-benefit (Tk. in million)	
Increased income due to saving time	3.40
Total co-benefit	3.40
Total benefit	14.20
BCR based on direct benefit	1.79
BCR based on co-benefit	0.56
BCR based on total benefit	2.35

A4. Solar Powered Ground Water Treatment Plant

Items	Value
Cost/Investment (Tk. in million)	
PBCRG investment	1.00
Co-finance investment	0.10
Total investment	1.10
Direct benefit (Tk. in million)	
Reduced expenditure for searching pure water	0.18
Reduced expenditure on health treatment	1.18
Total direct benefit	1.36
Co-benefit (Tk. in million)	
Increased income due to saving time	1.92
Total co-benefit	1.92
Total benefit	3.28
BCR based on direct benefit	1.24
BCR based on co-benefit	1.75
BCR based on total benefit	2.99

A5. Pond Water Treatment Plant

Items	Value
Cost/Investment (Tk. in million)	
PBCRG investment	2.37
Co-finance investment	0.00
Total investment	2.37
Direct benefit (Tk. in million)	
Reduced expenditure for searching pure water	1.40
Reduced expenditure on health treatment	1.13
Total direct benefit	2.53
Co-benefit (Tk. in million)	
Increased income due to saving time	1.50
Total co-benefit	1.50
Total benefit	4.03
BCR based on direct benefit	1.07
BCR based on co-benefit	0.63
BCR based on total benefit	1.70

A6. Improve WASH Facility in Flood Shelter

Items	Value
Cost/Investment (Tk. in million)	
PBCRG investment	1.94
Co-finance investment	0.10
Total investment	2.04
Direct benefit (Tk. in million)	
Reduced expenditure for searching pure water	14.09
Reduced expenditure on health treatment	5.00
Total direct benefit	19.09
Co-benefit (Tk. in million)	
N/A	0.00
Total co-benefit	0.00
Total benefit	19.09
BCR based on direct benefit	9.38
BCR based on co-benefit	0.00
BCR based on total benefit	9.38

A7. Solar Powered Pond Water Treatment Plant

Items	Value
Cost/Investment (Tk. in million)	
PBCRG investment	2.46
Co-finance investment	0.54
Total investment	3.01
Direct benefit (Tk. in million)	
Reduced expenditure for searching pure water	3.03
Total direct benefit	3.03
Co-benefit (Tk. in million)	
Increased income due to saving time	0.69
Total co-benefit	0.69
Total benefit	3.72
BCR based on direct benefit	1.01
BCR based on co-benefit	0.23
BCR based on total benefit	1.24
BCR based on total benefit	11.50

A8. Water Desalination Plant (Reverse Osmosis)

Items	Value
Cost/Investment (Tk. in million)	
PBCRG investment	2.00
Co-finance investment	0.00
Total investment	2.00
Direct benefit (Tk. in million)	
Reduced expenditure for searching pure water	2.19
Reduced expenditure on health treatment	2.56
Total direct benefit	4.75
Co-benefit (Tk. in million)	0.00
Increased income due to saving time	18.25
Total co-benefit	18.25
Total benefit	23.00
BCR based on direct benefit	2.37
BCR based on co-benefit	9.13
BCR based on total benefit	11.50

Annex B. Reduce Loss and Damage of Life and Property

B1. Provide Safety Equipment to Fishing Boats

Items	Value
Cost/Investment (Tk. in million)	
PBCRG investment	4.10
Co-finance investment	22.66
Total investment	26.75
Direct benefit (Tk. in million)	
Reduce expenditure on safety equipment	43.00
Total direct benefit	43.00
Co-benefit (Tk. in million)	
Increase income by fishing more with safety	31.00
Total co-benefit	31.00
Total benefit	74.00
BCR based on direct benefit	1.61
BCR based on co-benefit	1.16
BCR based on total benefit	2.77

B2. Lightening Shed

Items	Value
Cost/Investment (Tk. in million)	
PBCRG investment	0.95
Co-finance investment	0.00
Total investment	0.95
Direct benefit (Tk. in million)	
Reduce financial loss by protecting the livestock during lightening	1.50
Total direct benefit	1.50
Co-benefit (Tk. in million)	
Increase income by wage earning	0.18
Total co-benefit	0.18
Total benefit	1.68
BCR based on direct benefit	1.58
BCR based on co-benefit	0.19
BCR based on total benefit	1.77

B3. Provide Safety Equipment to Passenger Boats, Provide Safety Equipment to Fishing Boats

Items	Value
Cost/Investment (Tk. in million)	
PBCRG investment	1.36
Co-finance investment	0.00
Total investment	1.36
Direct benefit (Tk. in million)	
Reduce expenditure on safety equipment	1.45
Total direct benefit	1.45
Co-benefit (Tk. in million)	
Increase income by fishing more with safety	2.64
Total co-benefit	2.64
Total benefit	4.09
BCR based on direct benefit	1.06
BCR based on co-benefit	1.93
BCR based on total benefit	3.00

Annex C. Reduce Impacts of Flood and Waterlogging

C1. Culvert

Items	Value
Cost/Investment (Tk. in million)	
PBCRG investment	8.42
Co-finance investment	0.18
Total investment	8.60
Direct benefit (Tk. in million)	
Income increase due to higher crops production	22.00
Reduce financial loss from crop damage	0.84
Reduce financial loss from aquaculture damage	7.15
Reduce transportation cost	3.07
Total direct benefit	33.06
Co-benefit (Tk. in million)	
Increase income by wage earning	0.84
Total co-benefit	0.84
Total benefit	33.90
BCR based on direct benefit	3.84
BCR based on co-benefit	0.10
BCR based on total benefit	3.94

C1. Culvert

Items	Value
Cost/Investment (Tk. in million)	
PBCRG investment	8.42
Co-finance investment	0.18
Total investment	8.60
Direct benefit (Tk. in million)	
Income increase due to higher crops production	22.00
Reduce financial loss from crop damage	0.84
Reduce financial loss from aquaculture damage	7.15
Reduce transportation cost	3.07
Total direct benefit	33.06
Co-benefit (Tk. in million)	
Increase income by wage earning	0.84
Total co-benefit	0.84
Total benefit	33.90
BCR based on direct benefit	3.84
BCR based on co-benefit	0.10
BCR based on total benefit	3.94

C2. Drain

Items	Value
Cost/Investment (Tk. in million)	
PBCRG investment	3.69
Co-finance investment	0.96
Total investment	4.65
Direct benefit (Tk. in million)	
Income increase due to higher crops production	1.17
Reduce financial loss from crop damage	14.10
Total direct benefit	15.27
Co-benefit (Tk. in million)	
Increase income by wage-earning	0.77
Total co-benefit	0.77
Total benefit	16.04
BCR based on direct benefit	3.28
BCR based on co-benefit	0.17
BCR based on total benefit	3.45

C3. Culvert and Drain

Items	Value
Cost/Investment (Tk. in million)	
PBCRG investment	1.43
Co-finance investment	2.62
Total investment	4.04
Direct benefit (Tk. in million)	
Income increase due to higher crops production	2.00
Reduce financial loss from crop damage	4.00
Reduce financial loss from aquaculture damage	3.50
Reduce transportation cost	0.05
Total direct benefit	9.55
Co-benefit (Tk. in million)	
Increase income by wage earning	0.16
Total co-benefit	0.16
Total benefit	9.71
BCR based on direct benefit	2.36
BCR based on co-benefit	0.04
BCR based on total benefit	2.40

C4. Village protection wall

Items	Value
Cost/Investment (Tk. in million)	
PBCRG investment	2.00
Co-finance investment	0.08
Total investment	2.08
Direct benefit (Tk. in million)	
Reduce financial loss by protecting from household wealth damage	2.30
Total direct benefit	2.30
Co-benefit (Tk. in million)	
Increase income by wage earning	1.23
Total co-benefit	1.23
Total benefit	3.53
BCR based on direct benefit	1.11
BCR based on co-benefit	0.59
BCR based on total benefit	1.70

C5. Guide wall

Items	Value
Cost/Investment (Tk. in million)	
PBCRG investment	2.73
Co-finance investment	0.00
Total investment	2.73
Direct benefit (Tk. in million)	
Income increase due to higher crops production	6.00
Reduce financial loss from crop damage	0.33
Reduce financial loss from aquaculture damage	4.25
Total direct benefit	10.58
Co-benefit (Tk. in million)	
Increase income by wage earning	0.45
Total co-benefit	0.45
Total benefit	11.03
BCR based on direct benefit	3.88
BCR based on co-benefit	0.17
BCR based on total benefit	4.04

C6. Flood protection wall

Items	Value
Cost/Investment (Tk. in million)	
PBCRG investment	0.95
Co-finance investment	0.00
Total investment	0.95
Direct benefit (Tk. in million)	
Income increase due to higher crops production	0.35
Reduce financial loss from crop damage	2.50
Reduce financial loss from aquaculture damage	0.50
Reduce transportation cost	0.85
Total direct benefit	4.20
Co-benefit (Tk. in million)	
Increase income by wage earning	0.50
Total co-benefit	0.50
Total benefit	4.70
BCR based on direct benefit	4.42
BCR based on co-benefit	0.53
BCR based on total benefit	4.95

Annex D. Improve Accessibility to Flood Shelter, Cyclone Shelter, Kella, and Water Source

D1. Bridge

Items	Value
Cost/Investment (Tk. in million)	
PBCRG investment	2.66
Co-finance investment	0.09
Total investment	2.75
Direct benefit (Tk. in million)	
Income increase due to higher crops production	3.20
Reduce transportation cost	1.80
Total direct benefit	5.00
Co-benefit (Tk. in million)	
Increase income by wage earning	0.90
Total co-benefit	0.90
Total benefit	5.90
BCR based on direct benefit	1.82
BCR based on co-benefit	0.33
BCR based on total benefit	2.15

D2. Road Construction/Repair

Items	Value
Cost/Investment (Tk. in million)	
PBCRG investment	12.89
Co-finance investment	0.55
Total investment	13.43
Direct benefit (Tk. in million)	
Income increase due to higher crops production	12.52
Reduce financial loss from crop damage	21.62
Reduce financial loss from aquaculture damage	15.00
Reduce transportation cost	7.73
Total direct benefit	56.86
Co-benefit (Tk. in million)	
Increase income by wage earning	3.15
Total co-benefit	3.15
Total benefit	60.01
BCR based on direct benefit	4.23
BCR based on co-benefit	0.23
BCR based on total benefit	4.47

Annex E. Promote Climate Resilient Agriculture

E1. Canal Re-excavation

Items	Value
Cost/Investment (Tk. in million)	
PBCRG investment	2.39
Co-finance investment	0.04
Total investment	2.43
Direct benefit (Tk. in million)	
Increase income from crops	2.69
Total direct benefit	2.69
Co-benefit (Tk. in million)	
Increase income by fishing	2.40
Increase income by wage-earning	3.51
Total co-benefit	5.91
Total benefit	8.60
BCR based on direct benefit	1.11
BCR based on co-benefit	0.99
BCR based on total benefit	3.54

E2. Agricultural demonstration

Items	Value
Cost/Investment (Tk. in million)	
PBCRG investment	1.42
Co-finance investment	0.60
Total investment	2.02
Direct benefit (Tk. in million)	
Increase income from crops	2.40
Total direct benefit	2.40
Co-benefit (Tk. in million)	
Reduce financial loss by participation in training program	2.15
Total co-benefit	2.15
Total benefit	4.55
BCR based on direct benefit	1.19
BCR based on co-benefit	1.06
BCR based on total benefit	2.25

E3. Solar powered ground water irrigation

Items	Value
Cost/Investment (Tk. in million)	
PBCRG investment	4.42
Co-finance investment	0.59
Total investment	5.01
Direct benefit (Tk. in million)	
Reduced expenditure on diesel cost	1.33
Increase income from crops	3.95
Total direct benefit	5.28
Co-benefit (Tk. in million)	
Income increases by exchanging water from pond for aquaculture	3.90
Total co-benefit	3.90
Total benefit	9.18
BCR based on direct benefit	1.05
BCR based on co-benefit	0.78
BCR based on total benefit	1.83

E4. Solar powered surface water irrigation

Items	Value
Cost/Investment (Tk. in million)	
PBCRG investment	4.33
Co-finance investment	1.99
Total investment	6.32
Direct benefit (Tk. in million)	
Reduced expenditure on diesel cost	7.00
Increase income from crops	4.90
Total direct benefit	11.90
Co-benefit (Tk. in million)	
Income increases by exchanging water from the pond for aquaculture	3.60
Total co-benefit	3.60
Total benefit	15.50
BCR based on direct benefit	1.88
BCR based on co-benefit	0.57
BCR based on total benefit	2.45

Annex F. Improve Adaptive, Absorptive, and Anticipatory Capacity

F1. Shuhashni Sales Center

Items	Value
Cost/Investment (Tk. in million)	
PBCRG investment	1.80
Co-finance investment	0.00
Total investment	1.80
Direct benefit (Tk. in million)	
Increase income by selling agricultural crops	4.00
Total direct benefit	4.00
Co-benefit (Tk. in million)	
Decrease financial loss from crops	2.01
Total co-benefit	2.01
Total benefit	6.01
BCR based on direct benefit	2.22
BCR based on co-benefit	1.12
BCR based on total benefit	3.34

F2. Solar Panel Distribution (at Household Level)

Items	Value
Cost/Investment (Tk. in million)	
PBCRG investment	0.99
Co-finance investment	0.08
Total investment	1.07
Direct benefit (Tk. in million)	0.00
Decrease expenditure on fuel such as diesel, kerosene, and etc.	1.30
Total direct benefit	1.30
Co-benefit (Tk. in million)	
Increase income (such as handicrafts and other IGAs)	1.10
Total co-benefit	1.10
Total benefit	2.40
BCR based on direct benefit	1.22
BCR based on co-benefit	1.03
BCR based on total benefit	2.25

F3. Provide Instrument Support to PCSBA and Community Clinics

Items	Value
Cost/Investment (Tk. in million)	
PBCRG investment	0.50
Co-finance investment	0.00
Total investment	0.50
Direct benefit (Tk. in million)	
Reduced expenditure on childbirth	0.83
Total direct benefit (Tk. in million)	0.83
Co-benefit (Tk. in million)	
Decrease expenditure on other health costs	0.70
Total co-benefit	0.70
Total benefit	1.53
BCR based on direct benefit	1.67
BCR based on co-benefit	1.41
BCR based on total benefit	3.08

Annex G. Climate Resilient Livestock Solution

G1. Hydroponics

Items	Value
Cost/Investment (Tk. in million)	
PBCRG investment	0.52
Co-finance investment	0.00
Total investment	0.52
Direct benefit (Tk. in million)	
Increase income by selling milk	0.60
Total direct benefit	0.60
Co-benefit (Tk. in million)	
Decrease feed cost	0.70
Total co-benefit	0.70
Total benefit	1.30
BCR based on direct benefit	1.16
BCR based on co-benefit	1.36
BCR based on total benefit	2.52

Annex H. List of benefits identified by KII participants

Climate change adaptation category		Overall benefits	
	Environmental benefit	**Social benefit**	**Financial benefit**
Adaptive Water and Sanitation Solutions	Maintain the level of ground-water	Decrease scarcity of pure drinking water	Reduce expenditure on health treatment
		Increase social bonding among local people	Able to save money for not using purifier
		Children, adult and disabled person get more care from their household members	
Reduce Loss and Damage of Life and Property	-	Lightening shed ensure safe shelter for local people during adverse climate	Reduce expenditure on safety equipment
		Safety equipment reduces the life risks	Increase the income of farmers
Reduce Impacts of Flood and Waterlogging	Drain and culvert reduce water logging that helps further to reduce the nuisance of insects and mosquito	Flood protection wall and village protection wall protect local community from flush flood	Income increase due to higher crops production
		The flood protection wall protects the road from damage during floods which makes it easy for local people to go the cyclone center	Reduce financial loss by protecting household wealth damage
			Increase income by wage earning
Improve Accessibility to Flood Shelter, Cyclone Shelter, Kella, and Water Source	Reduce soil erosion	The use of renovated roads and bridges greatly improve the communication system	Income increase due to higher crops production
		Constructed or repaired roads help the local people to reach the cyclone center easily	Reduce transportation cost
		Students can go to school easily by using the constructed or repaired roads	Increase income by wage earning
		Sometimes riverside roads act as river embankments which helps to protect local community from flood	

Promote Climate Resilient Agriculture	Wash away garbage	The people of canal proximate areas consume fish from the canals	Increase crop production
	Reduce carbon emission		Reduce expenditure on diesel cost
			Increase income of fishermen
			Increase income by wage earning
Improve Adaptive, Absorptive, and Anticipatory Capacity	In solar panel systems, there is no use of fossil foil which helps to balance the ecosystem	Awareness raise through billboards	Increase income by selling agricultural crops
	Reduce carbon emission by using of solar panel system	Women empowerment through Shuhashini sells center	Decrease expenditure on fuel such as diesel, kerosene, and etc.
		The use of solar panels has greatly improved the quality of education for children	Reduce expenditure on childbirth
			Increase income by selling handicrafts and other IGAs
Nature-based Solutions	Carbon emission	Swamp forestation protect community from flash flood	-
Climate Resilient Livestock Solution	Hydroponics balance the ecosystem	Women and disabled cultivate hydroponics at their homestead area for other purpose	Increase milk production
			Decrease feed cost of domestic animal

Annex I. KII participant's perception (%) on how much benefited the vulnerable people from this project

Stakeholders	Very much	Much	Neutral	Less	Very less
DCFC	100.00	0.00	0.00	0.00	0.00
DDLG	42.86	42.86	0.00	14.29	0.00
Union Chairman	65.91	13.64	18.18	2.27	0.00
UNO	33.33	50.00	16.67	0.00	0.00
Overall	59.21	23.68	18.58	2.63	0.00

Annex J. KII participant's perception (%) on to what extent this project has solved climate change issues

Stakeholders	Very much	Much	Neutral	Less	Very less
DCFC	71.43	0.00	14.29	0.00	14.29
DDLG	42.86	14.29	28.57	14.29	0.00
Union Chairman	27.27	22.73	40.91	9.09	0.00
UNO	16.67	33.33	50.00	0.00	0.00
Overall	30.26	22.37	39.47	6.58	1.32

Annex K. KII participant's perception (%) on the extent of involvement of local government bodies in the project

Stakeholders	Very much	Much	Neutral	Less	Very less
DCFC	42.86	28.57	28.57	0.00	0.00
DDLG	42.86	28.57	28.57	0.00	0.00
Union Chairman	56.82	25.00	15.91	2.27	0.00
UNO	44.44	22.22	33.33	0.00	0.00
Overall	51.32	25.00	22.37	1.32	0.00

Local Government Initiative on Climate Change (LoGIC) Project

E/8-A, IDB Bhaban, Level-8, Sher-e-Bangla Nagar, Agargaon, Dhaka-1207, Bangladesh.

Phone: +88-02-55667788

www.logicbd.org

Local Government Initiative on Climate Change