ORCHID: Piloting Climate Risk Screening in DFID Bangladesh

Summary Research Report

Thomas Tanner[1], Ahmadul Hassan[2], KM Nabiul Islam[3], Declan Conway[4,5], Reinhard Mechler[6], Ahsan Uddin Ahmed[7], Mozaharul Alam[8]

[1] Institute of Development Studies (IDS), University of Sussex, UK
[2] CEGIS – Center for Environmental and Geographic Information Services, Bangladesh
[3] Bangladesh Institute of Development Studies (BIDS), Bangladesh
[4] School of Development Studies-Overseas Development Group, University of East Anglia, UK
[5] Tyndall Centre for Climate Research, University of East Anglia, UK
[6] International Institute of Applied Systems Analysis (IIASA), Austria
[7] Bangladesh Unnayan Parishad (BUP), Bangladesh
[8] Bangladesh Centre for Advanced Studies (BCAS), Bangladesh

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Section 1: Executive Summary

ORCHID (Opportunities and Risks of Climate Change and Disasters) responds to 2006 White Paper commitments by piloting a screening approach to consider climate risk management in DFID Bangladesh. The approach combines the related concerns of disaster risk reduction and adaptation to future climate change.

Climate change science inputs building on trend analysis suggest increases to the existing hazard burden in Bangladesh. Greater monsoon rainfall is likely to increase flooding and decreased dry season rainfall is likely to exacerbate drought and inland water salinity. Both problems are compounded by sea level rise in coastal regions.

The risk assessment found a prevailing level of risk to almost all projects from regular catastrophic disaster events. The most climate-sensitive DFID-B interventions were selected for more detailed assessment.

DFID-B already supports disaster risk reduction and climate change adaptation initiatives through targeted interventions such as the Comprehensive Disaster Management Programme. Other mainstream interventions also contribute to reducing climate-related vulnerability.

Current and future climate risks are being already managed by existing activities of the Chars Livelihoods Programme, including the raising of homesteads on earth mounds above the 20-year flood line. A cost benefit analysis of this option was undertaken factoring in projected climate change impacts. It suggests positive benefit to cost ratios (net efficiency) for commonly used discount rates even under a high cost assumption.

A variety of the screening recommendations have been integrated within DFID-B interventions. Reducing vulnerability to climate variability and change have been taken forward as key funding criteria for the Economic Empowerment of the Poorest (EEP) challenge fund. The second phase of the Rural Infrastructure Improvement Project (RIIP2) has included disaster risk assessment procedures as part of the strengthening of best practice in social and environment impact assessment procedures necessary for the envisaged infrastructure works.

A cost benefit analysis of flood-proofing of roads and highways suggests that road-raising and drainage measures could be economically efficient by reducing disaster impacts in the medium term. This is salient to ongoing DFID-B financial and technical support to the Bangladesh Roads and Highways Department.

Other recommended options for managing risks included greater attention to infrastructure design in health, education and private sector development programmes, to non-structural measures such as livelihoods diversification, education, training, and improved research and monitoring.

Strategically, climate risks in Bangladesh suggest that the DFID programme as a whole:

- Continues to support dialogue on disaster risk reduction and climate change adaptation in key sectors
- Seeks to integrate priorities elaborated in the Government of Bangladesh National Adaptation Programme of Action (NAPA) in future programme development
- Increases emphasis on urban areas, given that existing levels of rural-urban migration are likely to be reinforced by climate change impacts.
- Develops a UK government, multi-donor approach to stimulate international dialogue around crucial but complex and politically-charged issues of mass migration and trans-boundary water issues.

Section 2: Approach and Recommendations

2.1 Approach

The 2006 White Paper commitments have followed up agreements across the G8 and OECD that donors should make climate variability and climate change risk factors an integral part of their project planning and assessment. ORCHID (Opportunities and Risks of Climate Change and Disasters) pilots a screening approach in Bangladesh to enable a more systematic consideration of climate risks to the DFID programme.

Bangladesh is among the most disaster prone countries in the world. Climate change is likely to alter and in some cases exacerbate existing hazards, and create new hazards such as sea level rise. Poor people are commonly hardest hit by climate shocks and stresses, threatening progress on poverty reduction.

The *purpose* of this work is therefore to improve the ability to manage risks from current and future climatic impacts that might compromise the effectiveness of development assistance. The *aim* of this work was to develop a climate change screening process to identify and manage climate change impacts on development investments.

Use of a risk management approach acknowledges that:

1. Climate risks may not be the most important constraint on poverty reduction.
2. The basis for adapting to the future climate lies in improving the ability to cope with existing climate variations.
3. Adaptation has much in common with disaster management and emerging approaches to disaster risk reduction.
4. Many existing development programmes may implicitly contribute to adaptation through their efforts to reduce poverty and vulnerability.

2.2 Method

A screening and risk assessment procedure was developed and implemented during this work. The process, illustrated on figure 2.1, selected and analysed a sub-set of climate sensitive DFID-B programmes, recommending options for integrating adaptation in order to improve poverty reduction outcomes.

Sensitisation and awareness-raising was emphasised throughout the process. Climate change has risen rapidly in profile in recent years but there remains limited understanding of its impacts in developing countries, how it might affect poverty reduction, and how to minimise negative effects through adaptation.

Two initial inputs frame the process. A *strategic overview* outlines the relevance of climate change and disasters in the context of the relevant broader DFID policies and key national development policies, including the National Adaptation Programme of Action (NAPA). A *disasters and climate change profile* combines newly generated future climate scenarios with existing studies and data to assess the main climate impacts in key sectors and regions.

The *portfolio risk assessment* builds on these inputs using a checklist of criteria to prioritise key projects for a more detailed examination of project objectives and activities. This assesses risks in terms of current and future hazards, and the sensitivity and exposure of human systems. The analysis highlights opportunities for integrating disaster risk reduction and climate change adaptation within the context of programme activities or design, drawing on previous studies and government reports.

An *adaptation options assessment* uses a multi-criteria analysis and *economic cost benefit analysis* to prioritise options for *integration into programmes*. The exercise as a whole is used to inform the development of *future screening and risk assessment* as a regular part of development cooperation programming.

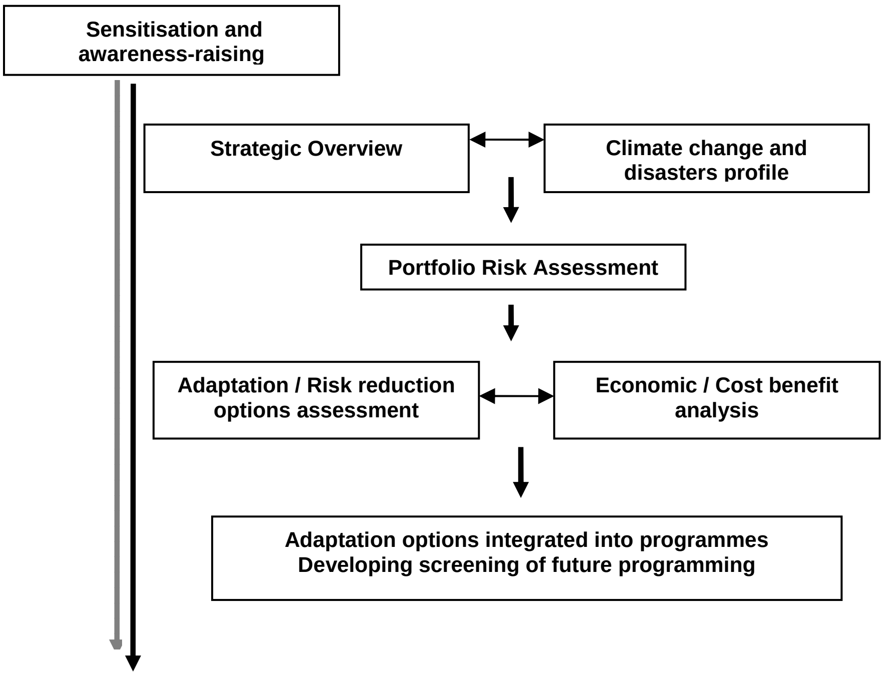

Figure 2.1: Main elements of the ORCHID climate risk assessment process

2.3 Strategic Recommendations

Climate change is poorly reflected in major national policies and programmes in Bangladesh. To date, the Coastal Zone policy is the only sectoral policy to explicitly consider climate change, although this is a key concern of current redrafting of the National Water Management Plan (NWMP). Analysis suggests that a wide range of other policies have the potential to incorporate factors to reduce vulnerability to climate-related hazards.

The Poverty Reduction Strategy (PRS) identifies the need for mainstreaming of climate change adaptation and disaster risk reduction, but these concerns are not integrated within sections on key climate sensitive sectors. The Bangladesh National Adaptation Programme of Action (NAPA) provides further guidance for incorporating urgent and immediate adaptation needs across sectors. Recommendations of this screening exercise are consistent with the NAPA priorities.

A low proportion of the DFID Bangladesh (DFID-B) portfolio is directly engaged in climate-sensitive water and agricultural sectors, but a prevailing background level of risk exists to infrastructure in many programmes from extreme events. The interim DFID-B Country Assistance Plan (CAP) priorities include reducing vulnerability to disasters and climate change as part of a priority area. Specific assistance to the World Food Programme for improved disaster emergency coordination, a disaster rapid response system to a network of NGOs, and support to the Comprehensive Disaster Management Programme (CDMP) reflect the frequency and severity of disaster episodes in Bangladesh.

Besides the incorporation of adaptation elements for specific projects recommended in this report, strategic recommendations for the DFID-B programme include:

- Continuing to support climate change from a risk management approach, whereby adaptation starts with adapting to existing variability in climate and its impacts. Risk reduction based on existing disaster burdens should therefore be as much of a priority as a focus on adaptation to scientifically determined future climate change.

- Incorporation of climate-related indicators within programmes to monitor climate impacts on poverty and the contribution of programmes to reduced vulnerability to climate risks.
- Continuing to foster adaptation as a process, rather than only as a set of discrete outputs. This means supporting dialogue on disaster management in key sectors, as well as linking with scientific climate information that is generated and presented in ways consistent with existing risk management practices.
- Integration of priorities elaborated in the Government of Bangladesh National Adaptation Programme of Action (NAPA) in future programme development
- Targeting of geographical regions most vulnerable to climate change, particularly the coastal zone, undertaken alongside existing poverty targeting of the DFID-B programme.
- Increased emphasis on economic diversification and poverty reduction in urban areas, given that existing levels of rural-urban migration are likely to be reinforced by climate change impacts.
- Development of a UK government, multi-donor approach to stimulate international dialogue around crucial but complex and politically-charged issues of mass migration and trans-boundary water issues.

2.4 Recommendations for programmes

Nine current and planned DFID-B interventions were selected during the screening exercise as high priority for further assessment. High priority was afforded to those interventions with significant climate risks and/or opportunities to contribute to targeted reduction of climate vulnerability, those with a budget of more than £1million and more than 2 years left to run, and with good opportunities to enact design changes.

Recommended adaptation options ranged from the strategic integration of climate change and disasters issues within strategic guidelines/criteria for challenge funds, structural changes to infrastructure design, to non-structural measures such as livelihoods diversification, education, training, and improved research and monitoring.

General findings from the screening exercise include:

- There is an underlying climate sensitivity of all programmes because climate shocks such as floods, cyclones and tornados regularly affect large parts of the country. Impacts on infrastructure and on water supply (quality and quantity) are particularly important, with the latter sensitive to gradual changes as well as extreme events. This prevailing level of risk was in evidence during the 2004 floods when significant losses and delays to programmes occurred, even in areas commonly regarded as less climate-sensitive such as public financial management.
- There are limitations to this top-level screening and more detailed individual assessments may be necessary for programmes in climate-sensitive sectors or with significant infrastructure components, where disaster risks and climate projections for specific regions locations are necessary. The cost of undertaking these assessments as well as any necessary design changes will need to be included in project.
- DFID-B need to improve connections between screened programmes and other DFID-funded activities designed to facilitate the coordination and mainstreaming of disaster risk reduction and climate change adaptation. For example, the Comprehensive Disaster Management Programme and World Food Programme Support can be harnessed to add greater value to other ongoing programmes, particularly in terms of compiling and updating data on hazards and impacts for different sectors and regions.

The following section outlines findings and recommendations for specific programmes.

2.4.1 Regulatory & Investment Systems improvement for Enterprise growth (RISE) Programme

The RISE programme, formerly Private Sector Development Support Project (PSDSP), aims to promote pro-poor growth by increasing income and employment for the poor through strengthening of the enabling environment. Financial and technical assistance will be provided to help streamline regulatory constraints on businesses, especially for small and medium-sized enterprises, and to improve the environment for foreign direct investment. It will also strengthen mechanisms to improve accountability and integration of environmentally and socially responsible business practice.

Climate risks to this project lie principally in damage and disruption to private sector infrastructure from extreme events such as floods, cyclones and storm surges. There have been widespread loses to private enterprise infrastructure from past climate-related disasters. Projected climate change impacts suggest that if no additional adaptive changes are made, key infrastructure will be damaged more frequently, causing deterioration of the enabling environment and putting private investment at risk.

The RISE programme work has undertaken an environmental impact assessment (EIA), but although it considers the impact of the enterprise zone development on the environment, it does not consider the potential impact of the environment on the zones themselves. In order to integrate climate risk into the RISE programme, the following is recommended

- Improving resilience of enterprise zones and related infrastructure to climatic hazards through design and maintenance.

The programme can promote or insist on assessments of risk from disaster events for sites selected for private enterprise grants. A pilot effort in key high risk enterprise zones might inform how these assessments can highlight and prioritise disaster risk reduction, including assessing future climate change impacts to enterprise zones on a regional scale.

- Improving awareness and development of guidelines on climate change and disasters impacts and risk management for regulatory bodies in the enterprise sector.

By working with Bangladesh Investment Climate Fund (BICF) and the regulatory bodies relevant to enterprise development, DFID-B could help develop and disseminate awareness-raising materials on climate change and disasters issues in the context of enterprise development. These materials would scope out and detail the range of impacts to private enterprise of current climatic hazards as well as assessment of the likely future hazard burden due to climate change. It would also examine potential risk management options to reduce risks associated with these hazards.

This work prepares the ground for the development of broad guidelines in partnership with enterprise regulatory bodies and other stakeholders on climate risk assessment for enterprise development. Both the awareness-raising materials and guideline development could potentially be carried out in conjunction with or under the activities of the Comprehensive Disaster Management Programme and its climate change cell, as part of its cross-sectoral mainstreaming activities.

Improved information would be required for both these recommended options on the impacts of recent hazards on private enterprise infrastructure and activities. Indicators can be developed to track progress on resilience-building of enterprise development by relating current to historic damages for given hazard levels (eg reduction in damage/disturbance for a flood of a given level).

2.4.2 Promoting Financial Services for Poverty Reduction (Prosper)

Prosper aims to establish a sustainable financial sector for the poor in Bangladesh, offering better financial services for previously excluded groups (the extreme poor, MSEs, and small farmers). The intervention seeks to increase access of two main groups to appropriate financial services: the ultra poor and micro-enterprises/marginal farmers. It also looks to support the formulation and adoption of regulation and professional standards in the microfinance (MF) industry – which will include capacity building on environmental procedures.

Given the broad-ranging nature of project, exposure to risks from disasters and climate change are likely. Many loans will involve agricultural activities that may involve large numbers of enterprises and knock-on effects (for example thousands of farmers taking up new cropping regimes, or having increased access to agricultural inputs). The programme therefore has opportunities to address negative impacts and maximise positive opportunities to increase environmental sustainability and the management of climate risk.

Project documents mention crop insurance as an example of a potential project, and there may be overlap with the rural finance programme of the World Bank, where weather-related crop insurance plays a role. Collaboration in designing a risk index for different sectors and activities in Bangladesh may benefit the development of both crop insurance for different crops and regions, and operating micro finance activities that relate to agriculture and other sectors.

- Integration of climate change and disasters issues within capacity building and funding criteria

As a baseline measure, capacity building and training could be provided to applicants to Prosper funding on disasters and climate change to raise awareness and promote integration of risk reduction measures. A bolder option would include assessments of climatic risks and risk reduction as part of funding or application criteria to Prosper for co-finance and technical assistance projects.

This process can draw from experiences of other challenge funds including the under Comprehensive Disaster Management Programme, Economic Empowerment of the Poorest, and Remittances Programme, RRP). A balance needs to be struck between providing incentives to tackle climate risks and creating excessive conditionalities that constrain innovation in the micro-finance sector.

2.4.3 Second Urban Primary Health Care Project (UPHCP-II)

This project aims to improve health of the urban population through access to and utilisation of efficient, effective and sustainable good quality health services for the poor, with a particular focus on women and girls. It emphasises social mobilisation, motivation and awareness, establishment of community level mini-clinic and outreach work, and capacity building of the community organizers/health educators. DFID is one of 6 development partners that include the Government of Bangladesh (GoB).

The key climate change risk in this project relates to the building of mini-clinics. This infrastructure will be exposed to the existing distribution of hazards and a new hazard environment as climate changes. Key risks include increases in flood frequency and magnitude, higher cyclone risk and sea level rise in certain areas.

In addition, climate change impacts may directly affect recipients' health. Climate change is likely to change the distribution of vector borne diseases, heat related problems, leading to negative health impacts due to declining water availability and quality, particularly after flood events.

The screening identified opportunities to incorporate climate risk management in the new infrastructure components of the programme and the potential to compile baseline data on health related effects of climate variability and extremes. In light of these limitations, recommendations were limited to:

- Compliance of programme infrastructure with existing regulations for climate hazards.

Opportunities exist to raise awareness and incorporate better monitoring of infrastructure compliance with government regulations on buildings in relation to climate related risks. As construction is tendered out and when contracts are awarded, the programme should require guidance with the construction firm to ensure compliance with government regulations.

- Baseline information on climate-related health impacts collected through DHS

The programme structure limits opportunity to build in policy related measures and baseline surveys as NGOs involved in programme implementation and delivery already stretched to meet current objectives. However, whilst it was felt that such baseline data could not easily be collected through UPHCP-II there is a strong case to include some additional questions in the Demographic and Health Survey (the DHS, funded by USAID for Ministry of Health), undertaken every 2-3 years for both urban and rural areas.

2.4.4 English in Action (EIA)

EIA focuses on developing innovative methods of teaching and learning which will complement existing activity and penetrate all areas of the country. It will significantly increase the number of people able to communicate in English to levels that allow them to participate fully in economic and social activity and opportunities.

Programme objectives and activities are judged to be only marginally affected by climate risks. However, EIA provides potential opportunities for greater awareness and dialogue on disasters and climate change by young people whose lifetimes will witness the significant projected changes in the climate. The screening therefore recommended that DFID undertake:

- Awareness raising, dialogue and the production of information and teaching materials on understanding of climate related hazards and guidance on mitigation and preparedness. Drawing on existing educational materials targeting climate change issues (ref. BHC, UNDP), activities could include:
    - Development of issues based education and training materials (e.g. flood, cyclone, drought);
    - Development of radio programme materials on climate change, disasters, adaptation, disaster risk reduction, early warning etc;
    - Development of posters on weather, climate and climate change issues as education materials and self study for different group of students and teachers.
    - Establishment of dialogue processes or young people to communicate their experiences and concerns to others in Bangladesh and internationally.

2.4.5 Second Primary Education Development Programme (PEDP-2)

This national programme will finance the 11 categories of school to deliver the government's primary education curriculum to over 17 million primary aged children per year. The PEDP-2 remit covers improvements to the built environment, educational resources and professional staff. DFID provides co-finance to Government of Bangldesh (GoB) along with eleven other development partners.

Principle climate risks to PEDP-2 stem from the nationwide construction of building and other educational facilities. 36,000 classrooms (new schools or extensions of old schools) have already been constructed as part of this programme, implemented by local government engineering departments. The current building plans follow a 'one size fits all' design with no limited account of local climate (and other) considerations. This results in both over-engineering of building built to higher specification than necessary as well as under-engineering.

Another key risk relates to the provision of water supply facilities for students and teachers. Ensuring that both quality and quantity of water supplies is sustainable in the medium term is a crucial consideration, but one which may not be afforded high priority given the multiple challenges of primary education provision in Bangladesh. Acknowledging these challenges and the multi-donor nature of the programme, the screening recommended that the DFID:

- Assess climate related problems due to 'one size fits all' school construction

The effectiveness of the infrastructure component of the project is limited by existing limitations in the design and construction of school classrooms. These tend to use a one-size fits all design that is not tailored to local hazard levels. A more detailed assessment of climate-related impacts on school infrastructure and factors contributing to resilient design across the country is recommended to raise awareness of climate risks and initiate dialogue on more locally appropriate design standards. This would primarily cover current climate stresses but could also consider future impacts using maps of projected inundation due to sea level rise, increase in cyclone hazard and estimates of future river flooding behaviour.

2.4.6 Chars Livelihoods Programme (CLP)

CLP targets extreme poverty in the Brahmaputra Chars area in northern Bangladesh through targeted provision of infrastructure and services, livelihoods activities, and influencing local and national policy and service provision. As a large-scale programme in riverine island (Chars) and riverbank areas, the screening highlighted risks to household and public assets through exposure to climate shocks and stresses, particularly riverbank erosion and flooding.

Science inputs suggest greater monsoon rains will increase riverbank erosion and extreme peak river discharges are likely to occur more frequently: The likelihood of the devastating 1998 flood reduces from roughly 1 every 50 years to 1 every 30 years in the 2020s and 1 every 15 years in the 2050s.

The screening noted how the CLP already targets vulnerability to a broad range of shocks and stresses and actively considers a range of current climate risks within its work. For example, livelihood promotion targets climate resilient activities, including poultry rearing to promote mobility, mobile identification cards, and flood compensation schemes. At household level, the project is facilitating the raising of homesteads onto mud banks above the 10 year flood level. A cost benefit analysis of this activity demonstrates economically prudent benefit-to-cost ratios even when future benefits are heavily discounted and high costs are assumed. Full results are shown in Section 4 of this report.

In addition, the screening recommended:

- Extending flood-proofing activities to public infrastructure in the Chars

A more detailed assessment needs to be conducted on how local transport, education, health, and water and sanitation infrastructure is currently affected by river floods and erosion. Dialogue with inhabitants, engineers and planners is necessary to devise appropriate design changes that limit anticipated impacts to an acceptable level.

- Screening diversification and enterprise activities for their climate-sensitivity

Future livelihoods and enterprise promotion will need to stress diversification of livelihoods strategies and be informed by participatory vulnerability assessment to develop locally appropriate responses that both reduce climate vulnerability and reduce poverty.

- Promote long-term adaptation by facilitating migration and remittances

Migration is already an important coping strategy for households, particularly during the seasonal food crises ('*monga*'). Improved empirical data on migratory flows, barriers and opportunities is required to enhance understanding and link with related urban services and remittances work.

- Incorporate climate issues into training, dissemination and awareness-raising activities

Materials should draw on local experiences of climate impacts and relate directly to char-dwellers livelihoods, informed by a participatory vulnerability assessment. This can draw on the Comprehensive Disaster Management Programme's Community Risk Assessments process and climate science inputs from this climate risk screening process.

2.4.7 Rural Infrastructure Improvement Project (RIIP-2)

In partnership with the Asian Development Bank and German technical assistance (GTZ), RIIP-2 will use locally sourced labour to help develop rural infrastructure in 23 of Bangladesh's poorest districts. Its remit covers rural roads, local market infrastructure, ferry jetties and local government public facilities, and the strengthening of local government delivery of rural infrastructure services to the poor. This includes improving the transparency and accountability of Local Government Engineering Department (LGED).

Rural roads and infrastructure are already exposed to regular climate shocks and stresses from temperature extremes, rainfall, riverbank erosion, floods and cyclones. Jetties in particular are prone to erosion and sedimentation. Currently, risk management practice only extends to resettlement, relocation and compensation policies for people displaced by road construction. However, rural infrastructure remains largely standardised, with limited attention to location, design, construction and maintenance to ensure that it can withstand commonly recurring flood levels in a given area.

Given the regular damage to rural roads and infrastructure during flood events documented by the Ministry for Food and Disaster Management, the screening highlighted the need to integrate of disaster risk assessments into technical assistance components of the programme. Central to this process is an examination of procedures for determining infrastructure location, design and strengthening LGED capacity on climate risk management.

This recommendation was taken on board during the design mission for RIIP-2, recognising the limited existing capacity of LGED and others. It proposes integrating disaster risk assessments in the context of the strengthening of best practice in social and environment impact assessment procedures necessary for the envisaged works.

On an initial practical level, this means improving existing hydrological assessments that feed into design and maintenance regimes. At a minimum, simple procedures for assessments need to be used in planning to ensure that Union Parishad buildings are not built in highly vulnerable locations. Where no alternative locations are available, they need to be built to withstand agreed levels of disaster event relevant to that area.

This requires improving the baseline data on impacts of hazards on infrastructure. This is central to informing the preparation of common guidance on disaster risk assessment and management for LGED, which can link with the ongoing work of the Comprehensive Disaster Management Programme. This work could also be complemented by a programme of training to local infrastructure maintenance groups on response options during extreme climatic events.

This intervention provides a good example of how the emerging risks from climate change can be used as an impetus for ensuring that investments manage current risks more effectively to build resilience for longer term change.

These assessments can also include a degree of additional resilience to cope with expected future climate changes during the investment lifetime, determined in consultation between LGED engineers and with the Department of Environment Climate Change Cell.

2.4.8 Economic Empowerment of the Poorest (EEP)

EEP is a pipeline Challenge Fund to finance the transformation of government, donor and NGO policies and programmes for tackling extreme poverty. Still in the planning stage, it will finance NGOs to develop innovative approaches to target both rural and urban areas to reduce extreme poverty and promote sustainable livelihoods.

The extreme poor are often the most exposed to climate hazards, particularly due to their location in marginal areas, and capacity to cope. The screening found a direct and statistically highly significant correlation between poverty and exposure to flooding in Bangladesh. With frequent extreme events in the country, tackling extreme poverty will need to target vulnerability to climate risks, and the programme could prove ineffective if these risks are not taken into account.

- Incorporating climate vulnerability reduction into funding criteria

The climate risk screening therefore recommended that reducing climate vulnerability through climate change adaptation and disaster risk reduction is among core considerations of the allocation criteria for funding of large and small scale projects under EEP. This has now been taken forward as part of programme design.

- Briefing and training programmes on climate change adaptation and disaster risk reduction

Given the relative infancy of climate change as an issue, briefing and training sessions need to be provided as part of a start-up phase for NGOs who express an interest in applying for funding. This could be undertaken in collaboration with the Comprehensive Disaster Management Programme, for which NGO outreach is an objective.

2.4.9 Roads and Highways Policy Management, budgetary and TA Support (RHD)

This programme of related interventions aims to strengthen the delivery and management of land transport at local and national levels. It provides technical assistance to improve accountability in Roads and Highways Department, establishes a Road Maintenance Fund and strengthens the capacity of the Transport Sector Coordination Wing in the Planning Commission.

Previous technical assistance programmes to the Roads and Highways Department (RHD) has successfully focused on engineering design and practice for road construction and maintenance. This considers the impacts of roads on the environment through environmental impact considerations and basic hydrological assessments, but the impacts of climate hazards on roads-related infrastructure are not factored into design or maintenance criteria.

While DFID-B assistance has improved the capacity of the RHD as an accountable and operational department, the impacts of climate hazards on the road network remain significant and largely undeveloped. During the 2004 flooding episodes alone, over 2,700km of roads in Bangladesh were destroyed, including 231km of the vital national trunk road network, for which the Roads and Highways Department (RHD) are responsible. Much of the damage to roads occurs through poor drainage facilities and saturation as well as inundation of the road itself.

Roads and transport play a vital role during disaster events in relief and recovery activities, and improving resilience against climate shocks and stresses will be increasingly important in light of climate change. This screening study undertook a cost benefit analysis for basic technical responses of raising road heights to maximum recorded flood depth and provision of related drainage. Elaborated in further detail in Section 4, it demonstrates a positive benefit to cost ratio for these measures for all but the most extreme cost assumptions. In addition, the screening recommended:

- Assessing climate-related impacts to roads and highways

Currently there is little systematised data on impacts. The screening recommended assessing and mapping the impacts from current hazards (particularly from flood, cyclone, salinity, rainfall, and extreme temperatures) on roads and highways. These baselines will enable integration of changing future hazard burdens, particularly floods and increased temperatures, drawing on science inputs for the screening process.

- Developing technical options for improved resilience

Understanding of techniques for reducing impacts remains limited in a Bangladesh context. The planned road-laying research element of the DFID-B assistance programme provides a useful entry point for examining impact assessments and developing suitable technical options to manage risks to an acceptable level of damage.

- Developing tools for regular climate risk assessment of roads

A medium term goal for the project is to combine the assessments of impacts and available technology to develop procedural tools for assessing climate risks to roads and highways. Integrated into design and maintenance policy, they would complement existing work on environmental safeguards.

- Improving awareness of disasters and climate change risk management

Research for the screening suggests a need to improve overall awareness within RHD on climate impacts and their management. A training and awareness programme among RHD staff relating climate change and disasters issues to RHD activities is therefore a priority. This could be carried out under activities of the Comprehensive Disaster Management Programme and the Government Bangladesh Climate Change Cell.

Section 3: Climate Scenarios and Impacts for Bangladesh

This section summarises findings on future scenarios for the climate in Bangladesh and its associated river basins. It then outlines the secondary impacts of such changes.

3.1 Future Climate Change Scenarios

To date, climate models have generally been consistent in simulating *warming throughout the country in all seasons, moderate increases in monsoon rainfall and moderate decreases in dry season rainfall.*

New climate change scenarios were generated based on a subset of climate models made available through the Intergovernmental Panel on Climate Change (IPPC) that best simulated the average rainfall during the main monsoon rainy season in Bangladesh. Changes were analysed based on two established scenarios of future greenhouse gas emissions, A2 (high emissions scenario) and B1 (low emissions scenario).

Projections for the Ganges-Brahmaputra-Meghna (GMB) basins include:

– Annual warming by the 2020s of 1.2°C (A2 and B1) and by the 2050s of 2.4°C (A2), 1.9°C (B1).
– Modest changes in annual rainfall by the 2020s (-1% (A2) and +4% (B1)).
– The seasonal rainfall changes are larger: drier winters (0% A2, -9% B1) and wetter monsoon summers (+4% A2, +8% B1). By the 2050s average changes are larger, with continued winter drying (-5% A2, -4% B1) and summer wetting (+9% A2, +10% B1).

In all seasons there are considerable differences between climate model simulations of future rainfall conditions; this emphasises the need to use a range of scenarios to represent the uncertainty in future climate change impacts. Table 3.1 below summarises findings and includes notes on the level of confidence of projections.

Table 3.1 Summary of climate change scenarios for Bangladesh and upstream basins.

Climate parameter	Future climate scenarios[1]	Confidence in projection[2]
Increasing temperatures[1]	**Warmer in all seasons.** Higher average temperatures likely to be associated with increase in extreme high temperatures.	High confidence, good agreement between climate models.
Change in rainfall amounts/ distribution[1]	Seasonal differences: **tendency for wetter monsoon (JJA), drier dry seasons (DJF)** Changes in the upstream basin region and Bangladesh broadly similar. See Tables 2 and 3 for details.	Medium confidence, less agreement between climate models on direction and magnitude of change.
Changing rainfall intensities[1]	Most models indicate wetter monsoon conditions. Likely to be associated with **higher rainfall intensities** causing higher peak flows in rivers and increases in flood magnitude/frequency. No clear signal of changes in variability in monsoon rainfall.	Medium confidence.
Droughts[1]	Given reductions in mean dry season rainfall it is likely that dry spells may increase/lengthen with negative consequences for water availability/soil moisture. Higher temperatures will contribute to increased evaporation losses, likely to worsen soil moisture deficits.	As for rainfall above. Likely to be a problem in areas already affected by drought. Medium confidence.
Cyclone and storm surge	Inconclusive – IPCC 2001 concluded that *'...there is some evidence that regional frequencies of tropical cyclones may change but none that their locations will change. There is also evidence that the peak intensity may increase by 5% and 10% precipitation rates may increase by 20-30%.'*	Low confidence, evidence points towards some increase in frequency/intensity.
Sea level rise (inc sedimentation and subsidence effects)	IPCC ranges; 2030s; 4.5 – 23cm (14cm used by NAPA) 2050s; 6.5 – 44cm (32cm used by NAPA)	High confidence, but wide range in estimates, depending on emission scenario and scientific uncertainties. Regional/local situation also important.

[1] Based on results from recent climate model experiments presented in this study.
[2] Considers inherent uncertainty of different variables produced by climate models and uncertainties due to differences between climate models (in particular some produce wetter conditions, some drier).

3.2 Secondary Impacts of Climate Change

This section summarises the secondary impacts of climate change on Bangladesh based on the future climate change scenarios discussed above.

3.2.1 Impacts on River Flows and Area Flooded

Bangladesh is mostly a low-lying delta formed at the confluence of three large rivers; the Ganges, the Brahmaputra and the Meghna (GBM). The Ganges and Brahmaputra have tended to be the main cause of major floods in Bangladesh. Extreme floods occurred in 1974, 1980, 1984, 1987, 1988, 1998, and 2004. Long term river flow records for the three rivers show slight increasing trends in peak flows of the Brahmaputra and Ganges, and no trend in the Meghna.

We follow a published approach to estimating future peak flows in the GBM basin by relating rainfall to river flows, and total maximum discharge to flooded area. We then derive estimates of total mean peak discharge and area flooded for the 2020s and 2050s with new climate change scenarios produced for this study (see Figure 3.1). Principle conclusions include:

- *Annual rainfall changes are modest, seasonal changes more significant:* The mean changes in annual rainfall from 10 climate models are relatively modest, even by the 2050s, however seasonal changes are larger but remain within 10% for the summer monsoon.
- *Monsoon rainfall increases:* Mean rainfall changes in summer monsoon are all positive suggesting wetter conditions in the future with A2 and B1 emissions in the 2020s and 2050s.
- *Flood magnitude and area flooded increases:* Rainfall changes produce similar size percentage changes in peak river discharges and larger percentage changes, mainly increases, in total flooded area. The recurrence interval for the devastating 1998 flood reduces from roughly 1 in 50 years to 1 in 30 years in the 2020s and 1 in 15 years in the 2050s.
- *Uncertainty in future flood conditions remains high:* While mean values are predominantly high, individual climate model results show a wide spread of rainfall changes and therefore potential future flood conditions.

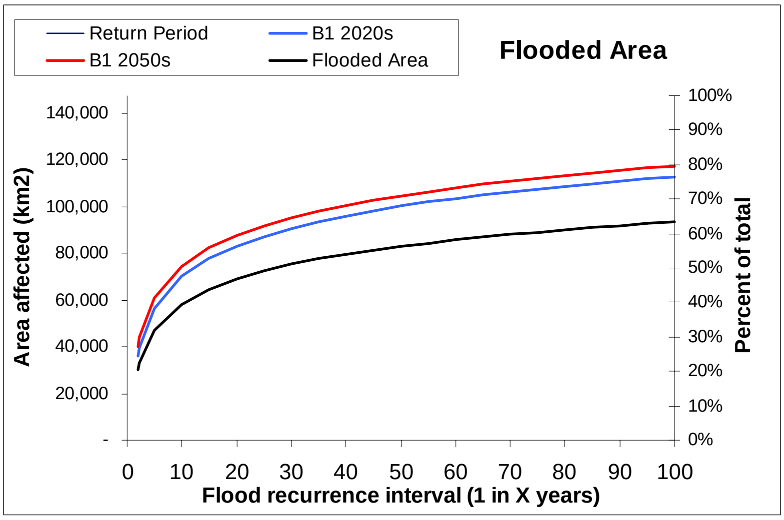

Figure 3.1: Increase in area and percentage of total area affected by flood from present situation (black line) to the 2020s (blue line) and 2050s (red line).

3.2.2 Impacts on Sea Level Rise (SLR), Coastal Inundation and Salinity Intrusion

Because of its low lying situation Bangladesh is very vulnerable to current coastal hazards and future sea level rise (SLR). Previous studies have highlighted the potential negative consequences of SLR, which are likely to be most serious through the effects of extremes such as storm surges. Drainage congestion is already a growing important problem in Bangladesh and is likely to be exacerbated by SLR and increased river flooding. We adopt generally accepted figures for SLR (Bangladesh NAPA, and IPCC) which suggest::

- *Increases in inundated areas* of up to 3% (2030s) and 6% (2050s): Primarily in coastal low lying areas (0 – 30 cm),
- Modelling studies show *salinity intrusions along much of the coastline*: Rates of intrusion vary with local conditions and are strongly influenced by dry season river flows and the rate of SLR**.**
- *Large uncertainties* associated with regional to district level estimates of inundation due to variable rates of uplift and sedimentation, river flooding and erosion.

3.2.3 Impacts on Cyclones and Storm Surges in Bangladesh

Roughly 3 to 7 cyclones hit the Bangladesh coast each decade year. About 53% of the total world deaths due to tropical cyclones have occurred in Bangladesh. There is some evidence that regional frequencies of tropical cyclones may change but none that their location will change. There is also evidence that peak intensity may increase by 5% to 10% which would contribute to enhanced storm surges and coastal flooding.

We calculate estimates of future wind velocity and surge height for the Bangladesh coastal zone, finding:

- *Cyclones may penetrate further inland and cyclone High Risk Areas are likely to increase in size:* Increases in the wind velocity and storm surge height result in further inland intrusion. The cyclone High Risk Areas (HRAs) of 8900 sq km will increase by 35% and 40% in the 2020s and 2050s, respectively.
- *The total population exposed to cyclone High Risk Areas is likely to increase:* The total coastal area is about 39 400 km^2 and population density is 930 person/km^2. Currently about 8.3 million people live in cyclone HRAs and, based on our results and projections of future population density, this will increase to 14.6 million in the 2020s and 20.3 million in the 2050s.

3.2.4 Impacts of Flooding on Agricultural Yields

There is a clear relationship between total damages and flood magnitude in Bangladesh. Our preliminary analysis at sub-national scale shows only weak relationships exist between agricultural yields (Boro, Aman and Aus crops) and river levels at key dates in the crop calendar. Changes in future flood frequency and extent will impact on agricultural yields but further analysis is necessary to quantify their impacts.

3.2.5 Impacts of Drought on Crop Production

Drought may affect crop production during three seasons Rabi, Pre-Kharif and Kharif. Existing work shows small changes in drought severity with one degree increase in temperature but substantial increased in stress with two degree increase for both Rabi and Kharif season.

Our climate change scenarios suggest moderate drying in the winter with implications for the Boro crop, although these will be mediated by availability of irrigation water. Higher maximum temperatures and increases in crop water requirements may negatively effect crop production but better understanding of current situation is required to quantify such effects.

Section 4: Cost Benefit Analysis (CBA) of Adaptation Options

This section discusses the appraisal of economic efficiency of selected adaptation options to extreme climate-related event risks of the DFID development assistance portfolio in Bangladesh via Cost-Benefit Analysis (CBA). The methodology developed was tested as a pilot study for selected intervention options within the DFID Bangladesh portfolio as part of the ORCHID project and should be understood as an exploration of the potential to conduct such analyses with available data and modelling techniques. Such an approach may inform the prioritization and implementation of efficient disaster risk management and climate adaptation ("no-regrets") options that help with coping with current and future extreme events as possibly increased in intensity and/or frequency by climate change.

4.1 CBA Methodology

The study uses two frameworks for the estimation and monetary quantification of disaster risk. The appropriate approach to be used depends on the objectives of the specific CBA conducted, the data situation and available resources and expertise. For this study:

- *An impact-based* framework was used to conduct a macro assessment of disaster risk and potential changes due to climate change on the national level.
- A *risk-based* framework was used to assess specific options for flood proofing of roads and highways nationally and of homestead in the Chars region.

4.2 CBA for Macro Assessment of Disaster Risk

In order to account for future changes in hazard frequency and/or intensity, the CBA draws on the results of the science components of this study. Given a lack of more detailed data, this economic analysis draws the assumption that economic impacts such as loss of assets would be proportional to area affected. Two vulnerability scenarios are then considered assuming different levels of adaptation.

The first scenario exemplifies a worst case, with no additional adaptation beyond current efforts and increased losses due to increased frequency of flooding (see Figure 4.1). This scenario reflects assumptions in the Stern Review on the economics of climate change.

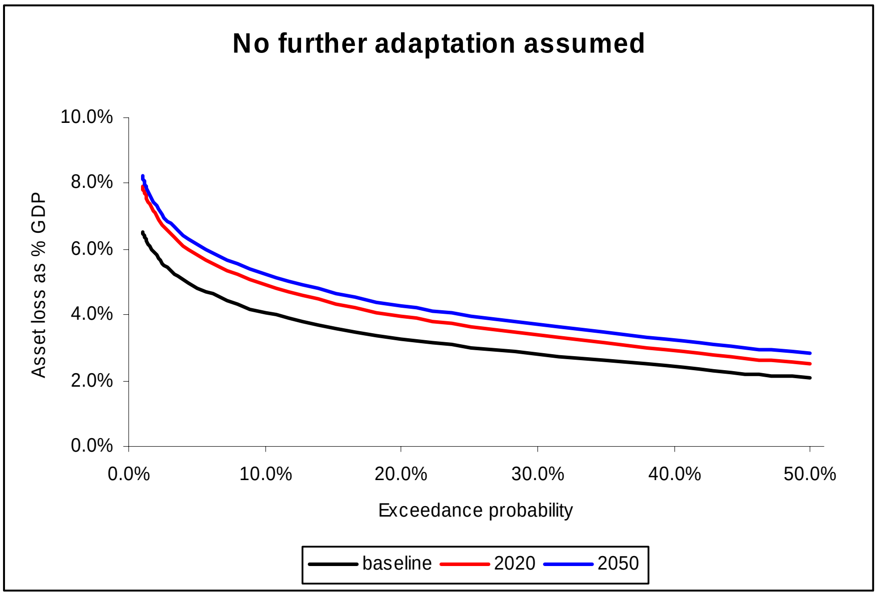

Figure 4.1: Asset losses for baseline, 2020 and 2050 without significant adaptation

In reality, it is likely that some degree of adaptive adjustment can be expected as a response to increasing losses. In the alternative scenario therefore, significant adaptation is assumed. The relationship is extrapolated from data on the reduction of losses in events in the past, for example where loss to life per event was reduced by two orders of magnitude due to better flood and cyclone preparedness measures. With such significant adaptation occurring, despite changing frequency of hazards, asset losses as a share of GDP would substantially be reduced (see Figure 4.2).

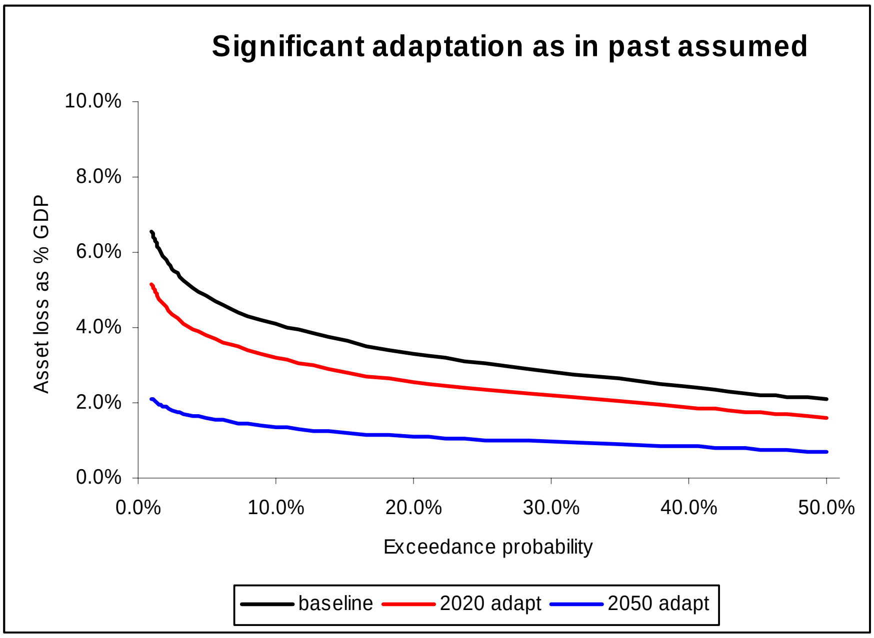

Figure 4.2: Asset losses for baseline, 2020 and 2050 with significant adaptation

Based on current loss estimates, annual economic asset losses from disasters currently amount to 0.6% of GDP per year. If no future adaptation is assumed, annual average losses could increase to 0.7% and 0.75% of GDP in 2020 and 2050. If significant adaptation is assumed based on past experience, annual losses would decrease to 0.5 and 0.2% of GDP for 2020 and 2050. These figures are shown in full in Table 4.1. These broad-brushed estimates indicate the potential for reducing risk through adaptation in the context of future climate change, although in reality, actual adaptation is likely to lie somewhere in between these scenarios.

Table 4.1: Losses for baseline, 2020 and 2050 with and without adaptation

	%	No further adaptation		Further adaptation assumed	
Return Period	Baseline	2020	2050	2020	2050
(T year)					
10	4.1%	4.9%	5.2%	3.2%	1.3%
50	5.8%	7.0%	7.3%	4.6%	1.9%
100	6.5%	7.9%	8.2%	5.1%	2.1%
Expected annual losses	**0.60%**	**0.7%**	**0.8%**	**0.5%**	**0.2%**

The representation of adaptation in this top-down assessment of necessity is broad-based, locale-unspecific and based on adaptation that occurred in the recent past. A key question for this assessment and the adaptation discussion in general (for example see Stern, 2007) is the extent to which such adaptation will occur “autonomously” or to which it will require specific planning and intervention.

In order to shed more light on these crucial issues, CBAs for two specific ongoing and planned adaptation options within the DFID-Bangladesh portfolio are analyzed using a more risk-based, bottom-up approach.

4.3 CBAs of Specific Adaptation Options

4.3.1 Flood-proofing of roads and highways by raising road height to the highest recorded flood and provision of adequate cross-drainage facilities

The first option considered the flood-proofing of roads and highways by raising this infrastructure above the highest ever-recorded flood levels within the DIFD-sponsored programme "Roads and Highways Policy Management, budgetary and TA Support" (RHD).

Specifically, some 170 Km of national and regional roads and some 518 Km of district (feeder) roads in high risk areas will be raised by 1m. In addition, about 124km of national and regional roads in low risk area will be raised by 0.5m. As the option comprises a long-term programme and since the costs would be very high if incurred at one time, it proposes action when a particular road is due for major maintenance or re-surfacing, with priority given to high risk areas.

Potential economic impacts on the roads and highways system were calculated from past flood events. The annual increase in risk from adding in climate change scenarios to the hazard burden amounts to roughly 2.6% per year, assuming linear increases over time. Assuming that roads and highways are flood-proofed to the highest ever-recorded flood and infrastructural rehabilitation costs due to floods can be avoided, the expected value of the benefits equals the area under the curves shown in Figure 4.3.

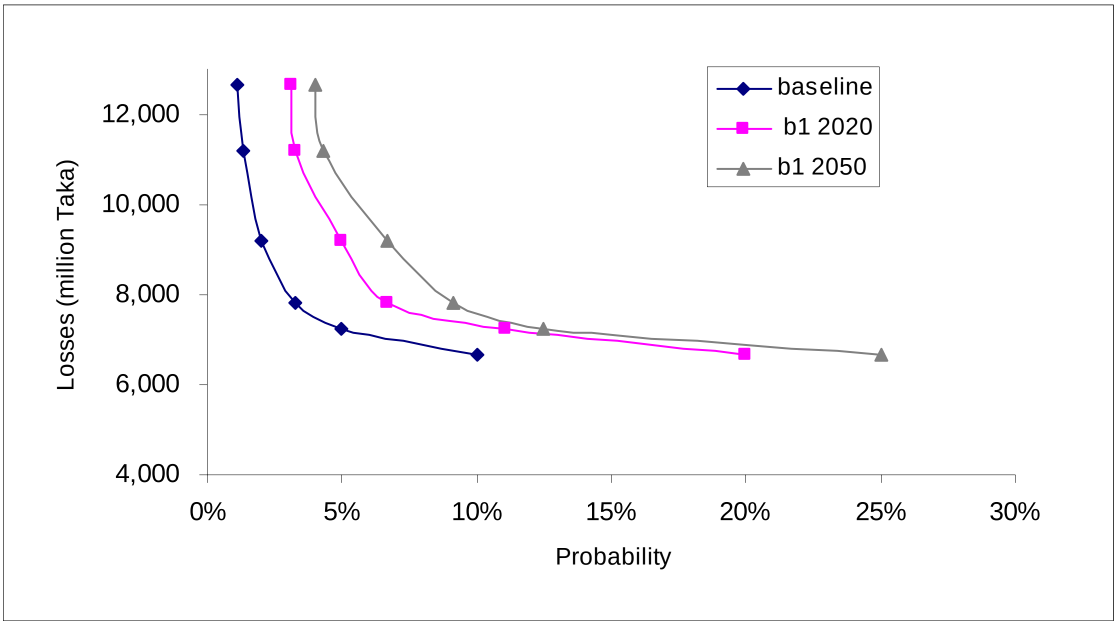

Figure 4.3: Potential impacts on the road sector (Current day baseline, 2020, 2050) for flood events of a given probability

Results of the cost benefit analysis calculations are shown in Tables 4.2 and 4.3. Although costly, the flood-proofing of RHD investments is efficient given the assumptions made. For the best estimate case, a positive benefit to cost ratio of 1.2-2.7 is calculated. It would mostly still be larger than 1 with more pessimistic assumptions such as costs increasing by 50%. If however, under very pessimistic assumptions, costs are increased and benefits are supposed to be decreased by 50%, then for all discount rates considered the option would not be efficient. This highlights the need, given lack of better data, for varying input parameters and studying the sensitivity of results.

Table 4.2: Overview over CBA calculations for RHD option for best estimate and 12% discount rate

Discount rate	12%							
Year	Calendar Year	Costs	Benefits	Net benefits: benefits-costs	Discounted costs	Discounted benefits	Discounted net benefits	
1	2007	352	70	-282	352	70	-282	
2	2008	352	144	-208	314	128	-186	
3	2009	352	217	-134	280	173	-107	
4	2010	352	291	-61	250	207	-43	
5	2011	352	365	13	224	232	8	
6	2012	352	438	87	200	249	49	
7	2013	352	512	160	178	259	81	
8	2014	352	586	234	159	265	106	
9	2015	352	659	308	142	266	124	
10	2016	352	733	381	127	264	138	
11	2017	352	807	455	113	260	147	
12	2018	352	880	529	101	253	152	
13	2019	352	954	602	90	245	155	
14	2020	352	1028	676	81	236	155	
15	2021	352	1101	750	72	225	153	
16	2022	352	1175	823	64	215	150	
17	2023	352	1249	897	57	204	146	
18	2024	352	1322	971	51	193	141	
19	2025	352	1396	1044	46	182	136	
20	2026	352	1470	1118	41	171	130	
21	2027	352	1543	1192	36	160	124	
22	2028	352	1617	1265	33	150	117	
23	2029	352	1691	1339	29	140	111	
24	2030	352	1764	1413	26	130	104	
25	2031	352	1838	1486	23	121	98	
	Sum	**8794**	**23853**	**15058**	**3090**	**4998**	**1907**	NPV
							1.62	B/C ratio
							12.1%	Estimated internal rate of return

Table 4.3: Benefit to cost ratio for current and future conditions

Scenario\Discount rate	**0%**	**5%**	**10%**	**12%**	**15%**	**20%**
Best estimate	2.7	2.2	1.8	1.6	1.4	1.2
Costs +50%	1.8	1.5	1.2	1.1	1.0	0.8*
Costs +50%, benefits -50%	0.9*	0.7*	0.6*	0.5*	0.5*	0.4*

*Not efficient

The raising of roads as suggested is highly expensive. However, as a long term project with national coverage, this option should be considered when a particular road is due for major rehabilitation, reducing substantial costs.

In addition to protecting roads infrastructure, the roads raising option will also generate a number of direct and indirect benefits, which are not factored into the analysis. These include social benefits which are difficult to quantify such as: avoidance of loss of human lives and livestock; use of roads as a refuge during the emergency period; and facilitation of the movement of relief goods during flood emergencies. Poverty reduction benefits will also accrue through employment opportunities during construction, repair and maintenance, which can target disadvantaged groups of people, particularly women.

4.3.2 Flood proofing of individual homesteads in the Char areas against 20 year floods by means of constructing raised earth platforms.

The second option considered in this analysis involves flood proofing individual homesteads against a maximum of 20 year floods on riverine islands, known as Chars, in Bangladesh. The option is already under implementation as part of the Chars Livelihoods Programme (CLP) through construction of earth platforms on beneficiaries land for the unit of a bari (homestead with 4 households).

The analysis calculates benefits of avoiding impacts of floods up to the 20 year flood (5% recurrency period), as shown for the current baseline, 2020 and 2050 cases in Table 4.4. As the option has a lifetime of 25 years, a climate-change induced annual increase of 2.6% in losses and benefits based on above calculations was used up to the year 2031 as for the RHD option.

Table 4.4: Flood Risk in the Chars: Now and projected for 2020 and 2050

Structural damage (main house) avoided (2007-TK)	Inventory damage avoided (2007-TK)	Income loss (2007-TK)	Other damages avoided*	Sum	Prob. baseline	Prob. b1 2020	Prob. b1 2050
591	0	355	0	946	50%	67%	67%
2,366	2,103	710	478	5,657	20%	33%	43%
5,159	5,594	1,419	1,911	14,084	10%	20%	25%
7,468	9,052	1,774	3,822	22,115	5%	11%	13%
				Expected losses (TK)	**4,118**	**7,790**	**9,528**

*Other damages include clean-up cost, loss of livestock, trees, gardens and other houses (including livestock shed, kitchen, toilets)

The homestead option was divided into two sub-options depending on whether or not the community will bear any associated costs.

Under the Option A, the CLP project will raise one common platform for 4 dwellings, each with 150 M^2 area and will reconstruct individual houses. Other infrastructure provision such as tube wells and sanitation will also be constructed by the project.

Under Option B, the project will only raise the common platform while the beneficiaries will reconstruct their individual houses, including making other infrastructure provision such as tube wells and sanitation. The analysis is carried out for both the cases.

Benefits, in terms of avoided economic damages include structural damages to the dwellings house, inventory (stocks and stores) damage avoided, income loss, and other damages avoided such as clean-up costs. Benefit to cost ratios for current and future climatic conditions are shown in tables 4.5 and 4.6, and in Figure 4.4.

Table 4.5: Benefit to cost ratio for homestead option for Option A

Interest rate	0%	5%	10%	12%	15%	20%
Baseline estimate	2.8	2.1	1.6	1.4	1.3	1.0
Costs +50%	2.4	1.7	1.2	1.1	0.9*	0.7*
Costs +50%, benefits - 50%	1.2	0.9*	0.6*	0.6*	0.5*	0.4*

*Not efficient

Table 4.6: Benefit to cost ratio for homestead option for Option B

Interest rate	0%	5%	10%	12%	15%	20%
Baseline estimate	3.2	2.6	2.1	1.9	1.7	1.4
Costs +50%	2.9	2.2	1.7	1.5	1.3	1.1
Costs +50%, benefits - 50%	1.4	1.1	0.8*	0.8*	0.7*	0.5*

*Not efficient

For best estimate cases, options A and B are beneficial given the assumptions. Option B scores higher, as costs for the project are reduced by the contribution of residents. If more pessimistic assumptions on costs and benefits are taken, both options eventually become inefficient with rising discount rates.

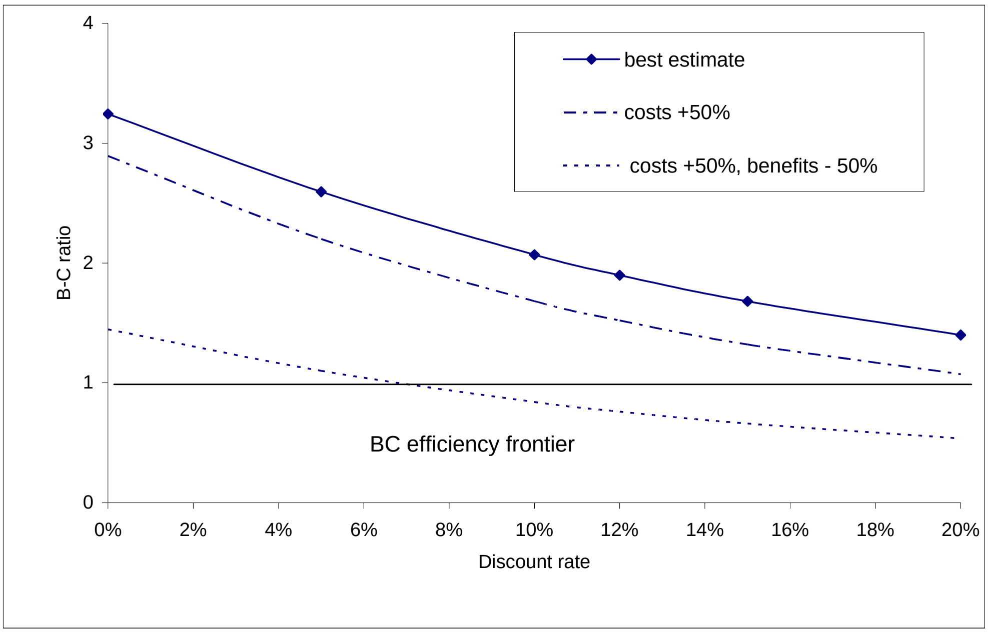

Figure 4.4: B/C ratio for homestead option B as function of discount rate

In addition to benefits calculated from flood damages avoided by the option, local people, particularly women, in Char areas gain opportunities to earn additional income from implementation of homestead raisin. These calculations suggest economic efficiency in raising homesteads in the Chars, particularly in light of climate change.