Climate-Resilient Development in Vietnam: Strategic Directions for the World Bank

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ABBREVIATIONS AND ACRONYMS

ADB	Asian Development Bank
AF	Adaptation Fund
AFD	French Development Agency
bcm	billion cubic meters
BRT	Bus Rapid Transit
CBM	coal-bed methane
CC	climate change
CCS	carbon capture and storage
CDM	Clean Development Mechanism
CER	certified emission reduction
CFL	compact fluorescent lamp
CIF	Climate Investment Fund
cm	centimeter
CO_2	carbon dioxide
CTF	Clean Technology Fund
CO_2e	carbon dioxide equivalent
COP	Conference of the Parties [of the UNFCCC]
CPF	Carbon Partnership Facility
DFID	Department for International Development [of the United Kingdom]
DPL	development policy loan
DRM	disaster risk management
DRR	disaster risk reduction
DSM	demand-side management
EACC	Economics of Adaptation to Climate Change
EVN	Electricity of Vietnam
FCPF	Forestry Carbon Partnership Facility
FIP	Forestry Investment Program
GDP	gross domestic product
GEF	Global Environment Facility
GFDRR	Global Facility for Disaster Risk Reduction and Recovery
GHG	greenhouse gas
IGCC	integrated gasification combined cycle
IPCC	Intergovernmental Panel on Climate Change
IWRM	integrated water resource management
JICA	Japanese International Cooperation Agency
kgoe	kilograms of oil equivalent
kWh	kilowatt-hour
LDCF	Least Developed Country Fund
MAC	marginal abatement curve
MARD	Ministry of Agriculture and Rural Development
MDB	multilateral development bank
MoNRE	Ministry of Natural Resources and the Environment
$MtCO_2e$	million tons of GHG emissions equivalent to CO_2
mtoe	million tons equivalent of oil

MW	megawatt
NAPA	National Adaptation Program of Action
NGO	nongovernmental organization
NTFP	non-timber forest product
NTP	National Target Program
NTP-RCC	National Target Program to Respond to Climate Change
ODA	official development assistance
PPA	power purchase agreement
PPCR	Pilot Program for Climate Resilience
PRSC	Poverty Reduction Support Credit
PV	photovoltaic
REDD	reduced emissions from deforestation and forest degradation
SCCF	Special Climate Change Fund
SCF	Strategic Climate Fund
SEIER	System Efficiency Improvement, Equitization and Renewables [Project]
SFE	State Forest Enterprise
SIL	Sector Investment Loan
SLR	sea level rise
SPA	Strategic Priority on Adaptation
SP-RCC	Support Program to Respond to Climate Change
SREP	Scaling-Up Renewable Energy Program
tCO_2/TJ	tons of CO_2 per terajoule of energy consumed
TWh	terawatt-hour
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
WBI	World Bank Institute

FOREWORD

Vietnam will be impacted negatively by climate change and this will have consequences for its future development and for its development choices. Under the leadership of the Ministry of Environment and Natural Resources (MoNRE), the country has adopted a National Target Program to Respond to Climate Change (NTP-RCC) and there are many efforts underway to operationalize and build on this strategic program.

The World Bank is a major development partner of Vietnam and over the coming years will need to respond to increasing levels of demand from the country on climate change. Vietnam needs to adapt to changes in the climate but also needs to grow and develop in a different way—minimizing to the greatest extent possible its own greenhouse gas emissions. The way forward will require a strong partnership between all stakeholders.

This report presents some strategic thinking on how the World Bank can prioritize our assistance on climate change to Vietnam and best respond to the country's needs. The report outlines the current understanding of what climate change actually means for Vietnam, relying heavily on the government's own scenarios. Short texts on each of a few key adaptation and mitigation sectors outline challenges, and opportunities, and present Bank activities. Based on some fundamental principles on how to set priorities for actions, the report lays out some key priorities for Bank activities and funding. A final section, Moving Forward, addresses the question of "How?", with a focus on the kinds of assistance the Bank can offer, with particular emphasis on emerging funding opportunities.

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This report can be downloaded from the World Bank's environment Web page for Vietnam (http://www.worldbank.org/vn/environment). See also the excellent climate change Web site of the World Bank, which has a wealth of information on climate change and development (http://www.worldbank.org/climatechange).

EXECUTIVE SUMMARY

Climate change (CC) is posing a serious challenge to development in Vietnam and the Government of Vietnam is responding to those challenges with seriousness. The National Target Program to Respond to Climate Change (NTP-RCC) provides an overall framework and work is now underway in each sectoral ministry and in each province to understand the implications of CC.

This paper seeks to provide strategic directions for mainstreaming support for climate change within the World Bank's broader program of assistance to Vietnam. It does so by reviewing the current understanding of climate change in Vietnam and likely impacts, outlining principles to guide the Bank's engagement in this field, and applying these principles across a range of sectors, taking into account both near- and longer-term considerations. The report identifies elements of the Bank's current and planned portfolio of projects and analytical work that are contributing or will contribute to improved knowledge, planning, and actions, and it points to additional areas where new or more work seems warranted. Beyond an internal audience, the document should be of interest to the government of Vietnam and other development partners.

<u>Adaptation</u>

Vietnam's climate shifts over the next decades as a consequence of human-caused climate change will generate an array of complex and interrelated consequences for every sector of society. Although there is a high level of confidence in the general direction of most changes, relatively little is known about their magnitude and speed and therefore what the impacts will be. The current models certainly suggest that some impacts will have important economic or human welfare impacts, at least over a time frame of the coming decades if not in the coming years. Vietnam and its development partners face the dilemma of what to do first, what to do differently, and how much to invest in different adaptation programs. Acknowledging the inherent risk in oversimplification, the Table at the end of this Executive Summary synthesizes the key findings relative to adaptation in terms of the most important climate changes that will occur, their likely significant consequences, and the "big ticket items" that the Bank could support government to address first, with the most attention and resources. This is not intended to mean that the government, the Bank, or other actors should not continue supporting many other kinds of adaptation studies and investments. It is intended only to ensure that, at a minimum, we do not lose sight of the most critical areas that need focus over the coming years. The report provides further detailed information as to why these areas are chosen as the highest adaptation priorities.

The report discusses six key adaptation priorities where the Bank believes it has a comparative advantage to support the Government:

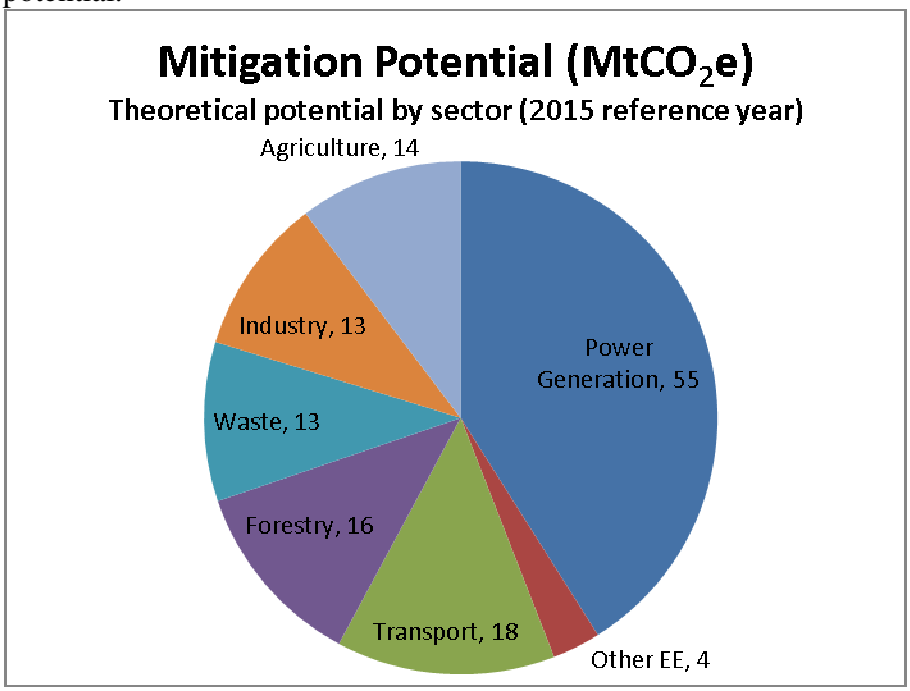
- Continue to seek out better information through analytical work on impacts and adaptation measures, given the considerable uncertainty that still prevails in all areas.
- Strengthen the management of water resources, which even in the absence of climate change is facing serious challenges—it is urgent to address institutional, planning, and information management issues as well as to develop critical policies and instruments to enhance water resources management to respond to what may well be the most important climate change impacts in Vietnam.

- Incorporate consideration of climate change into urban planning, as some urban areas (particularly Ho Chi Minh City) are particularly vulnerable to the water-related impacts of climate change.
- Improve management of fisheries and coastal resources to reduce vulnerability of the sector to possibly important and long-range changes in the marine environment.
- Improve resiliency of the agricultural sector to change and weather variability, taking into account the incremental challenges posed by changing climatic regimes

- Continue to support disaster risk management strategies and investments, strengthening them to respond to current challenges as well as possible future increases in natural disasters caused by CC.

Mitigation

On the mitigation front, reducing or reversing the rate of increase of the concentration of greenhouse gases in the atmosphere, it will take more research to produce a true marginal abatement curve that takes into account real costs (as well as feasibility from a technical and policy standpoint) and that lays out precisely which mitigation options offer the greatest benefits, both in terms of reducing greenhouse gases and generating financial benefits for the country. The following figure presents the Bank's calculation of where the potential greenhouse gas emissions savings are to be found over the next two decades. The Table at the end of the Summary outlines the main mitigation actions that the World Bank could support to realize this potential.



Source: World Bank analyses

World Bank Programs on Adaptation and Mitigation

Of the adaptation and mitigation priority areas identified in the report, is the Bank already appropriately engaged? And if not, where are additional efforts warranted? World Bank activities on climate change in Vietnam are numerous and cover analytical studies, national projects with

climate change–related investments, and regional studies or projects that include this country. The Bank is already one of the principal actors on climate change in Vietnam in the official development assistance community. In every priority area there is an active analytical and research agenda under way. Adaptation and mitigation investments, although difficult to distinguish from traditional development projects, cover most areas and, depending on how they are quantified, could be calculated as representing investments aggregating to hundreds of millions of dollars.

On the adaptation front, most key priority areas are already receiving attention in Bank programs (water resource management, agricultural sector resilience, natural disaster risk mitigation, urban investments). Areas that are not getting sufficient attention from the Bank include water resources management at a national level (tackling sector-wide issues beyond our current program in the Mekong Delta) and coastal resources/fisheries, although a project is now at the planning stage for management of coastal resources. In mitigation, the Bank is a major player on energy mitigation issues, and this needs to remain a focus, but more attention is needed in other areas, particularly in urban areas, transport, and agriculture.

Moving Forward

The final section of this strategic document provides some thoughts on the "how" as opposed to the "what." Developing necessary partnerships with the government and with other actors in the development community is indisputably important. The Bank has a comparative advantage in terms of the mobilization of resources, financial and human, for both analytical work and investments. The Bank's intended support to a climate change policy development loan offers an opportunity to focus on key policies and the partnerships needed to formulate and implement them.

Appendix 3 outlines many of the existing and new financial resources that are becoming available for both adaptation and mitigation investments. Finally, building capacity within the government for managing financial flows related to climate change needs more attention. This and other areas of capacity building will be a particular focus under the Bank's forthcoming partnership with the Department for International Development (DFID) of the UK.

Key Climate Change Priorities for which the World Bank could Support the Government, 2010–2020

ADAPTATION

Expected Climate Changes over Next Decades	Most Significant Consequences	Major Adaptation Measures
Temperature rise of 2.3°C by 2100	Reduced integrity of natural ecosystems; some agricultural sectors will be affected	Adaptation for natural ecosystems difficult to impossible; support resilience of agricultural sector
Sea level rise of about 3 centimeters/decade, perhaps increasing at a faster rate in future	Salinization, loss of land, impacts on agriculture, worsening of extreme weather events (storm surges)	Improved water resources management; support resilience of agricultural sector; support resilient urban planning (including infrastructure planning); analytical work on costs/benefits of coastal and river defenses
Seasonality of precipitation: wetter wet seasons and drier dry seasons	Impacts on agriculture; greater challenges for water resources management (particularly in dry seasons)	Improved water resources management; support resilience of agricultural sector
Changes likely in marine environment (changes in temperature, pH, currents, etc.)	Largely unknown; could affect fisheries, corals	Largely unknown (more analytical work needed) but must include enhanced fisheries management and better protection of marine resources
Total rainfall likely will increase	Impacts on agriculture, urban drainage	Improved water resources management; support resilience of agricultural sector; improved urban and infrastructure planning
Extreme weather events likely will be more common or more extreme	Potentially more economic impacts (particularly for vulnerable groups) and loss of lives	Improved natural disaster risk management

MITIGATION

Broad Areas of GHG Mitigation Potential	Mitigation Priorities for the World Bank
Power generation	Economic pricing of energy; energy efficiency (particularly in end-consumer appliances); displacement of coal as much as possible as a fuel source (by gas, renewables, hydropower)
Transportation	Electric motorbikes, modal shifts, urban planning
Forestry	Reduced emissions from deforestation and forest degradation (REDD)
Agriculture	Reducing methane from livestock waste; minimizing methane emissions from rice warrants more research and attention
Waste management	Better management of solid waste and domestic and industrial wastewaters to reduce methane emissions

INTRODUCTION

Weather is the term used to describe the atmospheric conditions (heat, wetness, wind, etc.) prevailing at any one place and time. Climate is the sum of the prevailing weather conditions of a given place over a period of time, typically summed over many decades. Weather variability and extreme weather events have a frequency and intensity that can be measured, and they are part of a region's climate.

Weather and climate are particularly important in Vietnam for several reasons:

- The agricultural sector is still a mainstay of the economy and is a sector that is much more sensitive to weather and climate than, for example, the industrial sector.

- More so than in many countries, extreme weather events are a part of Vietnam's climate, in large part because of its location in the typhoon belt.

- A disproportionate part of Vietnam's population is vulnerable to extreme weather events because people are physically clustered along a coastline susceptible to typhoons, in low-lying deltas susceptible to floods and sea surges, and in mountainous areas vulnerable to flooding from extreme precipitation events.

A change in climatic patterns therefore has important repercussions for Vietnam because as long-term climate change (CC) occurs, this will be reflected in day-to-day weather that will differ from what we now know as the norm. The weather will likely be more variable, and there will be more extreme events than in the past. Climate already poses a development challenge to Vietnam; with the projected levels of climate change, this will be even more so.

The term "climate change" also includes the phenomenon of sea level rise (SLR), which is not a weather phenomenon (although it ultimately is caused by a rise in atmospheric and oceanic temperatures, albeit at a global scale rather than a regional scale). Vietnam is rightly concerned about projected levels of SLR because most of the populace lives in the two low-lying deltas of the Mekong and Red Rivers. SLR is additionally worrisome because it can combine with extreme weather events to cause very damaging storm surges in low-lying areas. SLR represents thus an additional development challenge.

Climate change and SLR will mostly affect Vietnam negatively, and adaptation to these impacts is the focus of this report. However, we must also be concerned with long-term solutions to climate change, which requires a reduction, or "mitigation", of emissions of greenhouse gases (GHGs). This particular challenge is primarily the responsibility of those who caused the bulk of such emissions. Vietnam contributes a relatively small part of global GHG emissions, but this share is growing and is not insignificant; limiting its growth is important. Supporting Vietnam to incorporate mitigation into its long-term development is one of the strategic directions of the World Bank that is developed in this report.

This paper seeks to provide strategic directions for mainstreaming support for climate change within the World Bank's broader program of assistance to Vietnam. It does so by reviewing the current understanding of climate change in Vietnam and likely impacts, outlining principles to guide the Bank's engagement in this field, and applying these principles across a range of sectors, taking into account both near- and longer-term considerations. The report identifies elements of the Bank's current and planned portfolio of projects and analytical work that are contributing or

will contribute to improved knowledge, planning, and actions, and it points to additional areas where new or more work seems warranted.

The report represents a first iteration of a strategy for supporting Vietnam in managing the challenges posed by climate change. As more experience is gathered and as our understanding of both the science and the economics of climate change impacts in Vietnam improves, this strategy will need to be revisited and refined. While the process of climate change is expected to be a long-term phenomenon—with predictions for considerable changes through the second half of the twenty-first century, the focus of this report is on decisions and priorities that should govern the Bank's assistance during this decade. Given an array of uncertainties, extending the developing assistance planning vision much beyond 2020 is not practical. This time frame also corresponds to the government of Vietnam's own planning horizon.

VIETNAM'S CLIMATE IS CHANGING

The concept of climate change is used here in line with that of the Intergovernmental Panel on Climate Change (IPCC) (2007) as referring to any change in climate over time, whether due to natural variability or as a result of human activity. Climate change is already happening and will affect all countries, with the most serious impacts being felt in developing countries. According to the IPCC, there is clear evidence that average air and ocean temperatures are increasing and that sea levels are rising. Global average sea level has risen since 1961 at an average rate of almost 2 millimeters per year and, since 1993 at about 3 millimeters per year, due to thermal expansion and melting glaciers and polar ice sheets. These values are equivalent to a global average sea level rise of about 12 centimeters (cm) in the last 50 years. (Note that an average value can conceal considerable variability in sea level rise trends in different parts of the world; some parts of the Indian Ocean, for example, have experienced a decline in SLR in recent decades.) The average temperature of the earth has warmed 0.8° C since 1900, the beginning of the industrial period (World Bank 2009a).

There is no doubt that the unprecedentedly rapid changes currently taking place are principally caused by human activities. Rising levels of greenhouse gases trap heat, and humans are responsible for the steep rise in GHG emissions that began about 150 years ago. The dominant GHG is carbon dioxide (CO_2), accounting for some three-fourths of the total global warming potential (World Bank 2009a).[1] The future trend for global CO_2 emissions is of grave concern. Global emissions are currently following the worst-case scenario of the 2007 IPCC report.

Recent and Predicted Climate Change in Vietnam

A recent report from the Ministry of Natural Resources and the Environment (MoNRE) presents the official climate change scenarios for the country (MoNRE 2009). More detailed information is provided in a report from MoNRE's Institute of Strategy and Policy on Natural Resources and the Environment (ISPONRE 2009). Downscaled global climate change models were used to project actual changes for Vietnam. The B2 medium emissions scenario of the IPCC (2007) was

[1] The measure used in this report is million tons of carbon dioxide equivalent ($MtCO_2e$), which is the amount of emissions that has a greenhouse gas effect equivalent to 1 million metric tons of CO_2. Greenhouse gases (GHGs) include other gases, which often have a GHG potency much greater than CO_2, such as methane, nitrous oxide, or methyl bromide.

adopted to project the most likely changes. Projections are made to the year 2100 for temperature and rainfall. MoNRE's National Target Program (NTP) calls for a comprehensive reassessment of scenarios by 2015.

This section summarizes the projections for different climate variables. It also looks at historical changes over the past 50 years or so to give an idea of the climate change that is already happening. This may or may not be indicative of future change. Climate change is very complex and influenced by a great many factors, including feedback loops, response delays, and possibly abrupt changes that could result from passing certain thresholds (for example, oceans currently are buffering CC by absorbing CO_2 but this could dramatically slow once a certain concentration is reached).

According to MoNRE (2009), in the last 50 years the average temperature in Vietnam has risen 0.5–0.7° C. The increase has been relatively more important in the winter than the summer and is somewhat more pronounced in the north than the south. This is consistent with measured increases in global average temperature. The projected temperature rises this century (compared with the baseline period of 1980–99) are in the range of 1.1–3.6° C, depending on location and emissions scenario, with a mean rise of 2.3° C. Changes are expected to be more rapid after 2050, and increases will be slightly higher in the north. Models predict that by 2100 global average temperature will be 2.5–7° C above the preindustrial average (World Bank 2009a).

Documented changes in rainfall (ISPONRE 2009) do not show clear trends over time, and there is great variability according to the region of the country. In general, annual precipitation in the northern region has slightly decreased in the last 50 years but has slightly increased in the south. Annual rainfall in the future is generally expected by MoNRE (2009) to increase in the range of 1–10 percent until 2100. The increase will be higher in the north (4.8–10.1 percent by 2100) than in the south (1.0–4.1 percent). This is in line with IPCC predictions for Southeast Asia of a median 7 percent increase in annual precipitation. As just noted, however, at least in northern Vietnam rainfall has decreased over the last decades. This perhaps reflects the still considerable uncertainty in projections, particularly for rainfall. Seasonally, MoNRE expects rainfall during the dry season to decrease in most climate zones, particularly in the Mekong Delta, which could see a precipitation decrease of 20 percent in the dry season. The wet seasons correspondingly will generally be wetter.

The water balance, which measures available water, is the difference between potential evaporation and rainfall. It is important to note that a rise in temperature (and thus potential evaporation) can offset rainfall increases. For example, projections for Australia indicate that because of temperature increases, the net water balance deficit will increase in all areas of the country, even in areas where total rainfall will increase. Similar analyses have not yet been carried out systematically in Vietnam.

In an analysis of various regional projections of climate change (see more detailed discussion in World Bank 2010b), there was good agreement for projected temperature increases but great variability in rainfall projections. Overall, the various projections converge in predicting wetter rainy seasons and drier dry seasons.

An analysis of typhoon data for Vietnam (World Bank 2010a) indicates that there have been an average of nearly five tropical cyclone events per year over the past 48 years, but there are no statistically significant trends in the frequency of events over this period. Over the last 20 years, the pattern of severe typhoon events (Beaufort Categories 12 and 13) similarly does not show clear trends over time. Periods of activity and inactivity seem to cyclically follow each other.

Analysis of about 50 years of typhoon tracks in Vietnam by the Pacific Disaster Centre similarly did not indicate any clear spatial or temporal shifts.

The MoNRE Scenarios report does not make any predictions about future changes in typhoons and other extreme weather events. This indicates the difficulty of modeling extreme weather events and our still limited understanding of how typhoons and storms are related to global climate change. It seems not unreasonable to posit a general increase in typhoon activity as sea surface temperatures rise, since typhoons fundamentally function as a mechanism to transfer heat away from warm tropical waters. Allowances need to be made for the possibility of increased typhoons in the future, and this remains a priority for more basic data collection and modeling. Some models suggest that storm tracks might shift southward in Vietnam. If true, this would be potentially significant for areas such as the Mekong Delta, which is now rarely hit by major typhoons. (The most damaging typhoon to ever hit Vietnam in terms of loss of life was Typhoon Linda in 1997, which killed over 4,000 people in the Mekong Delta, in part because people were not prepared for such an event.)

Measurements of sea level rise are difficult and require precise instrumentation and careful data collection over decades. Important investments will be needed to upgrade equipment and capacity for this kind of data collection. MoNRE (2009), summarizing available data, reports that the rate of SLR in Vietnam has been about 3 millimeters per year over the last 15 years. This would be similar to average global increase in SLR documented by the IPCC. Doyle et al. (2010) used a rate of 1.8 mm/year for the China Sea for the historical SLR resulting only from eustacy (thermal expansion of the ocean), based on analyses of data from a number of stations in the region.

Predicting what will happen to future sea level is central to understanding the impacts of climate change. SLR models have, however, a great degree of uncertainty compared with models of global temperature change. The IPCC (2007) estimates a global SLR of 26–59 cm by 2100 (relative to 1980–99) under the most pessimistic A1F1 Scenario, while not excluding a possible higher rise. Some observers believe these estimates are the low side, as this considers only thermal expansion of the oceans and a contribution from melting polar ice at rates observed over the period 1993-2003 and does not include accelerated melting of polar ice caps. The fifth IPCC scientific assessment, now under way, will present a revised consensus view of the world's most prominent scientists. MoNRE (2009) has concluded that about 75–100 cm SLR (compared with the 1980–99 period) is the most likely SLR this century, with about 30–33 cm SLR by 2050. These "planning parameters," rather than modeled predictions, seem not unreasonable.

Few scenarios for Vietnam have taken into account geological subsidence. A recent paper from the U.S. Geological Survey (Doyle et al. 2010) highlights the importance of this in deltaic areas. Although it notes that reliable data from the Mekong is lacking, most similar deltas around the world are subsiding at a rate greater than current SLR. Deltaic subsidence can be caused by many factors but among the most important are a lack of sediment supply (typically caused by extensive upstream damming of the delta's river, cutting off a free flow of sediment), removal of groundwater, and compaction. They suggest that subsidence in the Mekong Delta could be currently as high as 9 mm/year (it is 10 mm/year in the Mississippi Delta). If this were true, under the worst case IPCC scenario for global SLR, the actual SLR for the Mekong could be 1.5 m by 2100 (compared to present levels). Clearly this is an area where more basic data is vitally needed, especially for the Mekong Delta.

Vietnam's Southern Institute of Water Resources Planning has modeled what SLR means for the Mekong Delta, the area of Vietnam that would be most affected by SLR because of its low

elevation. Its model takes into account canal systems and existing water control structures (see a more detailed summary in World Bank 2010b), using the Vietnam River System and Plains Model. As an example of what might be expected, under a scenario of 50 cm SLR, the most important hydrological impact is increased flooding from river discharge in the upper parts of the delta in Vietnam. Seaward of the embankment of Highway 1 (more or less a straight line between the towns of Bac Lieu and Ca Mau), flooding levels will rise, whereas inland of the embankment there will be little change. In addition, salinity intrusion in the dry season will increase. This is true especially for the part of the Ca Mau Peninsula facing the Gulf of Thailand. In summary, the most likely climate changes for Vietnam (those for which models converge) are increases in average temperature, drier dry seasons, wetter wet seasons, and an increase in SLR by 2100 (from a baseline of 1980–99) of somewhere between 25 cm and 1 meter, but very possibly toward the higher end of this range.[2]

Responses to Climate Change

Two general courses of action are taken to address climate change– adaptation and mitigation. *Adaptation* is defined by the IPCC as "Initiatives and measures to reduce the vulnerability of natural and human systems against actual or expected climate change effects." Adaptation can be anticipatory or reactive, private or public, and autonomous or planned. Examples are raising river or coastal dikes or introduction of climate-resilient crops. *Mitigation* is the reduction of GHG emissions or the physical sequestration of carbon in sinks, both serving to ultimately reduce atmospheric concentration of GHGs.

The government of Vietnam adopted its National Target Program to Respond to Climate Change (NTP-RCC) in December 2008 to determine the consequences of climate change and establish national priorities. The NTP-RCC is the country's guiding document for responding to CC in the medium term (2009–15). Its main objectives are to identify and assess the intensity of CC and develop scenarios of responses (adaptation and mitigation); to promote scientific and technological activities to respond to CC; to enhance public awareness, participation, and human resources to respond to CC; to promote international cooperation; and to integrate CC issues into development strategies, programs, and plans. The NTP-RCC states that the response to climate change is the responsibility of the whole political system and at all levels. It advocates the integration of climate change into development strategies, programs, plans, and planning in all sectors. It outlines an ambitious set of tasks, including:

- Assessment of climate change impacts on Vietnam
- Identification of responses
- Development of a scientific program on climate change
- Institutional strengthening
- Awareness raising

[2] The lower boundary is the lower end of the current IPCC global prediction (using the scenario of highest emissions) and the upper boundary is from MoNRE (2009). Further research and better models and projections will be needed to fine-tune these predictions.

- International cooperation

- Development of Action Plans at the level of ministries, sectors, and localities.

A detailed list of tasks and projects identifies 26 activities during 2009–15 at a total cost of VND1,965 billion (about $110 million). It was hoped that 50 percent of the NTP-RCC budget would come from international donors' assistance. The NTP-RCC is not however a true climate change strategy laying out the government's priorities; MoNRE in late 2010 has indicated it is now working on the preparation of such a strategy.

Numerous other important policy documents and plans collectively make up the key documents and plans of the government on climate change. These include, for example, the National Strategy for Natural Disaster Prevention, Response and Mitigation to 2020, the NTP on Water Resources, the National Strategy on Energy Efficiency and Power Generation, and ministerial and provincial climate change action plans that are now being prepared. Other key government documents are mentioned in this report where pertinent.

Institutionally, MoNRE takes the lead on behalf of the government in coordinating the response to climate change and has prepared the NTP-RCC. Within MoNRE, the Standing Office on Climate Change has been created. An interministerial committee, chaired by the Deputy Prime Minister, ensures coordination on the implementation of the NTP-RCC. It has the potential to play an important role. A Standing Office on Climate Change has been created within the Ministry of Agriculture and Rural Development (MARD), and there are similar offices or functions in other ministries. A policy dialogue both with the ODA community and internally within Vietnam takes place under the auspices of the Support Program to Respond to Climate Change (SP-RCC), managed within MoNRE. This is a budget support operation funded by Japan, France, and Canada (the World Bank is currently preparing a loan to add support to the SP-RCC starting in 2011).

Globally, the World Bank Group has adopted a strategic framework to guide and support its operational response to development challenges posed by global climate change: *Development and Climate Change: A Strategic Framework for the World Bank Group*.[3] The Framework lays down six action areas for the World Bank Group's work to support both mitigation and adaptation activities for its clients:

- Support climate actions in country-led development processes

- Mobilize additional concessional and innovative finance

- Facilitate the development of market-based financing mechanisms

- Leverage private sector resources

- Support accelerated development and deployment of new technologies

[3] The present report focuses only on the climate change work and strategic directions of the World Bank. Other branches of the World Bank Group, such as the International Finance Corporation, also have strong programs on climate change (see http://www.ifc.org/climatechange).

- Step up policy research, knowledge, and capacity building.

The Framework is intended to facilitate both growth objectives and poverty reduction goals while recognizing the added costs and risks of climate change. It will also facilitate new financial opportunities that will arise from the development of global climate policies. The Framework will guide the specific strategies and business plans of the World Bank Group in climate-sensitive sectors, such as agriculture and natural resources, water, energy, and health.

ADAPTATION PRIORITIES IN VIETNAM

The observed and likely future impacts of climate change in Vietnam were described earlier. What will be the significance of these impacts and which ones need to be addressed by the government first? In practice it is very difficult to say which of these impacts are the most important and which deserve priority attention from policy makers or the World Bank. For example, our understanding of impacts and responses is not advanced enough to allow a quantitative economic comparison between sectors.

Table 1 summarizes the most important likely climate changes, the most significant consequences, and the adaptation measures that might be needed. (See Appendix 1 for a more complete analysis.)

Table 1. Key Adaptation Considerations for Vietnam, 2010–2020

Expected Climate Changes over Next Decades	Most Significant Consequences	Major Adaptation Measures
Temperature rise of 2.3°C by 2100	Reduced integrity of natural ecosystems; some agricultural sectors will be affected	Adaptation for natural ecosystems difficult to impossible; support resilience of agricultural sector
Sea level rise of about 3 centimeters/decade, perhaps increasing at a faster rate in future	Salinization, loss of land, impacts on agriculture, worsening of extreme weather events (storm surges)	Improved water resources management; support resilience of agricultural sector; support resilient urban planning (including infrastructure planning); analytical work on costs/benefits of coastal and river defenses
Seasonality of precipitation: wetter wet seasons and drier dry seasons	Impacts on agriculture; greater challenges for water resources management (particularly in dry seasons)	Improved water resources management; support resilience of agricultural sector
Changes likely in marine environment (changes in temperature, pH, currents, etc.)	Largely unknown; could affect fisheries, corals	Largely unknown (more analytical work needed) but must include enhanced fisheries management and better protection of marine resources
Total rainfall likely will increase	Impacts on agriculture, urban drainage	Improved water resources management; support resilience of agricultural sector; improved urban and infrastructure planning
Extreme weather events likely will be more common or more extreme	Potentially more economic impacts (particularly for vulnerable groups) and loss of lives	Improved natural disaster risk management

This qualitative assessment suggests the following major groupings of CC-sensitive assets that the Bank identifies as being the most vulnerable to climate change: agriculture, water, biodiversity, infrastructure assets, human assets, and assets subject to natural disasters. For the most part, these are the assets that are already the most vulnerable to weather variability and therefore those that will be subject to the most impacts as weather changes occur with long-term climate change. (Some assets are likely to be affected by SLR, which is not a weather phenomenon per se.)

Within each sector, it will be necessary to carry out detailed assessments of vulnerabilities and impacts and propose risk mitigation strategies. In Vietnam, these have been done by the government, the World Bank, and other actors for subsectors (for aquaculture by the World

Bank, for instance, and for Ho Chi Minh City by the Asian Development Bank (ADB)), but it is beyond the scope of this paper to report on or carry out such detailed analyses.

At a general level, in order to help understand how to conceptualize and prioritize World Bank adaptation investments over the next 10 years within each of these areas, two approaches are used (while recognizing that they are not discrete categories and there is overlap between them). Underlying both approaches is the need for more and better information—with such high uncertainty about impacts, a strong and flexible focus on analytical work is still needed. (See also Box 1.)

The first approach involves addressing the "adaptation deficit" in existing resilience and risk mitigation strategies. The country's assets (natural, constructed, and human) are already subject to a wide range of predictable and less predictable external pressures and shocks, one set of which relates to weather variability and extreme weather events. The government and other stakeholders have adopted various strategies and instruments to manage these risks, albeit not completely and not always cost-effectively. Examples include: infrastructure to protect property and people from storms, flooding, and/or sea surges; social safety nets; farm and business management practices; property and agricultural insurance; and contingency budget financing. During the coming decade, it is likely that climate change will change these weather-related risks, although the changes are likely to be modest, at least in this time period. These incremental impacts create an "adaptation deficit"—CC-related actions that would not be included in "business as usual" approaches to resilience.

This argues for strengthening and extending existing strategies, systems, and approaches for managing weather-related risks and other sources of risk (such as vector-borne diseases). Focusing on resilience strategies needs to take place at household, enterprise, industry, regional, and national levels—making Vietnamese society more resilient in the face of potentially larger climate-related stresses and hazards in the longer term.

The second approach involves evaluating long-term investments with respect to CC outcomes. Some major investments of the government such as urban or transport infrastructure have a lifetime that will extend decades into the future. These investments have to be carefully screened and designed so they account for probable future climate changes that could affect their feasibility, desirability, or profitability.

Some long-term investments, such as sea dikes, may themselves be adaptation investments. They must be subject to the same careful evaluation and screening. Investing now in special adaptation measures in anticipation of long-term impacts is appropriate if these measures have long lead times for preparation and deployment and if there is reasonable certainty about the occurrence of changes and their local/national impacts. Whenever possible, major investments of this sort should be delayed, as there is a high opportunity cost to acting prematurely. Vietnam will be a wealthier country in 10 years. Making large investments now that will not be needed until far in the future would be inefficient, as those resources might have been directed to other investments—both physical and for human resources development—that could improve development outcomes and thus enhance adaptation to climate change. (It can be said that the best adaptation measure to climate change is development itself.)

Box 1. Total Adaptation Costs

For adaptation alone, the *World Development Report 2010* (World Bank 2009a) estimates that the global financing needs to adequately address mitigation will be on the order of $140–175 billion per year by 2030. The financing needs for adaptation during 2010–50 are estimated by the Economics of Adaptation to Climate Change (EACC) study (World Bank 2009b) to be on the

order of $75–100 billion per year. These estimates include only public sector "hard" investments, excluding costs such as training, capacity building, or policy reforms. This sum is of the same order of magnitude as the total amount of foreign aid that now flows from industrial to developing countries. We should not underestimate the difficulty of mobilizing this amount of incremental assistance to developing countries.
ADB (2009a) has looked at adaptation costs for southeast Asia region and some of the country-specific EACC studies for Vietnam have produced some estimates but limited only to certain sectors. No comparable and detailed estimates are available for adaptation costs across different sectors in Vietnam. Clearly however in some sectors they will not be negligible and many different kinds of development assistance will be needed to address the complex set of CC multi-sectoral issues. The principal modalities of World Bank development assistance are laid out in Appendix 3.

Water Resources

Challenges

The impacts of climate change on water resources in Vietnam are likely to be important, but there is considerable uncertainty about whether specific areas will become wetter or dryer and by how much the seasonality of precipitation will change. Much of Vietnam is projected to become wetter, with an average increase for the country projected to be about 7 percent by 2100 (MoNRE 2009). Rainfall during the dry season is expected to decrease in most zones, thus creating potential for more severe droughts. There will perhaps be more-intense flooding in some areas and in some seasons. These changes will differ, perhaps significantly, from region to region, but we do not yet have scenarios that provide information at that level of resolution. The average temperature will almost certainly rise, probably about 2° C, and one would expect that higher temperatures would increase evaporation, partially offsetting increases in precipitation. Water may thus be more abundant on an annual basis but not necessarily more available. Seasonally, water could become more of a limiting factor if rainfall becomes more concentrated in the rainy season and if the dry season becomes more pronounced.
The World Bank's EACC study (World Bank 2010b) analyzed climate change impacts on water resource availability in the Mekong, Red-Thai, and Dong Nai river basins for a limited number of scenarios. The results show that by 2050 there will be significant changes in the mean monthly runoff for those basins, suggesting a likely increase in the risk of flooding in the rainy season and droughts in the dry season. Both rural and urban land was found to be at risk of potential inundation and salinity intrusion in the deltaic areas, a situation that would be aggravated by an increase in the sea level (SIWRP 2008; Wassmann et al. 2004).
Water resource management stresses that will arise from climate change will be additional to the problems that exist today. According to the government/ADB water sector review (ADB 2009b), there are already serious concerns in Vietnam about meeting future projected water uses, particularly in the dry season. At the policy level there is little to promote water sharing at a river basin scale (ADB 2009b). There are no clear rules for the issuance and allocation of water rights. This constitutes a problem when there is serious competition between water uses, for example in dry periods. The government has recently issued a decree on river basin management to enable Integrated Water Resource Management (IWRM), but it is too early to assess its implementation. More-detailed analysis needs to be undertaken to better understand the incremental challenges that climate change will pose to water resource management in Vietnam. This calls for analyzing

how climate change will affect not only water supply but also water demand from all water-using sectors, such as agriculture, cities, river transport, ecological flows, and hydropower. The following paragraphs further delineate some of the sector-specific issues.

The water supply and sanitation sector is not delivering services adequately in urban and rural areas. Urban infrastructure for water supply and sanitation, such as wastewater treatment plants and sewerage and drainage systems, is not keeping pace with economic development and population growth. Rural water supply and sanitation coverage is still poor. Changes in the timing and reliability of rainfall and corresponding water resources availability caused by CC may worsen current conditions by increasing the cost of water services and the costs of reliability of service delivery. Urban water supply problems may be exacerbated during drought periods, and urban drainage may not be able to cope with increased flooding.

Agriculture currently accounts for more than 80 percent of surface water use (ADB 2009b). Irrigation uses are projected to grow at a modest rate, but the current deterioration of the hydraulic works on which irrigation depends as well as the minimal investment in new irrigation capacity and rehabilitation of inefficient irrigation infrastructure could be problematic in the future. The financing of irrigation infrastructure management, operations, and maintenance will suffer due to the revenue loss from the abolishment of the irrigation service fees that were paid by individual farmers. Climate change could contribute to existing problems by increasing crop water requirements, leading to greater irrigation water demand and causing additional stress to the sustainability of existing irrigation schemes. The intrusion of seawater into coastal freshwater systems and changes in flood regimes in acid sulfate soils in the Mekong Delta could be a further challenge.

Groundwater resources in Vietnam are currently overexploited in the Red River, the Southeast, the Mekong Delta, and Central Highlands area. In Hanoi, water levels are falling by more than 1 meter per year in some areas and have fallen a total of 30 meters. In parts of Ho Chi Minh City, the declines are also as much as 30 meters; in other parts of the Mekong, water level declines are also significant. Climate change can potentially affect groundwater through salinization and altered recharge rates, affecting the availability of groundwater resources and adding to the current overexploitation issues. Groundwater extraction is contributing to subsidence in the Mekong Delta, which can amplify the relative impact of any given amount of sea level rise.

Climate change also poses challenges for water quality. Reduction in river flows will reduce the dilution of wastes, necessitating additional investments to achieve the same standards of environmental protection, particularly in the dry season, when flows are already reduced. Changes in runoff patterns and temperatures may render water unusable in agriculture due to increased salinity or may impose additional treatment costs in the case of eutrophication of water used for domestic supply.

Although more analysis is needed on the minimum water flows needed to maintain ecosystem functions in the face of climate change, it is important to recognize that water availability for ecosystem preservation under possible future water scarcity conditions may be a problem. This is particularly important given that Vietnam's natural ecosystems are already stressed, degraded, and fragmented, and hence quite vulnerable to climate change.

Water developments in neighboring countries will also have an important effect on water availability in Vietnam, given its heavy dependence on international rivers. More than 60 percent of the total average yearly surface water discharge is generated outside the country. Six basins depend on water inflows from other countries—in the Mekong Delta, almost 95 percent of the average yearly surface water flows are generated in the upstream Mekong River countries. The

Red-Thai Binh has nearly 40 percent of basin surface water originating in China. In the Mekong River Delta, major hydrological changes are expected in the coming decades, primarily as a result of hydropower and irrigation investments that are taking place or are planned in China, Laos PDR, and Cambodia (MRC 2010). Climate change can cause additional stresses, creating another challenge for transboundary water management coordination. Climate change scenarios point to the likelihood of increased rainfall in the upstream part of the Mekong River basin, which may increase freshwater flows to the Mekong Delta (Hoanh et al. 2010); this could be a positive development that could help counter the more-intense dry seasons that are expected.

Emerging Solutions

Most of the emerging solutions with regard to water resources and climate change can be grouped around the objective of improving the resilience of the sector through better water resource management. Given the multisectoral nature of water resource management, approaches are needed that reflect the integrated nature of the water cycle by taking into account different users. Integrated water resource management is an approach that integrates the activities of a range of sectors that use, affect, or are affected by water, thus ensuring that activities in one sector do not undermine those in another. It allows for a comprehensive appraisal of climate-resilient strategies in a context of potential large-scale tradeoffs between supply and demand across multiple water-dependent sectors with varied socioeconomic, environmental, and institutional characteristics. The appraisal of strategies must be undertaken at both the national and the river basin level. In the case of international river basins, transboundary water resource management must be addressed to ensure climate resilience.

Climate-resilient water management strategies must balance engineering or "structural" measures and "soft" or "nonstructural" measures. It is widely agreed among water resource experts that engineering solutions, while important and an integral part of any future approach, may not be enough. A range of nonstructural measures can complement the infrastructural solutions and help address a range of social, economic, and political challenges in water management. The IWRM approach to building climate resilience demands the adoption of integrated river basin planning to ensure that plans for water development and management balance structural and nonstructural measures at the basin level.

Structural measures include building additional storage such as dams or reservoirs to retain flows that are in excess of wet season requirements in order to counter dry spells or salinity problems. Sometimes it may be useful to increase storage capacity of existing dams to be able to store increasing peak flows during flooding periods. Other examples of engineering solutions to build resilience in the water sector are:

- Reduce water distribution losses and increase efficiency in service delivery
- Improve maintenance of water infrastructure (dikes, sluices, irrigation schemes)
- Alter design standards and infrastructure operating rules
- Relocate water intakes to upstream clean water sources when salinity intrusion is happening downstream
- Build reservoirs for storage of fresh water and other similar structural investments
- Upgrade or build dikes and flood protection infrastructure

- Adequate design of access infrastructure and maintenance schemes for river navigation.

Some examples of nonengineering options are:

- Improve forecasting of hydrological changes resulting from climate change and other causes

- Development of an inter-ministerial coordination mechanism for dam safety policy and implementation and an agreement between MARD and Electricity of Vietnam (EVN) on standards for dam safety and principles regarding inspection

- Promote the use of decision support systems such as river basin models for analyzing climate change impacts and adaptation strategies in water resource planning

- Define clear extraction rights over water resources (mechanism include the forthcoming National Target Program for Water Resources and the planned Water Resources Law; both are policy actions under the SP-RCC)

- Create incentives for water users to exchange their current water allocations

- Build capacity for the assessment of minimum environmental flows to protect ecosystems under changing water regimes

- Create drought management plans and water allocation priority plans in case of water shortages

- Promote more sustainable use of groundwater (policy action under SP-RCC)

- Introduce land use planning such as flood zoning and human resettlement of low-lying areas threatened by sea level rise

- Adopt comprehensive water demand management programs that promote water conservation and that are community-based

- Adopt water pricing systems that ensure sustainable infrastructure management, operation, and maintenance (which requires water quantity metering); attention is needed in Vietnam to the consequences of waiving the irrigation services fee—this is a policy action under the SP-RCC

- Improve monitoring of water quality

- Improve cooperation between different water users and river basin organizations, particularly for transboundary issues in the Mekong River Basin; within Vietnam guidelines and support are needed for river basin committees (this is a policy action under the SP-RCC)

- Build capacity and awareness about climate change and water and promote the adoption of IWRM at the local (province/river basin) level.

The uncertainties of climate change projections should not be a reason for delaying climate-resilient investments, but it is advisable that expensive and irreversible investments in long-lived water infrastructure should be carefully assessed. For example, building an irrigation scheme in a drought-prone area that is expected to get drier may increase the vulnerability of the farmers by encouraging the continuation of unsustainable agricultural activities in a water-stressed area.

This is also true for all major investments in water control structures (sea dikes, river water control structures, salinization controls, water storage reservoirs). They will be expensive and need to be carefully evaluated to avoid the opportunity cost of a premature investment and also to be able to incorporate better modeling results which will be available in the future. Such structures can also have potentially negative impacts that need to be carefully evaluated.

In the next few years, the World Bank should assist with the careful study and evaluation of major water control investments that will likely be needed as CC adaptation investments in future decades.

World Bank Programs

A few of the more important past and current projects and studies that focus on developing and improving water resource management in general are noted in Appendix 1. Future directions the Bank could take primarily include continuing these investments to develop resilience and flexibility in the water system.

Activities focused on climate change are still in development but are expected to include:

- Investments in water management infrastructure in the Mekong in the forthcoming Mekong Water Resources for Rural Development Project

- Support for fostering regional cooperation in the forthcoming Regional Mekong Integrated Water Resources Management Project, which would support Cambodia, Lao PDR, and the Mekong River Commission in addition to Vietnam

- Technical assistance to improve hydrometeorological forecasting, monitoring, and modeling through the Natural Disaster Management Project, partially financed by the Global Facility for Disaster Risk Reduction and Recovery (GFDRR)

- Water resource management institutional strengthening and infrastructure investments through the proposed Managing Natural Hazards Project, which will support water management and flood control in selected river basins in the Central Region

- Water resource management as relating to brackish water aquaculture in the Coastal Resources for Sustainable Development Project, which will invest in improved water treatment, water quality monitoring, and drainage to support sustainable aquaculture production.

Assets Vulnerable to Natural Disasters

Groupings of climate-sensitive assets covered elsewhere in this report can be fairly well defined. However, assets vulnerable to natural disasters include a mix of natural, human-made, and human assets, which vary by hazard type and by region. Reducing the impacts of natural disasters is, however, the subject of specific government departments, policies, and investments and is the theme of major official development assistance (ODA) projects, including those supported by the World Bank.

Challenges

Every year, natural disasters in Vietnam cause an average of 750 deaths and result in annual economic losses equivalent to 1.5 percent of gross domestic product (GDP). However, damage and loss data are underreported, so the real totals may be much higher. As most people live in low-lying river basins and coastal areas, more than 70 percent of the population is estimated to be exposed to risks from multiple natural hazards. Often, the poor are most vulnerable to the impacts of natural hazards as they do not have adequate coping mechanisms or the ability to quickly recover from losses.

Vietnam has always been subject to natural hazards such as floods, droughts, storms, and typhoons. Analyses of data from recent decades do not point to any increases in extreme weather events in Vietnam. However, the impacts of natural hazards are increasing, in tandem with growing populations and economic activity in vulnerable areas. The reason for this increase in damage and losses is human-made factors, such as environmental degradation, poor land use planning, and increased urbanization in hazard-prone areas.

Although much work remains to be done to improve the reliability of scenarios, it seems quite possible that there will be a long-term increase in extreme weather events. With any amount of SLR, storm surge events will worsen, particularly if there are stronger typhoons. Modeled changes that suggest wetter wet seasons could also translate into more-frequent flooding events, while drier dry seasons will result in more droughts. Because the potential human and economic losses from flooding events, prolonged droughts, and typhoons associated with strong sea surges can be so devastating, the possibility that climate change could worsen such events is worrisome and deserves attention.

Emerging Solutions

The goal of natural disaster risk management (DRM) is to enhance Vietnam's resilience to the impacts of natural hazards. The current economic and human toll of natural disaster events in Vietnam already makes this a critically important area for investment and is even more so the case when factoring in climate change. Therefore, prioritizing investments for disaster risk reduction (DRR) is the optimal entry point for integrating adaptation measures (UNDP 2010). The United Nations Development Programme (UNDP) provides 10 general recommendations for integrating CC adaptation into DRR (UNDP 2010):

- Promote an integrated risk management approach to development, rather than isolated DRR or CC adaptation initiatives

- Avoid creating new institutions for either DRR or CC adaptation, instead focusing on joint integration of both concerns into regular and existing institutions

- Emphasize partnerships and participation

- Focus financing options on integration into regular planning and financing systems

- Support knowledge sharing and learning so as to facilitate informed decision making

- Enhance the use of existing methodologies and tools, including environmental impact assessments and comprehensive risk information systems (such as geographic information systems)

- Develop approaches for integrating DRR and CC adaptation into development planning and practice, to serve as guidance for plans and program design at all levels

- Mainstream gender into the overall analysis, plans, and programs

- Encourage public-private partnerships and market-based solutions, especially for risk transfer.

In Vietnam, a gradual shift is under way from post-disaster response to more proactive, *ex ante* disaster risk reduction efforts, which requires longer-term vision and action. An example is the mainstreaming of disaster risk reduction into the development planning process, as stated in the *National Strategy on DRM up to 2020* (Government of Vietnam 2007). However, this approach to mainstreaming DRR at the operational level has not been widely successful, in part due to the country's limited financial capacity. When coupled with the emerging CC agenda, the disaster risk reduction agenda becomes more pressing in the immediate term. The following are some suggested policy areas where attention is needed:

- Completion and launch of monitoring and evaluation (M&E) framework for the National Disaster Risk Management

- Completion of needs assessment/action plan for hydrometereological services and early warning systems, including plans for the sustainability of such services

- Climate change risk assessments of at least three existing sectoral master plans (from amongst transport, energy, irrigation systems, tourism, major cities, etc.)

- Development of mechanisms for enhanced inter-ministerial sharing of information/assessments pertaining to floods, landslides, salt water intrusion, and other climate or weather-related disasters

- Ensure that sea dike and river dike programs appropriately take into account climate change considerations

- Update Law on Natural Disaster Prevention (planned for 2012)

- Ensure that the National Program on Enhancement of Public Awareness and Community Based Disaster Risk Management (CBDRM) is adopted at provincial level

- Ensure appropriate preparation and implementation of Prime Minister's decision on "Planning of managing the activities of fishing harbors, safe shelters for boats and ships until 2020".

World Bank Programs

Over the past few years, the Bank has supported Vietnam to shift from focusing primarily on post-disaster response to dealing with disaster management in the context of development planning and budgeting; this will be even more important in view of the projected CC scenarios. Most analytical work on DRM carried out by the World Bank in the past three years has included climate change. Notably, the GFDRR Trust Fund managed by the World Bank, in its Phase I program from 2007 to 2010, has conducted a range of advisory work on topics such as:

- Local planning for climate-resilient cities
- Assessment of CC impacts on drainage design in coastal cities
- Sovereign financial protection against natural disasters for the government that looks into long-term and sustainable risk financing options
- The impact of weather-related shocks on vulnerabilities in Vietnam
- Development of the M&E framework for the National Disaster Risk Management Strategy
- Needs assessment/action plan for hydrometereological services
- The social dimensions of natural disasters.

A new $2 million GFDRR program for FY11–13 is under way to support MARD and MoNRE. The main focus of the Bank-executed part of the grant ($500,000) is on enhancing the resilience of the World Bank portfolio to the impacts of natural hazards and climate change.

While clearly justifying the need for a more strategic and longer term way of dealing with disasters and CC impacts, the Bank's work has also confirmed the lack of proper and systematic collection and use of data that are critical for informed decision making and longer-term risk management.

Since 2005, Vietnam has been implementing the Natural Disaster Risk Mitigation Project as well as grants from other donors. This project has helped to build and strengthen critical infrastructure for disaster mitigation and capacity building at the central and local levels, especially the modern technical capacities in terms of early warning and forecasting, and critical hazard data and information for decision making. (See Appendix 1 for other related DRM investments.) The upcoming Managing Natural Hazards Project will help put in place improved infrastructure, early warning systems, and provincial and community planning/contingency systems for DRR in selected provinces in the Central Region vulnerable to extreme weather events and associated flooding, river bank erosion, and so on. Community-based resource management will also be supported under the 2nd Northern Mountains Poverty Reduction Project. Finally, the Bank's urban development projects (see below) are also explicitly addressing issues related to vulnerability to natural disasters.

Urban and Infrastructure Assets

Challenges

Vietnam's largest cities have been widely recognized as some of the most vulnerable urban areas in the world to climate change (Stern 2006; IPCC 2007). A number of factors contribute to this, including the low-lying geography, continued rapid urbanization, poor infrastructure, insufficient urban planning capacity, and limited financial resources. In the climate and hydrological modeling conducted for Vietnam, flooding threats come from extreme weather events combined with sea level rise. Storm surge and tidal flooding are key climate change drivers behind the most damaging events in Ho Chi Minh City. It is also predicted that by the end of the century, rainfall will intensify during the monsoon period while extreme rainfall linked to storms is expected to become more common.

A recent ADB study modeled the impact of climate change on Ho Chi Minh City (ADB 2010). By 2050 they conclude that the extent of flooding by 2050 (compared to models without climate change) will be 3% greater for extreme events and 7% more for regular floods but that at the same time the increase in flood depth and duration will be significant. Southern satellite cities around HCMC, particularly those to the southwest and southeast of the city, could be vulnerable to regular and extreme flooding. A proposed flood control system of river dikes protects only some areas and then, only partially. The study uses a worst case SLR of 26 cm by 2050.

In recent years, Vietnam has experienced high rates of urbanization, and these trends are projected to continue, as only 30 percent of the population currently lives in urban areas and this is projected to increase to 50 percent by 2025 (World Bank 2010i). Increased urban construction will result in a larger percentage of the urban land mass being covered with pavement and buildings, reducing water infiltration into the soil and the ability of natural drainage systems to mitigate flooding. The demand for urban expansion will also create pressure to continue building in low-lying flood zones. Informal settlement sprawl will make poor and marginalized communities more vulnerable to the effects of flooding.

Emerging Solutions

Urban planning instruments can be a tool of choice for urban areas to strengthen resilience to change. The most pressing need in Vietnam with respect to adaptation to climate change in urban areas is to continue to support a strengthening of urban planning in general. Over the next 10 years, these instruments need to additionally incorporate climate change considerations.

In response to the growing evidence of climate change, the government needs to do more to incorporate climate change adaptation considerations into its infrastructure and policy planning process, while paying close attention to capacity building at the local level. Note also that in many areas there is a strong relationship between adaptation activities and mitigation. For example, urban planning and construction codes need to simultaneously address adaptation but also help cities move to a lower carbon future. Specific solutions include the following:

- Incorporating climate change strategies into a strengthened urban planning and disaster management processes at all levels of government (Dowall 2008)
- Rigorously enforcing urban plans to ensure that illegal construction and urban sprawl do not occur in low-lying and vulnerable zones (ADB 2010)
- Promote urban densification more generally, and improved transport planning to reduce overall amount of inter-urban travel
- Energy efficiency in buildings, and address large consumers of energy, such as WSS utilities

- Preserving green spaces, such as parkland, riverbank buffer zones, and recreational areas, to counterbalance the hydrological pressures from increasing urbanization (World Bank and DHI 2009)
- Locating and designing urban infrastructure, such as roads, dikes, and water treatment and waste management facilities, to reduce vulnerability and ensure their resilience in the face of extreme climate change–related events (ADB 2010)
- Raising funds from international capital markets to pay for the infrastructure needed to adapt to climate change while providing basic services to growing urban populations (Dowall 2008).

Some specific investments are needed to respond to long-term climate change and should be started now because of the decades-long lead time needed to plan and implement infrastructure investments. These likely include flood control systems in cities vulnerable to SLR and storm surges. Some long-term impacts will be addressed through major and expensive investments that are best delayed at this time, however. The focus in the next years should be on better analyzing these options.

World Bank Programs

The World Bank is currently implementing a series of projects that address climate change vulnerabilities in Vietnam's urban areas. These projects focus on two areas: capacity building for responding to climate change and the financing of urban infrastructure.

In 2008, the World Bank published *Climate Resilient Cities: A Primer on Reducing Vulnerabilities to Climate Change Impacts and Strengthening Disaster Risk Management in East Asian Cities* (World Bank 2008e). The report aims to build capacity by summarizing the best practices from cities around the world that are actively planning to address climate change risks. The key concept that emerged from this study is "resiliency"—the ability of a community to respond and recover from a climate change–related event or disaster. To implement the *Primer* in Vietnam, the World Bank is in the final stages of publishing a manual, entitled the *Workbook on Local Resilience Action Planning in Vietnam*, to help government officials prepare Local Resilience Action Plans. These are analytical frameworks to identify vulnerabilities to climate change impacts and which propose a methodology for how to address them.

The World Bank is also financing a range of urban infrastructure projects that incorporate measures to adapt to climate change. The largest of these projects include the Vietnam Urban Upgrading Project and the Ho Chi Minh City Environmental Sanitation Project, while the Coastal Cities Environmental Sanitation Project is the one most focused on climate change adaptation:

- The Vietnam Urban Upgrading Project will benefit about 3 million people in four cities. A central component of this project is the completion of major drainage and wastewater works benefiting over 400,000 people. The second phase, focused on medium-size cities of the Mekong Delta, includes a number of studies and investments to specifically address likely climate change impacts.
- The Ho Chi Minh City Environmental Sanitation Project is intended to reduce flooding by increasing the capacity and expanding the coverage of drainage, improving access to basic urban sanitation infrastructure, and enhancing environmental conditions in Ho Chi Minh City.
- The Coastal Cities Environmental Sanitation Project used hydrological modeling to assess the potential impacts of climate change on the performance of urban drainage infrastructure in three pilot cities along the coasts of central Vietnam. The models

predicted that in order to reduce vulnerability in these cities, urban design should include measures to reduce the volume of surface runoff entering the drainage systems. They also suggested that the application of hydraulic modeling to some or all of the drainage systems should be encouraged in order to better study and understand the impacts of climate change.

- Various projects in the pipeline focusing on eco-city concepts, such as the Danang Sustainable Cities Project.

Biological Resources

Challenges

Natural ecosystems and biodiversity make a major contribution to sustaining the livelihoods of the poor in Vietnam and make a substantial contribution to the national economy overall—particularly through the fisheries, forestry[4], agriculture, and tourism sectors. Most of the country's poor and vulnerable population live in rural areas and depend on natural ecosystems—many in the forestlands of the uplands, the storm-exposed lowlands of the central coast, and the low-lying coastal zones of the Red and Mekong River Deltas. But these systems are declining. Green accounting indicators collated by the World Bank show that Vietnam's gross national savings (as a percentage of gross national income) would adjust downwards from 35.5 percent to 15.2 percent if natural asset depletion were taken into account (World Bank 2009d).

Biodiversity and natural ecosystems are crucial for sustaining and building climate resilience and diversifying adaptation options for the poor and most vulnerable. Thus better management of Vietnam's terrestrial and marine ecosystems—and of the services they deliver—offers opportunities for maintaining and even improving the livelihoods of millions of the rural poor. Scenario analysis by the Millennium Ecosystem Assessment (MA 2005) at the global level indicated that ecosystem degradation risks are undermining progress toward four of the eight Millennium Development Goals, and this may also be true in Vietnam, especially if climate impacts accelerate ongoing rates of degradation. The impacts of such degradation could undermine the impressive progress in reducing poverty. Unfortunately, these natural systems are undervalued in local and national economic planning and suffer from, among other factors, unsustainable levels of resource extraction and the consequences of over-centralized state management and weak state institutional capacity (World Bank 2010i). Natural forests have declined precipitously in terms of both extent and quality, coral reefs have been extensively degraded, and both marine and coastal fisheries have declined.

There has been little specific research in Vietnam on the likely additional impacts of climate change on natural ecosystems, and for this reason an important focus of work going forward is improving the evidence base of these possible impacts. It seems likely that climate change may play a role in shaping and accelerating the decline of natural ecosystems in Vietnam, but considerable work is needed to guide specific management and investment decisions.

[4] Official figures show that the forest sector's gross national value is only 1 percent—but the actual contribution is much higher, since this figure does not include contributions for local and subsistence uses nor the sizable added value from wood processing, paper, and pulp.

It is possible to speculate on some possible scenarios. Many of Vietnam's natural ecosystems are already stressed, degraded, and fragmented, so their resilience to the impacts of climate change may already be compromised. For example, forests that are highly fragmented are particularly vulnerable to forest fires and encroachment, making their protection and management more expensive. Climate change has been extensively documented to have a range of impacts on migratory birds. Some of these impacts might be caused by changes outside of Vietnam (for example, associated with changing food availability) at breeding areas in China and Siberia. Pests and diseases may also play an important role in climate-driven changes to forest systems. In coastal areas, rising sea levels may increase coastal erosion and put pressure on remaining mangrove forests. Such ecosystemic impacts have implications for poverty alleviation, food security, and disaster risk for communities whose livelihoods and welfare are inextricably linked to their natural environments.

Global trends of ocean acidification and warming surface waters are also likely to have a negative impact on remaining coral reefs, which may reduce the productivity of fisheries, particularly in near-shore, coastal areas. As sea temperatures change, dramatic shifts in sea currents may also occur. The nature and magnitude of possible impacts that might occur in the marine realm in Vietnam are at present almost unknown, but given the economic importance of marine fisheries and the fact that marine stocks are already vulnerable due to mismanagement and overfishing (World Bank 2010i), there is every reason to give high priority to further research on marine climate change impacts.

Overall, the decline of natural ecosystems will reduce the capacity of vulnerable groups to adapt to climate change; more than 15 years of research on vulnerability to climate change shows that it is the marginalized who most suffer from changing environmental conditions (Ribot et al. 1996; Adger et al. 2001).

Emerging Solutions

More so than in other sectors covered in this report, the impacts of climate change on biological resources and the needed adaptation measures require more research. A focus is needed on improving the overall evidence base on the implications of climate change on natural ecosystems and their services for local and national economies and for the poor in particular. This information is needed to identify specific actions and investment priorities. As noted earlier, there is currently little (if any) empirical research or modeling of projected climate change trends on either terrestrial or marine ecosystems.

The research that is needed includes scenario analysis of climate change impacts on marine and terrestrial ecosystems, particularly in relation to coastal fisheries and forest-based economic and livelihood systems, and analysis of the impacts of climate-induced ecosystem change on vulnerability, resilience, and livelihoods.

Some of the specific research needs include the following:

- Policy support including definition of options for regulating resource access and benefit distribution that would increase incentives for better stewardship of coastal resources (such as community mangrove management systems or comanagement of coral reefs)

- Designs for ecosystem-based adaptation responses—including restoring or protecting wetlands to enhance coastal protection from storm surge, saltwater intrusion, and sea level rise—that will also deliver benefits for emissions mitigation

- Analysis of the contribution that marine protected areas could make to reducing local stress on critical habitats like coral reefs, protecting keystone species, and restoring depleted fish stocks

- Analysis of the impacts of climate change on forest resources and forest biodiversity, using downscaled global climate models, was the subject of one of the EACC studies (World Bank 2010b); this has helped identify likely adaptive management options (for example, forest fire and pest management strategies), implications for protected areas planning, and associated investment costs

- Likely impacts of sea level rise on mangrove forests, which play such an important role in reducing coastal vulnerability and supporting coastal food production; this could also identify adaptive management options

- Valuation studies of the ecosystem service values of floodplain wetlands—particularly in the lower Mekong River, where their contribution to groundwater recharge might have significant economic implications and where better wetland management might offer a cost-effective investment option for managing saline intrusion and declining groundwater supplies

- National-level economic analysis of the contribution of protection forests and protected areas (known as special use forests in Vietnam) to climate mitigation and resilience, including analysis of ecosystem service values (such as carbon sequestration, coastal protection, fisheries support, watershed protection, and groundwater recharge) and identification of options for optimizing their contribution to climate action through better management and more-effective financing from public expenditure and emerging market mechanisms (for example, REDD+ and payments for environmental services).

Without a robust evidence base about future impacts, the best investments that can be implemented now are those that will contribute to better ecosystem management in general—and thus to better prospects for maintaining resilience to climate change. (See Box 2.) In general, efforts to improve sustainable management of existing systems—for example, through better resource management planning, promoting community level management, and strengthening tenure arrangements—are likely to deliver improved climate resilience through maintaining and diversifying the range of options available to support adaptation.
Valuing natural assets such as fisheries, coastal wetlands, and terrestrial forests at the national level and better integrating these values into economic decision making ultimately strengthens resilience. This could be done both within the World Bank's own country strategy and planning processes and by helping the government to undertake this work for national economic planning purposes. It could start with provincial-level pilots and then be scaled up to national assessments.

Box 2. Investing in Better Ecosystem Management

Investments in environmental management interventions in general can be valuable, since globally these can deliver high benefit-to-cost ratios. Unfortunately, there has been little such analysis of environmental support in Vietnam. One of the few such studies—of mangrove reforestation and management in Thai Binh and Nam Dinh provinces—demonstrated just how

cost-effective such investments can be (study cited in DFID 2005). The authors found that planting and protecting 12,000 hectares of mangroves cost about $1.1 million, but this helped reduce the cost of dike maintenance by $7.3 million a year. It was also estimated that 7,750 families improved their livelihoods, and hence their resilience to future hazards, through the selling of crabs, shrimps, and mollusks. The mangroves were also thought to have substantially reduced damage to property and the loss of lives during severe tropical storm events.

The development of vulnerability maps that identify exposed populations with a high dependence on coastal and marine ecosystem services could also provide an effective tool for strategic planning and targeting interventions at communities most in need—that is, the least resilient. A resilience framework designed to decrease ecological vulnerability and enhance resilience by focusing on appropriate drivers, coupled with measures to increase social resilience to climate shocks within the community, would inform the design of adaptation programs. These need to be developed through the application of participatory approaches that complement scientific information with community-level consultations about the adaptation strategies they have developed thus far to address the growing environmental challenges. This would ensure that the response measures meet the needs of the affected communities, build on existing strategies, and strengthen ownership of the government's resilience strategies at the local level.

An important resilience strategy builds on all the measures inherent in a functioning forest management system, which protect and sustain forests and a significant part of terrestrial biodiversity. (These are discussed later, in the section on REDD.) Continuing to strengthen and support the protected area system is an important resilience measure.

A very important but challenging need is for the government and relevant line ministries to value the country's natural assets at the national level and to develop pathways for inclusion of natural asset values into national accounting systems. The aim of this work would be to develop a robust economic assessment of the current value of natural assets and services and include these in the national accounts. This could help ensure that the assets that will contribute increasingly to climate adaptation will be better integrated into economic decision making. Such analyses are rare in the world, but pilots and moving accounting systems in this direction are good first steps.

Adaptation will require active steps to reduce fragmentation of existing ecosystem resources and to improve connectivity by conserving and reestablishing corridors within landscapes. In a long-term perspective, a network of ecological corridors can allow entire ecosystems and their constituent floras and faunas to "migrate" to areas that have climates they are adapted to. Because habitat loss has been so extensive in Vietnam, the possibilities for corridors linking protected areas are minimal, but there are a few, and these need to be explored. (WWF's recently closed Green Corridor Project in Thua Thien Hue Province, for which the Bank was the GEF Implementing Agency, is one good example.) Preventing further fragmentation of Vietnam's ecosystems should be a key priority for government. This is also important in marine areas, and options for marine corridors and coral reef restoration initiatives need to be explored.

Future research might indicate that a few specific protected areas are particularly critical and particularly vulnerable to climate change (for example, a montane ecosystem being "squeezed" up into higher altitudes). Special future investments might therefore need to establish the priority of management and protection of these areas.

World Bank Programs

Various investments of the Bank have focused on forestry management, supporting terrestrial protected areas, strengthening the resilience of coastal communities, and supporting marine protected areas. (See Appendix 1.)

The Coastal Resources for Sustainable Development Project now under development will support various investments that are relevant to a climate change agenda: vulnerability mapping, integrated coastal zone resource planning, and fishery stock assessments and monitoring.

Terrestrial biodiversity protection projects are not a major part of the Bank's portfolio, as the government of Vietnam has not chosen to borrow funds for the protection of biological resources. Smaller GEF-financed projects are ongoing (notably, support to the Vietnam Conservation Fund and a range of small projects with nongovernmental organizations (NGOs) through the Critical Ecosystems Partnership Fund) and it is hoped that one or two other projects will be financed under the fifth round of GEF financing. Future investments in forestry operations could include greater attention to protection of terrestrial biological resources. The gradual emergence of possibilities for REDD financing (as discussed later) will offer some opportunities for strengthening incentives for conserving forest corridors.

It is intended that several of the top analytical priorities just described will be supported by the forthcoming DFID/World Bank Partnership on Climate Change.

Agriculture

Challenges

Agriculture (including aquaculture) will be affected by climate change in several ways. For example, increases in temperature may cause early crop maturation and/or increase pest and disease pressures, thereby reducing yields. Shifts in eco-agricultural zones could cause loss of varieties of indigenous breeds or species, although this may also extend the ranges of some crops. Hydrological changes and SLR will affect the availability of fresh water or even physically change the agricultural landscape. Climate change may affect the suitability of different post-harvest and crop storage practices (World Bank 2008c).

Few agricultural sector studies on climate change have been done in Vietnam. The World Bank's EACC study (World Bank 2010b) notes that with rising sea levels there is likely to be a loss of cropland in the major river deltas, increased flood inundation in the rainy season, and increased salinity intrusion in the dry season. Changes of rainfall and temperature as well as atmospheric CO_2 concentration will affect crop productivity (positively, in the case of increased CO_2 concentration). Yields in Vietnam, in the absence of adaptation measures, will likely be reduced for rice, maize, cassava, sugarcane, coffee, and vegetables. Impacts are predicted to be more significant under dry scenarios than wet ones.

All predictions are quite sensitive to climate change projections, and as these currently vary significantly, crop yield estimates similarly need to be considered as very tentative. It is important that future scenarios for Vietnamese agriculture should not be based purely on mechanistic considerations of climate, hydrology, and biology. These are clearly important, yet recent experience has shown that there are many other "drivers" influencing the structure and performance of Vietnamese agriculture and the behavior of its farmers and agro-enterprises. These major drivers include changes in diets and consumer preferences, market liberalization and trade integration, the development of land and labor markets, and urbanization. Certainly over the short to medium term (say, to 2020), these other factors—together with the "regular" patterns of weather variability—will have a more profound influence on Vietnam's farmers (and consumers of food) than climate change. This could, however, change over the longer term, and

as better climate change scenarios emerge we must be prepared to constantly reevaluate the state of our knowledge.

Overlaying SLR onto topographic maps has led to theoretical calculations of land loss and reduced rice production over the longer term. Physical flooding and saline intrusion could mean that farmers might have to (or find it advantageous to) switch from rice to aquaculture. This shift has costs and involves other challenges for risk management (in disease control, in marketing a perishable product, etc.) but also potential benefits. Long-term models predict a decline in rice production in Vietnam as a result of SLR and increased saline intrusion. Yet we would expect reduced rice production even in the absence of climate change, given changing Vietnamese diets (in which per capita rice consumption is steadily falling), labor and land market dynamics, and the economics of agriculture in a modernizing and increasingly international market–integrated economy.

A study of aquaculture and climate change has recently been undertaken for the World Bank EACC series, with the assistance of WorldFish (World Bank 2010b). This work focused on shrimp and catfish in the Mekong Delta. The sector will certainly be challenged by climate change. Impacts could include possible damage and loss of ponds in exposed coastal areas due to increased coastal erosion and rising sea level, loss of suitable land area for aquaculture caused by coastal inundation, rising feed costs if climate change adversely affects coastal marine fisheries, and adverse impacts on fishery health arising from an increased incidence of diseases, parasitic infections, and so on due to temperature changes and/or changes in the availability of fresh water. Reduced water availability may lead to more competition/conflict between agriculture, aquaculture, and other sectors over access to high-quality water.

As for rice, the challenges posed by climate change for aquaculture are among a wider set of factors affecting the sector today and expected to have an impact on its performance and viability in the future. These other factors relate to market opportunities and competition, the impacts of urbanization and industrial pollution, and others. Aquaculture producers are exposed to many types of risk, leading to the worldwide pattern of high levels of entry and exit from the sector. Climate change could well exacerbate several production risks.

In summary, in agriculture/aquaculture, most impacts associated with climate change will take place gradually over a long time. Impacts that need special attention are those in specific subsectors that could arise from flooding, salinization, and long-term temperature or water availability changes in the case of crops that are sensitive to small changes in temperatures or moisture availability.

Emerging Solutions

In common with other sectors grappling with adaptation issues, it continues to be very important to sustain ongoing research into scenario development and into potential agricultural impacts and adaptation measures. At this point, we simply do not know enough about what will happen to the climate in Vietnam and the effects any given change would have. This is the case not only in relation to Vietnamese rice and aquaculture, but also in relation to a wide set of commercial and industrial crops for which Vietnam has achieved notable growth in production and trade in recent years (coffee, pepper, cashew, cassava, and horticultural crops). Climate change will also affect animal husbandry and animal health challenges and practices in Vietnam on a longer-term basis.

Most of the emerging solutions in the agricultural sector for the next decade should focus on improving the resilience of the sector in the face of weather, biological, environmental, and commercial risks. This will lead the sector to be much better prepared to respond and adapt to the unknown longer-term impacts of climate change. The approaches to risk management in

agriculture—which will also constitute climate change adaptation measures—cut across infrastructure, technology, natural resource planning, farm/business management practices, and financial instruments. Areas warranting additional attention include:

- Improving weather and hydrological forecasting and early warning systems
- Increasing the area and operational efficiency of irrigation
- Improving water storage capacity at multiple levels
- Issuance of a circular pertaining to the Food Security Decree which provides for a balanced approach covering measures to ensure long-term food security, address vulnerable groups, and provide an enabling environment for a more flexible and efficient agricultural economy in the face of future climate change
- Promoting the use of scenario planning with local stakeholders to build consensus, understanding, and learning about the CC implications for agriculture and risk management plans (and generally strengthening attention to community-based models of adaptation)
- Strengthening land use and water resource planning
- Strengthening the resiliency of farm and market infrastructure to extreme weather hazards
- Making better use of weather and other data to promote insurance and sustainable rural financial services
- Refocusing farm advisory services to facilitate farmer adaptability and risk management
- Investing further in agricultural research to address climate-related stresses—for this to happen, it may be important to reexamine the prevailing rules for the release or commercialization of new varieties as well as the regulations that inhibit the emergence of private/cooperative seed companies
- Promote South-South cooperation and greater private sector participation in research
- Facilitating the transition from freshwater-dependent agricultural/aquacultural production systems to those involving brackish water systems.

The agricultural sector in Vietnam is so dynamic that climate change seems best addressed through the resilience and risk mitigation strategies of the sector, as noted above. Some major water sector investments (irrigation and reservoirs) are important for agriculture, but these are covered in the previous section, on water.

World Bank Programs

World Bank projects in Vietnam have long focused on the general development of the agricultural sector and on enhancing its resilience in the face of weather and other risks. Several of these investments and other areas of support are noted in Appendix 1. Current and planned projects address constraints and opportunities associated with plant and animal health,

agricultural and agro-enterprise financing, agricultural commercialization, and the application of sustainable "good practices" in crop and aquaculture production. A strategy is being used to mainstream attention to risk management, including weather/climate risk management, into the Bank's broader rural development work—both its existing and pipeline investment portfolio and its analytical work.

Selected examples of this effort include:

- Incorporation of alternative climate change scenarios (to 2030) into food security scenarios and policy options being examined under the Rural Development AAA cluster and possibly under the U.K. Department for International Development (DFID)/World Bank partnership

- Support for research on salt- and inundation-tolerant rice varieties under the Agricultural Competitiveness Project (which also supports other more extended application of good agricultural practices for rice)

- Potential support to the rehabilitation and management of mangrove areas in the forthcoming Mekong Water Resources for Rural Development Project and the Coastal Resources for Sustainable Development Project

- Investments to promote "good aquaculture practices" and climate risk management measures in brackish water aquaculture under the latter project

- Technical assistance, training, and investments to strengthen national and provincial capacities for weather forecasting and early warning under the forthcoming Managing Natural Hazards Project

- Technical assistance to improve hydro-meteorological forecasting and monitoring through the GFDRR and through project investments.

Vulnerable Social Groups

People are ultimately affected by every type of impact induced by climate change. Certain social groups or communities are inherently more vulnerable or likely to be more affected and therefore need special consideration.

Challenges

Social issues with regard to climate change were addressed under one of the EACC Vietnam country case studies (World Bank 2010b), and this report has been incorporated in the EACC synthesis report on social issues (World Bank 2010h). The study found that vulnerability to climate change is generally socially differentiated. For example, the impacts of extreme weather events are related to poverty status, access to resources, and social security systems. Across all the countries looked at, including Vietnam, groups that were already the most socially vulnerable (women, ethnic minorities, the disabled) were found to be disproportionally less likely to be able to adapt to climate changes.

One way that socially vulnerable groups might be particularly affected by climate change is their increased susceptibility to health problems. These could include an increase in diarrhea and

water-borne infectious diseases, including cholera; the lack of safe drinking water (same impact); a potential increase in endemic areas for malaria, dengue, and other vector-borne infectious diseases linked to water and temperature; nutritional impact resulting from impacts on agricultural outputs; and mental health impact of disaster-related stress. Linkages between climate change and health have been demonstrated for some areas of the world (for example, malaria-bearing mosquitoes moving up in altitude in the Colombian Andes to new areas), but as yet no such compelling links between health and climate change have been demonstrated in Vietnam.

Emerging Solutions

To address social vulnerabilities to climate change over the short term (until 2020), we need to strengthen our focus on reducing vulnerability of social groups to variability and external shocks. The possibility that weather will become more variable and more extreme makes it imperative to act on this front. Recommendations related to social sustainability should be considered for all adaptation measures considered above (i.e., in agriculture, water resources management, biological resources, and urban areas).

Some of the specific policy recommendations of the World Bank EACC report (2010h) are:

- Build on past strategies to respond to weather variability (taking into account indigenous knowledge, best practices) to build further adaptability

- Provide better access to information and planning processes to foster socially sustainable adaptation investments and reduce potential for conflict

- Pursue adaptation interventions that provide co-benefits for sustainable development, such as strengthening social safety nets; such no-regrets options can be implemented now and will improve livelihoods even in the absence of climate change

- Address governance by supporting actions for inclusive and participatory decision making, transparency, and accountability

- Use geographically targeted multisectoral interventions for vulnerable regions.

Experiences from across the globe and the region show that community-driven development operations can serve as a useful platform for the provision of disaster response assistance, and increasingly so for support of community-based climate change adaptation measures.

Looking ahead, it is possible that several decades from now we will be able to identify the need for special climate change–related social interventions. For example, induced migration away from affected areas could require special attention and investments that would not be sufficiently considered in social resiliency programs.

World Bank Programs

Considerable analytical work has been done by the Bank in Vietnam on social vulnerabilities and weather, natural disasters, and climate change. In addition to the EACC study, the Bank is currently beginning a study on the social safety net in Vietnam that includes analysis of the incidence of social safety net transfers. (This and other studies are documented in Appendix 1.) These studies, together with the work being done in minimizing disaster risk vulnerability, will help shape programs to reduce social vulnerability to climate change as it becomes clearer what kind of impacts are most probable.

We can also mention the Bank's community-driven development operations; in Vietnam this includes the Natural Disaster Risk Mitigation Project, which centers on reducing vulnerabilities of poor communities to natural disasters and other shocks, and the Program 135 (in part reducing vulnerability to disasters). It is possible that a Poverty Social Impact Analysis will be carried out to support potential policy-level CC investments in Vietnam. This could help institutionalize at the policy level the social resilience measures for assisting the most vulnerable groups to adapt to climate change.

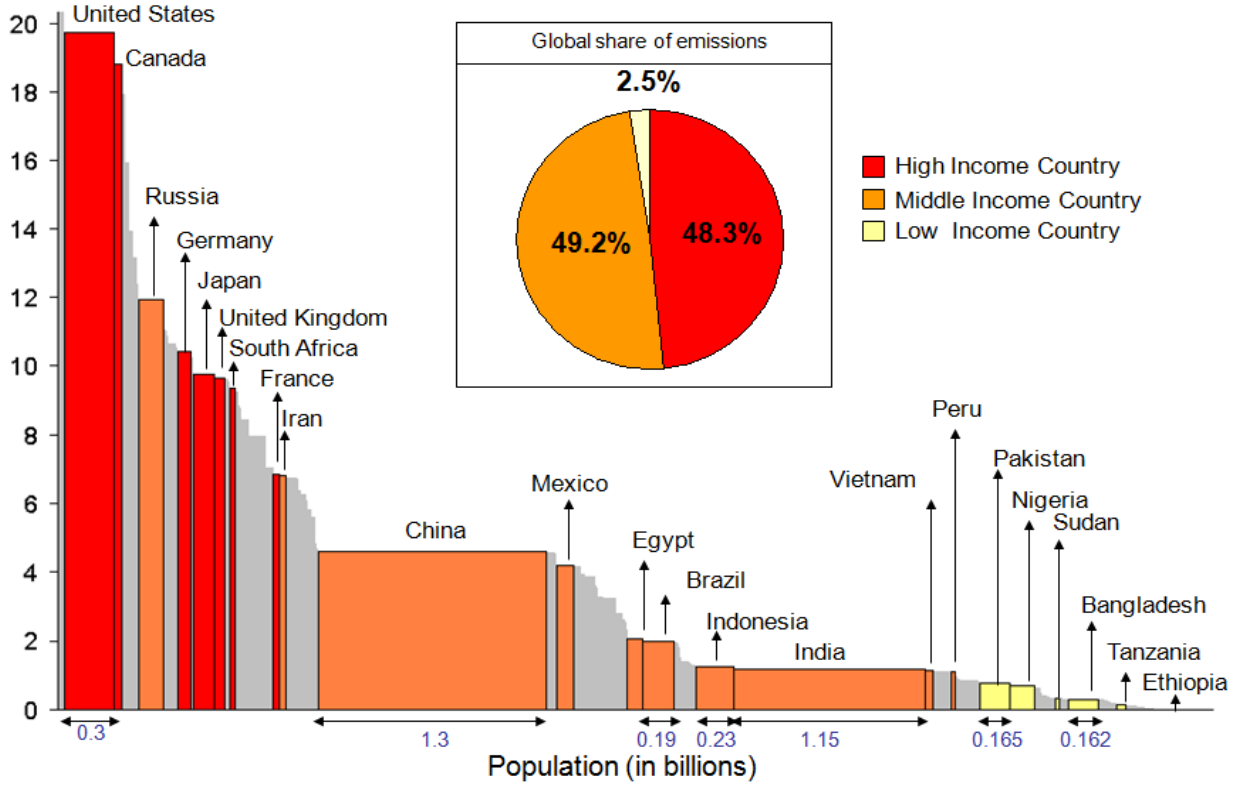
On human health issues, better information is needed and more consideration of possible linkages with climate change. The Bank is considering pathways by which climate change could affect human health, reviewing national assessments on vulnerability to climate change (including health impact vulnerability) and public health responses to it.

MITIGATION PRIORITIES IN VIETNAM

Background Information on Emissions of GHGs in Vietnam

Per capita emissions of CO_2 are much higher in industrialized countries, particularly in North America, than they are in Vietnam. Historically, global emissions have been dominated by North America and Europe. But the size of the population matters a great deal, and China now emits about the same volume of GHGs as the United States does (WRI 2009). However, Figure 1 also highlights the fact that middle-income and high-income countries are now responsible for about equal shares of GHG emissions. The Figure is particularly valuable for putting Vietnam's relative and absolute contribution of GHGs into perspective.

Figure 1. Emissions of CO_2 per Capita (in thousands of $MtCO_2e$)

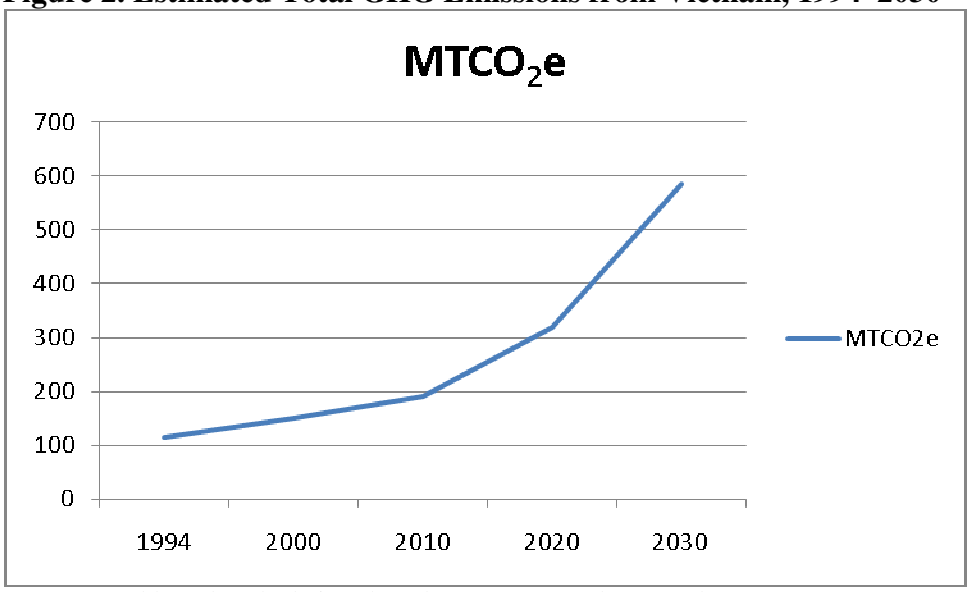


Sources: EIA International Energy Annual 2006 and World Development Indicators 2008

Published studies on GHG emissions from Vietnam can be quite confusing in terms of how their data are collected and presented. Reported values can be actual or projected, can refer to only CO_2 or all GHGs (measured then as CO_2 equivalent, or CO_2e), and can cover different emissions sectors that may vary from year to year. Caution is therefore needed when comparing cited data. Official emissions data are only available for 1994 and 1998 (published in MoNRE 2003), but an updated report (the Second National Communication to the UNFCCC) is expected from MoNRE at the end of 2010. JICA is beginning a technical assistance program with MoNRE that within a few years should help the country produce good emissions estimates using data from 2005 and 2010.

Figure 2 shows rough estimates of total GHG emissions from Vietnam for 1994 to 2030 (using the Bank's analysis of data sets, adjusted to ensure similar measurements were used). These estimates are mostly based on data provided by MoNRE (2003) and United Nations-Vietnam (2009a) and have been adjusted to include estimated emissions from waste and industrial processes that were missing in some of the original data sets. Various sources indicate a net sequestration of carbon from the forest sector after about 2000, due to expanding forest cover. We provisionally do not include any sequestration values pending more definitive data on changes in forest cover in Vietnam. The dramatically upward trend in projected total emissions is quite striking for Vietnam.

Figure 2. Estimated Total GHG Emissions from Vietnam, 1994–2030

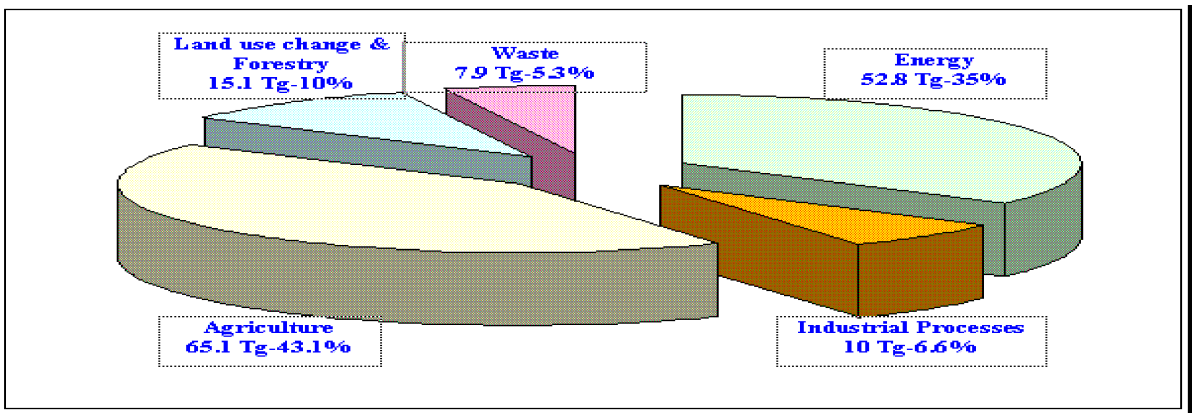


Source: World Bank Calculations based on MoNRE and UNDP data

According to WRI (2009), Vietnam emitted about 177 $MtCO_2e$ in 2005 (excluding offsets), the latest year for which internationally comparable data are available. That put Vietnam at rank 35 in absolute emissions in the world that year, with about 0.5 percent of the global total. The emissions per capita, not including contribution of offsets, were about 2 tons of CO_2e, which ranked the country one hundred and eleventh in the world. Although Vietnam is thus not a globally significant emitter of GHGs, it emits non-negligible quantities and these are growing every year.

Reliable and comparable data on which sectors contribute to the total overall emissions are challenging to find and interpret. Figure 3 shows a reasonable approximation of sources by sector for the year 2000 (United Nations-Vietnam, 2009a) based on MoNRE data. The energy slice in this graph includes both emissions from power generation and energy use, as in transport.

Figure 3. Sources of GHG Emissions in Vietnam, 2000



Source: United Nations-Vietnam (2009a) based on estimated 2000 emissions ($MtCO_2e$)

Looking forward to the next 20 years, a number of important changes are expected to occur. Total emissions from the agriculture sector will remain approximately constant (and thus their proportional contribution will decline). The most dramatic change will take place in the energy sector, which by 2030 is expected to contribute about three-quarters of total emissions.

Low-Carbon Opportunities

As a developing country, Vietnam is not obliged to make cuts in carbon emissions under the Kyoto Protocol. Indeed, it is certain that Vietnam's total emissions will continue to grow in the coming decades as its population and economy continue to grow, needed to reach and consolidate goals of poverty reduction. Well into the foreseeable future, per capita GHG emissions will however still be well below those of industrial countries.

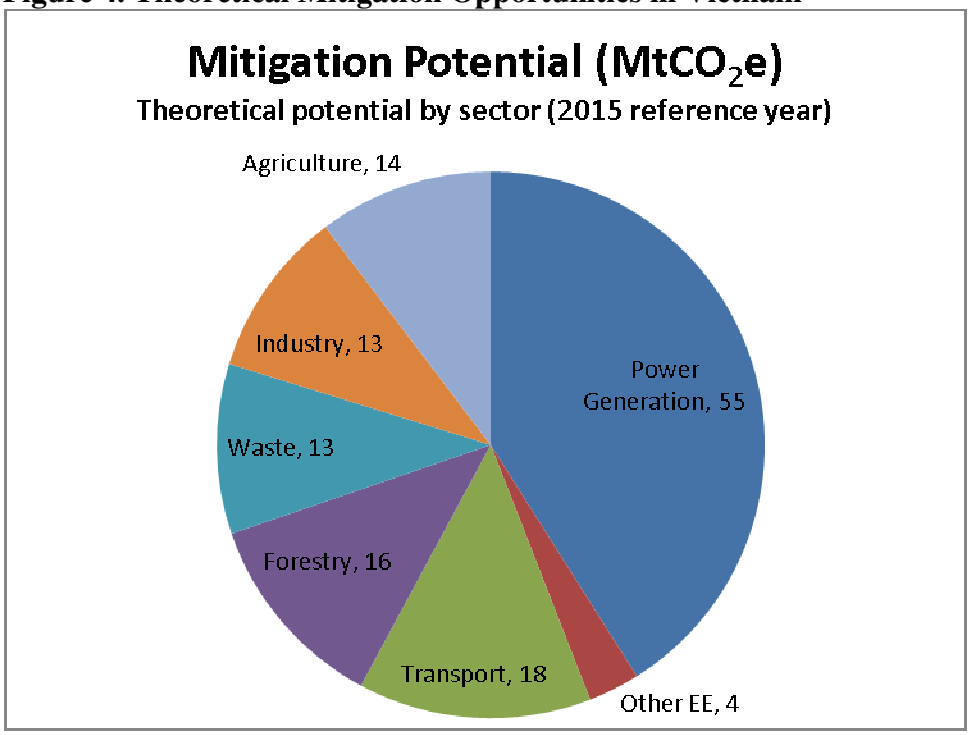
However, there are compelling reasons for Vietnam to take strong measures now to reduce its growth in emissions. First, industrial countries that must make cuts in emissions can choose to buy emissions reductions made in a developing country. Therefore, under certain conditions, Vietnam can sell its reduced carbon emissions on the global carbon market. The overall carbon market continues to grow, reaching in 2008 a total value transacted of about $126 billion (Capoor and Ambrosi 2009). Prices are highly volatile, however, and there is growing uncertainty about market conditions, given the lack of clarity emerging from global UNFCCC meetings at Copenhagen and Cancun. Second, reducing emissions by following a scenario of low-carbon economic development can reap benefits for the country, such as reduced energy use, lower cost, newer and more competitive technology, and reduced air pollution.

To provide an overview of the range of mitigation options available to Vietnam, we carried out an analysis of their theoretical annual mitigation potential. (See Figure 4, which groups the mitigation interventions by sector.) The analysis, which is presented in greater detail in Appendix 2, covered mitigation interventions commonly considered worldwide and in Vietnam and that, based on a review of feasibility studies and implementation experience, have the potential of being economically and/or financially viable investments. In other words, all these options can generate both GHG reduction benefits and a profit—they can be realized at negative cost. (See Figure 5.) The analysis indicates that such "no regrets" mitigation opportunities theoretically exist to reduce 133 MtCO2e per year. Table 2 explains how these groupings are constituted. (See also Appendix 2.) It should be stressed that we cover selected interventions based on available information, and this is not intended to be a comprehensive listing. Some important options are missing, such as fuel switching from coal to gas or carbon sequestration in

agricultural soils. Of those that are selected, some may not be feasible in the short term because of policy, economic, or technical barriers.

It will be helpful to expand this analysis to other options and to calculate detailed costs and benefits of each mitigation option in order to generate a true "marginal abatement curve" (MAC), which would rank the options from most profitable to least profitable. Crude MACs have been prepared for Vietnam, but it will take considerably more analysis and research to refine these.

Figure 4. Theoretical Mitigation Opportunities in Vietnam



Source: World Bank analyses

Table 2 outlines qualitatively the public co-benefits of each mitigation option and the financial profitability, assuming no policy barriers. Detailed analyses of the co-benefits should also eventually be carried out. The transport, forestry, and waste sectors will capture substantial ancillary public co-benefits. For example, the transport sector interventions could reduce 5.5 $MtCO_2e$ per year in the medium term while directly addressing the growing problem of congestion and road accidents in the country and will help avoid longer-term air quality problems. Mangrove reforestation and reducing deforestation and forest degradation could reduce 3.3 $MtCO_2e$ per year in the medium term while helping to preserve ecosystem services and protect biodiversity. Management of human and livestock waste could reduce 1.3 $MtCO_2e$ per year in the medium term while helping to address the environmental and public health problems associated with the growing volume of improperly treated livestock waste.

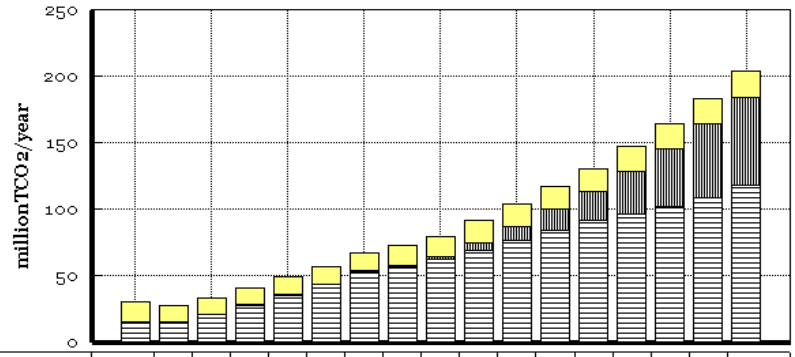
The following sections on the key mitigation opportunities in Vietnam provide further information on the sector-specific status and emissions, mitigation opportunities, and the current and planned investments of the World Bank.

Mitigation Options in the Energy Sector

Current and Projected Emissions from the Energy Sector

In 2005, emissions from energy use in Vietnam were estimated to account for roughly half of total emissions (JICA 2008). Power generation dominated these emissions from energy use. Total emissions from all sources are projected by the energy master plan study to reach 508 $MtCO_2e$/year in 2025 under a business-as-usual scenario. (See Figure 6.)

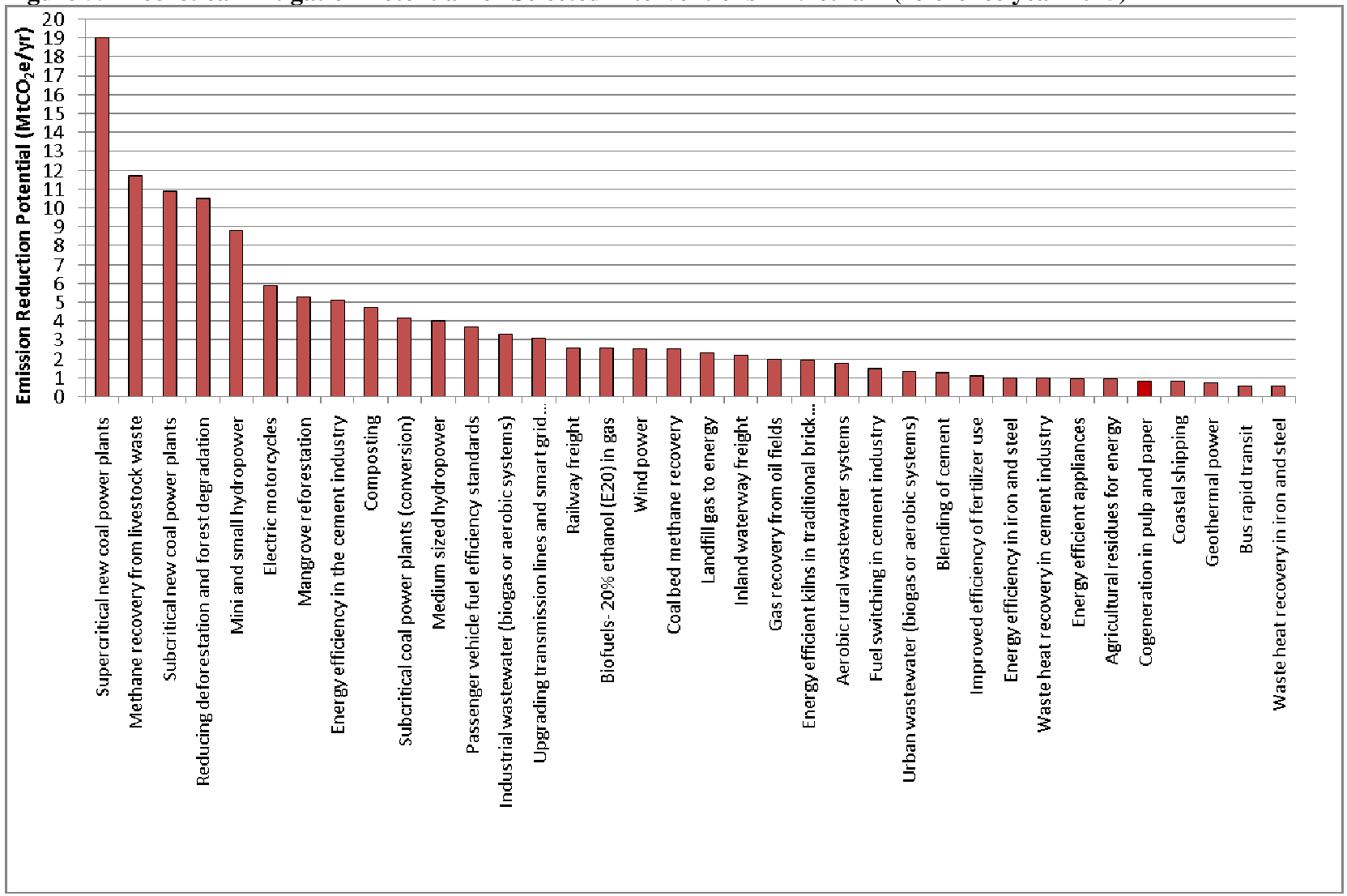
Figure 6. Vietnam: Emissions from Power Generation



	2009		2011		2013		2015		2017		2019		2021		2023		2025
domestic coal	15	16	21	28	35	44	53	57	62	69	76	84	91	96	102	108	118
imported coal	1	0	0	1	0	0	0	1	1	6	11	16	22	32	43	56	66
gas	14	12	12	13	14	13	13	16	15	16	17	17	17	18	19	19	20
oil	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Source: World Bank (2010d)

Figure 5. Theoretical Mitigation Potential for Selected Interventions in Vietnam (reference year 2015)



Source: World Bank analyses

Table 2. Financial Profitability and Co-benefits of Selected Mitigation Options									
	Financial profitability			Major Public Co-benefits					
	Not profitable	Marginal	Profitable	Energy supply	Energy demand	Air/water quality	Ecosystem services	Trade and production	Safety
Power Generation									
Mini and small hydropower									
Medium sized hydropower									
Wind power									
Geothermal power									
Energy efficiency in coal power									
Coal bed methane recovery									
Gas recovery in oil and gas industry									
Industry									
Energy efficiency in industry									
Waste heat recovery in industry									
Cogeneration in industry									
Fuel switching in industry									
Blending of cement									
Agriculture									
Improved efficiency of fertilizer use									
Agricultural residues for power									
Methane recovery from livestock waste									
Forestry									
Reducing deforestation and forest degradation									
Mangrove reforestation									
Transport									
Electric motorcycles									
Biofuels- 20% ethanol in gas									
Railway freight									
Waterway freight									
Bus Rapid Transit									
Coastal shipping									
Vehicle fuel standards									
Waste Management									
Landfill gas to energy									
Composting									
Aerobic rural wastewater systems									
Urban wastewater									
Industrial wastewater									
Other Energy Efficiency									
More-efficient electricity transmission and distribution									
Energy-efficient appliances									

Source: World Bank analyses

A World Bank study of power generation options for Vietnam (World Bank 2010d) estimates that, given current plans, emissions from power generation are projected to rise from an estimated 30 $MtCO_2e$/year in 2009 (nearly evenly divided between coal-fired and gas-fired generation) to a little over 200 $MtCO_2e$/year in 2025.

This implies that emissions from power generation will represent some 40 percent of the estimated 508 $MtCO_2e$/year in 2025 under a business-as-usual scenario. Emissions from coal-fired generation would constitute nearly 90 percent of all emissions from power generation in 2025—the rest coming from gas-fired generation.

High Energy Intensity

A World Bank review of energy efficiency in Vietnam presents calculations of energy intensity (World Bank 2010c). Between 1998 and 2007, modern energy consumption grew by 12.1 percent per year while Vietnam's GDP grew by 7.3 percent per year (both compounded annual growth). The energy use-to-GDP growth elasticity was a high 1.7. The energy intensity of Vietnam's economy grew from 387 kilograms of oil equivalent (kgoe) per $1,000 of GDP in 1998 to 573 kgoe in 2007 (in 2000 dollars). This was higher than the energy intensities of China, Indonesia, Malaysia, Thailand, and South Korea.

The national energy master plan study makes forecasts for 2005–25. In 2005, Vietnam's domestic supply of modern energy (primary energy)[5] was 26.9 million tons of oil equivalent (mtoe)—dominated by oil (45 percent)[6] and followed by coal (31 percent), natural gas (19 percent), large hydropower (5.2 percent), and other renewables (0.2 percent). The study forecast that domestic supply of modern energy would reach 40.9 mtoe by 2010. The actual rise has been faster, already reaching 38.6 mtoe in 2008 (MOIT 2009).

The study forecast that this domestic supply can reach 161 mtoe in 2025 under a business-as-usual scenario, with coal becoming the dominant energy source. These are large increases by any measure. In comparison, the 2005 domestic supply of modern energy of Malaysia was 55 mtoe, of Thailand 82 mtoe, of Indonesia 119 mtoe, and of South Korea 225 mtoe (BP 2009). Such large increases in energy consumption—with coal as the dominant fuel—have significant implications for GHG emissions.

Vietnam's Energy Strategy of 2007

The primary focus of Vietnam's energy strategy of 2007 is sufficient and reliable supply using domestic (and, where necessary, foreign) resources. Energy development is to be closely linked to the protection of the environment and development of new/renewable and nuclear resources. But a low-carbon growth path is not a specific focus. The strategy envisages major development of Vietnam's coal resources for domestic use as well as exports. In power generation, "priority shall be given to appropriate construction of hydropower plants as well as development of coal-fired and gas-fired thermal power plants…while mitigating adverse impacts on the environment."

From an emissions reduction perspective, the targets include aggressive plans to increase "zero-emissions" sources (new/renewable energy plus nuclear). (See Box 3.) Further, all energy

[5] In addition to this supply of modern energy, Vietnam also consumed some 14.7 mtoe of energy from traditional energy sources, mainly biomass. Biomass is treated as a carbon-neutral resource in this report.
[6] Including liquefied petroleum gas.

development is to meet internationally accepted environmental standards in 2015. But carbon pricing is not explicitly mentioned.

Box 3. Specific Objectives of Vietnam's Energy Strategy for 2007–20

- Sufficient supply for economic development: primary energy consumption of 49.5 mtoe by 2010; 120 mtoe by 2025; 320 mtoe by 2050
- Evaluation of reserves (coal, oil and gas, hydropower, and uranium)
- Compensation of energy shortages through international cooperation
- Power supply reliability of 99.7 percent and network standard 'n-1' in 2010
- Oil refining capacity of 25–30 million tons of crude oil by 2020
- Strategic petroleum reserve of 45 days in 2010 and 90 days in 2025
- Increased new and renewable energy to 3 percent of modern energy consumption by 2010, 5 percent by 2020, and 11 percent by 2050
- Half of households using modern energy for cooking by 2010, 80 percent by 2020
- All energy development compliant with internationally acceptable environmental standards in 2015
- First nuclear power unit in operation by 2020 with aim for nuclear power to cover 15–20 percent of national modern energy consumption
- Regional connectivity of power in 2010–15 and of gas in 2015–20

The strategy envisages a doubling of Vietnam's modern energy consumption between 2010 and 2020 but a tripling of total modern energy consumption between 2020 and 2050 to 320 mtoe. (In 2008, South Korea's primary energy was 240 mtoe, and Japan's was 507 mtoe.) To achieve these targets, emphasis is placed on energy security, energy efficiency, energy conservation (including energy-saving technologies), and loss reduction. In terms of energy market structure, the vision aims for a competitive energy market for the diversified exploitation of domestic (and foreign) energy resources. Energy pricing is to be "determined in accordance with the market mechanism," and price subsidies are to be gradually eliminated.

The strategy's major implications for emissions reduction are that Vietnam will develop its coal resources for power generation; that with market-based energy pricing, new and renewable energy resources will have to compete with fossil fuels without an explicit carbon price attributed to the latter; and that the aggressive targets for new and renewable energy and nuclear power are an opportunity.

The national energy master plan study (JICA 2008), closely linked to the strategy, shows that the energy strategy's target of primary energy not going beyond 120 mtoe in 2025 is achievable. But it also shows that business-as-usual can take primary energy to the vicinity of 160 mtoe. Given that fossil fuels are set to dominate both scenarios—and contribute to emissions—overall primary energy must be contained.

Three Key Policy Areas

Forecasts agree that large increases in Vietnam's energy consumption will take place in the coming two decades, with coal emerging as the dominant fuel. Mitigation of emissions from electricity generation can be achieved through strong policy action in three broad areas: economic pricing of energy, energy efficiency in industrial and household electricity consumption to achieve the same economic development outcomes with lower electricity use, and minimization of coal-fired electricity generation. These activities do not have to be sequential, but the order follows the logic that sound economic pricing underlies and is a pre-condition for real gains in energy efficiency. Efforts to reduce the contribution of coal to power

generation will be easier once there is economically optimal pricing of other energy sources (particularly gas) in the country.

Economic pricing of energy is a key policy tool for emissions mitigation. Market-based fuel pricing is a goal of the energy strategy 2007–20. But as just noted, lower-emission sources of energy (such as natural gas, new and renewable energy, and nuclear power) will have to compete with coal without an explicit carbon price attributed to coal (or gas). Price subsidies for fossil fuels further distort incentives away from lower-emission sources of energy. In Vietnam, subsidization of coal has meant that competing fuels (particularly a lower-emissions fuel like natural gas) are significantly less viable for electricity generation. But coal pricing is being moved to "market pricing" principles, making other fuels more viable for electricity generation.

On the demand side, the consumption of electricity is expected to rise significantly as Vietnam industrializes and incomes rise. Industrial and residential consumption of electricity is expected to continue as the dominant use of electricity, but specific information on the efficiency of energy use in these sectors is scarce. Emissions from the power sector are overwhelmingly dominated by coal-fired power generation, not electricity use in industry or homes. Vietnam can further contain emissions by using more-energy-efficient technologies in industrial and residential applications to achieve the same economic development outcomes. The key for facilitating more energy efficiency is to construct a strong and sustainable institutional platform for energy efficiency initiatives that can deliver large and measurable energy savings year after year.

Coal-fired electricity generation will be the dominant source of GHG emissions from energy use in the coming two decades, followed by energy use in transport (addressed elsewhere in this report). But most of Vietnam's coal-fired power plants are yet to be built. Therefore, a decisive impact on emissions can be made through the choice of generation technology and the extent to which other energy sources can compete with coal to become part of the electricity generation fuel mix. The priorities in emission reduction efforts in electricity generation must be reducing emissions from coal-fired generation and displacing coal from the electricity generation mix (to the extent possible). In this context, the development of Vietnam's significant natural gas resources for electricity generation becomes a high priority for emissions mitigation. A major opportunity is presented by the Vietnam energy strategy for 2007–20 in its aggressive targets for new and renewable energy and nuclear power.

Mitigation Priorities in Power Generation

Electricity sales in Vietnam quadrupled between 1999 and 2009 to 75 terawatt-hours (TWh), rising at 15 percent per year compounded annual growth. To meet this demand, Vietnam has rapidly added power generation capacity: from 4,890 megawatts (MW) available in 1998 to 16,813 MW at the end of 2009. Plans are to continue this pace of development and reach 30,600 MW by 2015 and 57,400 MW by 2025 (JICA 2008).

Vietnam's options for power generation are a hydropower potential of 20,560 MW, sizable resources of coal and gas, new/renewable potential of possibly over 13,000 MW, as well as some nuclear power. Among the choices of power generation sources available, anything that displaces coal from the generation mix would reduce emissions. (Anthracite coal combustion typically produces 98.3 tons of CO_2 per terajoule of energy consumed (tCO_2/TJ), compared with 56.1 tCO_2/TJ from natural gas combustion, based on IPCC default values (IPCC 2006); the rest are renewable resources or nuclear power.) But the choice of generation fuel is complicated by cost considerations. Under a market-oriented reform of the power sector, a competitive generation

market is being established. Coal is among the least-cost power generation options for base-load in Vietnam, and coal-fired generation will not be easy to displace from the generation mix without incorporating environmental costs into coal pricing.

Vietnam's power generation mix has been shifting—from a dominance of hydropower a decade ago (nearly 60 percent of total electricity generated) to a dominance of thermal generation, increasingly using coal and gas. In 2009, total electricity generated by hydropower had fallen to 39 percent, with gas 37 percent, coal 21 percent, and other sources 3 percent. Under current plans, coal-fired generation is to increase to 42 percent by 2015 and 64 percent by 2025 (with generation based on imported coal commencing in 2017 and contributing 23 percent of all power generation by 2025). In 2025, hydropower is expected to contribute only 22 percent of total electricity generated and gas only 12 percent under current plans, with renewable sources contributing 1–2 percent (and the rest from other sources, including nuclear).

Coal

Vietnam's coal deposits are estimated at 41 billion tons (Vinacomin 2008), with domestically verified proven reserves of 6.1 billion tons. Almost all these deposits are anthracite, or hard coal, located in the northeast (Quang Ninh province). Coal is found in four broad types, classified in descending order of heat content: anthracite, bituminous, sub-bituminous, and lignite. Potentially larger resources (estimated at 212 billion tons) of sub-bituminous coal are understood to be located in the Red River Delta (in addition to peat reserves in the Mekong Delta) but these are not easily recoverable. While only 150 million tons of proven reserves are internationally verified so far, this is a large coal resource by any standard.[7] In 2008, the internationally verified proven reserves of major coal-consuming countries were: Germany 6.7 billion tons, Indonesia 4.3 billion tons, and Thailand 1.4 billion tons (BP 2009).

In 2009, Vietnam produced 48 million tons of coal (up from 11.6 million tons in 2000) about half of which was consumed domestically and the rest exported. This implies a reserves-to-production ratio of over 100 years. With a view to the rapidly expanding power generation demand, Vietnam plans to produce up to 50 million tons of coal by 2010, 65 million tons by 2015, 75 million tons by 2020, and over 80 million tons by 2025.

Once a coal plant is in operation, it is likely to run for 30 to 40 years. Therefore the choice of generation technologies with high thermal efficiencies (that is, less fuel use for producing a kilowatt-hour) can reduce emissions over a long period. Vietnam's existing coal-fired plants are subcritical plants typically running at 30–33 percent thermal efficiency (two plants run at 24–27 percent). Anthracite is a difficult fuel to burn and cannot take advantage of higher-efficiency technologies such as supercritical (38–39 percent), ultrasupercritical (40–41 percent), and integrated gasification combined cycle (IGCC) (38–39 percent). This limits generation efficiencies for anthracite today to typically less than 36 percent using subcritical coal technologies. Technological developments in conventional coal-fired generation technologies are expected to make supercritical technology available for anthracite by 2020 and for ultrasupercritical conditions after 2030. IGCC is more suited to carbon capture and storage (CCS).

<u>Mitigation Opportunities and Constraints</u>

[7] The global coal industry recognizes the estimates of only a handful of established institutions. Those "internationally verified" reserves are quoted internationally (such as in the *BP Statistical Review of World Energy*). The 6.1 billion and 41 billion tons numbers are domestically verified.

Forecasts show that Vietnam will have to import coal to meet its power generation needs, particularly in the south. Today, Vietnam can raise the efficiency of new coal-fired plants by designing them for either a blend of domestic anthracite and imported coal (to make supercritical technology feasible) or imported coal only (to make ultrasupercritical or IGCC technology feasible). From a financial perspective, however, these options mean that Vietnam would be spending precious foreign exchange on importing coal (when it could use domestic coal with no need for foreign exchange) and earning revenue in Vietnamese dong to pay for coal in foreign currency, which carries the risk that exchange rate changes could create payment difficulties for a fast-growing economy. Whichever option is selected, the deployment of these technologies would also require a comprehensive effort to build national capacity for planning and implementing such projects and operating the power plants.

The possibility of converting Vietnam's existing anthracite-burning coal plants to burn bituminous and sub-bituminous coal has been raised. While technically feasible, this is unlikely to be attractive because the existing plants (small and inefficient, with limited remaining use life) are not good candidates for conversion. Furthermore, conversion will not increase the low efficiencies of these plants to levels approaching those of new ones.

The pricing of coal has traditionally been segmented, with exports (and sales to some domestic sectors) at international prices and sales to the power and cement sectors at subsidized prices. In 2006, for example, the export price was $35/ton and the price for power plants was $20/ton. This subsidization of coal meant that competing fuels for power generation (particularly, a lower-emission fuel like natural gas) would be unviable in a competitive generation market. But domestic coal pricing is gradually being moved to "market pricing" principles. In August 2009, the government announced that the domestic coal price should be no less than 90 percent of the export price, except for power generation. For power, a market-based domestic coal price was to be announced in 2010.

Coal-bed methane (CBM) is methane gas entrained in coal deposits (World Bank 2010d). Three types of coal mining–related activities release methane to the atmosphere: underground mining, surface mining, and post-mining (coal-handling) activities. Underground coal mines contribute the largest share of these emissions. Coal-bed methane can be captured and burned for power generation. Methane is a much more potent greenhouse gas than carbon dioxide (by a factor of 25 times over 100 years). There is no comprehensive assessment of the CBM resource in Vietnam. For example, the Quang Yen Basin, which has an estimated 5 billion tons of anthracite, should have a substantial amount of CBM, but no assessment of this has been carried out. The only estimate available is for the Red River Delta area, which is expected to have at least 6–10 trillion cubic feet of CBM. Specific data on CBM emissions are not available.

Carbon capture and storage has the potential to reduce emissions from a power plant by 90 percent. But CCS is not expected to become commercially available to Vietnam until after 2020. Therefore, the development of "CCS-ready" coal projects—which would require minor changes when CCS does become feasible—has been tabled. An ultrasupercritical plant's cost would be higher by about a third if it were made "CCS-ready" (World Bank 2010d), though its performance would be unaffected. Whether Vietnam should or could assume such costs for saving emissions in the future needs to be considered.

World Bank Programs

The World Bank's internal guidelines for investment support to coal-based power require that coal-fired plants be confirmed as the least-cost option after full consideration of alternatives, with inclusion of environmental externalities in the analysis. The guidelines also require that coal projects seeking Bank support be designed to use the best appropriate available technology to allow for high efficiency and therefore low GHG emissions. For Vietnam, these guidelines point to higher-efficiency generation options that require imported coal. Since supercritical and ultrasupercritical technologies are commercial and Vietnam is located near two major coal exporters (Indonesia and Australia), there may not be an obvious need for the World Bank to provide investment support to the development of such plants. The private sector should be able to develop such projects with appropriate project design and financing structure.

In general, few existing financing sources pay for the high incremental costs of new technologies. For example, CCS is not eligible for the Clean Technology Fund (CTF) (World Bank 2010e). Funding is available for capacity building and studies: the Carbon Capture and Storage Trust Fund (launched in December 2009 and administered by the World Bank) seeks to strengthen capacity and disseminate knowledge to help developing countries explore their CCS potential and to facilitate inclusion of CCS options in low-carbon growth strategies. But technical assistance for evaluating alternative generation technologies and designs, for identifying geological storage options for CCS, and for assessing the CBM potential is needed. For the past two years, the Bank has provided advice on a framework for private sector involvement in the reformed power generation market, including for coal-fired generation. World Bank Group technical assistance for facilitating private sector involvement in coal-fired generation using higher-efficiency technologies could be beneficial to Vietnam.

Natural Gas

Natural gas is a fossil fuel, but its combustion leads to CO_2 emissions that, for every unit of energy consumed, are at least 50 percent lower than those from the combustion of anthracite. (See Table 3.) Gas-fired power generation also produces fewer air pollution impurities such as sulfur oxides or solid waste (ash), unlike coal-fired generation. Among gas-fired generation technologies, combined-cycle gas turbines typically reach efficiencies of 54–56 percent—significantly higher than typical commercial coal-fired generation technologies.

Table 3. Emissions from Coal and Gas-fired Power Generation

Technology	Fuel	Thermal Efficiency	tCO_2/GWh
Subcritical PC	Coal	34.3%	931
Subcritical CFB	Coal	34.8%	1030
Subcritical PC	Coal	38.5%	830
Ultra-supercritical PC	Coal	43.3%	738
Combined Cycle GT	Gas	54.5%	370
Gas Turbine	Gas	45.0%	450

Sources: MIT, World Bank (based on IPCC default values)

Vietnam has significant gas resources. Its internationally verified proven reserves are estimated to be 560 billion cubic meters (bcm). With 2008 production of 8 bcm per year, Vietnam has a reserves-to-production ratio of 70 years. The bulk of these reserves are located in southern Vietnam and are mainly offshore. Eighty-eight percent of gas production goes to power generation, with the remainder going to fertilizer plants, ceramics, and metal-working industries—almost all in the south. There is virtually no commercial and residential consumption of piped gas. Therefore, the gas transmission network is limited mainly to high-pressure

pipelines dedicated to the bulk customers. This means gas losses (which usually occur in low-pressure retail distribution networks) are at a minimum.

Mitigation Opportunities and Constraints

Vietnam has plans for large-scale development of its gas resources, with production expected to reach 24 bcm per year in 2025 (three times its 2008 level). Demand for gas-fired power generation is the main driver behind these plans. There are three barriers to rapid development of Vietnam's gas resources.

First, the absence of generic gas pricing creates uncertainty for investors in gas exploration and production. Currently, Vietnam's standard production sharing contracts provide no guidance on the price an investor can expect on future gas finds. Negotiated pricing based on an unclear pricing methodology is practiced on a case-by-case basis and is delaying gas production projects.

Second, there is significant uncertainty in gas supplies (particularly beyond 2015) because potential gas resources are not being turned into proven gas reserves fast enough.

Third, gas sector management and the sector structure impede private investment as they stand today: the forecasted investment requirements for the sector are large, and private investment will be needed in all links of the gas chain. But private investors are faced with the risk of possible monopolistic behavior by an unregulated, public sector operator of gas transmission and distribution.

An additional mitigation opportunity is offered by gas flaring. Methane that is captured during oil or gas production can be captured and used as a fuel source. The methane may however be released because of accidental leakage or the absence of a methane capture system. In this event, the flaring of this potent GHG represents an effective mitigation opportunity.

Some of Vietnam's gas fields include large amounts of inert gases, particularly CO_2. In the case of some new fields under development, the CO_2 content is reported to be as high as 23 percent. As such fields are developed, much of the CO_2 will be separated from the methane and vented into the atmosphere before the methane enters a pipeline. This source of GHG emissions needs to be better understood and factored into analyses of mitigation value of gas development.

World Bank Programs

The Bank supported Vietnam's first major gas-fired generation transaction with international private involvement (Phu My 2.2, 1996–2002). The World Bank has recent produced a recommended framework for gas sector development in Vietnam in consultation with government experts (World Bank 2010j). The framework emphasized a shift away from negotiated pricing to a competitive pricing regime under which gas pricing is linked to the competing fuel (coal) in the main market for gas (power generation). This pricing methodology is intended to ensure that, with coal moving toward market pricing, power generators have the right incentives for selecting between a coal-fired and a gas-fired plant. If the development costs of an upcoming gas field allow lower-cost power generation than the development costs of an upcoming coal field, the power generator should choose to develop a gas-fired power plant.

The framework also recommends moving toward regulation of transmission and distribution and, eventually, an open access transmission regime that allows any producer of gas to contract directly with a wholesale buyer of gas. Both these pillars of reform are intended to increase investment across the gas chain for maximum additional production of gas (and gas-fired power generation). The next step is the development of a detailed roadmap for reform under this framework.

Hydropower

Vietnam has a high hydropower potential, with 2,360 rivers and streams that are longer than 10 kilometers, with the Mekong and Red River being the largest ones (EVN 2007). In 2009, installed hydropower capacity was 6,600 MW. It has been estimated that the theoretical hydropower potential in Vietnam amounts to about 35,000 MW and nearly 300 TWh/year (180 TWh/year in the north, 80 TWh/year in the central highlands, and 40 TWh/year in the south). Of this, the economically viable hydropower potential is assessed at 20,560 MW and 83.4 TWh/year (EVN 2007).

In this 20,560 MW, there are only three large hydro sites, of which one—Hoa Binh (1,950 MW)—entered service in 1989. A second—Son La (2,400 MW)—is under construction and the third—Lai Chau (1,200 MW)—is at the planning stage. Vietnam aims to develop about 5,000 MW of medium-sized hydropower capacity by 2015 (30–600 MW each). It is expected that most of the available medium- and large-scale hydro projects will have been developed in the next decade: 18 of the 19 projects in the National Hydropower Plan will either be under construction or already built by 2020 (World Bank 2010d).

Hydropower cannot automatically be assumed to emit no greenhouse gas (World Commission on Dams 2000). As a dam reservoir is flooded, biomass in the reservoir begins to decay without oxygen, gradually leading to a buildup of dissolved methane. The methane is released into the atmosphere when water passes through the dam's turbines. But the flooded biomass alone does not explain the observed gas emissions. Carbon flows into the reservoir from the entire basin upstream and other development and resource management activities in the basin can increase or decrease future carbon inputs to the reservoir. Net emissions need to be calculated on a case-by-case basis.

Mitigation Opportunities and Constraints

The development of Vietnam's economically viable hydropower sites does not face major energy policy constraints today. Hydropower is likely to fare well under a competitive generation market, given its relatively low cost. However, social and ecological impacts of large (and medium-size) hydropower sites can be substantial. Current hydropower plans will leave almost no free-flowing rivers in Vietnam, which has serious implications for other uses of water and for the conservation of freshwater biodiversity that merit careful consideration (ICEM forthcoming). Dam safety has also become a serious issue for the hydropower sector.

Data on GHG emissions from dams are scarce. The practice of biomass removal from a reservoir before flooding can be introduced at moderate additional cost.

World Bank Programs

The 260 MW Trung Son Hydropower Project in Thanh Hoa Province, northwestern Vietnam, represents the Bank's return to financing generation in Vietnam after an absence of 10 years and its re-engagement in the medium- and large-scale hydropower sector. The rationale for this engagement is not just the support of renewable energy but also the introduction of international best practice in areas of environmental and social impacts, mitigation, resettlement, and livelihood restoration, consistent with the Bank's safeguards policies. The Bank's future engagement in hydropower is under consideration.

Nuclear

The government's energy strategy of 2007 aims for Vietnam's first nuclear power plant to be in operation by 2020, with the longer-term aim of nuclear energy constituting 15–20 percent of primary energy by 2050. Nuclear power is a "no GHG emissions" option for power generation.

Mitigation Opportunities and Constraints

Nuclear power is subject to significant economies of scale, and for units commercially available

today, the minimum unit size is around 1,000 MW. A new generation of small units (of 200–250 MW) is under development globally but not commercially viable yet, and the costs are subject to large uncertainties. For the larger units, reliable cost information is difficult to come by, and estimates in the recent literature vary from $2,000/kW to $10,000/kW, compared with typically $1,200–1,400/kW for coal-fired plants, $600–800/kW for gas-fired plants, and $800–2,100/kW for potential hydropower sites in Vietnam.

In general, whether a country has nuclear fuel resources (uranium or thorium) has little bearing on its fuel costs for nuclear power generation. Without fuel processing capability, even a country with good resources is dependent on the international market for power plant–grade nuclear fuel. If Vietnam had exploitable nuclear ores, whether their development for export (and overseas processing) is economical is an entirely separate question to whether nuclear power plants should be built in Vietnam itself.

Apart from cost, nuclear power involves issues of reactor safety and treatment of radioactive waste. Nuclear power has long lead times, even in countries with developed nuclear industries. Planning, licensing, and constructing a single nuclear plant typically takes a decade or more. Building the first new nuclear plant in Vietnam is expected to take at least this long, if not more. Therefore, from a mitigation perspective, nuclear power is not expected to make a significant dent in emissions from power generation by 2025.

World Bank Programs

Nuclear power would seem to merit consideration, given the unattractiveness of Vietnam's plentiful coal resources due to their high CO_2 emissions, the social and ecological constraints of developing hydropower, and the limited options for electricity trade. Making the right decisions on the suitability of nuclear power proposals is challenging, given the complex issues of safety, proliferation, and waste disposal. Vietnam needs assistance to help consider these decisions and to build capacity for the long term. World Bank support for nuclear power is, however, currently not envisaged.

New Renewables

Vietnam's potential for renewable energy (excluding hydropower plants of more than 30 MW, discussed above) is estimated to be over 6,000 MW, including 2,900 MW of grid-connected small hydro, over 2,000 MW of wind power, 750 MW of off-grid small hydro, 400 MW of biomass, 200 MW of geothermal energy, and 2 MW of solar photovoltaics (PV). Of the small hydro potential, some 2,000 MW is considered economical (MOIT 2008). While the extent of Vietnam's small hydro resources is well documented, that of the wind resource is still controversial: past estimates of physical potential are considered to be speculative (World Bank 2010d). The off-grid small-, micro-, and pico-hydropower potential is unlikely to have a significant bearing on emissions mitigation. The same may be said about the potential for biomass, geothermal, and solar PV, since they are not likely to displace a significant proportion of coal-fired generation.

New renewables do not play an important role at this time in the generation mix of Vietnam (575 GWh in 2007, which is 1 percent of total electricity sales and an even smaller proportion of all modern energy consumed). But renewables are targeted to become 5 percent of all modern energy by 2020 and 11 percent by 2025. From the point of view of mitigation, renewable energy sources are highly attractive, as they can in theory provide energy with almost no emissions of GHGs. For displacement of coal from the power generation mix, grid-connected renewables

(particularly small hydropower plants) are the primary target. Grid-connected projects between 1 MW and 100 MW also are good candidates for carbon finance.

Mitigation Opportunities and Constraints

The government laid a foundation with the Renewable Energy Action Plan adopted in 2001, which has supported the development of the policy and regulatory framework for small renewable energy projects. But several barriers to large-scale development of grid-connected renewables remain: the high transaction cost of negotiating a power purchase agreement (PPA) with Electricity of Vietnam (EVN); an inhospitable and nontransparent regulatory framework with a lengthy approvals process; the absence of a procedure for allocating (or reallocating) project sites to those most able to develop them; the weakness of private sponsors to develop a site in technically, socially, and environmentally sustainable manner and to take it to financial closure; the same licensing burden that large projects have; and the absence of suitably long financing terms.

As the cornerstone of the strategy to address these barriers to small-scale (up to 30 MW) renewable energy development, MOIT has issued a standardized "no negotiations" PPA and an avoided-cost tariff formula for small renewable energy projects selling to the national grid (EVN). The avoided-cost tariff[8] for grid-connected renewables is based on EVN's financial costs (the prices in Vietnam's emerging competitive generation market do not reflect the environmental damage costs of fossil energy generation). The tariff should provide clearer signals to developers about the type of renewable energy facility that is of most value to the system and the least/fair cost to consumers.

Notwithstanding doubts about the extent of Vietnam's onshore wind resources, estimates based on the best available data find the cost of wind power to be significantly above the avoided cost of thermal generation. Since the capital costs of wind power are significantly more expensive than small hydro, every dollar of investment in small hydro power reduces GHG emissions almost 2.5 times more than the same investment in wind power would (MOIT 2008). The bulk of upcoming new renewables capacity can be expected to be small hydro, with some biomass.

A reasonable target for grid-connected electricity by 2015 is 5.3 TWh (or 1,200 MW). For 2025, a reasonable target is considered to be10.8 TWh (or 2,500 MW). Depending on whether or not the wind potential is used by Vietnam to mitigate emissions, the emissions avoided due to renewable energy are estimated to be modest (MOIT 2008): 4–5 $MtCO_2e$ per year by 2015 and 10–15 $MtCO_2e$ per year by 2025 (which would be 5–7.5 percent of all emissions from power generation in 2025).

World Bank Programs

The Renewable Energy Action Plan (MOIT 2008) was financed through the World Bank's System Efficiency Improvement, Equitization and Renewables Project (SEIER, approved in fiscal year 2003). The standardized PPA and the avoided-cost tariff methodology issued in 2008 were developed by the Electricity Regulatory Authority of Vietnam with World Bank technical assistance. In 2009, the World Bank approved the Vietnam Renewable Energy Development Project, which will finance the development of small hydro plants, biomass, and

[8] An avoided-cost tariff is based on the costs that the buyer avoids when an additional kWh of renewable energy is purchased from the renewable energy producer. In theory, the buyer would reduce the dispatch of the most expensive thermal (coal- or gas-fired) unit in operation, and therefore the avoided cost would be based on the variable operating cost—mainly fuel—of that highest cost (or "marginal") plant.

wind energy projects, with small hydro expected to constitute the bulk of these projects. This project will provide a refinancing facility to participating commercial banks for loans to eligible small renewable-based projects. The facility will refinance up to 80 percent of the loans made by these banks to eligible projects. Under the SEIER project, the Bank is also supporting an advanced wind measurement program.
Currently, the Bank is finalizing a carbon-financed renewable energy project (P110477), which will be the first project in Vietnam financed by the Carbon Partnership Facility. The project is intended to support mini- and micro-hydro development in tandem with the Rural Energy Development Project.

Transmission and Distribution
Although transmission and distribution losses are pretty low by developing-country standards, there are some gains to be made, especially in the power distribution system. (See Table 4.)

Table 4. EVN Power Losses in Transmission and Distribution System

	2004 (%)	**2005 (%)**	**2006 (%)**	**2007 (%)**	**2008 (%)**	**2009 (%)**
Transmission	4.14	4.1	3.37	2.98	2.69	2.97
Distribution	19.88	19.46	18.73	18.14	15.73	16.43
Total	12.01	11.78	11.05	10.56	9.21	9.7

Source: EVN

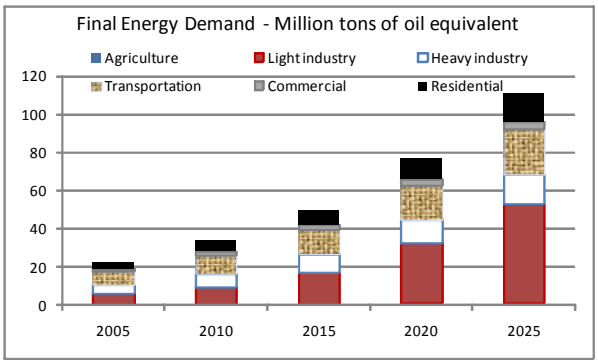
The high losses are because of inefficient local distribution systems, which EVN is now inheriting. From an emissions reduction point of view, these are "low hanging fruit" because there is a strong incentive to reduce these financial losses. There are no informational or other technical barriers to doing this. It is purely a question of investment financing.

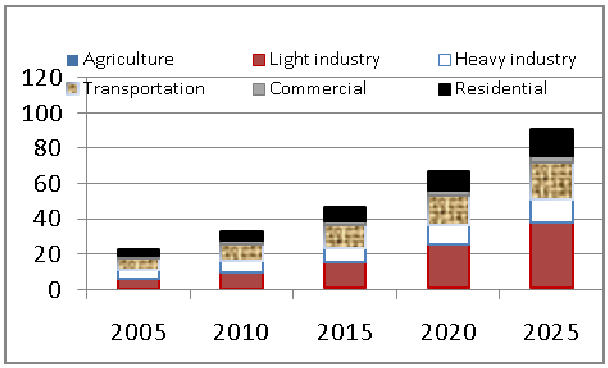
The World Bank is addressing transmission and distribution in multiple investment projects. A "smart grid" component of a future project, to be financed with resources from the CTF, is being prepared at this time.

Lower-Carbon Energy Consumption

While heavy industries (such as cement and steel) have grown in the past decade, Vietnam's national energy master plan study (JICA 2008) forecasts that energy demand growth in light industry (mostly dependent on electricity, such as food processing and light manufacturing) will outstrip energy demand growth in heavy industries (mostly dependent on coal).

Figure 7. Energy Consumption, 2005–25, under Business as Usual and National Energy Plan





In 2005, final energy consumption in industry was split evenly between energy-intensive heavy industry and less energy-intensive light industry.[9] (See Figure 7.) Vietnam's expected growth path implies that the light industry subsector will register the fastest energy consumption growth. Under a business-as-usual scenario, light industry is expected to consume over nine times more energy in 2025 than it did in 2005 (compared with a fivefold increase in overall energy consumption during the same period), reaching 44 percent of total energy consumption. Energy demand growth in light industry will experience nearly twice the growth rates projected for heavy industry. Electricity-dependent light industry should be the focus.

With greater industrialization and rising household incomes, electricity consumption per capita is expected to increase from 550 kilowatt-hours (kWh) per annum in 2005 to 1,600 kWh in 2015 and nearly 4,000 kWh in 2025 under a business-as-usual scenario—an almost eightfold increase in two decades. By comparison, China's electricity consumption per capita in 2005 was 1,781 kWh per capita, Thailand's was 1,988 kWh per capita, Malaysia's was 3,262 kWh per capita, and South Korea's was 7,779 kWh per capita (World Bank 2008d).

Industrial and residential consumers are the dominant electricity-use sectors in Vietnam, with industry consuming 53 percent of the total and residences 39 percent in 2007 (World Bank 2010c). Commercial and public sector electricity use was reported at 8 percent. These sectors are making distinct contributions to peak load in the electricity system. A 2009 review (APEC 2009) noted that the residential sector contributes about 66 percent of the evening peak in the

[9] Final energy is primary energy supply less energy lost in transformation in the energy supply chain.

Vietnamese electrical system. A daytime peak is also emerging, which the industrial and commercial sectors contribute about 55 percent to. This daytime peak is rising and in fact may have already overtaken the evening peak.

Mitigation Opportunities and Constraints

This section focuses on opportunities to lower electricity use (and GHG emissions) in industrial, commercial, and residential sectors. (Transport is addressed in the next section.) From an emissions mitigation perspective, the efforts to introduce more-efficient energy-use equipment can reduce Vietnam's energy consumption overall (and reduce emissions). Efforts to shift demand from peak hours to off-peak hours probably have a limited impact on emissions mitigation—because energy use is shifted to another time, not eliminated. For emissions mitigation, therefore, programs need to be evaluated for their energy efficiency outcomes rather than their demand management outcomes.

Energy efficiency investments are lower-cost than other options to reduce emissions from the electricity sector, such as shifting generation away from coal to other energy sources. For example, successful energy saving programs in Thailand have been shown to cost just a fraction of what it would cost to supply electricity by building new power plants. The cost of saved energy for the Thailand programs has been just THB 0.49 per kWh ($0.013/kWh) compared with the average levelized (that is, lifetime) cost for new power plants of approximately THB 2 per kWh ($0.05/kWh) (Danish Energy Management 2008).

Concrete information on the potential of energy efficiency in Vietnam's industry is scarce. The general impression is that while many of the energy-intensive industries such as cement are beginning to consider conversion to more modern and energy-efficient technologies, retrofits of old plants and new industrial capacity are not taking full advantage of the potential energy efficiency gains. The energy efficiency master plan study (JICA 2009a) conducted a small survey of industrial facilities and found that the potential for energy efficiency and conservation among the surveyed factories was up to 12 percent of electricity in food processing and up to 11 percent of fuel in steel manufacture. (See Table 5.) The JICA energy master plan study estimates that under a lower-carbon scenario, energy use in light industry could be reduced by 30 percent of what it would have been in 2025 under business-as-usual.

Table 5. Possible Energy Savings in Surveyed Factories in Vietnam

	Potential Fuel Savings (%)	Potential Electricity Savings (%)
Food processing	4	12
Textiles	6	8
Ceramics	11	7
Cement	0	4
Steel (only improved operation and equipment)	6	6
Steel (with new technology)	11	4

Source: JICA 2009a

A recent World Bank report (World Bank 2010e) estimates that Vietnam's overall household electricity use will nearly triple from some 15 TWh per annum in 2006 to around 42 TWh in 2030, with important changes in its composition. In 2006, lighting accounted for the largest share (about 30 percent), with entertainment appliances (dominated by televisions), kitchen appliances

(dominated by refrigerators), and space heating/cooling devices (air conditioners, fans) accounting for some 20–25 percent each. With rising incomes and greater use of appliances that use a lot of energy, lighting is expected to constitute a little less than 20 percent of total electricity consumption by Vietnamese households in 2030. Entertainment appliances, kitchen appliances, and space heating/cooling devices are expected to each account for 25–30 percent of household electricity consumption.

The report recommends concentrating energy conservation efforts on appliances. It estimates that energy savings of 7–8 percent compared with a business-as-usual scenario should be possible for appliances and savings of some 2 percent for lighting.

The average electricity intensity (2007 annual electricity consumption per gross floor area) of buildings was measured by the energy efficiency master plan study (JICA 2009a). The intensities for hotels and supermarkets were found to be large; for offices and hospitals, they were small. For schools, intensity was extremely small because schools only need minimum electricity consumption (daytime lighting or air conditioning in limited rooms). In comparison with Indonesia and Japan, hotels' intensity was over two times (four times for Japan), supermarkets 1.5 times (a little less than two times), and offices 0.7 times (equal with Japan). In general, intensity was found to be higher in buildings that had done retrofits (installation of an air conditioning system for an old building, for instance) and lower in old buildings that had not yet done retrofits (JICA 2009a).

Priorities for Mitigation

It costs more to adopt energy-efficient technologies than less-efficient technologies. A key finding of international experience is that a regular and stable funding mechanism is critical to the success of any such efforts (Danish Energy Management 2008). The reasonable payback periods of energy efficiency investments need to be demonstrated to end-users of energy through awareness programs. Even with awareness, know-how about energy efficiency investments is needed in banks in order to finance these investments. Government financial support is best used to leverage large-scale financing for these investments across the economy. Thailand's Energy Efficiency Revolving Fund (launched in 2003) is often quoted as an example. Its objective is to stimulate financial sector involvement in energy efficiency projects and to simplify project evaluation and financing procedures (USAID 2009). The fund provides capital at zero interest to Thai banks, which then lend funds at up to 4 percent for energy efficiency investments. Vetting by a government department ensures that these are energy efficiency investments.

Like many utilities worldwide, Vietnam's electric utility (EVN) conducted a program to distribute 1 million 20W compact fluorescent lamps (CFLs or "energy saver lamps") to urban as well as rural consumers in 2004–07. These lamps provide the same amount of light as a 100W incandescent bulb at a slightly higher unit cost and are cost-effective for customers using the lamps for more than four hours a day. The objective was to reduce lighting load during the evening peak hours. A 2008 review of the program (Danish Energy Management 2008) found that distributing 300,000 CFLs in 2005 and 700,000 in 2006 reduced peak demand by an estimated 30.1 MW. Higher savings would have been possible if 20W CFLs uniformly replaced 75MW incandescent bulbs, but 20W and 40W bulbs as well as a significant number of fluorescent tube-lights were replaced with 20W CFLs. With replacement of 75W bulbs, the direct savings targeted for this effort were 33.4 MW. The review also estimated the indirect savings induced by the program (as CFL sales increased due to the EVN program) to be 280

MW. Another review estimated that the domestic CFL market size was about 20 million units in 2009 (APEC 2009).

The global experience with energy efficiency standards and labeling of appliances is that it takes 10 to 15 years to change a market using this approach. But when it does happen, the change is dramatic, long-term, and always cost-effective (USAID 2009). Australia's success with standards and labeling in the domestic refrigerator market is often quoted for the Asia-Pacific region. Australia introduced labeling for refrigerators in 1986 and launched its Minimum Energy Performance Standards program in 1999. Between 1986 and 2006, average energy consumption by domestic refrigerators fell by more than 60 percent—from some 1,300 to about 400 kWh/year. In December 2008 and April 2009 the government of Vietnam issued energy efficiency standards for consumer goods that account for large quantities of electricity consumption today and that are expected to increase in the future, particularly CFLs, refrigerators, air conditioners, and fans.

The Danish Energy Management (2008) review of EVN's energy-saving activities recommended as immediate measures an expanded CFL program and a general awareness campaign; beyond that, it recommended introduction of solar water heaters, "transformation of markets" for high-energy-use appliances (refrigerators, air conditioners, etc.) to adhere to higher energy efficiency standards, and energy audits for large facilities. The review notes that the remaining potential of these programs is an estimated 1,200 MW of evening peak reduction and 450 MW of daytime peak reduction, for a total of 6,000 gigawatt-hours of energy savings in 2015. This is some 3.6 percent of projected electricity sales in 2015 under a business-as-usual scenario.

The key for the future is to construct a strong and sustainable institutional platform for energy efficiency initiatives that can deliver large and measurable energy savings year after year. In 2006, Vietnam's Prime Minister launched the National Program on Energy Efficiency and Conservation, with a set of national targeted goals for the country to save energy (APEC 2009): for 2006–10, a 3–5 percent reduction in total energy consumption compared with the business-as-usual forecast, and for 2011–15, a 5–8 percent reduction compared with the forecast.

A further rollout of a wide range of activities has been planned for the second phase. The Law on Energy Conservation and Efficient Use has recently been approved by the National Assembly. A wide range of international donor activities has been launched to help. Backed by concrete policies, an effective platform requires institutional clarity as to who is responsible for what, a major effort to build capacity in the government and its implementing entities as well as in the market at large, strategic planning, sufficient funding, step-by-step follow-through on implementation, and a focus on achieving measurable energy savings results.
A focus on urban areas in a national mitigation program makes sense as globally, cities are responsible for the bulk of GHG emissions. An urban CC mitigation program must be multisectoral involving urban planning; energy efficiency measures in buildings, homes, and offices; transport-specific measures; and many others.

World Bank Programs

In 1997, the Bank-supported Demand-Side Management Assessment for Vietnam identified opportunities for cost-effective electricity savings in a number of sectors and end-use

applications. It recommended a two-phase approach for implementing demand-side management (DSM), which would save an estimated 680 MW of capacity and more than 3,550 gigawatt-hours/year by 2010. Under the first Phase, the government developed an energy-efficiency building code and minimum efficiency criteria and standards for energy-efficient lighting and industrial motors. The second phase was initiated under the World Bank's System Efficiency Improvement, Equitization and Renewables Project with DSM activities (including the CFL program) and a pilot commercial energy efficiency program. It was complemented by a stand-alone GEF project, the Demand Side Management and Energy Efficiency Project.

The government's energy efficiency program has been designed with assistance from World Bank analytical reports financed by the Demand Side Management and Energy Efficiency Project, including *Final Evaluation of CFL Program Phases 1 and 2* (2007) and *EVN's Phase 2 DSM Program* (2008). More-recent technical assistance has allowed the preparation of *Vietnam: Expanding Opportunities for Improving Energy Efficiency* (World Bank 2010c). These studies have identified both the significant potential for energy efficiency and the numerous policy and regulatory barriers, particularly when addressing DSM in a restructured power sector. The Bank is currently considering International Development Association and GEF-financed energy efficiency projects for FY12 to reinforce Vietnam's National Program for Energy Efficiency and Conservation.
In urban areas, the World Bank has been or will be involved in a number of mitigation areas including the following:

- An "Urban Transport Capacity Building Program" in development at the Bank's Singapore Urban Hub

- A range of initiatives under the "Eco 2 Cities" program looking at the greening of urban transport and urban planning

- Medium Cities Transit and Climate Change Strategy (planned)

- A possible GEF operation looking at urban transport modernization and integrated planning

Transport

Rising incomes are associated with higher levels of motorcycle and passenger car ownership and usage as well as greater trip rates and distances, with corresponding increases in CO_2 emissions (Timilsana and Shrestha 2009). Vietnam's energy consumption for transport increased more than tenfold between 1980 and 2005, from 0.6 Mtoe to 6.8 Mtoe. Correspondingly, CO_2 emissions from the transport sector have also increased nearly 10 times, from 2 $MtCO_2$ to 19.2 $MtCO_2$. Road transport is the principal reason: its share of energy consumption in transport rose from 75 percent (followed by air at 15 percent and rail at 10 percent) in 1980 to 92 percent in 2005, with a corresponding increase in emissions from road transport. This modal mix as well as fuel pricing policy has tilted the transport fuel mix in the direction of diesel: from 60 percent gasoline, 16 percent diesel, 15 percent aviation fuels, and 10 percent coal in 1980 to 56 percent diesel, 41 percent gasoline, and 3 percent aviation fuels in 2005.There has been a corresponding shift in emissions due to the use of these fuels in transport.

Motorbikes are used widely in Vietnam as a popular transportation vehicle, with 19 million units registered in 2005. There is already an average of one per household, with sales still running at a high level. On the other hand, the number of four-wheel vehicles is only 577,000, among which passenger cars were only 195,000 units in 2005. As income level improves, however, it is possible that passenger car ownership will rapidly increase, as has happened in other Asian countries, triggering increases of gasoline and diesel consumption.

Mitigation Opportunities and Constraints

It is therefore expected that, if present policies continue, Vietnam's growth in vehicles will continue at its rapid pace and the transport fuel mix will get further concentrated into diesel and gasoline—thereby increasing emissions. A 2009 World Bank study decomposed the growth in CO_2 emissions from the transport sector and concluded that population growth, per capita economic growth, and change in transportation energy intensity (fuel consumed in transport for every dollar of GDP) are generally found to be the principal drivers of transport sector CO_2 emissions growth in Asian countries (Timilsina and Shrestha, 2009). The implication of this finding is that the overall direction of growth in Vietnam's population and economic output will increase emissions but that a change in fuel consumed in transport for every dollar of GDP can make a difference to emissions no matter which fuel is used and in which mode of transport. The clear policy implication is that energy efficiency in transport must be a priority for Vietnam. Among other opportunities that can complement interventions to improve fuel efficiency while providing substantial co-benefits are the introduction of electric motorcycles and a modal shift from road freight to lower greenhouse gas intensity modes such as inland waterways, coastal shipping, and railways.

Some specific policy actions have been identified in the SP-RCC program:

- Adopt the "Master Plan for development of Public Bus System"

- Adopt the regulatory framework for controlling exhaust gas emissions and for periodical inspection of motorcycles and mopeds.

World Bank Programs

Opportunities to incorporate mitigation measures in transport projects take two forms: more-efficient energy use in urban transport through a modal shift from private to public transport and reductions in GHGs through an increased use of more-efficient modes of transport, particularly for freight.

For urban transport, the Bank is active in both major and medium cities. Work includes the introduction of mass transit systems in Hanoi, advanced planning in Da Nang, initiating work in Ho Chi Minh City to identify options, and working with the Ministry of Construction to identify appropriate planning for urban transport in medium-size cities. In the larger urban centers the focus is on planning of integrated urban transport systems that will result in an increase in the use of public transport as a share of total trips. In Hanoi, work is in progress on the first Bus Rapid Transit project in Vietnam, which is expected to be a pilot for other centers.

The Bank has been active in working with the government to identify opportunities to encourage shifts to modes that are more energy-efficient. A particular focus in this work is inland waterways, where ongoing projects are addressing improvements to both the institutional arrangements and the physical infrastructure of inland waterways in the Mekong and Red River Deltas. Work has recently been initiated to extend this program to coastal shipping with funding from the Energy Sector Management Assistance Program and the Trade Facilitation Facility.

The GEF-financed Hanoi Urban Transport Project is helping efforts to reduce vehicular carbon emissions in Hanoi. In Ho Chi Minh City, a program has been initiated to work with the Eco2 initiative to assist the city in sustainable planning. Under this program, interventions will be designed to help the Peoples' Committee develop an efficient, integrated mass transit system that will result in a major shift in journeys from personal transport (particularly motorbikes) to mass transit facilities. If successful, this will not only address the direct economic costs of increasing congestion but will also result in a significant reduction in GHGs caused by urban transport. To support this work, other initiatives are being planned to help the major cities improve the provision of urban transport through integration of the urban planning process in terms of land use planning, mobility and demand management, vehicle fleet improvements and renewal, and fuel policy and pricing. This work will include the development of planning tools to integrate low-carbon strategies into the planning process. Support for this agenda will require use of a combination of funding sources, including the International Bank for Reconstruction and Development and GEF.

The Bank also supports a regional Knowledge Partnership for Managing Air Pollution and GHG Emissions in Asia; it is supported by a Development Grant Facility grant.

Waste Management

Emissions from waste management are driven by the rapid growth in domestic and industrial waste resulting from urbanization and industrialization, the use of methane-emitting open systems for disposal of wastewater, and the modernization of the solid waste system, which as a result of the adoption of landfills will increase greenhouse gas emissions. (Livestock waste is covered in the previous section, on agriculture.)

The country produces annually an estimated 16 million tons of municipal solid waste, 1.6 billion cubic meters of wastewater from domestic sources, and 400 million cubic meters of wastewater from industrial sources.

In urban areas, less than 30 percent of the wastewater is treated in centralized treatment facilities; the remainder is discharged untreated into polluted canals and waterways that are largely anaerobic, thus producing methane. In rural areas, a large portion of the wastewater is treated in methane-producing septic tanks and latrines or otherwise degrades under methane-producing anaerobic conditions. Similarly, only a portion of the industrial facilities treat their wastewater, and very few have measures to recover or avoid methane release into the atmosphere.

Vietnam is in the process of modernizing its municipal solid waste disposal sites by upgrading from open dumps to managed disposal sites. Without facilities to collect and destroy the methane produced at these sites, these new management practices—although beneficial in terms of solid waste management—will result in higher methane emissions.

Mitigation Opportunities and Constraints

Some mitigation opportunities in waste opportunity are detailed on Figure 5 and in Appendix 2. At this time there are no plans to incorporate stand-alone mitigation investments in World Bank projects, although various approached to limiting methane emissions are included in all Bank investments in municipal wastewater storage and will be included in forthcoming project on industrial wastewater management. A few discrete policy actions have been identified in this sector by the SP-RCC:

- Prepare the national strategy to improve solid waste management in an integrated manner

- Develop comprehensive action plan on 3R (recycle, reuse, and reduce) and implement pilot project on household solid wastes management based on the National Strategy on Integrated Solid Waste Management.

Agriculture Sector

Emissions from agriculture are expected to grow slowly relative to transport and energy emissions, but they are a significant contributor to overall emissions due to the large areas of rice cultivation in the country, manure management practices in the livestock industry, and fertilizer use. Agriculture accounted for about 43 percent of emissions in 2000, but this proportion is expected to decline. (Total emissions are expected to remain stable but as other sources of emissions will grow so quickly, agriculture's proportional share will drop.)

Mitigation Opportunities and Constraints

Vietnam is one of the world's largest rice exporters and has 4.1 million hectares of irrigated cultivation. These large areas of wetland rice agriculture are responsible for one-third of Vietnam's greenhouse gas emissions as a result of the methane produced from anaerobic decay during the extended flooding periods. While there is active research on interventions, including using different varieties and controlling water use to reduce the time period of flooding, models that would scaled this up in a financially viable manner have not been developed that can be deployed in the short term. Clearly, reducing these large emissions remains a longer-term priority that needs more attention.

In 2006, the livestock population in Vietnam included about 26.9 million pigs, 6.5 million cattle, and 2.9 million buffalo. These numbers are expected to increase to meet the growing local demand even as the intensification is increased through the development of commercial farms. Significant methane emissions result from livestock flatulence for which there are limited mitigation opportunities. Additionally, the common practice in Vietnam is to allow livestock waste to degrade in rivers, streams, or open lagoons, where it emits large quantities of methane. The major mitigation opportunities are through the introduction of wastewater systems in livestock farms that recover methane for use in cooking and for energy. As of 2008, some 140,000 small-scale biogas systems have been introduced through the MARD Biogas Program for the Animal Husbandry Sector. With the planned increase in the number of commercial-scale livestock farms, opportunities for large-scale systems will increase.

Vietnam uses approximately 7.7 million tons of inorganic fertilizers each year. With an efficiency of use of only 40 percent, a large quantity of nitrous oxide is released into the atmosphere. There is some considerable potential to reduce these GHG emissions. (See data in Appendix 2 and mitigation potential earlier in Figure 5.)

Significant amounts of carbon are stored in soil in agricultural areas. Under some conditions, perhaps changing to a different cropping method, this carbon could be released as emissions. Under other conditions, soils could become a carbon sink. Further work is needed to understand these issues in Vietnam.

World Bank Programs

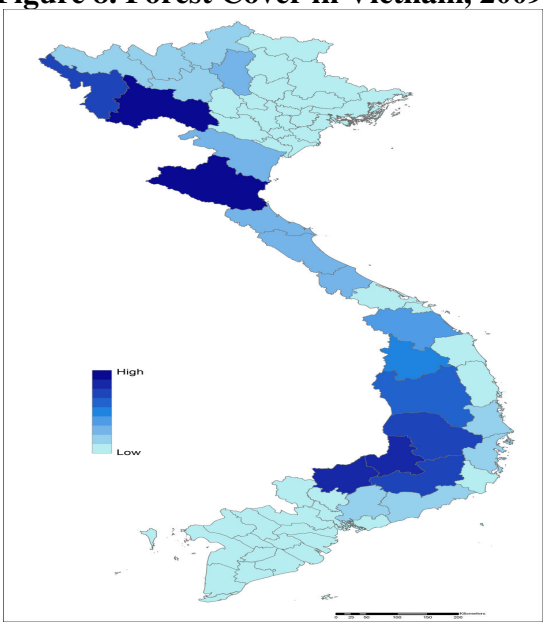
A number of actors (Netherlands Development Organisation (SNV), ADB, and others) are heavily involved in supporting MARD in the management of livestock waste to reduce methane emissions. The Bank has a small regional GEF project that also assists Vietnam in this area: the

Livestock Waste Management in East Asia Project. Support is also provided under the Livestock Competitiveness Project.
The development of policy actions and investment lending in the area of mitigation in agriculture remains to be developed.
Methyl bromide is a potent GHG that is used in Vietnam primarily as a soil fumigant. The Bank is currently supporting a Montreal Protocol project to phase out the use of methyl bromide.

Reduced Emissions from Deforestation and Forest Degradation

Better forest governance and stronger financial incentives for the sustainable management of forests could deliver major reductions of emissions. Based on estimates of emissions and abatement costs, improvements to forest management represent one of the most cost-effective climate change mitigation options currently available to Vietnam, as detailer earlier in Figure 5. Healthier, more extensive, less fragmented forests will also be more resilient to the impacts of climate change and will increase the resilience of forest-dependent communities by enhancing incomes, diversifying livelihood options, and offering protection from extreme climate efforts. Healthy forests will also protect and sustain ecosystem services—such as watershed protection and clean water provision for downstream water users—as well as deliver broader economic benefits through timber and non-timber forest products (NTFPs) and ecotourism.
Forest cover trends show an overall increase in forest cover due to extensive plantation development, but also a continuing decline in natural forest cover. Much of the 10 million or so hectares of natural forest is heavily degraded. (See Figure 8; the darker colors indicate serious deforestation and degradation.) Accurate figures are not available, as forest cover statistics are unreliable due to systemic deficiencies in the approaches used to collect and report on forest cover and to periodic changes in forest classification systems. This decline can be attributed to strong financial incentives for logging and converting forests, weak incentives for keeping natural forests standing, and limited capacity to enforce the legal framework with respect to forest protection.

Figure 8. Forest Cover in Vietnam, 2009



Source: JICA (2009b).

Globally, the scale of financing required to "tip the balance" from logging and forestland conversion to more-sustainable forest management practices for natural forests will be enormous and will therefore require market-based approaches.[10] (See Box 4.) To develop these markets, substantial public funding is now becoming available. These funds are being used to help prepare forest-rich countries to gain access to possible future markets for forest carbon. (Afforestation and reforestation are already eligible for carbon financing under the Clean Development Mechanism.)

Box 4. The REDD Program

Reduced Emissions from Deforestation and Forest Degradation is a proposed market-based or fund-based approach for rewarding efforts to reduce the rate of forest loss and degradation against a specified baseline. REDD+ would extend the scope of coverage to reward carbon sequestered by improved management of degraded forests—for example, in forests previously subject to overharvesting. This could include sustainable forest management or enhancement of forest stocks. Given that a large proportion of Vietnam's natural forests have been degraded already, a REDD+ mechanism could generate revenues and incentives for forest restoration and sustainable forest management. Market payments would need to be based on results—subject to verified progress in slowing deforestation compared with baseline trends—and so substantive forest governance reforms will be needed to realize carbon market revenues.

A number of REDD-related initiatives are under way in Vietnam. Efforts are being led by the Department of Forestry in MARD with support from the UN-REDD program and many donors, particularly Norway, as well as the World Bank.

Challenges

There continues to be uncertainty around REDD+, as international agreement still needs to be reached on how such a mechanism would work. A number of outstanding issues need to be addressed before REDD or REDD+ mechanisms become operational. The recent launch of the REDD Interim Financing Partnership should help advance these discussions. It will be several more years before forest carbon revenues generate substantive incentives for improved forest management and/or forest protection. This provides the time for countries to become REDD-ready. If Vietnam accepts the challenge of reducing deforestation and forest degradation, the government will need to use this time to put in place the necessary reforms to address several systemic challenges that face the forest sector.

First there is a lack of understanding of the costs and benefits associated with participation in future REDD schemes. There has been no objective analysis of the likely transaction costs for a national REDD strategy (for example, for improved forest inventory, monitoring and verification, and the operation of benefit-sharing schemes) or of the revenues that might be derived under a range of different scenarios for trends in deforestation and degradation and carbon prices. Comparative economic analysis is also needed to determine whether REDD (perhaps in combination with other payment for ecosystem services schemes) will be significant

[10] International interest in generating these financial incentives is based on the premise that forest loss, degradation, and land use change account for 12–17 percent of global GHG emissions and that if these trends could be halted and reversed, this could tremendously benefit the world's economy by minimizing climate change.

enough to displace competing land uses such as conversion to coffee and cashew. This very basic analysis is needed as soon as possible as a guide for planning and decision making.

In addition, the forest inventory capacity needs to be strengthened and modernized to ensure this can deliver the international-standard forest cover monitoring that will be required by a future forest carbon marketplace. A number of donor-supported projects are currently investing in this. There also needs to be systems in place to ensure appropriate incentives for correct monitoring data to be reported.

Forest management planning needs to be strengthened as well. Adjustments to forest planning will be needed to translate future REDD revenues into improved forest management. Forest planning and regulatory systems are currently based on three forest management categories (production, protection, and special use). While this separation of forest function has a certain logic, it has not proved to be effective. Reforms will be needed on several fronts: to legitimize access arrangements for local forest users so that these resources can be used to underpin local resilience to climate change; to accelerate the establishment of community forest management arrangements to provide incentives for local engagement and to build social cohesion around resource management; and to undertake participatory zoning plans to demarcate forest corridors and invest in the management of these areas to ensure connectivity across forest landscapes. This will build the overall resilience of the forest estate to changing climatic conditions and will also deliver co-benefits such as the delivery of ecosystem services and the conservation of biodiversity. In addition, there is a need to reform the forest administration system to ensure it can provide the services required to ensure functional forest management.

Another area needing reforming is the management boards and forest protection units that are currently responsible for the management of most remaining natural forests. In future, they will need to play an effective role in facilitating and coordinating sustainable forest management at the forest level, ensuring that local forest users and managers share the benefits from forest management—including future REDD revenues, and monitoring forest management at the field level, including possible future REDD compliance agreements.

Forest land tenure needs to be improved. Currently, most of Vietnam's natural forests are under state ownership (for example, State Forest Enterprises (SFEs), forest management boards, and forest protection units). Although the National Forest Development Strategy aims to rebalance this situation through a greater focus on "socializing" forest management (through forestland allocation, for instance), progress has been extremely slow. SFEs have tended to keep the best forestland and allocate to communities the poorer quality forestlands. The lack of secure land tenure for forest management over most of the natural forest estate poses a major barrier to developing the incentive structures necessary to deliver sustainable forest management practices at the forest level—and thus for achieving reductions in the rate of loss of forest carbon from natural forests. A rapid acceleration in the rate of establishing community forest management arrangements must be part of the solution if incentive structures are to be put in place for a substantial part of the natural forest estate. There also needs to be support and finance to help people benefit from land allocations.

Last, it will be important to prevent "leakage" associated with displacing illegal logging and land use change from areas where REDD incentives exist to areas where they do not.

Solutions

The challenges facing future market-based approaches to carbon management are largely the same as those that face the forest sector today, mostly identified in the government's sector policy: the need to accelerate implementation of forest tenure reforms, institutional

strengthening, and the need for better forest planning. Investments in addressing these challenges will therefore bring benefits for REDD per se and for the sector in general.
Some specific policy actions, which have been developed under the SP-RCC, include:

- The "Coastal mangrove rehabilitation and development program in period 2008 – 2015" has been approved by the Government but attention is needed for its implementation and policy considerations at provincial level

- Issue a Government Decree on special use forests

- Formulate proposal on forest development and protection for 2010 - 2020

Leakage issues can only be addressed by introducing REDD at national level in Vietnam and also regionally—especially in Lao PDR and Cambodia, the source of much unregulated timber entering Vietnam. Both Lao PDR and Cambodia are also developing REDD policies; in the longer term, this should help address leakage issues at the regional level.
Success in addressing these challenges will also bring wider "co-benefits," such as:

- Protection of important forest-based ecosystem services such as watershed protection and clear water supply—services that are likely to become increasingly important with climate change

- Protection of "provisioning services"—of timber, firewood, NTFPs, and forest grazing—that are essential for the livelihoods of forest-dependent groups and that could contribute to resilience in times of environmental and economic stress

- Conservation of biodiversity—which is mostly perceived as a national or global "public good" but also important for delivering livelihood benefits and, to a growing extent, economic benefits through nature-based tourism in Vietnam.

World Bank Programs
The World Bank is a major player in supporting Vietnam in implementing REDD. An agreement has been signed between the World Bank–managed Forestry Carbon Partnership Facility and the government of Vietnam to provide $3.2 million of support for preparing the country for REDD. The exact use of these funds is pending definition.
Investments in management of mangrove forests could be included under the forthcoming Mekong Water Resources for Rural Development Project or the Coastal Resources for Sustainable Development Project. Other future projects focused on the forestry sector could play an important role by continuing to support the reform agendas outlined here.

MOVING FORWARD

The previous sections have suggested the "what": the main climate change priorities for Vietnam with which the Bank could assist. A summary table is included in the Executive Summary. The "how" has also been addressed through the provision of extensive information on past, present, and future projects, both loans and grants. Financing for climate change is, however, becoming increasingly more complicated, with many potential funding sources and the emergence of innovative approaches to funding. These are explored in more detail in Appendix 3.

But the World Bank's program of climate change assistance needs to be built on much more. Another important element is technical assistance to build the government's capacity to carry out its own programs of response to climate change. This is discussed here, as are the critical partnerships that must be built and strengthened.

Knowledge Sharing and Technical Assistance

A tremendous wealth of knowledge on climate change has been generated by the World Bank. Much of it is available through the Bank's climate change portal at www.worldbank.org/climate. Selected information of direct relevance to Vietnam is or will be posted at the Bank's environment Web site for Vietnam (www.worldbank.org/vn/environment). However, continuing effort is needed to both generate new knowledge and to share that knowledge with other key actors in Vietnam. The Bank commits to that agenda, will provide technical assistance whenever possible, and will continue to make knowledge sharing a priority. One example is a matrix, currently maintained by the Bank, that lists all the ODA-financed climate change activities under way in Vietnam. (This can be downloaded from the environment section of the country Web site). The management of this matrix will be transferred to the Government.

This section briefly describes a few of the major programs of technical assistance and analytical support in addition to those directly financed with Bank resources.

The Global Facility for Disaster Reduction and Recovery aims at mainstreaming disaster reduction and climate change adaptation measures in developing countries to reduce vulnerabilities to natural hazards. The facility is supported by a large number of donors and hosted in the World Bank. GFDRR funds disaster risk assessments, risk mitigation policies and strategies, and disaster prevention preparation projects and recovery; it has also financed projects on climate resilience and adaptation to climate change impacts. The program has three tracks that support global, regional, and country-specific activities. GFDRR has an active program in Vietnam.

The Economics of Adaptation to Climate Change (EACC) has financed six important studies on climate change in Vietnam. The EACC is carried out by the World Bank and financed by the governments of Netherlands, United Kingdom, and Switzerland. The six studies, discussed in more detail elsewhere in this report, cover aquaculture, agriculture/water, forestry, ports, computed general equilibrium, and social issues. The country synthesis report for Vietnam has been issued.

Finally, mention can be made of a forthcoming partnership between DFID and the World Bank that is now being finalized. A dedicated trust fund will be created to support analytical work and pilot interventions on climate change. It is expected to last about three years, and its fundamental

orientation will be to support the government of Vietnam in the implementation of its climate change strategies. For example, the Bank proposes, in this partnership, to work closely with the government on a low-carbon growth country study.

Support to the Government of Vietnam

The government has produced a strong NTP-RCC, as described earlier, and has made a demonstrated commitment to address climate change seriously. The Prime Minister has designated the Ministry of Natural Resources and the Environment as the lead agency on the NTP-RCC. MoNRE's Standing Office on Climate Change and its unit to implement the JICA/French development agency-financed Support Program to Respond to Climate Change (SP-RCC) can play an important role in donor/government CC policy discussions. MoNRE already benefits from strong assistance from UNDP and DANIDA, as well as from JICA and other sources. The World Bank is preparing to join the SP-RCC.

Box 5. Management of Financial Flows

In UNFCCC international fora, developing countries are requesting "new and additional" finance broadly equivalent to a doubling of the agreed global ODA goals of 0.7 percent of industrial-country GDP. Since most industrial countries never reached the ODA target, the challenge of raising this additional financing for climate change is daunting. Even if financing falls short of these targets, there will certainly be new financing flows, and they will be combined in complex ways with existing ODA flows. With Vietnam's new status as a middle-income country, traditional ODA flows will decrease, so the relative share of climate change financing will likely increase.

A Climate Finance Knowledge Platform has been developed jointly with UNDP and in consultation with the UNFCCC as a service by "the UN and MDBs delivering as one." A prototype is on-line that is being continuously expanded. The World Bank has allocated seed funds and a launch was expected in late 2010.

The roles of the Ministry of Planning and Investment and the Ministry of Finance are particularly important in terms of management of financial flows and investment planning at the national level. Their roles, however, need strengthening. Considerable domestic financing and private sector financing needs to be made available. Reforms in public finance generally will have many important benefits for climate change programs, e.g., by better and more transparent data collection.

A great wealth of information on this new global architecture for global climate change finance is now available (see the World Bank's Web site). A priority for the World Bank should be to assist the government of Vietnam in this area. Some of the specific climate change financing instruments available through the World Bank are covered in Appendix 3.

Other line ministries and provinces and cities are required under the NTP-RCC to produce their own climate change action plans. Each of these actors needs support and technical assistance to comply with this requirement and to fully mainstream climate change into their current and future investments and plans. (See Box 5.)

Other priorities for the Bank in its work with the government include the following:

- Enhanced support to MoNRE to help them better provide technical assistance and carry out focused parts of the NTP that are their responsibility (note that other ODA actors are already providing substantial support to MoNRE on coordination issues)

- Working with line Ministries (particularly MARD, the Ministry of Industry and Trade, the Ministry of Transportation, and the Ministry of Construction), and with provincial and municipal authorities on preparing and implementing sector-specific climate change plans that are to be prepared under the umbrella of the NTP-RCC

- As appropriate in the context of specific projects or programs, playing enhanced technical assistance and capacity building roles at central and local levels.

Partnerships with Donors and NGOs

The Bank participates in a number of different fora on climate change with key development partners and will continue to participate actively. A number of joint analytical and investment programs are under way or being considered with ADB. The Bank is involved on a CC activity with many different bilateral or multilateral actors and NGOs in Vietnam. For several years, on behalf of the donor and NGO community, the World Bank has maintained a comprehensive and public matrix on climate change activities in Vietnam, as noted earlier.
Passage of the NTP was included as a policy trigger under the multidonor financed Poverty Reduction Support Credit (PRSC) 8. PRSC 9 and PRSC 10 continue to address cross-cutting issues relevant to climate change while the SP-RCC addresses specific CC policy issues. For the last several years the Consultative Group meetings have always included a session on climate change. This has been another forum for government/donor consultations on climate change.
In 2010, the theme of Vietnam Innovation Day was climate change. This World Bank–managed program provides small grants to NGOs and communities to support local efforts on climate change. Currently about $200,000 in funding available; the Vietnam Innovation Day is cofinanced by a number of donors.

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APPENDIX 1. POSSIBLE IMPACTS OF CLIMATE CHANGE IN VIETNAM AND EXAMPLES OF ADAPTATION MEASURES

Climate Change–Sensitive Assets	Vulnerability	Possible Impacts in Absence of Adaptation Measures[11]	Examples of Adaptation Measures	World Bank Studies and Projects[12] (active and in pipeline)
NATURAL ASSETS				
Agriculture	High because of concentration of agricultural activity in low-lying delta areas	Loss of delta land, salinization, temperature and rainfall changes could reduce yields; changes in rainfall and hydrological patterns will affect irrigation; possible loss of crop varieties; physical impacts to irrigation infrastructure from SLR, flooding	In short term, improve existing resilience strategies; adapt water management (see section below); research into CC-adapted varieties; coastal reforestation; facilitate transition to more brackish water aquaculture	Agricultural Diversification (P004844); Water Resources Assistance Project (P065898); Vietnam Livestock Competitiveness and Food Safety (P090723); Agricultural Competitiveness Project (P108885); EACC study on agriculture and water (P114750); Inception report on Agriculture and CC (P115519); *Mekong Water Resources for Rural Development Project (P113949); Coastal Resources for Sustainable Development Project (P118979); Natural Disasters Reduction and Adaptation (P118783); further analytical work on CC and agriculture to be supported (P115519); further analytical work under DFID TF; GFDRR investments in forecasting and monitoring*

[11] Qualitative assessments of potential development impact, in the absence of adaptation measures, are shown by the colors: pink for high development impact, blue for moderate, and uncolored for low. A high development impact is one that could significantly slow economic growth in the sector and/or have significant consequences on the livelihoods of millions of people. A moderate development impact could slow economic growth in the sector and have significant consequences on livelihoods of a large number of people, but primarily those directly involved in the sector. A low impact indicates that, because of some combination of low vulnerability and inherent adaptability, the impacts do not significantly stand out from the "background level" of variability inherent to the sector.

[12] World Bank studies and projects are all mentioned in this Appendix with their numerical code, a P followed by a number. Entering this P code in the Projects & Operations or Publications search tools at the Bank's public site (http://www.worldbank.org) provides access to all publicly available reports and documents for that study or project. Sometimes additional information could be available on the Web site for the country (http://www.worldbank.org/vn). The projects and studies in italics are planned as of December 2010.

Climate Change– Sensitive Assets	Vulnerability	Possible Impacts in Absence of Adaptation Measures[11]	Examples of Adaptation Measures	World Bank Studies and Projects[12] (active and in pipeline)
Aquaculture	High economic importance, high poverty in the sector, and geographic proximity to coasts	Loss of coastal areas, salinization, storm damage, changes in hydrological patterns; many factors other than CC are critical for future of this sector	Investments are needed in resilience strategies generally of this sector, fine-tuned for emerging CC issues	EACC study on aquaculture (P114750); *Coastal Resources for Sustainable Development Project (P118979)*
Water resources	Almost all sectors of the economy are dependent on, and vulnerable to, water resource changes; water control structures preponderantly occur in vulnerable low-lying areas	Water resources will be affected by precipitation and temperature changes and by SLR; dikes are an adaptation measure but also subject themselves to impacts from SLR and storm surges; changes in river flow could affect water quality; water resource management will become more challenging	Improvements in water resource management, needed in any event, will address many of the emerging CC impacts on water resources; specific investments (mostly should be long-term) will include dikes and other water control structures, salinization controls, and water storage (reservoirs)	Coastal Wetlands Protection and Development Project (P042568); Vietnam Water Supply Development (P073763); Water Resources Assistance Project (P065898); EACC study on agriculture and water (P114750); *Mekong Water Resources for Rural Development Project (P113491); Red River Delta Rural Water Supply and Sanitation, Program APC, 2nd Phase (P105137); further analytical work on CC and WRM to be supported possibly under DFID TF; GFDRR*
Hydropower resources	Hydropower accounted for 39% of power generation in 2009 (expected to fall to 22% by 2025); power generation is a function both of total water and seasonality of flow	Changes in hydrological patterns are expected to generally increase water availability in dam reservoirs, a potentially positive impact (could decrease in some areas); impacts of seasonal changes in water availability are uncertain; greater flooding events could threaten some dam structures	Better modeling and CC scenarios needed before specific adaptation investments or measures can be implemented	See publication from World Bank's Development Research Group: *Estimating Global Climate Change Impacts on Hydropower Projects: Applications in India, Sri Lanka and Vietnam* (Iimi 2007)
Forests (upland)	Forests are vulnerable to climatic shifts; forest-dependent human populations tend to be quite poor	Changes in climate could affect growth rates, forest fires, disease patterns	Measures to better manage forests, which in any event are critically needed in Vietnam (see under REDD), could be instrumental to adapt to new	Forestry Sector Development Project (P066051); EACC study on forestry (P114750); Forest Sector Development Project (P074414)

Climate Change–Sensitive Assets	Vulnerability	Possible Impacts in Absence of Adaptation Measures[11]	Examples of Adaptation Measures	World Bank Studies and Projects[12] (active and in pipeline)
	and vulnerable		challenges of CC	
Forests (mangroves)	Any losses (or additions) affect many coastal poor populations	Mangroves could be vulnerable to major impacts from SLR and storm damage but note that mangroves are already storm-adapted and highly adaptable coastal ecosystems	Mangroves themselves are also important adaptation measures to SLR and sea surges	Coastal Wetlands Protection and Development Project (P042568); mangroves could possibly be supported under *Mekong Water Resources for Rural Development Project (P113949)*; see also *forthcoming engagement on REDD*
Terrestrial biodiversity	Ecosystems will not be able to respond to speed of CC; highly vulnerable because of current fragmentation of natural ecosystems; large numbers of rural poor dependent on natural ecosystems	Impacts on natural ecosystems and biodiversity arising from rapid climate shifts; impacts on forestry; changes in temperature and hydrological patterns might affect stocks of freshwater fisheries		Green Corridor Project (P059144); Integrating Watershed and Biodiversity Management in Chu Yang Sin National Park (P068249); EACC study forestry (P114750); VDR 2011 (P118764) focused on natural resource management, addressing as appropriate CC issues; *planned studies on terrestrial environmental services under DFID partnership;*
Marine biodiversity and fisheries	Coastal ecosystems vital to survival of millions of poor fishers and important for tourism industry; many unknowns about nature of impacts and vulnerability of marine fisheries sector	Coastal marine areas and coral areas subject to potentially large impacts from storms, SLR, acidification of coastal waters; stock distribution of marine fisheries could change dramatically with changes in marine environment; more-intense and more-frequent storms; impacts on corals and marine environments		Hon Mun Marine Protected Areas Project (GEF) (PP067804); *Coastal Resources for Sustainable Development Project (P118979)*
CONSTRUCT-ED ASSETS				
Urban and coastal cities	Cities are the economic heart of Vietnam and where	Subject to more damage from floods, storms; localized issues with water	Urban plans will need to be far more flexible and resilient to take into account all the likely	Coastal Cities Environmental Sanitation (P082295); Ho Chi Minh City Environmental Sanitation Project (P052037); Vietnam Urban

Climate Change–Sensitive Assets	Vulnerability	Possible Impacts in Absence of Adaptation Measures[11]	Examples of Adaptation Measures	World Bank Studies and Projects[12] (active and in pipeline)
	most of the population lives; coastal cities are extremely vulnerable to SLR and storm surges	supply	impacts of CC on cities; must be adapted to greater flow variability from flooding episodes or storm damage; many specific kinds of investments such as water control structures, protection of parklands and buffer zones; specialized risk financing instruments	Upgrading Project (P070197) and Additional Finance (P115897); Coastal Cities Environmental Sanitation Project (P082295); and many other urban investment projects; Climate Resilient Cities Primer (P110591); WBI work on incorporation of CC into planning; study on impacts of CC on drainage systems in coastal cities (GFDRR-funded; P114603); GEF – Coastal Cities project (P090374); *Second Vietnam Urban Upgrading Project (P113904)*; *Vietnam Medium Cities Development Project (P116398)*
Roads and railways (coastal)	Transportation infrastructure in areas now subject to coastal flooding will be particularly vulnerable	All roads subject to more flood damage; coastal transport infrastructure also exposed to storm damage, SLR; likely impacts mostly unknown	Some changes may be needed in the way transport infrastructure is built (but need to take into account limited lifetime of such investments); careful attention needed to siting of infrastructure	For the World Bank's large portfolio of transport projects, there is an increased awareness of the need to include climate change considerations in investment design and long-range planning. However, the extent to which this is being done is limited by the availability of sufficiently detailed data on the specific impacts on infrastructure during its economic life
Ports	Critical economic importance and, by their location, inherently vulnerable to SRL and coastal storms	Impacts currently unknown but WB study under way; could be incrementally subject to storm damage, SLR, flooding and impacts on infrastructure	World Bank study pending	EACC study on adaptation and ports (P114750)
Coastal tourism areas	Vulnerable because of coastal location; quite high economic importance in many areas	Impacts possible from SLR (physical loss of beaches, seaside areas), storms; no study known has evaluated these impacts	No study in Vietnam has evaluated possible adaptation measures in the tourism sector	World Bank has no investments in the tourism sector in Vietnam
HUMAN ASSETS				
Health changes	Degree of	Vector densities and	No specific adaptation measures	World Bank has a large portfolio of health

Climate Change–Sensitive Assets	Vulnerability	Possible Impacts in Absence of Adaptation Measures[11]	Examples of Adaptation Measures	World Bank Studies and Projects[12] (active and in pipeline)
	vulnerability largely unknown	distributions could theoretically change, causing differences in patterns of malaria, dengue, etc.; such impacts are largely unknown but not yet demonstrated that disease patterns will significantly change	seem justified in the short term other than continued strengthening of health care systems related to vector-borne diseases	projects that provide support to the general strengthening of Vietnam's health system
Vulnerable social groups	Vulnerable groups (the poor, women, ethnic minorities) may be disproportionately affected by CC and will be inherently less able to adapt	Possibly could result in wider poverty gaps or a cycle of increasing vulnerability	At least in the short term, the best adaption measures would seem to be those focused in any event on reducing vulnerabilities of targeted social groups (capacity building, safety nets, etc.)	EACC Study on social vulnerability (P114750)
COMBINED ASSET CATEGORIES				
Assets vulnerable to natural disasters	The communities most affected by natural disasters are often already among the poorest and most vulnerable in Vietnam	Some types of natural disasters can expect under CC to increase in intensity and frequency (particularly coastal storms, flooding events, possibly droughts in some areas); potential incremental impacts of CC are important	Most critical is strengthening of existing disaster risk reduction and natural disaster risk mitigation strategies	Natural Disaster Risk Management (P073361); NDRMP Additional Financing (P119684); Evidence-based natural disaster risk management (P102378); Mekong Transport and Flood Protection Project (P042927) and Additional Finance (P105120); *further analytical work to be done on sovereign financial protection against natural disasters through use of financial tools such as risk reduction infrastructure, contingent credit, CAT DDO insurance; Managing Natural Hazards Project (P118783); Natural Disaster Risk Management Project Additional Finance (P119684); and FY11 planned GFDRR program*

APPENDIX 2. SELECTED MITIGATION OPPORTUNITIES IN VIETNAM

Intervention and Theoretical Emission Reduction	Feasible Medium-Term (2015) Reduction Potential	Public Co-benefits	Financial Profitability	Major Barriers	WB Studies/Projects
POWER GENERATION					
Medium-size hydropower (4 $MtCO_2e$/yr)	Electricity generated by 3 medium-scale hydro power plants under pre-FS stage (1.3 $MtCO_2e$/yr)	Increased energy supply; air quality improvement relative to fossil fuels	Profitable in Vietnam	Financial: Available financing for investment does not meet the needs for Vietnam	Trung Son Hydropower Project (P084773)
Small and mini hydropower (8.8 $MtCO_2e$/yr)	Electricity generated by 44 out of 1,013 small-scale hydro power plants that are between 15 and 30 MW (2.7 $MtCO_2e$/yr)	Increased energy supply; air quality improvement relative to fossil fuels	Profitable: IRRs found to be between 12% and 16% with carbon finance revenues	Regulatory: lengthy approval and licensing process Financial: Difficulty in negotiating PPA and perceived risk from Banks due to lack of familiarity with technology	Renewable Energy Development Project, financed by Carbon Partnership Facility (P110477); Vietnam Renewable Energy Development Project (P103238); System Efficiency Improvement, Equitization, and Renewables Project (P066396)
Wind power (2.5 $MtCO_2e$/yr)	Electricity generated from the largest out of eight wind farms will be sold to the national power grid (1.4 $MtCO_2e$/yr)	Increased energy supply; air quality improvement relative to fossil fuels	Marginal or not profitable in Vietnam; one project was found to be profitable with CDM benefits	Technology: lack of operational experience Regulatory: lengthy approval and licensing process Financial: Marginal returns, difficulty in negotiating PPA, perceived risk from Banks due to lack of familiarity with technology	Various analytical studies (see references in energy section)

Intervention and Theoretical Emission Reduction	Feasible Medium-Term (2015) Reduction Potential	Public Co-benefits	Financial Profitability	Major Barriers	WB Studies/Projects
Geothermal power generation (0.7 $MtCO_2e$/yr)	Two 20 MW geothermal plants developed for 2015 (0.09 $MtCO_2e$/yr)	Increased energy supply	One project developed for the CDM is profitable with CDM revenues	Technical: Technology is not widespread in Vietnam Regulatory: lengthy approval and licensing process Financial: Difficulty in negotiating PPA and perceived risk from banks due to lack of familiarity with technology	
Recovery and use of gas from oil fields (2.0 $MtCO_2e$/yr)	Recovery of associated gas from the seven available oil fields and use for power generation or heating (2.0 $MtCO_2e$/yr)	Increased energy supply; improved safety at oil fields	Found to be profitable with CDM benefits in one project in Vietnam	Financial: Financial attractiveness of such and investment and common practice are key barriers	Gas study (see references in energy section)
Coal bed methane recovery from underground coal mines (2.5 $MtCO_2e$/yr)	Recovery and utilization of methane gas from coal mines: 20% of underground coal mines in country (0.50 $MtCO_2e$/yr)	Increased energy supply; improved safety at oil fields	Shown to be profitable internationally, but never tried in Vietnam	Technical: Not a proven technology in Vietnam and lack of experience in design	
Subcritical energy efficiency improvements in old coal-fired power plants (4.2$MtCO_2e$/yr)	Energy efficiency improvement in the three largest pre-2001 coal plants by applying subcritical technology (2.7 $MtCO_2e$/yr)	Decreased energy demand	Typically profitable but less so than for new plants	Technical: Lack of familiarity with regard to the energy-efficient technologies in old plants Financial: Investment costs of retrofitting plants are high; there are differing opinions as to whether or not this mitigation option is viable at this time	
Supercritical energy efficiency improvements in new coal-fired	Adoption of supercritical boilers in 50% of new coal-fired power plants constructed from 2010 to	Decreased energy demand	Profitable in other countries but never tried in Vietnam	Technical: Supercritical boilers are new technologies to Vietnam Financial: Upfront	

Intervention and Theoretical Emission Reduction	Feasible Medium-Term (2015) Reduction Potential	Public Co-benefits	Financial Profitability	Major Barriers	WB Studies/Projects
power plants (19.0 $MtCO_2e/yr$)	2015 (9.5 $MtCO_2e/yr$)			investment costs are high	
Subcritical energy efficiency improvements in new coal-fired power plants (10.9 $MtCO_2e/yr$)	Adoption of energy-efficient subcritical technologies in 50% of new coal-fired power plants constructed from 2010 to 2015 (5.4 $MtCO_2e/yr$)	Decreased energy demand	Profitable in other countries but never tried in Vietnam	Technical: Lack of familiarity with regard to the energy-efficient technologies in old plants Financial: Upfront investment costs are high	
INDUSTRY					
Fuel switching in cement industry (1.5 $MtCO_2e/yr$)	Applying fuel switching in cement factories of VICEM (0.65 $MtCO_2e/yr$)	Decreased energy demand	Found to be profitable with CDM in other countries	Technical: Logistics of gathering source material; familiarity and confidence in technology	
Blending of cement (1.25 $MtCO_2e/yr$)	Increased blending of cement for cement factories of VICEM (0.5 $MtCO_2e/yr$)	Decreased energy demand	Found to be profitable in other countries	Technical: Awareness of implications of cement blending on product Financial: Uncertainties that more blended cement can sustain a market in Vietnam	
Recovery of waste heat in cement industry (1.0 $MtCO_2e/yr$)	Recovery of waste heat in cement factories of VICEM for power generation (0.4 $MtCO_2e/yr$)	Decreased energy demand	Found to be profitable in Vietnam with CDM benefits	Technical: Complications with the dust and temperature of the exit gases and lack of experience in operation Financial: Involves higher investment costs	

Intervention and Theoretical Emission Reduction	Feasible Medium-Term (2015) Reduction Potential	Public Co-benefits	Financial Profitability	Major Barriers	WB Studies/Projects
Energy efficiency in cement industry (5.1MtCO_2e/yr)	Energy efficiency improvement for plants of VICEM (2.1 MtCO_2e/yr)	Decreased energy demand	For older industrial plants, there are selective cost-effective and profitable interventions available in each subsector; for new industrial plants, energy-efficient technology is profitable in the long term but requires higher upfront costs	Technical: Awareness of technologies and their benefits among managers Regulatory: Regulatory incentives need to be implemented Financing: Sources of financing for these types of investments are limited in some cases	
Energy efficiency in brick industry (1.9 MtCO_2e/yr)	Replacement of traditional kilns with vertical shaft brick kiln for 40% of traditional kilns (0.8 MtCO_2e/yr)	Decreased energy demand	Investments in vertical shaft brick kilns have been shown to be profitable in Vietnam	Technical: Awareness of the technology and its availability are the major barriers to its adoption	
Recovery of waste heat in iron and steel industry (0.56 MtCO_2e/yr)	Recovery of waste heat in iron and steel factories belonging to VSC for power generation or heating (0.2 MtCO_2e/yr)	Decreased energy demand	Typically profitable with CDM	Technical: Familiarity with technology Financial: High upfront investment costs	
Energy efficiency in iron and steel (1.0 MtCO_2e/yr)	Improving energy efficiency in iron and steel plants belonging to VSC (0.4 MtCO_2e/yr)	Decreased energy demand	Typically profitable with CDM	Technical: Awareness of technologies and their benefits among managers Regulatory: Regulatory incentives need to be implemented Financing: Sources of financing for these types of investments are limited in some cases	

Intervention and Theoretical Emission Reduction	Feasible Medium-Term (2015) Reduction Potential	Public Co-benefits	Financial Profitability	Major Barriers	WB Studies/Projects
Cogeneration in pulp and paper industry (0.84 tCO_2e/yr)	Cogeneration in pulp and paper plants belonging to Vinapimex (0.45 tCO_2e/yr)	Decreased energy demand	Studies have shown this is profitable (IRR between 15% and 30%) in pulp and paper industries in Vietnam	Technical: Awareness of technology and its operation Financial: High costs of equipment	
AGRICULTURE					
Improving efficiency of fertilizer use in order to reduce nitrous oxide emissions (1.1 $MtCO_2e$/yr)	Improving the efficiency of fertilizer use in rice cultivation from 40% to 45% nationally (0.41 $MtCO_2e$/yr)	Reduced runoff from fertilizer; improved productivity	Profitable	Technical: Lack of knowledge of correct levels of application and variable quality of fertilizers	
Agricultural waste to energy (0.9 $MtCO_2e$/yr)	Utilization of 20% of rice husk production and 40% of bagasse production for power generation (0.15 $MtCO_2e$/yr-0.06 $MtCO_2e$ rice; 0.09 $MtCO_2e$ bagasse)	Increased energy supply	Studies in Vietnam indicate large rice hull plants can be profitable and smaller plants can be profitable with additional revenues from CDM and ash; studies on bagasse in Vietnam indicate it is profitable option for traditional and modern mills	Technical: Technology is not widespread in Vietnam Regulatory: lengthy approval and licensing process Financial: Difficulty in negotiating PPA and perceived risk from Banks due to lack of familiarity with technology	Low-Cost Housing: Waste Rice Straw Construction Panels – GEF (P114893)

Intervention and Theoretical Emission Reduction	Feasible Medium-Term (2015) Reduction Potential	Public Co-benefits	Financial Profitability	Major Barriers	WB Studies/Projects
Livestock waste (11.7 $MtCO_2e$/yr)	Livestock waste: Methane capture and electricity generation in 80 percent of large-scale livestock farms and an additional 75,000 small-scale biogas digesters through MARD program (1.26 $MtCO_2e$/yr)	Increased energy supply; improved water quality and sanitation	Typically profitable with CDM and at times need subsidized credit in order to encourage adoption	Technical: Awareness of benefits and technology Financial: Farms lack investment capital and perceived risk among banks is high due to lack of knowledge	Regional GEF Livestock Waste Management in East Asia Project (P079610); Livestock Competitiveness Project (P090723)
FORESTRY					
Mangrove reforestation (5.3 $MtCO_2e$/yr)	Reforestation of 22,000 ha of mangrove forest (1.2 $MtCO_2e$/yr)	Improved biodiversity; improved fisheries; disaster risk management	Not profitable	Social: Demand for land in coastal areas Financial: Availability of financing Regulatory: Enforcement of conservation	Vietnam Coastal Wetlands Project (P065898) supported mangrove planting; *analytical work to be done under DFID Partnership; mangrove management could be potentially supported under projects in preparation: Mekong Water Resources for Rural Development Project (P101690)*
REDD interventions (10.5 $MtCO_2e$/yr)	Reduce primary forest loss by 20% of 2000–05 rate (2.1 $MtCO_2e$/yr)	Improved biodiversity; forest product livelihoods	Not profitable	Social: Pressures on forest resources Financial: Availability of financing Regulatory: Enforcement of conservation	Forest Sector Development Project (P066051); REDD FCPF implementation support (P119983); great wealth of analytical work in this area has been done by the Bank; GEF Sustainable Forest land Management (P112661)
TRANSPORT					

Intervention and Theoretical Emission Reduction	Feasible Medium-Term (2015) Reduction Potential	Public Co-benefits	Financial Profitability	Major Barriers	WB Studies/Projects
Introduction of electric motorcycles (5.9 $MtCO_2e/yr$)	100% introduction of electric motorcycles in five major cities (HCMC, Hanoi, Hai Phong, Da Nang and Can Tho) (2.3 $MtCO_2e/yr$)	Air quality improvement	Typically involves costs for consumers and government; financials not fully analyzed for Vietnam	Regulatory: Both standard for electric motor cycles and regulatory control on the use of motorcycles are key driving factors Market: A large enough demand is necessary to increase demand	
Biofuel E20 (20% ethanol gasoline) in vehicles (2.6 $MtCO_2e/yr$)	Introduction of E20 to substitute for gasoline used nationally using the planned production capacity for bioethanol (equivalent of 1% of gasoline supply) (0.1 $MtCO_2e/yr$)	Air quality improvement for some parameters; diversification of agricultural products and employment	Not profitable or marginal typically but in rare instances has been profitable internationally; typically needs government support through regulation or subsidies; not undertaken in Vietnam	Regulatory: Program normally necessitates mandatory blends or other government fuel price control Technology: Introduction of technology and increase in processing capacity is needed	
Modal shift from road to inland waterway freight (2.2 tCO_2e/yr)	Shift of 10% of road freight traffic to inland waterways through improved waterways, infrastructure, and other incentives (0.22 tCO_2e/yr)	Improved air pollution; trade facilitation; road safety improvement	The Bank has found these investments to be highly viable	Technical: Lack of infrastructure including logistics and intermodal linkages Financial: Underinvestment in waterways as a mode of transport	Bank supports a number of projects that finance inland waterways, such as Inland Waterways and Port Rehabilitation Project (P004843)
Modal shift from road to rail freight (2.6 tCO_2e/yr)	Shift of 10% of road freight traffic to railways through improved infrastructure (0.26 tCO_2e/yr)	Improved air pollution; trade facilitation; road safety improvement	Commonly marginal or not profitable in Vietnam but may be profitable for some lines	Technical: Lack of infrastructure including logistics and intermodal linkages Financial: Requires large infrastructure investments	

Intervention and Theoretical Emission Reduction	Feasible Medium-Term (2015) Reduction Potential	Public Co-benefits	Financial Profitability	Major Barriers	WB Studies/Projects
Modal shift from road to coastal freight (0.8 $MtCO_2e/yr$)	Shift of 10% road freight traffic to coastal shipping using larger capacity vessels and improved infrastructure (0.08 $MtCO_2e/yr$)	Improved air pollution; trade facilitation; road safety improvement	Initial estimates indicate it may be profitable in Vietnam	Technical: Lack of infrastructure including logistics and intermodal linkages Financial: Underinvestment in coastal shipping as a mode of transport	Bank supports a number of projects that finance inland waterways, such as Mekong Delta Transport Infrastructure Development Project (P083588)
Bus Rapid Transit in five major cities (0.57 tCO_2e/yr)	City program for construction of BRT system for Hanoi and Ho Chi Minh to replace 30% of motorcycles and 30% cars in the city (0.53 tCO_2-e/yr)	Improved air pollution; trade facilitation; road safety improvement	Involves large investments that are typically marginal or not profitable; not undertaken in Vietnam	Institutional: Fragmented planning process Financial: Financing for urban transport infrastructure is below targets	Hanoi Urban Transport Project (GEF) (P083593); possible support to BRT in Danang
Passenger vehicle fuel efficiency standards (3.7 $MtCO_2e/yr$)	EU standards (from five years ago) met in HCMC and Hanoi (2.0 $MtCO_2e/yr$)	Improved air pollution	At the consumer level can be profitable expenditures with limited fuel subsidies and high fuel prices; costs associated with financial incentives for retiring old low energy efficient fleets and enforcing energy efficiency standards	Regulatory: Fuel efficiency standards are not in place	
WASTE					

Intervention and Theoretical Emission Reduction	Feasible Medium-Term (2015) Reduction Potential	Public Co-benefits	Financial Profitability	Major Barriers	WB Studies/Projects
Low methane-emitting technologies in urban wastewater (1.32 $MtCO_2e/yr$)	Increasing centralized wastewater treatment to 50% with aerobic sludge treatment; land farming of 100% sludge from centralized wastewater treatment plants; desludging and aerobic treatment of 50% of septic tanks for five major cities (0.3$MtCO_2e/yr$)	Improved water quality and sanitation	Can be profitable with right institutions		Many WB projects finance urban wastewater treatment and some are piloting low methane technologies
Low methane-emitting technologies in rural wastewater (1.73 $MtCO_2e/yr$)	Rural domestic wastewater: Methane avoidance through switching 25% of septic tanks to aerobic sanitation and 25% adoption of aerobic sanitation systems for those without sanitation (0.45 $MtCO_2e/yr$)	Improved water quality and sanitation	Not profitable	Technical: Awareness of technologies are limited Financial: Rural customers are cash-limited	Many WB projects finance rural wastewater treatment and some are piloting low methane technologies
Low methane-emitting industrial wastewater systems (3.30 $MtCO_2e/yr$)	Industrial wastewater: Methane recovery (biogas) and avoidance (aerobic systems) for 75% wastewater of bioethanol, meat & poultry, pulp & paper, liquor & beer, tapioca starch, and fishing processing industries (1.6 $MtCO_2e/yr$)	Improved water quality	Systems have been found to be profitable with CDM in Vietnam	Technical: Technology is more sophisticated than traditional technologies Financing: Is considered a risky investment and are barriers to obtaining commercial financing	The Bank's analytical work on industrial pollution has looked at all issues involved in treatment of industrial wastewater. *Reduced methane emissions should be one result of forthcoming Vietnam Industrial Pollution Control Project (P113151).*
Composting (4.7 $MtCO_2e/yr$)	Methane avoidance through solid waste composting in eight cities (Hanoi; Nam Dinh; Quy Nhon; Vung Tau; Vinh; Lao Cai; Phu Lay) (0.9 $MtCO_2e/yr$)	Reduced waste in disposal site and subsequent reduction in water pollution	Not profitable or marginal with CDM		

Intervention and Theoretical Emission Reduction	Feasible Medium-Term (2015) Reduction Potential	Public Co-benefits	Financial Profitability	Major Barriers	WB Studies/Projects
Landfill gas to energy (2.3 $MtCO_2e$/yr)	Methane recovery through landfill gas to energy projects in urban disposal sites for eight cities (HCMS; Hanoi; Hai Phong; Can Tho; Da Nang; Ha Long; Nha Trang; Nam Dinh) (1.9 $MtCO_2e$/yr)	Reduced odor and improved safety near landfill sites	Typically profitable with CDM		Many Bank projects finance landfills for municipal waste and some are piloting low methane technologies; PCF Landfill Gas (P082320)

Intervention and Theoretical Emission Reduction	Feasible Medium-Term (2015) Reduction Potential	Public Co-benefits	Financial Profitability	Major Barriers	WB Studies/Projects
OTHER ENERGY EFFICIENCY					
Improved transmission and distribution (3.1 $MtCO_2e$/yr)	Deployment of AC3 and smarter grid technology in 500 KV lines, reducing losses by 3.6 percent (0.15 $MtCO_2e$/yr)	Decreased energy demand	Profitable- Deployment of 1000 km of AC3 lines costs $900 million and can result in cost savings of $228 million per year and the equivalent avoided generation capacity of 814 MW, represents an avoided cost of $1 billion; smart grid technologies are expected to be profitable but have high upfront costs and uncertainty over benefits	Technical: Uncertainty about the costs and benefits and perceptions of rick to the availability of the transmission system Financial: High upfront costs	System Efficiency Improvement, Equitization and Renewables (SEIER) (P066396); SEIER GEF component (P073778); Demand-side Management and Energy Efficiency Project (P105834) and GEF component (P071019); Transmission and Distribution Project (P084871); System Efficiency Improvement, Equitization and Renewables (SEIER) Additional Finance (P120540)*; Transmission and Distribution Additional Financing (P114875), Planned CTF-financed component under Transmission and Distribution Additional Financing (P114875) will finance smart grids; Energy Efficiency Project (P114065).*

Intervention and Theoretical Emission Reduction	Feasible Medium-Term (2015) Reduction Potential	Public Co-benefits	Financial Profitability	Major Barriers	WB Studies/Projects
Energy-efficient appliances, potential of 6.7% improvement (0.95 $MtCO_2e/yr$)	Energy-efficient appliances improvement, by 0.9%. (0.13 $MtCO_2e/yr$)	Decreased energy demand	In longer term is financially profitable and can be driven by market forces; shorter terms issues of initiating the transformation may necessitate costs related to subsidies for adoption and awareness programs	Technical: Awareness of manufacturers, distributors, and consumers of energy efficient technologies and benefits Financial: Higher upfront costs of appliances	*Planned GEF Project on Energy Efficiency of Household Appliances (P116846)*
INDUSTRIAL GASES					
Reduction of GHGs that are also ozone-depleting substances subject to Montreal Protocol phase-out. No detailed statistics available	No detailed statistics available.	Reduction of ODS emissions	Typically profitable with CDM and can under some circumstances be financed with resources from Montreal Protocol	Difficulty of associating carbon finance with Montreal Protocol funds.	National CFC and Halon Phase-Out Project (P083593); *HCFC Phase-Out Project (Phase 1) (P115762)*

EMISSION REDUCTIONS ESTIMATES (METHODOLOGICAL NOTES)

Intervention	Sector statistics	Projection to 2015	Basis of emission factor calculation	Emissions calculation method
TRANSPORT				
Passenger vehicle fuel efficiency standards	Fleet estimated based on available studies: World Bank Transport Strategy (2006); VRA (2007); World Bank Energy Flagship (2009)	Adapted from trends in reports with the following assumptions of annual growth: HCMC and Hanoi: cars 25% Haiphong, Da Nang, Can Tho: cars 20% Other areas of the country: cars 15% **Taxi cars** / **Non taxi cars** All Vietnam: 78.418 / 4.110.335 Ho chi Minh city: 30.518 / 2.410.889 Hanoi: 18.311 / 656.128 Hai Phong: 4.977 / 124.416 Danang: 1.244 / 49.766 Can Tho: 1.244 / 74.650	Estimated based on typical fuel efficiency, distance travelled per yr, and emissions per l for fuel use for cars and motorcycles Emissions per vehicle: Taxi: 4.381 t CO_2/car yr Non taxi: 3.991 t CO_2/car yr Motorcycle: 0.32 t CO_2/motorcycle/yr	World Bank Energy Flagship study estimates that implementing these standards can reduce fuel consumption by 15% in 2015
Electric motorcycles	Fleet estimated based on available studies: World Bank Transport Strategy (2006); VRA (2007); World Bank Energy Flagship (2009)	Adapted from trends in reports with the following assumptions of annual growth: HCMC and Hanoi: motorcycles 5% Haiphone, Da Nang, Can Tho: motorcycles 8% Other areas of the country: motorcycles 8% **Motorcycles** All Vietnam: 33.719.502 Ho chi Minh city: 6.381.408 Hanoi: 3.828.845 Hai Phong: 1.469.328 Danang: 881.597 Can Tho: 1.028.530	Emissions per vehicle estimated based on typical fuel efficiency, distance travelled per yr. and emissions per l for gasoline and electric powered Emissions per motorcycle: electric: 0.14 t CO_2/unit yr; gasoline: 0.32 t CO_2-e/unit yr.	Calculated as difference in emissions per motorcycle for electric and gasoline

Intervention	Sector statistics	Projection to 2015	Basis of emission factor calculation	Emissions calculation method
Modal shift from road to other modes of freight (railroad, inland waterway and coastal shipping)	Road freight traffic based on Vietnam Statistical Yearbook (2007)	Adapted from Vietnam transport Sector Development Plan until 2020 (16 billion ton-km), assuming a 7% growth rate per year from 2010 to 2015	Estimated based on international emission factors for different modes: Diesel truck: 140 g CO_2/ton-km Inland waterway: 42 g CO_2/ton-km Railway: 25 g/ton-km Coastal Shipping: 90 g/ton0km	Calculated as different in emissions per ton-km of freight for different modes
Use of E20 (20% of gasoline) biofuel	Gasoline fuel demand based on Vietnam CDM guidebook (2004)	Projections based on Vietnam CDM Guidebook 2010 estimates (5,910811 kL) and assuming 10% growth in fuel demand per year for 2010–15.	Estimated based on lifecycle emission per l of gasoline (2.327 kg CO_2/l) and bioethanol (0.97 kg CO_2/l) from cassava using numbers from Thailand	Difference in emissions of the two fuels associated with the substitution of 20% of total demand for gasoline with bioethanol
Bus Rapid Transit (BRT)	Passenger vehicle fleet estimated for five cities based on available studies: World Bank Transport Strategy (2006); VRA (2007); World Bank Energy Flagship (2009)	Same assumptions as above for passenger vehicle fuel standards and electric motorcycles	Estimates of fuel use for motorcycles and cars and for BRT based on persons-km/day for typical bus capacity and route lengths scaled to these cities	Difference in emissions of the two modes assuming 30% of motorcycle and car fleet will be replaced by BRT
ENERGY				
Energy efficiency in new coal power plants	A Study on National Energy Master Plan (2008) and studies described under projections	Projections for generation capacity expansion for coal power plants between 2010 and 2015 (7,585 MW) based on 2015 projections of total coal thermal capacity (12,130 MW) in 2015 from the 2007 Institute of Energy Analysis of Vietnam Energy Review and Power Development Plan period 2006-2105 with outlook to 2025 and updated number on 2010	Emission factor based on 0.37 kg CO_2/kwh for coal at 100% efficiency	Calculated as difference in emissions using project efficiencies (35% for subcritical;

Intervention	Sector statistics	Projection to 2015	Basis of emission factor calculation	Emissions calculation method
		capacity (4545 MW) from 2009 Institute of Energy Analysis on Vietnam Power Sector Status and Outlook of Thermal Power plants		40% for supercritical) relative to baseline (30%)
Energy efficiency in old coal power plants	2009 Institute of Energy Analysis on Vietnam Power Sector Status and Outlook of Thermal Power plants; capacity added before 2005 is 1245 MW and before 2001 is 669 MW	No projections needed	Emission factor based on 0.37 kg CO_2/kwh coal at 100% efficiency	Calculated as difference in emissions using project efficiency (35%) relative to baseline (23% for pre-2001 capacity and 28% for 2001–05 capacity)
Improved transmission and distribution	The Study on National Power Development Plan for the period 2006-2010 perspective up to 2020 in Vietnam (JICA 2008)	Projections of total transmission and distribution and power flows for 500 KV lines (925 MW in dry season; 500 MW in wet season) based on The Study on National Power Development Plan for the period 2006-2010 perspective up to 2020 in Vietnam (JICA 2008)	Based on emission factor for Vietnam grid (0.59 kg CO_2/kwh) from RCEE 2008	Assumes nationally a 6% loss reduction can be achieved to come close to international benchmarks; for 500kV line assumes 3% reduction due to AC upgrading and 0.6% due to smart grid technology (adapted from CTF Investment plan for Vietnam)
Energy-efficient appliances	World Bank analysis of appliance energy use using IEA household consumption data (15,445 GWh in 2006)	World Bank projections of energy use by appliances in 2015 (23,014 GWh)	Emission factor for Vietnam grid (0.59 kg CO_2/kwh) from RCEE 2008	Calculated as the amount of electricity saved (6.7% improvement potential and 0.9% in 2015), multiplied by the

Intervention	Sector statistics	Projection to 2015	Basis of emission factor calculation	Emissions calculation method
				emission factor
Small and mini hydropower	Institute of Energy 2006 data on hydropower development potential (4,136 MW)	No projections needed	Emission factor for Vietnam grid (0.59 kg CO_2/kwh) from RCEE 2008	Calculated as the amount of grid electricity displaced multiplied by the emission factor
Medium-sized hydropower	Institute of Energy 2006 data on hydropower development potential (1,710 MW)	No projections needed	Emission factor for Vietnam grid (0.59 kg CO_2/kwh) from RCEE 2008	Calculated as the amount of grid electricity displaced multiplied by the emission factor
Wind power	Institute of energy data on potential wind farm projects for eight largest projects (4,249 GWh/yr)	No projections needed	Emission factor for Vietnam grid (0.59 kg CO_2/kwh) from RCEE 2008	Calculated as the amount of grid electricity displaced multiplied by the emission factor
Agricultural residues for power	Draft Master Plan of Renewable Energy Development in Vietnam up to 2015 with orientation until 2025 (419 MW)	No projections needed	Emission factor for Vietnam grid (0.59 kg CO_2/kwh) from RCEE 2008	Calculated as the amount of grid electricity displaced multiplied by the emission factor
Geothermal Power	Institute of Energy 2006 data (300 MW)	No projections needed	Emission factor for Vietnam grid (0.59 kg CO_2/kwh) from RCEE 2008	Calculated as the amount of grid electricity displaced multiplied by the emission factor
Recovery and use of gas from underground coal fields	Institute of energy data on coal supply and demand (2006)	Projections for 2015 based on Institute of Energy 2006 data (41,425,000 tons)	IPCC emission factor (10 m^3 of methane per ton of coal exploited)	Multiply emission factor times the tons of coal exploited, assuming 40% is exploited in

Intervention	Sector statistics	Projection to 2015	Basis of emission factor calculation	Emissions calculation method
				underground mines.
Gas recovery and use from oil fields	PetroVietnam data on existing and planned oil fields in Vietnam (7 planned oil fields)	No projections needed	Based on Rang Dong Project emissions reductions	Scale the emission reductions to Rang Dong to other projects
WASTE SECTOR				
Low methane-emitting technologies in urban wastewater	Population figures National Statistics, reports on wastewater systems in place	Projections for 2015 of urban population using 2002 to 2007 growth rates from National Statistics Vietnam 3.4% HCMC 3.3% Hanoi 4.9% Hai Phong 3.7% Can Tho 5.5% Da Nang 3.5%	Wastewater generation based on typical number per unit population; emission factor depended on system used but chosen based on international emissions factors provided from CDM methodologies	CDM methodologies were used for various combinations of interventions
Low methane-emitting technologies in rural wastewater	Population figures from National Statistics; types of wastewater systems adopted based on national reports and statistics	Projections for 2015 of rural population using 2002 to 2007 growth from National Statistics (1.2%)	Wastewater generation based on typical number per unit population. Methane emissions estimated based on system used and chosen based on international standards from CDM methodologies	CDM methodologies were used for various combinations of interventions
Low methane-emitting industrial wastewater systems	Industrial output by subsector based on 2007 Vietnam Statistical Yearbook and various sector development plans (for 2010)	Forecast to 2015 based on estimates of COD growth using national statistics on growth trends: National 24.7% bioethanol 25.0% meat 33.0% liquor, bev 12.7% pulp and paper 37.7% tapioca 5.0% fish 5.2%	Wastewater generation based on IPCC standard factors per industry; methane emissions estimated based on system used and chosen based on international standards from CDM methodologies	CDM methologies used for calculation
Composting	Population figures from	Projections for 2015 of urban population using 2002 to 2007	Solid waste generation	CDM methologies

Intervention	Sector statistics	Projection to 2015	Basis of emission factor calculation	Emissions calculation method
	National Statistics	growth rates from National Statistics as with urban wastewater and assuming national growth for cities for which growth was not estimated	based on typical number per unit population; methane emissions estimated based on international standards from CDM methodologies	used for calculation
Landfill gas to energy	Population figures from National Statistics	Projections for 2015 of urban population using 2002 to 2007 growth rates from National Statistics as with urban wastewater and assuming national growth for cities for which growth was not estimated	Solid waste generation based on typical number per unit population; methane emissions estimated based on international standards from CDM methodologies and only for those cities likely to produce adequate waste to support a landfill gas facility	CDM methologies used for calculation
INDUSTRY				
Fuel switching in Cement Industry	Production and number of plants based on Vietnam Cement Corporation Statistics	Projections to 2015 of fuel (coal) energy use based on MoNRE 2004 data and Vietnam Cement Development plan up to 2010 with perspective to 2020 (4,132 kTOE)	Total emissions based on emissions factor for coal (0.37 kg CO_2/kwh for 100% efficiency) and assuming 40% efficiency of burning of coal plants	Multiplying the assumed 13% reduction in coal use by emission factors
Blending of cement	Vietnam Cement Development Plan up to 2010 and prospective to 2020	Projections based on Vietnam Cement Development Plan up to 2010 and prospective to 2020 (62.8 million tons)	IPCC emission factor of 0.5071 t CO_2/ton clinker	Multiplying the reduction in clinker based on production projections and change in blend (20–25% additives)
Recovery of waste heat in cement industry	Vietnam Cement Development Plan up to 2010 and prospective to	Projections of electrical energy use based on MoNRE 2004 data and Vietnam Cement Development plan up to 2010 with perspective to 2020 (8,644 Gwh)	Used emission factor from electricity grid (0.59 kg CO_2/kwh)	Multiplying the average % electricity energy

Intervention	Sector statistics	Projection to 2015	Basis of emission factor calculation	Emissions calculation method
	2020			production (assumed to be 20% of total based on performance of other plants)
Energy efficiency in cement industry	Vietnam Cement Development Plan up to 2010 and prospective to 2020	Projections of electrical and fuel (coal) energy use based on MoNRE 2004 data and Vietnam Cement Development plan up to 2010 with perspective to 2020 (4,132 kTOE).	Used emission factor from electricity grid (0.59 kg CO_2/kwh) emissions factor for coal (0.37 kg CO_2/kwh for 100% efficiency) and assuming 40% efficiency of burning of coal plants	15% improvement in electrical energy use and 26% in fuels multiplied by total emissions
Energy efficiency in brick industry	Production based on MoNRE 2004; % of traditional brick manufacturers based on project reports from GEF project	Projections in brick production for 2015 based on MoNRE 2004 (27,515 million bricks)	Conventional technology (0.3 t CO_2/1000 bricks); project (VSBK) (0.161 t CO_2/1000) bricks based on Vietnam data	Multiplying the production of facilities by the difference between traditional and project emissions factors
Recovery of waste heat in iron and steel industry	2005 production of steel billet (875,000 tons) and pig iron (202,000 tons) is based on data from South East Asia Iron and Steel Institute (SEAISI) 2006 Country Reports and Steel Statistical Report	Projections in steel production for 2015 based on the Vietnam Steel Development Plan up to 2010 and prospective to 2020 and it is assumed total production growth (from 6,466 to 17,000) is proportional to the growth in production of steel billet (2.3 million tons) and pig iron (531,000 tons)	Emission Reductions are: For Blast Furnace Top Pressure Turbine: 17.4 kg CO_2/ton pig iron; For Basic Oxygen Furnace: 49.3 kg CO_2/ton billet Based on review of Vietnam and international studies	Multiplying emissions reduction by projected production
Energy efficiency in iron and steel industry	2005 production of pig iron (202,000 tons) and long products (3,264,000 tons) is based on data from South East Asia Iron and Steel Institute	Projections in steel production for 2015 based on the Vietnam Steel Development Plan up to 2010 and prospective to 2020 and it is assumed total production growth (from 6,466 to 17,000) is proportional to the growth in production of pig iron (531,000 tons) and long products (8,634)	Coke Dry Quenching: 61 kg CO_2/ton pig iron Pulverized Coal Injection (PCI): 126 kg CO_2/ton pig iron Reheating for Electric Arc	

Intervention	Sector statistics	Projection to 2015	Basis of emission factor calculation	Emissions calculation method
	(SEAISI) 2006 Country Reports and Steel Statistical Report		Furnace: 31 t CO_2/ton long product Based on review of Vietnam and international studies	
Cogeneration in pulp and paper industry	Actual production for 2006 from VPC (960,000 tons paper)	Projected production for 2010 based on VPC targets (1,400,000 t paper; 600,00 t pulp) to get 2015 estimate (2,154,000 t paper; 923,000 t pulp) 2010 to 2015 based on assumed growth of 9% per year	Energy use based on Ernst and Young (2003) Typical paper: 0.25 MWh/ton paper pulp: 2.5 MWh/ton pulp Used emission factor from electricity grid (0.59 kg CO_2/kwh)	Multiplying energy savings times electricity grid, assuming cogeneration can supply 50% of electricity from pulp and paper plants
AGRICUL-TURE AND FORESTRY				
Improving efficiency of fertilizer use in order to reduce nitrous oxide emissions	Ministry of Industry and Trade (2008) data on urea use (1.624 million tons)	Assuming 7.2% annual increase in urea use up to 2015 (2.29 million tons of urea)	1.54 t CO_2/ ton urea from IPCC	Assume potential decrease in urea use by improving to 60% efficiency from 40% in Vietnam
Livestock waste	Population of livestock from General Statistics Office (2007) and number in commercial farms based on MARD report on animal husbandry 2001-2006 (traditional: 25,582,000; commercial: 1,317,000)	Growth up to 2015 assumes a 3% growth rate of population overall with and 8% growth of those in commercial farms, assuming 10% will have biogas (traditional: 29,906,884 heads; commercial: 3,198,407 heads)	For traditional farms emission reduction from Vietnam experience (SNV) 0.31 t CO_2 per head/yr For commercial farms from USEPA report on Vietnam: 0.42 t CO_2/head/yr	Multiplying emission reduction times population of commercial and traditional farms

Intervention	Sector statistics	Projection to 2015	Basis of emission factor calculation	Emissions calculation method
Mangrove reforestation	Based on available data on potential mangrove area for reforestation in beginning of 2000 of 22,681 ha in Red River Delta and 111,873 ha in the Mekong River Delta from published reports	No projections made	90.2 t CO_2 per ha per year based on Vietnam studies	Multiplying area by sequestration potential
Forest protection	Based on Vietnam Forest Facts and Figures from UN REDD website (primary forest loss for 2000–05 of 20,400 ha/yr)	No projections made	Using carbon stock of Vietnam forests of 140 tC/ha (for aboveground biomass for tropical rainforest in continental Asia from IPCC)	Multiplying carbon content per ha times loss in ha per year

APPENDIX 3. WORLD BANK'S CLIMATE CHANGE FINANCING INSTRUMENTS

General Financing Instruments

The most traditional financial instrument of the Bank is a *Sector Investment Loan* (SIL). These are loans to the government based on the Country Partnership Strategy, which in turn is based on the country's Socio-Economic Development Plan. SILs that incorporate appropriate mitigation and adaptation considerations will be the Bank's primary financial tool to address climate change in Vietnam over the next 10 years. The present paper will be used to better include CC in the next CPS.

The Bank has three major adaptation-oriented SILs in preparation at this time for a total funding of about $500 million (Mekong Water Resources for Rural Development Project, Coastal Resources for Sustainable Development Project, and the forthcoming Managing Natural Hazards Project). Much of the Bank's large energy portfolio can be considered as mitigation investments to some degree.

In addition, the Bank must ensure that adaptation to climate change as well as mitigation is included in every project that is either ongoing (by retrofitting where necessary) or in preparation. Appropriate screening tools need to be piloted and used in Vietnam. Climate change screening tools have been developed by the World Bank and by a variety of other organizations. Some of these should prove quite useful in ensuring that climate change considerations are duly considered in project development and project implementation. It is beyond the scope of this report to list them, but good reference information can be found on the World Bank's climate change Web site.

The World Bank has used *development policy loans* (DPLs) to help tackle climate change in several countries, such as Mexico and Indonesia. These DPLs typically have involved large loans of several hundreds of millions of dollars to the central Treasury, accompanied by a range of policy actions and triggers that the country agrees to act on. Funds under a DPL cannot be earmarked for any specific investment and typically do not result in accrued funding flows to line ministries, although this can be an indirect result, depending on the definition of policy triggers. The Japanese government, with cofinancing from the French Agency for Development, is moving forward with a large climate change DPL to Vietnam. The World Bank is supporting the policy dialogue and is preparing a loan to co-finance the SP-RCC as of 2011.

Many other new or innovative forms of financing are being developed. The inaugural "World Bank Green Bonds" were issued in November 2008, raising a total of $1.5 billion equivalent through 20 transactions in 15 currencies for IBRD-financed mitigation and adaptation projects. The World Bank also expanded the range of products available to clients for catastrophe risk management and launched a catastrophe bond issuance program to help governments from developing countries get access to affordable insurance coverage for natural disasters through the capital market. (See the box on financing in the main text for references to key documents and Web sites with much more information on new CC financing tools.)

In addition to its traditional lending instruments, the World Bank has used three dedicated climate financing instruments as key tools for increasing support to climate- friendly and climate-resilient infrastructure, particularly for the energy, urban, transport, and agricultural sectors: the Global Environment Facility (GEF); carbon finance, especially the Carbon Partnership Facility (CPF); and the Climate Investment Funds (CIF). Combined, they represent a worldwide potential resource flow of about $3 billion per year. In April 2010, a new financial

mechanism, the Adaptation Fund, started accepting proposals for climate adaptation financing in eligible developing countries under the Kyoto Protocol of the UN Framework Convention on Climate Change (UNFCCC). These are described further below.

Global Environment Facility

The GEF was established in 1991 just prior to the U.N. Convention on Environment and Development to provide incremental cost financing for projects with global environmental benefits. It was originally a partnership between the United Nations Development Programme (UNDP), the United Nations Environment Programme, and the World Bank, but it now provides its support through 10 agencies to 181 member governments. GEF has used three Trust Funds to provide financing for both climate mitigation and adaptation under UNFCCC: the GEF Trust Fund, the Special Climate Change Fund (SCCF), and the Least Developed Country Fund (LDCF). Vietnam is not eligible for the LDCF.

GEF Trust Fund and Climate Mitigation

Under its GEF Trust Fund, the GEF has been committing about $250 million per year largely in the form of grants to eligible countries as the financial mechanism of the UNFCCC. These projects are designed to support energy efficiency, renewable energy, new clean energy technology, and sustainable transport projects. Its approach focuses on removing barriers to "win-win" mitigation projects by providing support for technical assistance, policy reform, capacity building, piloting, and partial risk guarantees. GEF grants through the World Bank average between $8 million and $10 million each and are meant to be implemented as part of a larger investment engagement.

Since 1999, Vietnam has obtained over $42 million of GEF grants in supporting its climate mitigation activities. The World Bank has administered about 60 percent of these funds. Projects managed by the World Bank have focused mainly on power system efficiency, demand-side management, energy efficiency, and, very recently, sustainable forestry management.

In its Fourth Replenishment Period (July 2006 to June 2010), the GEF adopted a Resource Allocation Framework to allocate its climate change mitigation resources to its member countries. Under the GEF Fourth Replenishment, Vietnam obtained $8.55 million. Under the GEF Fifth Replenishment Period (July 2010 to June 2014), Vietnam will receive $14.56 million.

GEF Trust Fund and Adaptation

Established in 2001 under UNFCCC, the Strategic Priority on Adaptation (SPA) was a program with a $50 million allocation inside the GEF Trust Fund to support pilot and demonstration projects to show how adaptation planning and assessment can be practically translated into projects. The SPA funding was accessible to all countries eligible for GEF funding. Vietnam benefited from the SPA program by participating in a UNDP managed $4.5 million project and a 10-country Community-Based Adaptation Project (http://www.gefonline.org/projectDetailsSQL.cfm?projID=2774). By September 2009, all the SPA funding had been allocated. After the closure of SPA, all adaptation-related work of the GEF has been financed through the LDCF and SCCF.

SCCF for Mitigation and Adaptation

The Special Climate Change Fund was also created under the UNFCCC in 2001 to "finance activities, programs, and measures relating to climate change that are complementary to those funded by the resources allocated to the Climate Change Focal Area of the GEF and by bilateral and multilateral funding." The SCCF has four different windows: adaptation; transfer of technologies; energy, transport, industry, agriculture, forestry, and waste management; and activities to assist developing countries whose economies are highly dependent on income

generated from the production, processing, export, or consumption of fossil fuels and associated energy-intensive products in diversifying their economies.

Implementation of SCCF has focused mainly on adaptation. As of February 2010, the GEF has mobilized a total of $129 million voluntary contributions, with $110 million for the adaptation program and $19 million for the technology transfer program. The SCCF resources were in high demand and oversubscribed quickly. The GEF is hoping to mobilize additional voluntary contributions to SCCF and LDCF under GEF V.

Only a single SCCF adaptation project from Vietnam has been approved by the GEF Council:

the ADB/UNDP Climate-resilient Infrastructure Planning and Coastal Zone Development

Project. The GEF approved $3.4 million for this project in April 2009. This project is now under preparation.

Carbon Finance Funds and Facilities

The World Bank's carbon finance initiatives are an integral part of the Bank's mission to reduce poverty through its environment and energy strategies. The World Bank carbon finance operations mobilized resources from governments and companies in industrial countries to purchase project-based greenhouse gas emission reductions in developing countries and those with economies in transition. The emission reductions are purchased through one of the Bank's carbon funds and facilities (see Figure A1) on behalf of the contributor and within the framework of the Kyoto Protocol's Clean Development Mechanism (CDM) or Joint Implementation. Since the creation of the first carbon fund in 1999, the World Bank has demonstrated global leadership in the development of carbon markets and continues to play a leadership role in the development of CDM methodologies.

Figure A1. World Bank's Carbon Finance Funds and Facilities

Unlike its other development products, the World Bank does not lend or grant resources to its carbon finance projects but rather contracts to purchase emission reductions, similar to a commercial transaction, paying for them annually or periodically once they have been verified by a third-party auditor. The selling of emission reductions—or carbon finance—has been shown to increase the bankability of projects, by adding an additional revenue stream in hard currency, which reduces the risks of commercial lending or grant finance. Thus, carbon finance provides a means of leveraging new private and public investment for projects that reduce greenhouse gas emissions, thereby mitigating climate change while contributing to sustainable development.

With the closing of most of the carbon finance funds supporting project-based activities, the World Bank has developed two new initiatives to support programmatic and sector-wide interventions: the Carbon Partnership Facility and the Forestry Carbon Partnership Facility (FCPF). Both facilities are operational.

Carbon Partnership Facility

The CPF aims to bring buyers and sellers together in a partnership forum to focus on national priorities and strategies and to develop carbon revenue streams around programs of interest to both. It in particular intends to scale up carbon finance through efforts that integrate carbon into investment decisions early on, work with client countries over a long time (at least 10 years beyond 2012), and move to more programmatic and sector-wide approaches. The CPF partnership consists of two trust funds: the Carbon Asset Development Fund to prepare emission-reduction programs and the Carbon Fund to purchase carbon credits from the pool of emission reduction programs.

The CPF is open for all types of activities that reduce greenhouse gases, are suitable for scaling up (that is, can be replicated as part of a program), and where World Bank involvement would enable or add value to the proposed programs. Examples of the types of programs that can be included in the CPF portfolio include power sector development, energy efficiency, gas flaring, transport sector, and urban development.

A single project in Vietnam funded by the CPF, the Renewable Energy Development Project, is now moving forward.

Forestry Carbon Partnership Facility

The FCPF assists developing countries in their efforts to reduce emissions from deforestation and forest degradation by providing value to standing forests. The FCPF has the dual objectives of building capacity for REDD in developing countries and testing a program of performance-based incentive payments in some pilot countries, on a relatively small scale, in order to set the stage for a much larger system of positive incentives and financing flows in the future. The FCPF has two separate mechanisms: the Readiness Mechanism to provide technical assistance to interested developing countries, such as estimating carbon stocks and defining reference scenarios, and the Carbon Finance Mechanism to implement and evaluate pilot incentive programs for REDD. Through the Carbon Finance Mechanism, payments will be made to countries that achieve measurable and verifiable emission reductions.

See the section in the main text on REDD for further details on the Bank's engagement in Vietnam through the FCPF.

Climate Investment Funds

The Climate Investment Funds are an important new source of interim funding through which the multilateral development banks (MDBs) will provide additional funds to developing countries to support low-carbon and climate-resilient development. The CIFs were approved in July 2008 with over $6 billion in pledges. They consist of the Clean Technology Fund (CTF) and the Strategic Climate Fund (SCF). As shown in Figure A2, the SCF currently has three programs: the Pilot Program for Climate Resilience (PPCR), the Forestry Investment Program (FIP), and Scaling-Up Renewable Energy Program (SREP). The CIF design includes a sunset clause that enables closure of funds once a new financial architecture has become effective under UNFCCC.

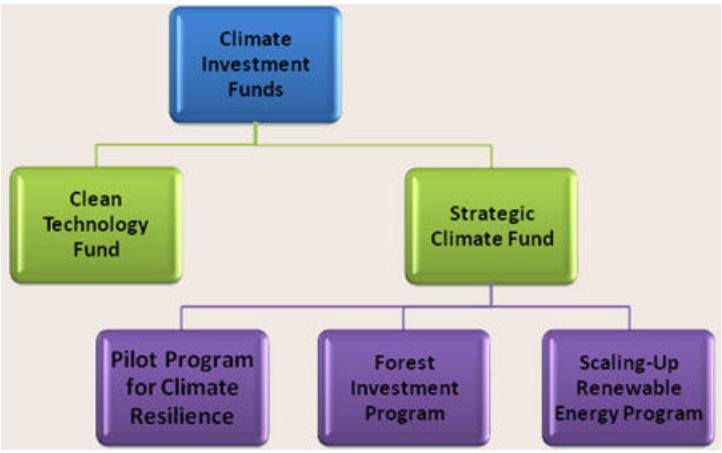

Figure A2. Structure of CIF Funds

Clean Technology Fund

The Clean Technology Fund seeks to scale up financing to contribute to demonstration, deployment, and transfer of low-carbon technologies with a significant potential for long-term greenhouse gas emissions savings. It is meant to be transformative, taking clean technology investments and markets to scale in the participating recipient countries. The CTF provides limited grants, concessional loans, and partial risk guarantees to help countries scale up clean technology initiatives intended to transform a country's development path. It includes programs in the power sector (renewable energy and highly efficient technologies to reduce carbon intensity), the transport sector (efficiency and modal shifts), and energy efficiency (buildings, industry, and agriculture). When a country expresses interest in obtaining CTF financing, the MDBs concerned conduct a joint mission, involving other relevant development partners, to discuss with the government, private industry, and other stakeholders how the CTF may help finance scaled-up low-carbon activities. The outcome of the joint mission will be an investment plan, developed under the leadership of the recipient country, for the use of CTF resources in major sectors of the economy through projects with one or several of the participating MDBs. Investment plans will be submitted to the CTF Trust Fund Committee to endorse further development of activities for later approval of CTF financing and to facilitate prioritization of the pipeline projects. As of April 2010, CTF funding of $4.3 billion had been committed to 13 investment plans for total funding of $40.4 billion.

The government of Vietnam submitted an investment plan in late 2009 (MoNRE et al. 2009) and it was accepted by the Committee, making available $250 million of highly concessional lending, conditioned on the preparation and approval of the relevant multilateral institution projects. The World Bank agreed with the government to add $40 million of CTF funding to the forthcoming Transmission and Distribution Additional Financing Project in order to finance implementation of smart grids in Vietnam.

Strategic Climate Fund

SCF was created to serve as an overarching platform to support its three targeted programs "to pilot new approaches with potential for scaled-up and transformational action aimed at specific climate change challenge or sectoral response."

Forest Investment Program. Approved in May 2009, FIP supports the investments needed to reduce deforestation and forest degradation and promote sustainable forest management. An important objective is to maximize co-benefits of sustainable development, particularly in relation to the conservation of biodiversity, natural resources, ecosystem services, and ecological

processes. The government of Vietnam has formally expressed its interest in the FIP; funding to support FIP programs in Vietnam has not been approved yet, however.

Pilot Program for Climate Resilience. Approved in November 2008, PPCR was the first program under the SCF to become operational. Its objective is to pilot and demonstrate ways to integrate climate risk and resilience into core development planning while complementing other ongoing activities. Vietnam has not participated in the PPCR, which was focused on countries with a lower per capita GDP.

Program for Scaling-Up Renewable Energy in Low-Income Countries. Approved in May 2009, SREP is aimed at demonstrating the social, economic, and environmental viability of low-carbon development pathways in the energy sector. Initiated very recently, SREP seeks to create new economic opportunities and increase energy access through the production and use of renewable energy. Again, as an emerging middle-income country, Vietnam has not been eligible for the SREP.

Adaptation Fund

The Adaptation Fund (AF) has been established by the Parties to the Kyoto Protocol of the UNFCCC to finance concrete adaptation projects and programs in developing countries that are Parties to the Protocol. This newly created fund has an independent Board supervising and managing the Fund, with GEF providing Secretariat services and the World Bank providing Trustee services on an interim basis. Currently the AF is financed with 2 percent of the Certified Emission Reduction (CERs) issued for projects of the CDM and other sources of funding. Dependent on CER prices, it is expected that the AF could raise $250–350 million by 2012.

Key features of the AF include that there is no cofinancing requirement, it is open to both multilateral and national implementation entities accredited by the AF Board, proposals can be submitted on a rolling basis, proposals need to be endorsed by a National Designated Authority, and proposals needed to be submitted at least seven weeks before a Board meeting for consideration in that meeting. In terms of funding level, a country cap between $5 million and $15 million was discussed, but a decision on that has not yet been made.

In March 2010, the AF formally issued its first Call for Proposal to its member countries for projects to be considered in its 10th Board Meeting in June 2010. As of 2010, the World Bank and UNDP are two accredited multilateral implementation entities, while no national implementation entities from Vietnam were accredited yet. However, Vietnam has assigned the Ministry of Natural Resources and Environment as its National Designated Authority.

An emerging challenge for the government of Vietnam is the management and monitoring of financial flows for climate change. There are difficult issues involved in defining what is a climate change project, calculating additionality, and then tracking the great variety of ODA financing that is now coming on-stream. "Future technical solutions for monitoring official (ODA and non-ODA) financial flows toward climate action will most likely be a combination of current and improved OECD Development Assistance Committee Rio Markers, more consistent reporting by the multilateral development banks (MDBs), reporting by the UNFCCC on new funding through levies, and an increased capacity by recipient countries to track incoming flows, etc. *Increasingly reliable, comprehensive, and transparent reporting is needed to demonstrate that new climate finance instruments are not introduced at the expense of those targeting other objectives"* (World Bank 2010g).

Blending Financial Instruments for Low-Carbon Development

For many developing countries, low-carbon development options frequently require significant financial support to become financially and economically attractive. Each of the financial instruments just described will help narrow the funding gap, but even so, their reach—in isolation—remains insufficient to translate many expensive and largely pre-commercial low-carbon technologies from the drawing board into reality. In a recent report, the World Bank (2010f) has drawn lessons from its recent project experience on how resources from different climate financing instruments can be combined for expanded impact, increased leverage, and enhanced efficiency of development interventions. The report noted that with differences in orientation, priorities, and governance structures, the efforts and resources from the GEF, CTF, and carbon finance complement one another. It concluded that if carefully designed, projects and programs blending resources from these various funding tools can actually create synergies, wherein the total impact exceeds the face value of the resources contributed as they interact and create transformative processes and increase both scope and scale of the projects and programs.

Different resources can be blended creatively. GEF resources can thus be used as an early benefit, establishing the enabling environment necessary to make a clean energy project sustainable. CTF resources can be mobilized to reduce the cost burden of financing the project, covering part of the additional costs that show up as a financing gap early in the project's life. Finally, carbon finance provides performance-linked revenues that improve a project's cash flow once it becomes operational. In addition, Montreal Protocol projects to phase out ozone-depleting substances are an additional source of grant funding that can address mitigation needs, as some of these substances are also potent greenhouse gases.

Following this approach, the World Bank is developing a number of operations using, CTF, and carbon finance resources. An example in Asia is geothermal development in Indonesia, which has received a $4 million GEF grant in 2008. The World Bank is now preparing a $150 million Bank loan and $125 million CTF loan, with the expectation that CPF could be mobilized accordingly. With all these resources, the World Bank would be able to support Indonesia's use of renewable energy in an efficient and cost-effective manner while greatly reduce the country's greenhouse gas emissions. Similarly blended financial packages can be developed in Vietnam.