BANGLADESH: EXECUTIVE SUMMARY

Assessing the Investments & Financial Flows Required to Address Climate Change





UNDP ENVIRONMENT & ENERGY GROUP | DATE 2012?

Investment and Financial Flows to Address Climate Change UNDP Global Project

Climate Change poses significant challenges to development and policy makers are faced with complex tasks to respond to them and to ensure sustainable development. Particularly in Least Developed Countries decision makers have to balance poverty alleviation, economic development as well as social and environmental questions, while also questions of costs that occur with associated policies and measures play a vital role.

To better understand the magnitude of funds needed to tackle climate change now and in the long term, developing countries are undertaking assessments of investment and financial flows (I&FF) to address climate change for key sectors in a groundbreaking UNDP Environment & Energy Group project: Capacity Development for Policy Makers to Address Climate Change.

Bangladesh is one of 19 countries participating in this project, which was launched in May 2008 with the generous contributions of the Government of Norway, Government of Finland, Government of Switzerland as well as the UN Foundation and UNDP.

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Message
Stefan Priesner
UNDP Bangladesh

On behalf of UNDP, I express my satisfaction to partner with the Government of Bangladesh to support assessments to identify investment and financial flows needed to address climate change in key sectors. The assessment reports provide pragmatic approaches in estimating investments and financial flows to address climate change adaptation in the agriculture and water sector, as well as mitigation in the energy sector, which are important aspects to implement Bangladesh Climate Change Strategy and Action Plan, National Adaptation Programme of Actions and other actions to make the country's development climate resilient.

Climate change affects all sections of our society and almost all sectors of our economy, leaving particularly the poorer section of our society more vulnerable to this challenge. Bangladesh is facing the brunt of global warming and climate change in multiple dimensions. The lives of people, their livelihood, agriculture, infrastructure, access to potable water and energy are most vulnerable to the changing climate. It is satisfying to note that the Government has not limited its intervention to develop the Bangladesh Climate Change Strategy and Action Plan only but taking a proactive role for its implementation with its own funding.

UNDP has launched the global project "Capacity Development for Policy Makers to Address Climate Change ", to support countries to understand the magnitude of funds needed to tackle climate change now and in the long term, as well as to strengthen national capacities of decision makers on climate change. The results of this effort will also support the implementation of the Bangladesh Climate Change Strategy and Action Plan. We are very pleased that Bangladesh is participating in this project and has assessed the investment and financial flows to address climate change in key sectors of its economy. This is a substantive step to activate the process of addressing the issues of climate change in a practical and effective way. UNDP is proud to be part of this process.

We identify this endeavor as a fundamental effort to identify requirement of investment and financial flows to address climate change in Bangladesh and as the beginning of a journey to build a comprehensive approach for robust development plans and programmes that will be pro-poor and climate resilient and environmentally sustainable. We would therefore welcome any feedback and contribution in achieving this objective. It is our sincere hope that these documents would lead us towards practical actions for a sustainable Bangladesh.

Thank you.

CONTENTS

ACRONYMS

IF	Investment Flows
FF	Financial flows
O&M	Operation and maintenance costs
I&FF	Investment and Financial Flows
GDP	Gross Domestic Product
USA	United GOBs of America
UNDP	United Nations Development Programme
	United Nations
UN	United Nations
PDB	Energy and Power Development Board
TPP	Thermal Energy and Power South
GHG	Greenhouse gases
CO_2	Carbon dioxide (greenhouse gas)
RES	Renewable Energy
WAPDA	Integrated Water Resources
	Managemen
million	Million$
billion	billion$
tn.	Ton
m^3	cubic meter
km^3	Cubic Kilometers
MW	A measure of electrical Energy and Power
	(megawatt-hour of 1 MW = 1000 kWh)
Taka	The national currency of Bangladesh
%	Percent sign

1. INTRODUCTION

Bangladesh is most severely affected by climate change and that is internationally recognized. The impact of climate change will continue to be more severe as the international community is yet to agree on a mitigation measure that will stabilise the climate within an acceptable temperature level in the near term. It is essential that Bangladesh undertakes required adaptation measures in order to increase the country's resilience in areas including: health and social systems; agriculture; water resources, biodiversity and ecosystems; production systems and physical infrastructure including energy, and also pursue a clean development pathway, albeit subject to availability of financial and technological support, to contribute towards fulfilling of global goals of reduction of GHG emissions.

A general overview of the impact of changes in the climate parameters developed during the formulation of the National Adaptation Programme of Action (NAPA) in different sectors and geographical location is as follows:

The following are also the manifestations of climate change, as perceived by the local population in Bangladesh:

- Change in the flowering of fruits by delaying the flowering season.
- Rainfall in winter and pre-monsoon seasons has increasing trends all over Bangladesh except Bhola.
- Increase in tidal surge and the number of cyclonic events, and variation in tidal flow: Five deadly tropical cyclones (super cyclones) arising in the Bay of Bengal, during the last five years, were recorded in a study, four of which hit Noakhali and Chittagong coast with two of them causing havoc in coastal districts and beyond.
- Increase in the frequency of flash flood: During the past 25 years, Bangladesh has experienced six severe floods. In 2007, two severe floods visited the country in the same season. River bank erosion is common during high floods that results in loss of

CLIMATE & RELATED ELEMENTS	CRITICAL VULNERABLE AREAS	RESULTANT IMPACT
Temperature rise and drought	North-west	Agriculture (crop, livestock, fisheries)
		Water scarcity
		Energy
		Health
Sea Level Rise and Salinity Intrusion	Coastal Area, Island	Agriculture (crop, fisheries, livestock)
		Water (water logging, drinking water, urban)
		Human settlement
		Energy
		Health
Floods	Central Region, North East Region, Char land	Agriculture (crop, fisheries, livestock)
		Water (urban, industry)
		Infrastructure
		Human settlement
		Health
		Disaster
		Energy
Cyclone and Storm Surge	Coastal and Marine Zone	Marine Fishing
		Infrastructure
		Human settlement
		Life and property
Drainage congestion	Coastal Area, Urban, South West	Water (Navigation)
		Agriculture (crop)

thousands of hectares of agricultural land and even whole villages.
- Increase in surface temperature: A study found that surface air temperature is increasing at the rate of 0.03-0.060C/decade. The Sea Surface Temperature has increased by 0.470C over the past 50 years and at the rate of 0.0940C/decade.
- Increases have occurred in droughts and dry spells, storms and hailstorms.
- Intensity of mist fog in the winter has increased.
- Monsoon rainfall has shifted, requiring shifts in land preparation and crop plantation in respect of Kharif II.
- Severity of cold and its duration are decreasing
- Because of reduced winter period, insect infestation in the crop field is increasing.

Numerous studies have predicted that Bangladesh will be most severely affected due to global warming and rising sea level, melting of Himalayan glaciers, intensified natural calamities and water scarcity leading to loss of livelihood and rising unemployment and poverty. Furthermore, a rise in the sea level of about one meter would cause permanent coastal submergence (of up to 17 % of the country) that will displace about 15% of the national population. The interactions of environmental degradation and climate change could have severe consequences, especially for the poorer segments of the population, who do not possess coping mechanisms. Climate change for Bangladesh is a development issue as well as a human security issue, and poses to some extent an existential threat. It is argued that the signs of the intensifying future changes have already begun to become apparent. Climate change is a big challenge threatening the survival of millions people of Bangladesh and its potential for destabilizing many of the natural systems is immense.

Over the past many years, the Government of Bangladesh has invested over US$10 billion to make the country less vulnerable to natural disasters. These investments, in many cases supported by development partners, include flood management schemes, coastal polders, cyclone and flood shelters, and the raising of roads and highways above flood level. In addition, the Government of Bangladesh has developed state-of-the-art warning systems for floods, cyclones and storm surges, and is expanding community-based disaster preparedness. The research community is also active in developing climate resilient varieties of rice and other crops.

The challenge for Bangladesh at present is to scale up these investments to create a suitable environment for the economic and social development of the country and to secure the well-being of the people, especially the poorest and most vulnerable groups, including women and children. The Government of Bangladesh's vision is to eradicate poverty and achieve economic and social well-being of all the people. To contribute towards achieving this goal, a pro-poor Climate Change Management Strategy has been adopted, which prioritizes adaptation and disaster risk reduction, and also voluntarily focuses on low carbon development. Its proper implementation calls for adequate technology transfer and provision of adequate international finance.

The UNDP global project "Capacity Development of Policy Makers to Address Climate Change" is a timely initiative to assist the developing countries in assessing the investment and financial needs to address climate change issues, using a common method so that comparable estimates can be generated. The outcome of the project will also help the countries in their negotiations in the UNFCCC process on the financial issues. Particularly for Bangladesh, the I&FF assessment to address climate change impacts in the selected sectors will be useful for the decision makers and planners to discuss, debate and further refine the estimates in their efforts to allocate funds to deal with the impacts of climate change.

1.1 Objectives

The objectives may be categorized as follows:
- To identify and describe the various options and actions related to addressing impacts of climate change in the selected sectors – agriculture, water management and energy.
- To assess investment and financial flows needed for combating climate change in Bangaldesh in the energy, water and agriculture sectors till 2030.
- To ensure that reliable information to deal with the impacts on the above mentioned three sectors in monetary terms are available to the policy makers and those who are responsible for integrating climate change adaptation and mitigation measures in the national plans.

- To develop technical knowledge and methodologies to assist in estimating costs and prioritizing and sequencing robust adaptation strategies in the development plans and budgets of Bangladesh.
- To inform the international community's efforts in mobilizing additional resources needed to enable developing countries adapt to climate change.
- To assist the policymakers of Bangladesh in their efforts to further articulate the national positions in the UNFCCC negotiations.

1.2 Reasons for the choice of sectors

The sectors for the I&FF assessment for addressing climate change impacts in Bangladesh were selected based on the importance of the sectors in the national socio-economic setting and the extent of likely impact of climate change in those sectors. On this basis, the three sectors that become prominent are agriculture, water and energy.

Bangladesh being one of the worst victims of climate change has to give importance to adaptation to climate change impacts that would fall to a large extent in the agriculture, energy, and water sectors. At the same time, to strive for becoming a middle income (middle living standards) country, Bangladesh has to accelerate its economic growth and that will require manifold increase in the demand for energy. In order to further lower the carbon footprint in achieving this goal, low carbon development path has been chosen. Bangladesh accounts for only a negligible 0.3 tonnes per capita per annum. Moreover, as an LDC Bangladesh is exempted from mandatory mitigation activities. Energy sector has been chosen as it has high potential for mitigation. Agriculture and water are the main climate change impact sectors urgently needing proper adaptation. This selection process has also taken consideration the priorities expressed at first interministerial dalogue of this project. In addition, it was decided to include the assessments on advocacy and awareness, and policy implications in relation I&FF analysis.

1.2.1 Production and consumption of energy - climate change mitigation

Evaluation of investment and financial flows for the energy sector is based on an analysis of energy efficiency measures both in terms of production and use of environment friendly energy. Energy, both primary and secondary energy, is a basic sector of the economy, the level of development of which both depends on and supports the implementation of national plans to accelerate the socio-economic growth.

In recent years, the development of energy sector of Bangladesh received a prominent impetus from the need to meet the growing demand of domestic consumers and various socio-economic and other sectors. The import of energy supplies from neighboring countries has also assumed an important policy stance. The energy sector of the country is the largest consumer of natural gas.

Inventory of greenhouse gas (GHG) emissions in 2005 shows the bulk of GHG emissions in Bangladesh comes from, energy-related activities (85%), including GHG emissions from fuel combustion and methane from activities related to oil and gas. Other sectors that contribute to GHG emissions include agriculture, transport, and domestic and commercial activities.

1.2.2 Water management - Adaptation to Climate Change

Water sector is the sector on and through which climate change impacts overwhelmingly play out. Water management is critically important in Bangladesh as the country's water sector is characterized by too much (monsoon, June-October) or too little (dry season, Janyary-May, particularly March-April) water. In the "Initial National Communication" under UN Framework Convention on Climate Change, noted that "Bangladesh is one of those regions that may be most affected by global warming." In particular it will affect agriculture, which is based mostly on irrigated agriculture. But water is critical with regard to the prospects of other sectors as well.

Anticipated increase in air temperature and decrease in annual rainfall, as a result of climate change, leads to decreased water flow, increased evaporation from water surface, and changes in the hydrological cycle, which ultimately affect the availability of irrigation water. Preliminary calculation shows that the flows of the local rivers will decline by more than 30%. In the water balance of Bangladesh, the contribution of the Ganges, Brahmaputra, and Meghna (GBM) basins is about 90% of the total flow. According to specialists, the GBM runoff may

decrease by 10-15%, which will significantly affect the total water resources of Bangladesh. Agricultural prospects in Bangladesh are largely dependent on the availability of water for irrigated agriculture. To ensure sustainability of agriculture and the need to meet other growing need of water, the management of the impact of climate change on water is important.

All adaptation measures, which are discussed in this paper, aimed at water management in the country in the context of the evolving climate change should help guarantee sustainable development of water sector and ensure adequate water resources for agriculture and other pruposes.

1.2.3 Agriculture – Ensuring food security in the changing climate

The important considerations for the agriculture are the infrastucture that will be affected by climate change, increased salinity in the coastal areas and river erosion that will reduce land availability and can lead changes in the land use pattern, and the climate parameters that will necessitate the development and diffusion of new crop varieties and adjustments in the cropping pattern and have implications for livestock, poultry, fishery, and plantation.

Reduction of crop yield by gradual change and total or partial damage due to extreme events are key impacts facing by crop agriculture sector. Damage of crop is a key effect of climate variability and extremes. Flood (all types) and cyclone damage standing crops severely. In addition to direct climate and climate related disaster, other key factors of yield reduction are degradation of soil health by sand deposition and erosion of cultivable land.

1.3 Previous Analyses Utilized

Bangladesh had submitted the first national communication in response to the UNFCCC COP decision. The second national comunications is in its final stages of submission. The second national communication makes in-depth study on potential mitigation options for Bangladesh and also reviewed the adaptation needs due to climate change impacts. Besides, there are national policies and strategies related to the three sectors, already in place, which have been taken into consideration in the analysis for I&FF assessment. Bangladesh also participated in the Asia Least Cost Greenhouse Abatement Strategy (ALGAS) of the Asian Development Bank. The ALGAS study was mainly for GHG assessment using guidelines provided by UNFCCC and to develop projects for mitigation. Two important documents made use of in the context of this exercise are the NAPA and the Bangladesh Climate Change Strategy and Action Plan (BCCSAP). Other available and useful materials hae also been utilized as apprppriate.

1.4 Institutional arrangements and collaborations

The first inter-ministerial dialogue held in November 2008 participared by the senior officials of the selected sectors was the starting point of the institutional cooperation for the I&FF assessment. The report of this dialogue provided the substantive basis and priorities for the analysis. This was followed by the Orientation Workshop held in Nivember 2009 in which the relevant officials of the three sectoal ministries, the planning commission and other concerned government agencies and private sector and NGO representatives participated. A Mid-term workshop was also held in November 2010 in which relevant stakeholders from the Government and civil society were invited. The recommendations from those dislogues and workshops generated ideas about the scope of the study and helped in identification of experts and officials to be part of the I&FF assessment process. Finally, the workshop held in May 2011 provided comments on the contents of the draft assessment that helped in finalising the assessment reports.

The project is implemented by the Ministry of Environment and Forests (MoEF). The Secretary of the Ministry is the National Focal Point (FP) for climate change and in this capacity is also the lead person of the Country Team (CT) of this project. The Secretary provided policy guidance to it and maintained overall oversight of the activities through the Joint Secretary (Development), MoEF who was designated as the Administrative Focal Point (FP) of the project for coordination of the project implementation activities. Three sectoral teams have carried out the activities of the project in the three key sectors. Two other teams with responsibility for policy and advocacy and awareness have supported this study. To

produce a consolidated report as the executive summary of the project, Babgladesh Unnayan Parishad together with a support staff was selected.

While the MoEF was the lead ministry for the study, the Ministries of Agriculture, Water Resources and Power & Energy took the lead in their respective sectors. Other ministries with cross-cutting or cross-thematic or inter-sectoral linkages such as the Ministries of Food and Disaster Management, Health, Land, Fisheries & Live-stock, LGE&C, Communication, Science & Technology, Industries, Commerce, Finance, and Planning played useful roles in the thematic area consultative groups together with relevant civil society representatives, NGOs, academia and think tanks.

1.5 Basic methodology and key terminology

Each of the sectoral assessments of I&FF performed the following steps, which include the eight basic steps facilitated by UNDP:

1. Set the key evaluation parameters (broder sector, sub-processes, activities and organizations)
2. Collect relevant (historical, current and projected) information to develop scenarios
3. Develop determine the baseline scenario on each sector
4. Scenarios for mitigation / adaptation
5. Perform an assessment I&FF and O&M for the baseline scenario
6. Perform an assessment I&FF and O&M for the scenario to mitigate
7. Calculate the change in IF, FF and O&M expenditures necessary to implement the required mitigation/adaption processes
8. Develop policy recommendations
9. Prepare sectoral reports (Energy, Water and Agriculture)
10. Agree and get the reports approved by the relevant ministries and partners.

Key Concepts

1. A baseline scenario, which reflects a continuation of current policies and plans, i.e., a future till 2030 without any new measures taken to address climate change (otherwise referred to as a "business-as-usual" scenario), and
2. A climate change scenario till 2030, in which new mitigation measures are taken (a "mitigation scenario") and new adaptation measures are taken (an "adaptation scenario").

The cost accounting parameters include two distinct types of money flows: investment flows and financial flows.

- An "investment flow" (IF) is the capital cost of a new physical asset with a life of more than one year, such as the capital cost of a new agricultural irrigation system or flood control embankments. Investment flows are limited to new physical assets because such investments have climate change implications for the duration of the operating lives of the facilities and equipment purchased.
- A "financial flow" (FF) is an ongoing expenditure on programmatic measures. Financial flows encompass expenditures other than those for expansion or installation of new physical assets. Examples of financial flows include expenditures for an agricultural extension program for farmers, a malaria prevention program e.g. distribution of mosquito nets, or the implementation of improved forest management techniques.
- "Operation and maintenance" (O&M) costs are separate from the IF and FF flows. These costs relate to the operation and maintenance of the investments made to address climate change issues.

Other concepts used in this study are given below:

- An "investment entity" is an entity responsible for an investment. In this report, three types of investment entities are used: families, companies and government.
- The "sources of I&FF funds" are the origins of the funds invested by investment entities, e.g. domestic equity, foreign debt, domestic subsidies, foreign aid.
- A "scenario" is an internally consistent and plausible characterization of future conditions over a specified period. For example, for assessment of I&FF for adaptation in the water sector, the team used a baseline scenario and an adaptation scenario.
- The "evaluation period" is the time horizon for assessment i.e. the number of years.
- The "base year" is the first year of the assessment period, that is to say the first year of initiation of adaptation and mitigation activities.

2. SUMMARY OF SECTORAL ASSESSMENTS OF I&FF

2.1 Energy Sector

Traditional sources of energy such as firewood, tree leaves, crop residues and animal wastes currently account for half of the country's energy consumption. Only 40 percent of the population have access to electricity with per capita consumption of 136 kwh per year which is the lowest in South Asia. As of 2008, the installed capacity including those owned by independent power producers was 5,202 MW of which 4,130 MW was feasible. This capacity for power generation, even with the recent additions of generation capacity, is insufficient to meet the growing demand for electricity.

The two principal primary energy resources in Bangladesh are natural gas and coal. Coal deposits have been discovered in five locations in the northern districts but extraction is taking place only from Barapukuria for 250 MW power production. Imported crude oil and refined petroleum are also used to meet the energy demand. Natural gas as of now meets 75% of all commercial use of energy in Bangladesh, out of which 55% is used for generation of grid and captive power. The non-energy sectors such as fertilizer production, manufactiring and tea production, residential use and transport also account for an important share of the use of natural gas. Imported coal is mostly used for running the brick kilns.

2.1.1 Scope of the Sector

The potential scope for the energy sector is vast and it is the prime mover of the economic and social development touching almost all sectors. In view of resource and time limitation, the I&FF assessment for the present would include the primary energy sources, supply and demand for primary and secondary energy (electricity), and industrial use under the folowing headings:

Supply side

1. Production of Primary Energy: Natural Gas and Coal
2. Production of Secondary Energy: Electricity (generation, transmission and distribution) and Liquid Fuels

Demand Side

1. Demand for Primary Energy: Natural Gas (for electricity and fertilizer production & boilers) Coal (for electricity and brick manufacturing)
2. Demand for Secondary Energy Grid Electricity (supplies for iIndustrial, commercial uses and to households), CNG and liquid fuels for transport

2.1.2 Base year Assessment Period

The time horizon proposed for the analysis is 25 years beginning with the "base year" 2005 and ending in the "framework year" 2030. In this study a new base year, 2010, was chosen. This means that all future costs have been discounted to 2010. The reason for this choice is the large price escalations in the early 2000s for which using historical data prior to 2005 does not serve much useful purpose. Inflation rate of 6 percent has been used in the assessment, while the discount rate for present value conversion is 12 percent.

Sources of data: Bangladesh Bureau of Statistics and the Ministry of Energy and its affiliated agencies such as the Power Development Board, Petrobangla and to a lesser extent the Rural Electrification Board are the major sources for the data used. The O&M calculations relied on data gathered from secondary sources available nationally and internationally and from research papers, published reports and personal contacts.

2.1.3 Mitigation Measures are Included in the Assessment of I&FF

A number of GHG mitigation measures such as switching to low-carbon and renewable technologies, increasing energy efficiency in both demand and supply sides, and reducing demand for carbon-intensive products are among the possibilities. Given the time and resource constraint, this study focused only on switching to low carbon intensive technologies as a way to mitigating GHG emissions from the use of fossil fuels.

The following GHG mitigation sectors/areas have been taken into consideration along with the findings of the Second National Communication (SNC).

- Primary energy: gas and coal
- Secondary energy production (only power)

- Transport – road, rail and water
- Energy intensive industries – bricks (direct users of primary energy)
- Cross-sectoral options: boilers and motors

Some specific measures proposed for cosideration in various studies:

- Retiring the obsolete and worn-out steam turbine plants
- Conversion of existing gas turbine plants to cobined cycle plants.
- Construction of new super critical power plants;
- Harnessing grid level renewable energy sources (wind, solar, biogas)
- Use of clean coal technologies
- Vehicle fuel use efficiency improvement
- Shift to more fuel efficient transport mode- road to railway and water ways
- Introduction of fuel efficient technologies in industries such as Hybrid Hoffman Kiln replacing the present inefficient Fixed Chimeny Kiln.
- Efficiency improvement in industrial boilers with installation of economizers, installation of pre-heaters, and installation of auto blow down systems
- Efficiency improvement in motors to reduce electricity consumption

2.1.4 Incremental I&FF for the Energy Sector for 2010-2030

The incremental I&FF for mitigation in the energy sector over 2010-2030, as estimated by the Energy Sector Study is shown in th following Table. The amount comes to US$13.84 billion in 2010.

Mitigation Scenario

Costs of Mitigation: Costs for GHG mitigation include the expenditure on developing and deploying low-emission and high-efficiency technologies and the cost to consumers of switching from emission-intensive to low-emission goods and services. These are additional costs due to climate change.

Mitigation cost concerning primary energy for the options selected in this study is US$51 billion with the O&M cost being $15 billion over 21 years. The mitigation cost for the secondary energy is US$31 billion with O&M cost over $10 billion. The mitigation cost for T&D is over $9 billion.

Incremental Changes in IF, FF, O&M Costs, and Subsidy Costs

Incremental changes represent the difference in all types of investments in the mitigation scenario compared to the baseline scenario. It will be seen from the Table below that a total of US$26.6 will be required to lower the carbon footprint in selected interventions in the energy sector. These estimates do not account for potential costs associated with substitution of fossil fuels by supplies from renewable options, DSM type activities and energy efficiency projects and programs.

Costs of Mitigation Measures

SECTOR	INDUSTRY	MITIGATING MEASURES	INVESTMENT COST (MILLION USD)	O&M COST (MILLION USD)	TOTAL COST FOR THE SECTOR (MILLION USD)
Primary energy	Coal production	Mitigation in coal mines	209.73	159.15	368.88
Secondary energy	Electricity generation				
	Natural gas simple cycle	Conversion of simple to combined cycle	611.19	-42.12	569.07
	Natural gas combined cycle	Add CO_2 scrubber to combined cycle	7,737.9	1102.15	8840.05
	Coal conventional	Add Desulf/DeNox unit & CO_2 scrubber	1,934.13	4,263.34	6,197.47
	Electricity transmission and distribution	T&D rehabilitation	217.86		217.86
	Transport	Shift from road to railway & waterway	230.27		230.27
Energy intensive industry	Brick industry	Establishment of HHK brick kilns	681.28	8,415.59	9096.87
Cross sectoral	Boilers and motors	Addition of energy efficiency (EE) equipment	1,089.11		1,089.11
Total Incremental Cost:	12,711.47	13,898.11	26,609.58		

2.1.5 Investment Organization

The government of Bangladesh is the major investment entity to assess I&FF and internal budgetary source of I&FF for the energy sector. Therefore, the realization of all investments offered in this paper will only be possible with public funds or foreign grants/credits secured/guaranteed by the government.

2.1.6 Recommendations for Policy Makers

Given that the savings in gas can be realized in the foreign market at a price of per 1 m3, the country's budget will earn a further sum of about $ 8 billion (proposed) for the years 2010-2030, which fully covers the additional costs (billion U.S. dollars) for the implementation of the mitigation scenario. A number of measures to save energy, provided in the mitigation scenario can be implemented as Clean Development Mechanisms, which will attract additional investment finances.

Policies in energy conservation should focus on improving the norms and standards in the field of energy, such as target setting standards for the efficiency of power plants and fuel rate for energy consumption. It is important to develop a national program for energy conservation, which will establish the main strategic tasks, such as the annual reduction in energy intensity of GDP, the achievement of targets for energy efficiency in various sectors of the economy.

The legal basis for implementing energy efficiency measures for energy conservation should be established by enacting a law on energy conservation, aimed at promoting energy conservation, creating the foundation for GOB regulation in the field of energy use and development of renewable energy (RE). To stimulate the introduction of renewable energy sources in the energy balance of the country, the law may provide tax incentives for investment in renewable energy and exemption from import duties on equipment for renewable energy.

For the investment of energy efficiency measures and the development of renewable energy sources can serve as GOB fund energy efficiency, financed by saving of energy efficiency measures. In order to implement productive activities and strategies for energy efficiency, a National Body should be established in Bangladesh, which will be responsible for carrying out GOB policy on efficient use of energy resources and energy conservation.

2.1.7 Key Uncertainties and Methodological Limitations

At the time of this I&FF assessment, development program for energy until 2020 and until 2030 was not approved by the Government. Energy and Power legislations on energy conservation was developed over 20 years ago. They are outdated and inconsistent with the realities of the present time. As the uncertainty it may be noted a significant increase in the dollar against the national currency in 2005, which impacted on the fact that the assessment costs for the period 2020-2030 O&M years based on data from 2005.

Table 2: Incremental Annual IF & FF for All Investments in Energy Sector

Category of Investment Entity	Incremental Cumulative Discounted IF, FF & O&M Estimates (in million 2010USD)														
	Primary Energy			Power			T&D			Transport			All Types		
	ΔIF	FF	ΔO&M	ΔIF	FF	ΔO&M	ΔIF	FF	ΔO&M	ΔIF	FF	ΔO&M	ΔIF	FF	ΔO&M
2010	37.04		-341.44	261.53		0.00	17.03		0.00	18.00		0.00	333.60		-341.44
2011	39.19		-340.21	361.78		6.64	16.12		0.00	17.04		0.00	434.12		-333.58
2012	41.01		-338.99	570.66		15.76	15.25		0.00	16.12		0.00	643.05		-323.22
2013	42.99		-337.77	980.31		36.45	14.44		0.00	15.26		0.00	1053.00		-301.31
2014	140.72		-336.55	1196.11		53.70	13.66		0.00	14.44		0.00	1364.93		-282.85
2015	47.52		-328.22	676.41		227.19	12.93		0.00	13.67		0.00	750.53		-101.03
2016	50.10		-327.40	594.31		252.32	12.24		0.00	12.94		0.00	669.58		-75.07
2017	149.93		-326.56	562.47		274.11	11.58		0.00	12.24		0.00	736.22		-52.44
2018	55.98		-319.67	532.34		292.84	10.96		0.00	11.59		0.00	610.87		-26.83
2019	59.32		-319.12	503.82		308.78	10.38		0.00	10.97		0.00	584.48		-10.34
2020	62.97		-318.54	476.83		322.17	9.82		0.00	10.38		0.00	559.99		3.62
2021	66.94		-317.94	451.28		333.23	9.29		0.00	9.82		0.00	537.34		15.30
2022	71.27		-317.30	427.11		342.19	8.80		0.00	9.30		0.00	516.47		24.89
2023	75.98		-316.64	404.23		349.23	8.32		0.00	8.80		0.00	497.33		32.59
2024	81.12		-315.96	382.57		354.54	7.88		0.00	8.33		0.00	479.90		38.58
2025	86.72		-315.26	362.08		358.27	7.46		0.00	7.88		0.00	464.14		43.01
2026	92.82		-314.53	342.68		360.59	7.06		0.00	7.46		0.00	450.02		46.06
2027	99.47		-313.79	324.32		361.63	6.68		0.00	7.06		0.00	437.53		47.84
2028	106.71		-313.02	306.95		361.52	6.32		0.00	6.68		0.00	426.66		48.50
2029	114.59		-312.25	290.50		360.39	5.98		0.00	6.32		0.00	417.40		48.14
2030	123.18		-311.45	274.94		358.34	5.66		0.00	5.98		0.00	409.76		46.89
TOTAL	1645.57		-6782.60	10283.22		5323.37	217.86		0.00	230.27		0.00	12376.92		-1459.23

2.2 Water Resources Management Sector

Bangladesh being a riverine country with too much water during the monsoon and too little during the dry season, and the lowest riparian of three major river systems—the Ganges, the Brahmaputra, and the Meghna, its water sector and its peculiarities have attracted researchers of various disciplines for a long time. The Government also from time to time developed master plans, perspective plans, strategies. and action plans to deal with the water related issues and to enhance food production. The latest such documents are the National Water Management Plan (NWMP) and the Bangladesh Climate Change Strategy and Action Plan (BCCSAP). Use has been made of these documents in this study. There are also other outcomes of assessments related to climate change such as the Economics of Adaptation to Climate Change conducted by the World Bank, and a research report - Economic Modeling of Climate Change Adaptation Needs for Physical Infrastructures in Bangladesh prepared by the Climate Change Cell of the Ministry of Environment and Forests, which have also been used in the analysis. Besides, the annual development programmes of the Government gives the financial allocations during the financial years, which have been used in the business as usual scenario.

2.2.1 Scope of the Sector

The climate change impact on water sector is widespread, encompassing all economic sectors such as agriculture, energy, industry, health, communication, and also involves most infrastructures, land and the livelihood of the people. Based on the suggestion of the first interministerial dialogue, the vulnerability due to climate change and the priority needs for adaptation in Bangladesh, the following aspects of the water sector of Bangladesh have been included in this assessment of I&FF.

- Flood management
- Drought management
- Water supply and sanitation
- Urban drainage
- Storm surges and cyclone
- Erosion control.

2.2.2 Base Year, Assessment Period and Costing Parameters

In this study, year 2010 is considered as baseline investment period. For future IF and FF calculations, next 20 years (up to year 2030) have been considered as the assessment period. The accounting unit is constant 2005 U.S. dollar and a conversion rate of 1 USD=BDT 70 has been used.

2.2.3 Description of the Adaptation Measures for which I&FF have been assessed - Summary of Evaluation of I&FF

Baseline Scenario

Ministry of Water Resources published the National Water Resources Management Plan (NWMP) in 2004, in which a total of 84 projects are listed under eight clusters as the detailed investment portfolio. In this study, the baseline projects for I&FF assessment were selected considering their relevance to climate change adaptation needs and the scope of the study. The NWMP's investment portfolios for 29 programmes have been included in the baseline scenario. The main focus of those programmes are improvement of flood control and drainage infrastructures, land reclamation, protection of coastal areas, flood protection including urban areas, urban drainage improvement, river erosion control, irrigation and drought management including surface water development, water supply and sanitation provision in urban and rural areas, and addressing arsenic contamination in drinking water. The assessment of I&FF in the selected areas for the baseline scenario is shown in the following table:

Cumulative Discounted I&FF (IF, FF and O&M) Estimates, by Investment Type, Investment Entity and Funding Source (in million US$)

Funding source	Coastal protection	Erosion control & dredging	Flood protection & management	Irrigation & drought management	Urban drainage	Water supply & sanitation	Grand Total
	Total	Total	Total	Total	Total	Total	
Beneficiary	194	61	197	158	1,094	11,433	13,138
Government	615	393	530	201	3,014	5,758	10,510
Private	-	-	-	-	-	1,398	1,398
GRAND TOTAL	**809**	**455**	**727**	**359**	**4,108**	**18,589**	**25,046**

Adaptation Scenario

The same areas like coastal protection, erosion control and dredging, flood protection and management, irrigation and drought management, urban drainage and water supply and sanitation considered in baseline have also been considered for I&FF assessment for adaptation scenario. As for the selection of programme areas once again the NWMP programmes have been taken up but this time in conjunction with the Bangladesh Climate Change Strategy and Action Plan (BCCSAP) of 2009. BCCSAP is a 10-year programme (2009-2018) for adaptation and mitigation activities and capacity building and to make the country resilient to climate change. This document has the flexibility include additional programmes beside the 44 programme areas already identified, if justified in view of new and emerging challenges and new knowledges arising from new assessments.

A total of 33 investment programmes have been planned to be implemented over a period of next 20 years till year 2030 for I&FF assessment to address climate change issues for adaptation in water sector. These are mainly based on 13 adaptation, food security and disaster related programmes of BCCSAP and the rest selected from the NWMP that fall in the adaptation catagory in the water sector. These programmes can be categorised as infrastructure development for protection against cyclones and floods, river training works including resuscitation of river networks through dredging and other measures, soil salinity control, improvement of disaster warning system, repair and maintenance of existing polders, water supply and sanitation. The I&FF estimate for the selected areas of water sector are shown in the table below:

Table: Adaptation Scenario: Cumulative Discounted I&FF (IF, FF and O&M) Estimates, by Investment Type, Investment Entity and Funding Source (in million US$)

Funding source	Urban drainage	Coastal protection	Erosion control & dredging	Flood protection & management	Urban drainage	Water supply & sanitation	Grand total
	Total	Total	Total	Total	Total	Total	
Beneficiary	194	61	167	1,160	12,151	375	14,109
Government	1,182	516	3,146	3,729	6,880	1,716	17,169
Private	2,572	302	1	857	1,551	2,173	7,457
GRAND TOTAL	**3,948**	**879**	**3,314**	**5,747**	**20,582**	**4,263**	**38,734**

2.2.4 Incremental I&FF

A total of USD 13.69 billion is estimated as incremental adaptation costing for major investment components in the water sector. Majority of the investment proportion is planned to be invested for the flood management (26%) followed by protection of coastal zone (23%), irrigation and drought management (22%), water supply and sanitation (14%), urban drainage (12%) and erosion control and dredging (3%).

Coastal protection: Effective management and up-gradation of existing polders and construction of additional new polders; provision of support to scale up afforestation and reforestation; development of coastal green belts as a measure against storm surges, Repair, maintenance and construction of cyclone shelters for protection against storm surge; Improvement of existing cyclone forecasting and warning systems; Analysis of meteorological data to improve prediction of changes in patterns of cyclonic events (US$ 3139 mil);

Erosion control and dredging: Planning, design and construction of river training works; planning, design and implementation of resuscitation of the network of rivers and khals through dredging and de-siltation work; river dredging for navigation (US$ 425 mil);

Flood protection and management: Flood forecasting system – improvement of the existing flood forecasting and early warning systems by increasing lead times and strengthening dissemination mechanisms; flood evacuation shelters – establishment of multipurpose shelter more as well as management of infrastructure; flood zoning, flood insurance, adjustment of cropping calendar, watershed management; flood management infrastructure – effective management and up-gradation of existing flood management infrastructures such as polders, embankments, sluices, pump stations (US$ 3537 mil);

Irrigation and drought management: Food security, social protection and health – institutional capacity for research towards climate resilient cultivars and their dissemination, development of climate resilient cropping systems and production technologies, adaptation against drought, salinity submergence and heat; supplementary irrigation and drought proofing of rural water supplies, improving water distribution networks (US$ 2956 mil);

Urban drainage: Improvement in the urban drainage capacity including pumping provisions, detention storages; restoration of pervious surfaces for enhancing infiltration capacity; design and construction of adequate sewers in new urban areas (US$ 1639 mil);

Water supply and sanitation: Effective conservation of water; harvesting rainwater; recycling and reusing water; construction of deep tube wells; desalinization of saline water (US$ 1992 mil).

2.2.5 Investment Organization

Although it was planned in the NWMP that different investment programmes were to be started from year 2001, but its implementation was based on the allocation that was made in the ADP making reference to NWMP. For the purpose of this assessment,it is assumed that all the investment programmes will be started just after the current year (2011). Based on this a total of USD 5,441,089 million is proposed to be invested over the next 19 years period (2012-2030). Majority of the investment will be made for the development of water supply and sanitation facilities in the rural and urban areas (60%), followed by 14% of total investment for urban drainage, 12% for major river development and water management and 4% for flood protection.

The main source of investment for the sector i.e. “water management“ in Bangladesh is national. For the development of water infrastructure large amounts of funds are allocated from the country’s own resources through the Ministry of Water Resources of Bangladesh. Hence, the implementation of adaptation measures proposed in this paper will only be possible with public funds or foreign grants and loans secured or guaranteed by the government guarantee.

2.2.6 Recommendations for Policy Makers

For the sustainable development of the sector i.e. “water management“ in Bangladesh is necessary to improve the national management efficiency and regional water relations. Including:

- Transition from administrative district based approach to water management to the project/ programme approach e.g. management of irrigation

systems within Integrated Water Resources Management (IWRM) framework
- Take evaluation-based measures to make water user associations and farmers associations more purposeful and effective
- Introduction of payment for water use in a gradual manner
- Encouraging the introduction of new technologies that economize irrigation water use
- Increased breeding work on the cultivation of drought-and salt-tolerant crops
- Improving regional cooperation for transboundary water sharing and management.

2.2.7 Key Uncertainties and Methodological Limitations

1. The main uncertainty may be noted as the absence of a formally approved action program in the water sector for the period up to 2030 that can serve as the basis for determining the baseline scenario. The NWMP has been used as a guide in determining the baseline scenario.
2. Cost calculations of adaptation activities have been made without developing specific projects for implementation.
3. Although climate change is evident in many ways, the pattern, the nature and instensity of of climate change is still uncertain.
4. The persistent uncertainty in respect of regional management of regional water resources at the governmental level in South Asia.

2.3 Agriculture Sector

Sectoral Overview

Agriculture is the most important sector of Bangladesh economy due to its role in food security, employment and livelihood. The current share of agriculture to GDP is around 21%, although this share has been declining in the last ten years along with the one of the agricultural sub sectors. Still more than 70% of the people in Bangladesh are directly or indirectly employed in this sector (Karim and Islam 2010). The agriculture of Bangladesh is dominated by crops which accounts about half of total agricultural GDP Fisheries & livestock are also important sub-sector contributing to agricultural GDP. It is important to note that in the recent decade the subsector of livestock, forestry and fisheries had faster growth rate.

Rice dominates Bangladesh agriculture covering more than 80% of the land area. The production of main staple rice has shown a long term growth trend of 2.8 percent per annum over the period from 1981/82 to 2006/07. During 1997 to 2005, Boro acreage substantially increased with the reduction of rain-fed Aus which showed about 6.3 percent annual growth during the same period. Boro rice accounts for about 60 percent of total food grain production. During recent years both production and area of wheat, oilseed and pulses have greatly reduced. The growth of pulses was only 0.3% while sugar was negative 1.2% other than rice and potatoes all other crops showed the decline in growth rate.

Livestock: In 2006-07, total cattle population of the country was about 23 million, buffaloes 1.21 million, goat and sheep 23 million and poultry and duck 246 million. The production of milk, meat (beef, mutton and chicken) and eggs had an increasing trend over the past several years. However, its total production is still far below the national requirements. The milk production showed slow growth but sustained growth while recently meat production is slightly decreasing. On the other hand, the egg production largely fluctuates due to avian influenza.

Fisheries: Long term growth rate in production of fish during 1971 to 2007 was 2.5%. During 2001-02 to 2007-08 total fish production increased from 1.89 million MT to 2.59 million MT with an average annual growth rate of 5.3%, while inland fish and cultured fish production had growth rates of 8.2% and 4.2%, respectively. Overall shrimp production has increased steadily over the last 20 years, but still much lower than that of the neighbouring countries such as Thailand with 800 kg/ha (Samsak et al. 2005) and India with 600 kg/ha (Vasudevappa, 2005). Among shrimp producing countries, Bangladesh ranks fourth with respect to area under shrimp farming and sixth in volume of production.

Agro-Forestry: Over 10 million homesteads in about 88 thousand villages across the country possess a large quantity of trees. These homesteads are the major suppliers of fruits and wood for the nation. The role of the homesteads in growing stock. The total forest area in Bangladesh

is 2.53 million hectare in 2007; but all do not necessarily carry tree cover. The tree covers 48.8% of the forest land. The present study includes agro-forestry. In this non-food forest sector is not included as forestry is a large separate sector.

Climate Change impacts

Likely substantial reduction in crop yields as a result of changing and shifting rainfall and weather conditions, degradation soil quality due to climate change and extreme climate events as well as reduction of agricultural land due to river and coastal erosion, and salinity ingress and permanent inundation of coastal lands due to sea level rise faced by agriculture pose huge food insecurity scenario in the coming decades.

Loss of and damage to crops is another key effect of climate variability and extremes. Flood (all types) and cyclone cause damages to standing crops severely. Department of Agriculture Extension (DAE) under the Ministry of Agriculture has estimated that 1.39, 1.26 and 14.48 lakhs hectares of crop land was affected by flood in 2005, 2006 and 2007, respectively. The danages were understandably much larger as a result of the particularly devastating the widespread and particularly devastating floods such as those of 1998 and 2004. Cyclone Sidr has fully damaged 300,940 ha of Transplanted Aman and partially damaged 700,533 ha (Draft report on cyclone Sidr, CDMP).

Usually adverse impacts of climate change on soil quality and its subsequent effects on crops are not recognized. Experts interviewed informed that temperature variation could increase biotic activity of the soil and increase deficiency of soil nutrient and is likely to reduce crop production. Flood, however, has both positive and negative impact on soil. Sand cover degrades the quality of soil, while silt deposition improves soil quality and has positive impact on crop production.

Future Impacts

Various studies indicate that a temperature rise of 1 to 2^0C in combination with lower solar radiation causes sterility in rice spikelets. High temperature was found to reduce yields of HYVs of aus, aman and boro rice in all study locations and in all seasons. The effect was particularly evident at a rise of temperature by 4^0C. Climate changes, especially in temperature, humidity and radiation, have great effects on the incidence of insect pests, diseases and microorganisms. A change of 1^0C changes the virulence of some races of rust infecting wheat (Rahman, 2005).

It was noticed that temperature increase of 4°C would have severe impact on food-grain production, especially for wheat production. On the other hand, carbon-dioxide fertilization would facilitate food-grain production. A rise in temperature would cause significant decrease in production of 28 % and 68 % for rice and wheat respectively. Moreover, doubling of atmospheric concentration of CO_2 in combination with a similar rise in temperature would result into an overall 20 % rise in rice production and 31 % decline in wheat production. It was found that boro rice would enjoy good harvest under severe climate change scenario with doubling of atmospheric concentration of CO_2 (Karim et al., 1999).

The apparent increase in yield of boro (dry season rice crop generally grown under irrigated conditions and includes high yielding varieties) and other crops might be constrained by moisture stress. A 60 % moisture stress on top of other effects might cause as high as 32 % decline in boro yield, instead of having an overall 20 % net increase. It is feared that moisture stress would be more intense during the dry season, which might force the Bangladeshi farmers to reduce the area for boro cultivation. Shortfall in foodgrain production would severely threaten food security of the poverty-ridden country.

Under a severe (4°C temperature rise) climate change scenario, the potential shortfall in rice production could exceed 30 % from the trend, while that for wheat and potato could be as high as 50 % and 70 % respectively (Karim, 1996). Under a moderate climate change scenario the crop loss due to salinity intrusion could be about 0.2 Mt (Habibullah et al., 1998). The loss of production due to such effects may be relatively higher compared to that under floods. However, the loss incurred in other sectors could be much higher in case of floods than the direct climatic changes. The effect of low-flow on agricultural vulnerability is considered to be much less intense compared to other effects. The ultimate impacts of loss of food grain production would increase import of food which will require spending hard currency.

2.3.1 Scope of the Sector

Bangladesh grows 46 economic crops of which rice are the dominant, producing more than 33 million metric tons annually. Besides, about 8.0 million metric tons of potato, 0.79 million metric tons of oilseed and 0.66 million metric tons of pulses are produced. All these crops require temperature between 18-25°C and are highly sensitive to fog, cloud and change in humidity. Results from crop simulation studies examining climate change impacts on agriculture showed a negative impact on crop productivity in Bangladesh.

Fisheries, livestock and forestry sectors are also largely affected by climate change variability. The impact is aggravated by disaster, flood, rising salinity, changing course of the rivers etc. It affects habitat's alteration, fish reproduction, fish migration, natural fish breeding and fish biology. Livestock production is also affected by the climate changes due to reduction in the quality and availability of feed, water, increased diseases and other environmental stresses. The assessment in this sector included the crop agriculture, fisheries and livestock, and a separate study on rice and few other crops as part of crop agriculture as a case study.

It is to be noted that in the agriculture assessment only government expenditures were analyzed, not those from corporations or households.

2.3.2 Base Year, Assessment Period and Costing Parameters

In this study, year 2011 is considered as baseline investment period. This base year is the single year which builds the first year of both baseline and adaptation scenario. For future IF and FF calculation, the next 20 years (up to year 2030) have been considered as the assessment period. In order to address inflation and fluctuation in values of Bangladesh currency (BDT), the accounting units are U.S. dollars in 2005 constant values and a conversion rate of 1 USD=BDT 70 has been used. We enumerated all costs valued in constant 2005 US dollars values using the conversion rate and future costs were discounted at a rate of 5% for computation of present value at 2005 constant price, the formula used was $P_n = P_t/(1 + r)^t$, where Pn is present value of investment, P_t= is investment cost in year t, r = interest rate, 5%.

2.3.3 Description of the Adaptation Measures for which I&FF have been assessed - Summary of Evaluation of I&FF

Base Line Scenario

The baseline scenario for IF, FF and O&M were assessed for this study within the following 17 programme areas: 1. Awareness building. 2. Infrastructure development, 3. Disaster preparedness, 4. Disaster rehabilitation, 5. Research, Technology generation and knowledge management, 6. Agricultural extensions, 7. Livestock development, 8. Fisheries development, 9. Food and nutrition security, 10. Wet land conservation , 11. Biodiversity management, 12. Improved agricultural production and adaptation practices to reduce emissions of green house gases from agricultural land,13. Agro-processing & agri-business development, 14. Market infrastructure development, 15. Irrigation and water management, Irrigation and water management adaptations includes cannel digging, capital dredging, development of irrigation structure, improving water distribution system, increasing on-farm irrigation efficiency, training of water users association/groups, etc. Some of these programmes of Ministry of agriculture (MOA) may overlap with water sector programmes in Bangladesh under Monastery of water resources. 16. Agro-forestry, 17. Coastal zone management.

For adaptation investment planning, the same investment heads as of the baseline investment like have been considered. A total of 17 investment programme areas have been planned to be implemented over a period of next 20 years till year 2030. The following programmes were identified for detail IF and FF calculation in the agriculture sector.

Table - Various adaptation to climate change in agriculture of Bangladesh

BROAD PROGRAMME AREAS	SPECIFIC ADAPTATION
1. Awareness building	Specific extension and mass media programmes
2. Infrastructure development	Construction and repairing of roads and embankments
3. Disaster preparedness	Climate services, cyclone shelters, training and awareness
4. Disaster rehabilitation	Construction and management of food storage, silos, etc; distribution of inputs (seeds, fertilizers, saplings).
5. Research, Technology generation and knowledge management:	Development of climate resilient cultivars, species and management practices and the specific on-farm adaptation measures.
Crops:	Varietal development: salt and draught tolerant varieties, management practices: short maturing varieties, fertilizer and soil management trials
Livestock:	Development of livestock species tolerant to climatic conditions, Animal health and diseases, Feeds and fodder production, Animal insurance, special breeding and
Fisheries:	Technology generation for increasing shrimp and fishery productivity, dredging of rivers, channels, community based management of water bodies and rehabilitation of fishers
6. Agricultural extensions services development	Technology disseminations: salt and draught tolerant varieties, improved farming practices for crops, livestock and fisheries, sustainable supply of inputs (seeds, fertilizers, breed, feed, fingerling, vaccines, etc.), irrigation and water management, soil fertility management (conservation and restoration of soil quality), plant protection and epidemiological surveillance.
7. Livestock development	Expanding veterinary health services, disease control, feeds and fodder production, special breeding and biogas production.
8. Fisheries development	Management of water reservoir, improved sanctuaries, disease control, improvement of fish landing sites and market infrastructure development, enhanced R & D and for climate resilient species development and management practices, protection of fish habitat from intrusion of slat water and establishment of improved hatchery
9. Food and nutrition security	Ensuring food availability, access, and utilization
10. Wet land conservation	Dredging, development of mangroves, sanctuary management and alternative income generation activities
11. Biodiversity management	Regeneration and protection of biodiversity in varied ecosystems and promotion of improved management practices.
12. Improved agricultural production & adaptation practices to reduce emissions of green house gases from agricultural land	Adaptation measures on land management practices including different form of tillage and conservation agriculture towards ensuring ecology and reduction of emissions from agricultural land in the diversified agricultural system(crop, fisheries, livestock and agro-forestry).
13. Agro-processing	Promoting climate resilient agro-processing technique, value chain management specifically HRD and post harvest loss minimization
14. Market infrastructure development	Creation of facilities at all stages from farm to fork, development of long term storage facilities and quality control
15. Irrigation and water management	Improved water reservoir, channels, rivers and improved distribution system and on-farm water management technology, restructuring of land use based on availability and productivity. Interventions in this programme area is focused to increase water productivity and solely on the agriculture system.
16. Agro-forestry	Improved nursery plantation an d management practices, development of climate resilient species, training on nursery and plantation
17. Coastal zone management	Polder management towards enhanced agricultural productivity, development of improved drainage, land suitability zoning, and agricultural intensification, , climate resilient technology and improved management practices, establishment of special agricultural R & D centres, market development, promotion of off-farm activities, agro-tourism and human resettlement

Adaptation scenario assumes implementation of the necessary adaptation measures for climate change conditions for the sustainable provision of agricultural needs for water for irrigation. As mentioned above, water scarcity can be about 5.5 km 3 without the expansion of irrigated area. Specific indicators for the calculation of investment in specific activities, such as Solar Irrigation system-an introduction of advanced irrigation methods are the same as the baseline. Due to the fact that the implementation of these activities in the adaptation scenario assumes a substantially larger area, their total value has grown. The list of key adaptation measures as defined by experts, includes:

- Improving water resources management (transition to integrated water resources management)
- Optimization of the distribution of agricultural production with due regard for the needs of the country in need of agricultural production and minimize the use of water resources (here the need to consider the development of economic and mathematical models of optimization of distribution of agricultural production)
- Implementation of measures that increase efficiency of irrigation systems - reconstruction of canals and hydraulic structures, the implementation of anti activities, etc.
- The introduction of advanced irrigation methods (drip, sprinkler irrigation) and the improvement of existing (traditional), namely, the use of siphons, tubes
- Implementation of a comprehensive reconstruction of irrigated land. Complex reconstruction includes the following activities: Per capita intake of water, Main canal and distribution network, Sprinklers and spillway, the waste network, Drainage network, A capital planning, Pumping stations (if available), Maintenance of the road.
- Implementation of measures to improve the reclamation of land used - performed on lands that do not require complete reconstruction. In general, this work is the reconstruction and, if necessary, additional construction of collector-drainage network
- Construction of additional reservoirs and increasing capacity of existing ones. The latter include such reservoirs as required in drought area in Northern district.
- Reconstruction of existing and construction of new hydraulic structures that reduce waste and water management, etc
- Implementation of breeding work on the cultivation of drought resistant crops
- The possibility of the involvement of additional water (slightly saline drainage water, underground water and sewage) and their quantitative capabilities.

2.3.4 Incremental I&FF

US$ 39.67 billion is needed to adapt to the effects of climate change in the agriculture sector through the implementation of 17 measures:

- Awareness building: Specific extension and mass media programmes (US$ 30.8 mil);
- Infrastructure development: Construction and repairing of roads and embankments (US$ 11791.0 mil);
- Disaster preparedness: Climate services, cyclone shelters, training and awareness (US$ 599.0 mil);
- Disaster rehabilitation: Construction and management of food storage, silos, etc.; distribution of inputs (seeds, fertilizers, saplings) (US$ 4010.1 mil);
- Research, technology generation and knowledge management: Development of climate resilient cultivars, species and management practices and the specific on-farm adaptation measures (US$ 173.7 mil);
- Agricultural extensions: Technology disseminations – salt and draught tolerant varieties, improved farming practices for crops, livestock and fisheries, sustainable supply of inputs, seeds, fertilizers, breed, feed etc.), irrigation and water management, soil fertility management (conservation and restoration of soil quality), plant protection and epidemiological surveillance (US$ 1488.7 mil);
- Livestock development: Expanding veterinary health services, disease control, feeds and fodder production, special breeding and biogas production (US$ 664.4 mil);
- Fisheries development: Management of water reservoir, improved sanctuaries, disease control, improvement of fish landing sites and market infrastructure development, enhanced research and development for climate resilient species development and management practices, protection of fish habitat from intrusion of salt water and establishment of improved hatchery (US$ 823.4 mil);
- Food and nutrition security: Ensuring food availability, access and utilization (US$ 1919.6 mil);

- Wetland conservation: Dredging, development of mangroves, sanctuary management and alternative income generation activities (US$ 819.9 mil);
- Biodiversity management: Regeneration and protection of biodiversity in varied ecosystems and promotion of improved management practices (US$ 432.5 mil);
- Reducing emission of greenhouse gases from agriculture land: Adaptation measures on lang management practices including different form of tillage and conservation agriculture towards ensuring ecology and reduction of emissions from agricultural land in the diversified agricultural system (US$ 888.7 mil);
- Agro-processing & agri-business development: Promoting climate resilient agro-processing technique, value chain management specifically post harvest loss minimization (US$ 763.5 mil);
- Market infrastructure development: Creation of facilities at all stages from farm to fork, development of long term storage facilities and quality control (US$ 6630.2 mil);
- Irrigation and water management: Improved water reservoir, channels, rivers and improved distribution system and on-farm water management technology, restructuring of land use based on availability and productivity. Interventions focused to increase water productivity fort the agriculture system (US$ 5775.4 mil);
- Agro-forestry: Improved nursery plantation and management practices, development of climate resilient species, training on nursery and plantation (US$ 284.1 mil);
- Coastal zone management: Polder management towards enhanced agricultural productivity, development of improved drainage, land suitability zoning, and agricultural intensification, climate resilient technology and improved management practices, establishment of special agricultural research and development centres, market development, promotion of off-farm activities, agro-tourism and human resettlement (US$ 2577.2 mil).

2.3.5 Investment Organization

Necessary incremental investments will have to be fully funded by the government, 29% of investments will be needed for infrastructure development, 17% for market infrastructure development and 15% for irrigation and water management.

2.3.6 Recommendations for policy makers

Two types of policy recommendations follow from the above for the public sector. First, there must be adequate attention to capacity building for investments but more so for O&M. Particularly if these investments are made for generation of new technology and their dissemination, O&M remains a major area for budgetary support. This is more so because if support to agriculture in the form of subsidy is continued it may be unsustainable over the long run, Hence rather than continuing with diffusion of old technology through subsidy, it would be better to expend resources for developing new ones which may provide farmers with more opportunities and flexibility. Such findings indicate the need for longer-run efforts to contain the impact of climate change, rather than simply one-off investments. The findings for farm household investments, O&M and other financial flows show that attention should be paid more to the last category than others. In case of investments, if these are non-equipment capital formation (e.g., land improvement), the role of the community may be crucial for collective action for raising productivity of natural resources such as land.

2.3.7 Key uncertainties and methodological limitations

Many of the estimates may be quite sensitive to the assumptions made. Yet, this provides certain lessons for prioritisation of allocation of resources. First, investments and O&M are of similar importance. It was found to be true for projects evaluated officially and also as estimated here. Thus capacity building and logistics for sustained efforts to make investments pay is required. Note further that future subsidies have not been projected. These may remain a major issue if farmers are to be encouraged to adopt new technology under adaptation. Second, for the farm household, investments, O&M and more particularly expenditures related to other financial flows are extremely important both in case of baseline as well as for adaptation. Particularly, here probably capital formation through land improvements rather than the conventional capital acquisition is more important.

3. SUMMARY OF TABLES OF INCREMENTAL INVESTMENT COSTS

Table: Cumulative discounted IF and FF for all investments in each sector, by investment entity and funding source. Incremental cumulative (2005-2030) discounted sectoral investments (million 2010 US$).

INVESTMENT CATEGORY	FUNDING SOURCE		MITIGATION			ADAPTATION					
			Energy			Agriculture			Water		
			ΔIF	ΔFF	ΔO&M	ΔIF	ΔFF	ΔO&M	ΔIF	ΔFF	ΔO&M
Households	Total	-	-	-	-	-	-	-	6	38	9719
Corporations	National	Total	-	-	-	-	-	-	-	-	-
	Foreign	ODA	-	-	-	-	-	-	-	-	-
	Total		7546.1	-	397.32	-	-	-	0	7071	0
Government	National	National Budget	-	-	-	-	-	-	-	-	-
	Foreign	Loan	-	-	-	-	-	-	-	-	-
		Bilateral ODA	-	-	-	-	-	-	-	-	-
		Multilateral ODA	-	-	-	-	-	-	-	-	-
		Total foreign source	-	-	-	-	-	-	-	-	-
	Total		5605.5	-	984.64	27700.1	5361.5	6613.2	743	4956	3315
TOTAL		-	13152.6	-	1381.96	27700.9	27700.1	5361.5	6613.2	12065	13034

Negative values mean net savings
IF = Investment Flows, FF = Financial Flows
ΔI&FF = incremental changes of Investment and Financial Flows
Source: National I&FF assessment

Table 2: Annual IF and FF for all investments in each sector.
Annual sectoral investments (million 2005 US$)

Year	Mitigation			Adaptation					
	Energy			Agriculture			WATER		
	ΔIF	ΔFF	ΔO&M	ΔIF	ΔFF	ΔO&M	ΔIF	ΔFF	ΔO&M
2010	333.60		-340.56				643.9	61.8	149.2
2011	434.13		-333.57				726.7	72.7	395.5
2012	643.04		-323.55	1173,5	227	279,9	1072.4	82.0	523.8
2013	1053.00		-301.62	1267,9	245,2	302,6	1126.0	84.7	740.3
2014	1364.93		-283.15	1369,1	264,9	326,7	1182.4	87.3	834.1
2015	750.53		-101.30	1478,5	286,1	352,9	1168.5	93.7	898.5
2016	743.51		-36.62	1596,9	309	381,1	1219.7	97.0	974.3
2017	806.18		20.60	1724,7	333,6	411,6	1269.9	95.1	1052.6
2018	677.08		76.99	1862,7	360,5	444,7	1333.4	99.9	1103.7
2019	647.15		120.74	2011,6	389,1	480	1400.0	104.9	1157.1
2020	619.31		158.75	2172,4	420,2	518,3	908.5	27.0	1158.9
2021	593.46		191.52	2346,2	453,9	559,8	910.9	20.9	1229.4
2022	569.60		219.50	2533,8	490,3	604,8	929.3	21.9	1283.2
2023	547.60		243.11	2736,6	529,6	653,2	945.3	23.0	1336.9
2024	527.49		262.75	2955,6	571,6	705,2	786.7	13.8	1444.2
2025	509.17		278.76	3192,1	617,7	761,8	758.4	10.6	1488.0
2026	492.64		291.51	3447,2	667,1	822,8	796.3	11.1	1562.2
2027	477.87		301.27	3723,2	720,3	888,5	385.4	9.7	1588.8
2028	464.84		308.36	4021,2	778,1	959,8	404.7	10.2	1668.3
2029	453.53		313.00	4342,8	840,4	1036,6	391.4	10.7	1623.9
2030	443.96		315.48	4690,2	907,5	1119,6	411.5	11.2	1705.0
Total	**13152.60**		**1381.96**	**48646,2**	**9412,1**	**11609,9**	**18771.3**	**1049.2**	**23917.9**

Negative values mean net savings
IF = Investment Flows, FF = Financial Flows
ΔI&FF = incremental changes of Investment and Financial Flows
Source: National I&FF assessment

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