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CLIMATE CHANGE: SCIENTIFIC ASSESSMENT FOR THE GEF

Introduction

Climate change is one of the great global environmental challenges facing humanity. The consensus within the scientific community, amongst national and international policy makers, and in civil society is increasingly pointing towards the urgent need for coordinated and transformational international action to address climate change.

The Intergovernmental Panel on Climate Change (IPCC) periodically prepares assessment reports on the status of climate change science, including impacts, adaptation and mitigation. It reports on the state of science and knowledge, providing an important basis upon which the UNFCCC takes decisions on addressing climate change. Most international agencies, including the Global Environment Facility (GEF), use IPCC Assessments for policy formulation and designing programmes to both mitigate and address the impacts of climate change. IPCC Working Group III submitted its Fourth Assessment Report (AR4) on *Mitigation of Climate Change* in 2007, covering the literature up to 2006. Preparation of the IPCC Fifth Assessment Report has begun, but is not due to be published until 2014.

The science of climate change, of course, is continuously evolving and improving. Knowledge is expanding at an unprecedented rate compared to any other branch of science. The GEF, as the financial mechanism for the UNFCCC, will soon start planning for GEF-6 (2014 to 2018), however the findings from the IPCC 5th Assessment Report will be too late for informing the GEF policy formulation process on climate change. The aim of this report, therefore, is **to provide an analysis of recent scientific findings in order to assist the GEF to formulate its strategies and priorities in the context of GEF-6, and hence support its efforts in helping the world move towards a low-carbon green economy**.

This executive summary highlights recent developments in climate change projections, including projected impacts and needs for adaptation, and presents key mitigation technologies, policies and opportunities, particularly those relating to energy efficiency, renewable energy, transport and urban systems. Strategies for stabilizing atmospheric GHG concentrations are described, as are other technology options. Some can be controversial at times, such as reducing short-lived climate forcing agents (including black carbon), geo-engineering proposals, carbon dioxide capture and storage (CCS), and nuclear power. Reducing emissions from deforestation and forest degradation (REDD+) is also presented, although few technical or scientific advances have been developed since the IPCC AR4.

The mitigation opportunities are considered in the context of the 2010 Cancun and 2011 Durban Agreements of the UNFCCC (UNFCCC, 2011a). These Agreements aimed to stabilize global warming below 2^{0}C in order to avoid the most dangerous consequences of climate change (Article 2 of the UNFCCC). The need for a transformational shift to low carbon development pathways in order to achieve global warming stabilization is highlighted, and possible future roles for the GEF in this context are presented.

Climate change projections, impacts and resilience

To stabilize atmospheric GHG concentrations at levels low enough to avoid mean global temperatures rising above 2^{o}C**, incremental reductions in GHG emissions or mitigation interventions will be inadequate**. **A transformational shift, leading towards a significantly lower energy demand and the decarbonization of energy supply and economic systems, will be required**. This shift must be closely linked with the sustainable development aims and objectives of developing countries and Economies in Transition (EIT).

Normally, the focus of discussion on impacts of climate change is restricted to natural resources, food production systems, and water resources. However, since a significant amount of GEF support for mitigation is through the energy sector, it should be noted that implications of projected climate change and extreme weather events are also important for this sector. Both energy supply chains and energy demand are already being affected by increasing climate variability and temperature extremes, examples being less reliable hydropower storage reservoir levels, periods of insufficient cooling capacity for thermal and nuclear power stations, and increasing air-conditioning demands.

The highlights of climate change projections, impacts and the need for resilience are presented below:

- Concomitant with our greatly improved understanding of climate change and its impacts, global GHG emissions and the related impacts continue to reach new highs. During 2010, carbon dioxide emissions from fossil fuel combustion exceeded 33 billion tonnes (33 $GtCO_2$ or 9 GtC) for the first time.

- There is international agreement that the maximum global temperature increase should be limited to <2^{o}C. The world has already warmed by 0.8°C since pre-industrial times, and a further 0.6°C warming is already locked into the future climate system due to elevated GHG concentrations in the atmosphere. On the current trajectory, **a warming of 2°C could be achieved as early as the 2030s.** The International Energy Agency **(IEA)** warns that if we continue on the current emissions path based mainly on fossil fuel combustion, **a warming of 4°C could be reached by the 2060s,** and the world will head towards a warming of 6°C or more before the end of this century.
- Observed sea level rise of 0.18 to 0.59m has been higher than the model projections according to AR4. **New research projects that sea levels could rise between 0.5 to 2m** towards the end of this century**.**
- **Limiting mean global warming to roughly 2°C by the end of this century is now appearing as increasingly unlikely to be achieved, since it requires an immediate ramp down of emissions accompanied by enhanced carbon sequestration.**
- **Land and water resources are already critically stressed, and climate change will have an adverse impact on agricultural productivity in the coming decades. Areas currently suffering from food insecurity are expected to witness disproportionately negative effects.** According to AR4 (IPCC, 2007a), climate change is expected to exacerbate current stresses on

water resources from population growth, land-use change (including urbanization), along with inadequate soil conservation and management.

- The IPCC *Special Report on Managing the Risks of Extreme Events* (2012) concluded that there is evidence of some weather extremes changing as a result of the atmospheric build-up of GHGs. It projected that by the end of the 21st century there will be a substantial rise in temperature extremes in many regions of the world. The frequency of heavy rainfall events will likely increase, and there is medium confidence that droughts will intensify in some seasons and areas due to reduced rainfall and/or increased evapotranspiration.
- **Climate change could adversely impact net primary productivity and carbon stocks of forests. Forests and other terrestrial ecosystems could undergo large-scale change, from being a net carbon sink to a carbon source.** There is **a risk of substantial restructuring of the global terrestrial biosphere** with approximately half of the Earth's land surface area likely undergoing significant plant community changes, and over one-third of terrestrial ecosystems undergoing biome-scale changes by the end of this century.
- Existing stresses of climate change impacts on hundreds of eco-regions of exceptional biodiversity around the world will increase the likelihood of habitat loss and species extinction over this century. **Traditional conservation practices may prove insufficient for the continuation of many eco-regions**. The actual biodiversity loss could be higher than thought previously as by 2080, more than 80% of genetic diversity within species may disappear in certain groups of organisms.

Recent observations and modeling clearly suggest that the threats from climate change are more immediate and severe than those projected by the AR4. This underscores the need for pursuing urgent mitigation strategies to limit warming below 2°C.

The GEF should recognize the severity of the threats posed by climate change and its impact on the delivery of global environmental benefits across focal areas. Thus, the GEF should adopt strategies to screen for climate risks and incorporate resilience enhancement measures in all GEF programmes.

Energy Efficiency

Most **assessments of mitigation opportunities agree that improved energy efficiency (EE) should be the highest priority option for achieving climate goals**. This is especially true for developing countries where improved EE also brings significant social and economic co-benefits such as poverty alleviation, improved health and air quality, increased social welfare, energy security, and reduced stress on the need to expand energy system capacities. While there is a broad portfolio of low-cost mitigation options which vary by climate, level of economic development and culture, a number of options stand out as potential "leap-frog" strategies or key opportunities (Table ES.1).

Due to the diversity of energy end-uses, **rather than supporting single technologies, the main interventions that the GEF should consider relate to policies that ensure a broad proliferation of EE technologies**. Several key policies are particularly applicable in developing countries and economies in transition (EITs) in order to unlock this potentials (Chapter 4). **The most relevant policy instruments are energy efficiency regulations, most notably EE performance standards for appliances, vehicle fuel economy standards, building codes, and energy management systems.** Such regulations can ensure broad adoption of many of the most relevant technologies. In order for these standards to be transformational and to avoid lock-in (especially of infrastructure-related technologies), EE regulations need to be set at ambitious performance levels and be properly enforced.

Table ES.1: ***Key mitigation options for, and leap-frogging opportunities in, improving energy-efficiency in the building industry and transport end-use sectors:***

Applicability	*Low cost and high mitigation potential*	*High cost and high mitigation potential*	*Social relevance (e.g., energy access)*
Developing countries	White roofs, light surfaces.	Urban greening. Very low or zero energy commercial buildings (heat resistant designs, shading, natural ventilation). Novel cooling systems.	Efficient, clean cookstoves
EITs	Thermostatic valves.	Very high performance new buildings (insulation, air tightness, heat recovery, solar gains). High-performance building retrofits.	Energy-efficient retrofits of social housing.
Both	Phase-out of incandescent lighting. Energy-efficient appliances. Reduction of standby losses. Solar or heat pump water heating. Industry and building energy management systems. High-efficiency electric motors. Energy-efficiency improvements in cement, steel, and chemical industries. High-efficiency two and four wheel vehicles. Low-steam shipping.	Heat energy cascading (including co-generation). High-efficiency vehicles. Transport planning and management systems. Intermodal transport. Promotion of IT infrastructure enabling system optimization opportunities.	Infrastructure and facilities enabling non-motorized and two and four wheeled motorized transport.

Renewable Energy

The recent growth of renewable energy (RE) technologies to provide electricity, heating, cooling and transport fuels has been significant, but the share of total global primary energy remains low (when traditional biomass is excluded). Many RE technologies continue to mature, and significant reductions in costs are becoming evident. Most countries have abundant RE resources available for capture and use. Where these resources are particularly good government support may not be required, as renewables may already compete with conventional fossil fuel energy systems.

The co-benefits resulting from the deployment of RE technologies include energy security, improved health, employment and training opportunities through capacity building, improved social cohesion of communities, increased mobility of people and freight, and local community pride. These should all be considered when developing policies and formulating assistance programmes for developing countries.

Some potential RE mitigation options and leap-frogging technologies, such as bioenergy-carbon capture and storage (BCCS) and advanced biofuels for transport are summarized in Table ES.2.

Table ES.2: Key renewable energy technology mitigation options and leap-frogging opportunities in the electricity, heat, and transport fuel supply sectors of developing countries and EITs:

Sector	***Low cost and high mitigation potential***	***High cost and high mitigation potential***	***Socially relevant, such as for energy access***	***Comments***
Electricity and heating (either as stand-alone systems or as cogeneration combined with power generation).	Hydropower -medium and small-scales. On-shore wind power. Geothermal power and heat. Bioenergy systems using biomass from wastes and residues.	Solar PV systems- small and large-scales. Concentrating solar power (CSP). Distributed energy systems, using small-scale RE technologies and mini-grids. Bioenergy + CCS.	Most RE systems have social co-benefits (such as energy access, improved health, employment).	The viability of a RE project partly depends on the local RE resources. Wide energy cost ranges therefore exist. RE resource availability first needs to be assessed.
Transport	1st-generation biofuels from food crops but can have low potential due to land use competition.	Advanced biofuels, mainly using ligno-cellulosic and algal feedstocks.	Small scale biofuel systems could provide mobility access in developing countries and overcome dependence on imported oil products.	Liquid or gaseous biofuels should be produced sustainably with net GHG benefits, including when taking indirect land use change into account.

- Recent growth in 1st-generation liquid biofuel production from sugar, starch and oil crops has leveled off, partly due to concerns over competition for land and water with food and fiber production, possible loss of biodiversity, loss of livelihoods of small landholders, and poor cost competitiveness without subsidies. Ethanol production from sugarcane varies with the sugar commodity price.
- Advanced biofuel options tend to have lower life-cycle emissions than 1st-generation biofuels if forest and wood processing wastes, crop residues, or animal wastes are used as feedstocks. Where purpose-grown energy crops are used, the aim should be to obtain high yields (in terms of GJ/ha) with low inputs of irrigation, fertilizers, agro-chemicals, etc. Although life-cycle analyses of some advanced biofuels show GHG emissions to be relatively low, data remains uncertain. When indirect land-use change impacts are included, in specific cases, emissions per km travelled might exceed those using petroleum-based fuels. Overall, for the GEF to fund large-scale commercial projects, the biofuels need to be based on biomass feedstocks that are sustainably produced. Most of the advanced biofuels, with the possible exception of hydrogenated vegetable oils, have not sufficiently proven themselves commercially for the GEF to consider supporting them other than as demonstration projects.

- Agriculture, fishing, food processing, transport, storage, retailing and cooking of food are increasingly becoming fossil fuel dependent. There is, therefore a need to develop opportunities from shared land use to increase renewable energy when combined with food production, as well as using biomass arising from food and fiber processing. In addition, energy efficiency should be improved at each stage along the entire food supply chain: encouraging food systems and diets that minimize GHG emissions per capita; optimizing food transport and processing needs to meet local demands in ways that minimize total GHG emissions; and reducing food wastage at the production, storage and consumption stages.
- Any approved RE project should clearly demonstrate GHG reductions on a life-cycle basis and, in addition, it should not lead to loss of biodiversity, food production and local livelihoods.

Urban energy, transport and infrastructure

Urban areas require large and concentrated energy supplies for lighting, heating and cooling, food and water supplies, waste treatment, information, communication, entertainment and mobility services. They are, therefore, responsible for large shares of global GHG emissions. Energy use in cities produced 71% of global energy-related CO_2 emissions in 2006, with an expected increase to 76% in 2030 (IEA, 2008). Due to the integrated governance structures of most urban areas, cities offer numerous opportunities to scale up responses to climate challenges in an integrated manner, combining energy efficiency, renewable energy, and broader development issues.

- Climate change policy responses in urban areas can be designed and implemented utilizing the governance opportunities that cities provide in key sectors: transport, land use zoning, buildings, energy, waste treatment, water and food.
- Opportunities for the transport sector include eliminating long commutes and encumbered traffic by re-designing the physical dimensions of cities, shifting to more environmentally efficient modes of transport such as walking, cycling or public transport, and by improving vehicle and fuel technologies.
- Sustainable low-carbon transport policies can help improve local air quality, reduce congestion, reduce travel time, and increase the efficiency and capabilities of transport services, including freight.
- Combining technology solutions in the energy domain and physical sectors such as buildings and transport together with broader development issues related to urban functions, as well as water and food supply, and waste treatment remains a challenge to the planning and development of sustainable urban areas.
- Lack of appropriate climate governance institutions or necessary authority, insufficient expertise, and a lack of funding or central government support are key barriers to climate integrated urban policies (OECD, 2010).

Mitigation opportunities associated with risks

Several technologies are considered controversial and/or unproven, yet they may prove to be critical to achieve stabilization of warming at $<2^0$C.

- **Short-lived climate forcers:** Mitigation of short-lived emissions can bring significant and immediate climate benefits, along with bestowing human health and agricultural co-benefits. However, focusing on the mitigation of black carbon and organic aerosols should not postpone the existing need for reduction of long-lived GHGs. Rather, it must be viewed as a complimentary strategy.

- **AFOLU/REDD+**: Avoiding deforestation and forest degradation can provide immediate opportunities in mitigating climate change, and therefore should form an integral part of any strategy to stabilize atmospheric CO_2 concentrations. If implemented effectively and combined with adequate safeguards, REDD+ could provide multiple environmental and socioeconomic benefits including biodiversity conservation, improved livelihoods, security to local rural communities, and increased revenues to forest-dependent communities. The GEF has SFM/REDD+ and LULUCF (land use land-use change and forestry) programmes. In addition, the GEF could adopt the AFOLU (agriculture, forest and other land use) approach used by the IPCC-2006 GHG inventory guidelines as well as the IPCC fifth assessment report. AFOLU includes all six production land categories as well as non-CO_2 emissions from livestock and rice production. The addition of the AFOLU approach as a conceptual framework would enable supporting mitigation projects through agricultural soil carbon enhancement and methane emission reduction from livestock and rice production, in addition to LULUCF and REDD+ projects.

- **Geoengineeering:** Solar radiation management (SRM) projects have high risks and uncertainties, and should therefore not receive GEF support until specific technologies and approaches are more clearly defined. Geoengineering will remain a potential option in the context of reaching (or crossing) tipping point thresholds that could lead to abrupt climate impacts, particularly if other GHG reduction approaches deliver less mitigation potential than expected. Large-scale biological atmospheric CO_2 removal projects have lower risks, and the GEF could consider supporting these once potential trade-offs in these initiatives are better understood. Increasing the carbon content of soils, for example by the addition of biochar, can help significantly reduce atmospheric CO_2 concentrations.

- **Carbon dioxide capture and storage**: These could become an integral component of any deep GHG emission reduction strategy, provided current and future risks are addressed. Carbon capture and storage (CCS) projects are now under the umbrella of the Clean Development Mechanism (CDM). CCS, combined with biomass combustion (such as when co-fired with coal) or gasification could have negative emissions if the biomass is sustainably grown; it then offers a very high mitigation potential. Therefore, within its future strategies, the GEF should consider including rigorous monitoring and ongoing project evaluation of CCS projects during demonstration and implementation stages.

- **Nuclear energy**: This low-carbon technology already contributes significantly to global electricity demands (currently contributing approximately 13% of the total generation mix), and could further contribute to GHG emission reduction strategies. The unsubsidized costs of nuclear power are high, however, including waste treatment along with the associated risks of accidents and weapons proliferation. In addition, public acceptance is often a major issue. It is therefore unlikely that nuclear energy will be a viable option for the foreseeable future. Hence, GEF support may not be advantageous.

Achieving <2^0C stabilization, mitigating climate change, and promoting a green economy: Recommendations for the GEF

The UNEP 2012 synthesis report, *Bridging the Emissions Gap,* suggested that if global emissions do not exceed 44 Gt $CO_{2\text{-eq}}$ in 2020, and emissions are sharply reduced thereafter, then there is a 66% probability that the politically agreed target of 2°C global temperature rise can be met. Early "peaking" of emissions below 44-46 Gt CO_2 by 2020 is a necessary pre-condition. The International Energy Agency (IEA) stated that **it is feasible to reduce GHG emissions using existing technologies in order to be on the 450 ppm stabilization pathway, but non-OECD countries will have to play a critical role, given their share of current and projected global GHG emissions.**

As an implementing mechanism of UNFCCC, the GEF has acquired extensive experience over its 20 years of promoting climate change mitigation in a large number of developing countries and EITs at different levels of economic development. The GEF has significantly adapted its climate change mitigation strategies and implementation arrangements over this period. However, recent scientific analysis clearly shows that climate change impacts are projected to be more immediate and severe than was previously thought. T**he GEF, therefire, should re-evaluate its approach and strategies in the context of recent UNFCCC agreements based upon emerging scientific evidence on the need to stabilize GHG concentrations in the atmosphere to limit warming at below 2^oC**. This will likely require an alternate but complimentary approach to the present GEF strategies that tend to be sector or technology-based. Recommendations for future consideration by the GEF are as follows:

- Assist developing countries and EITs to produce short and long-term low-carbon development strategies to help achieve the <2^0C stabilization target consistent with their national economic development goals.
- Support countries by enabling them to analyze, evaluate and identify options for achieving transformational shifts in energy supply and mitigation strategies for forests and agriculture.
- Support "leap-frogging" opportunities for transformational change in energy systems to enable developing countries and EITs to shift to low carbon pathways. Additional effort may be required to assist poorer countries improve energy access in a climate friendly way.
- Shift away from promoting single technology and single sector approaches, recognizing that the key mitigation opportunities are increasingly focused on system optimization rather than improvements to individual technologies because:
    - improvements in mature technologies are approaching their thermodynamic, technical or cost-effective limits**;** and
    - recent improvements in ICT have already led to its increasingly widespread use, even in poorer regions.
- National and international experiences widely agree that while improving the efficiency of individual components might yield minor gains, only system optimization can result in significant

gains, with payback periods of less than two years. In general, the recycling of materials and the optimization of whole systems offer profitable investment opportunities.

- Assist the higher GHG emitters (such as Brazil, Russia, India, China and South Africa) to evaluate and pursue transformational shifts through energy efficiency improvements and renewable energy deployment in the industry, building, and transport sectors, as well as mitigation options in the forest and agricultural sectors. These countries could then significantly contribute, along with OECD countries, to early peaking of annual GHG emissions and deep GHG emission reductions through large, cost-effective interventions from which economies of scale could derive.
- Promote demonstrations of selected cutting-edge and emerging mitigation technologies such as very high performance building designs (both new and retrofit), novel and alternative cooling systems for commercial buildings (such as desiccant dehumidification), very high-efficiency appliances, and bioenergy + CCS.
- Encourage policies that set ambitious appliance standards, building codes, and fuel economy norms. Promote minimum efficiency performance standards because of their cost-effectiveness and high policy acceptability in most jurisdictions. Support “feebates” and proactive utility regulations that provide real mitigation opportunities, as well as significant social and economic co-benefits.
- Promote the development of carefully designed policy mechanisms which have the potential to increase the uptake of renewable energy power systems in a cost effective manner.
- Support projects that have the potential to overcome the challenges of RE deployment by encouraging commercial scale-up to reduce costs, and enable integration into present and future energy supply systems.
- Support development of new state and national policies that remove subsidies for fossil fuels, and promote the carefully designed transfer of subsidies to renewable energy technologies.
- Build and sustain strategies that reduce the present fossil fuel dependence of the agri-food supply chain, and reduce agricultural-related GHG emissions through efficiency improvements and shifts to renewable energy.
- Adopt sustainable integration of agricultural production systems that reduce GHG emissions and other negative environmental impacts from agriculture. Discourage the development of peat-lands (they already contribute about 2 $GtCO_2$ emissions annually) for energy crop production.
- Respond to climate change in urban systems by developing an integrated, continuous, and long-term strategy based on combined approaches in transport, buildings, water supply, waste treatment, food supply and land use zoning. Such an integrated approach should adequately address other challenges that have interfaces at the urban level, such as management of chemicals, coastal management (where appropriate), and development goals for overall human well-being.
- Support urban-level policies, measures and practices. Policies and actions by national and state governments can often be difficult to negotiate and implement, whereas local governments can act sooner and in more flexible ways. This has been demonstrated in many countries where

even though national climate-related actions are paused, cities have been dynamically transforming. Local and regional authorities provide the governance opportunities, the decisiveness, and the scale to approach the climate change challenge in an integrated manner combining energy efficiency, renewable energy, and broader development issues.

- Adopt the AFOLU approach covering REDD+, LULUCF, soil carbon enhancement, and methane emission reduction options (from livestock and rice production); these can provide low cost and immediate GHG mitigation opportunities, as well as provide biodiversity conservation, land reclamation, and livelihood improvement benefits when implemented with adequate environmental and social safeguards.
- Identify climate risks (and mitigation opportunities) throughout the GEF portfolio, across all sectors, and mainstream resilience enhancement measures to combat projected climate change impacts.
- **Overall, the GEF should assist recipient countries to assess, select and evaluate technologies, policies, measures, regulations, financial incentives and disincentives, financial needs, technology transfer mechanisms, and institutional capacity that will enable them to shift more rapidly and comprehensively to a low-carbon pathway, consistent with national sustainable development goals.**

Principles for defining the GEF strategy towards GEF-6 and a Green economy

Reducing the carbon footprint of key economic sectors (energy supply, industry, transport, buildings, waste, forestry and agriculture) in order to achieve sustainable levels is possible, but will require substantial resources and innovative, transformative ways of addressing climate change mitigation. In the long term, low-carbon technologies will improve economic performance and global wealth whilst enhancing natural capital. These approaches will also make a significant contribution to poverty alleviation.

Towards GEF-6 and a Green Economy. The GEF's approach to climate mitigation through market transformation and investment in environmentally sound, climate-friendly technologies remains highly relevant in the context of a future green economy, and the need for keeping global temperature increases below 2°C. Within this context, the GEF could consider the following principles to achieve maximum impact in future strategy development.

Principle 1: Have a common goal but with differential delivery approaches. Focus on the more rapidly urbanizing economies and major GHG emitting countries to enable deep emissions reductions. In GHG emitting countries, focus on energy access for all**.** A common goal towards reducing GHG emissions and supporting low-carbon development paths should be implemented – taking into account differing geographies and levels of national development.

Principle 2: Enhance leverage of available global climate financing. Existing barriers to leveraging a range of public and private sector resources for GEF projects should be significantly relaxed. To make a transformational impact, private sector financing for GEF projects should be increased significantly.

Principle 3: Utilize economies of scale and potential synergies between sectors and GEF focal areas. In GEF-6 and beyond (assuming similar or higher levels of funding become available), a strong focus on systemic and programmatic approaches to energy production and consumption would utilize economies of scale, and produce multiple benefits from several sectors and focal areas. There is a need to explore and promote mitigation and adaptation synergies when addressing climate change.

Principle 4: Account for climate risks and increase the resilience of GEF climate mitigation projects. Climate change risks have to be recognized so that every GEF programme and project addresses these risks and achieves climate resilience wherever possible.

Principle 5: Assure transparency, accountability and global learning. Higher levels of transparency, GHG accountability, and support for global learning should become essential ingredients of GEF funding support for climate change mitigation initiatives.

Undertaking an optimization approach to provide systemic solutions should become the focus for GEF-6 project support. Rather than supporting single, low-carbon technologies or improving the performance of individual components, the GEF should consider supporting more complete systems that could encompass a combination of energy demand reductions, low-carbon option deployment, innovative IT systems, capacity building, energy security, and policy development whilst leading towards sustainable development. Monitoring of such integrated projects and assessing their success will present challenges, so careful consideration will need to be given as to how this may best be achieved.

Organization of Report and Chapters

This report, **"Climate Change; Scientific Assessment for the GEF,"** is organized into eight chapters covering the following topics:

Chapter 1 presents an introduction to the GEF and the evolution of GEF support to the climate change portfolio.

Chapter 2 outlines the science of climate change projections, possible impacts of climate change, and adaptation strategies to cope with climate change in the context of GEF portfolios.

Chapter 3 highlights the global agreement on the need for stabilization of global warming at $<2^0$C.

Chapter 4 describes mitigation opportunities through energy efficiency.

Chapter 5 presents mitigation alternatives through renewable energy (including biofuels).

Chapter 6 describes mitigation options in the transport and urban sectors.

Chapter 7 outlines some of the emerging and controversial mitigation opportunities such as reduction of short-lived climate forcers, REDD+, geoengineering, CCS, and nuclear.

Chapter 8 in closing discusses the need for a transformational shift to low carbon development strategies and the unique role of the GEF in promoting and supporting this shift to achieve stabilization of global temperature increases below 2°C.

Full report available on: http://www.unep.org/stap