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Adaptation to Climate Change: how much will it cost?

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ABSTRACT

In order to face the unavoidable and severe climate change impacts expected in the near future the world will have to adapt. Various adaptation options exist in response to specific vulnerabilities, but their efficiency, effectiveness and equity dimension varies across space, time and sector, and deserves more attention. Developing countries, and within those countries the agricultural sector, are estimated to be the most vulnerable to future impacts. Nevertheless, lots of uncertainties must be solved in climate science, particularly in downscaling climate and socio-economic scenarios. In addition, a major challenge for research in support to the design of future policies is to identify the optimal mix between adaptation and alternative climate policies, namely mitigation policies. Given the strong interdependencies between adaptation and development, strategic complementarities between climate and development policies should also be further investigated, identifying the most adequate mechanisms to generate new and additional funds for adaptation. In this direction, mainstreaming adaptation into Overseas Development Assistance funding, as well as devoting to adaptation part of the auction revenues from existing cap and trade programmes are potentially very promising options.

Policy Challenge

Difficulties to implement effective international mitigation policies and the increasing awareness of climate inertia have brought adaptation upfront in the scientific and policy debate. Adaptation to climate change is becoming a priority for global climate policies, with crucial implications for development in the poorest and most vulnerable countries.

But several key policy questions urgently need more exhaustive answers: if we really need to adapt, when, where and how should we adapt? How much will it cost to adapt and who will bear the costs of adaptation? Are there any strategic complementarities or trade-off with alternative policies? Where will the funds for adaptation come from?

Why adaptation: is it really necessary?

In a world expected to warm by 1.8 to 4 °C within the end of the century compared to 1990 levels (best estimate of the Special Report Emissions Scenarios (SRES) described in the latest report of the Intergovernmental Panel on Climate Change (IPCC) [1]), effects of climate change will potentially cause very large impacts on the socio-economic and environmental systems.

Altered precipitation patterns, increased frequency and intensity of extremes events, impacts on crops productivity are visible already. Especially after the 21st century, they will affect adversely the world as a whole, but particularly those regions, populations and sectors which are more vulnerable. As a consequence, these areas in particular will have to get ready to face the new living conditions dictated by climate change through adaptation i.e. taking actions - a few examples in table 1 below – for protection against the damage.

Indeed, even if a successful international mitigation agreement were reached and if the world succeeded in reducing its GHG emissions, it will take time to recover from the GHG already cumulated in the atmosphere. In order to face the unavoidable impacts expected in the near future the world will necessarily have to adapt.

Table 1. A few examples of adaptation options in key economic sectors

Sector	Adaptation options
Agriculture	Crop insurance More efficient irrigation systems Forestry with shorter rotation periods
Coastal areas	Coastal protection infrastructures Enhanced drainage system Restricted land-use planning Insurance, warning and evacuation schemes Creation of institutions for long term planning and risk analysis Relocation and retreat of production and services (including tourism) in coastal areas
Housing and Health	Air conditioning Improved energy efficiency standards in the building sector R&D on vector control, vaccines Improvement in public health systems
Water	Water saving measures in supply (leakage control) and demand Increase in water capacity Desalinization and water transport Development of early warning systems Flood protection infrastructures
Tourism	Creation of artificial snow ski-plants in mountain regions Adaptation of infrastructures to face shifts and changes in seasons (such as improved energy efficiency standards in vacation resorts, or creation of swimming pools in resorts located in warmest regions) Supply of services for changed seasonal tourism patterns (for instance supply of services less sensitive to climate, such as health and fitness centres)

SOURCE: Adapted from Hallegatte, 2009

What is exactly meant by adaptation? Some definitions

Adaptation defines a process which involves several dimensions, related to space, time and context. The context may cover natural and socio-economic systems, as well as private and public domains.

[1] Fourth Assessment Report (4AR), IPCC, 2007.

Several definitions of adaptation exist in the literature. The most comprehensive and probably most quoted one is that proposed by the IPCC in the Third Assessment Report (TAR, 2001), which defines adaptation as the '*adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities*'. It distinguishes between anticipatory, autonomous, planned, private, public, and reactive adaptation responses[2]. These distinctions are partly overlapping, e.g. public adaptation is usually planned adaptation and vice versa.

Crucial to climate control policies is the distinction between autonomous and planned adaptation, since the capacity of a system to adapt autonomously to climate change will affect the nature of the impacts, the entity of the damage and the urgency to plan adaptation strategies. However, disentangling policy-driven decisions from private initiatives with the aim to provide an economic assessment of planned adaptation strategies may not be so easy. Adaptation in agriculture provides a straightforward example in this regard. Climate change will affect yields and crops' prices, inducing farmers to adapt, for instance by rotating crops or shifting the growing season. This form of private adaptation will be considered autonomous, even if farmers may base their rational economic decisions not only on climate-driven factors, but also on government policies such as agricultural subsidies.

Also the distinction between anticipatory or reactive adaptation, based on the timing of adaptation actions, is relevant to the economic analysis of adaptation strategies. In some contexts anticipatory actions may be less costly and more effective than reactive actions, as in the case of flood protection. Reactive adaptation indeed is typically a major characteristic of unmanaged natural systems and of autonomous adaptation reactions of social economic systems.

The table below synthesises the main attributes which characterise the effects of adaptation.

Table 2. Adaptation: Possible criteria for classification

Concept or Attribute	Type of adaptation
Purposefulness	Autonomous → Planned
Timing	Anticipatory → Reactive, Responsive
Temporal Scope	Short term → Long term
Spatial Scope	Localised → Widespread
Function/Effects	Retreat – accommodate – protect – prevent
Form	Structural – legal – institutional
Valuation of Performance	Effectiveness-efficiency-equity-feasibility

SOURCE: Bosello et al, EEA, 2006

Most important perhaps is to underline that the efficiency, effectiveness and equity dimension of adaptation strategies are context specific, as they can vary across time, between countries, between sectors within and across countries, and between actors engaged in adaptation processes.

For instance, some adaptation actions that are successful today could increase vulnerability in the future. Some examples of this "mal-adaptation" are sea level rise or flood protection infrastructures that may disturb the intrinsic dynamic nature of coastal and river systems; or cooling and water supply technologies that may increase energy consumption.

For these reasons in the design of adaptation strategies it is important to account for 'spillovers', i.e. external effects, of adaptation measures across space and time.

[2] Anticipatory Adaptation- Adaptation that takes place before impacts of climate change are observed. Also referred to as proactive adaptation.
Autonomous Adaptation- Adaptation that does not constitute a conscious response to climatic stimuli but is triggered by ecological changes in natural systems and by market or welfare changes in human systems. Also referred to as spontaneous adaptation.
Planned Adaptation- Adaptation that is the result of a deliberate policy decision, based on an awareness that conditions have changed or are about to change and that action is required to return to, maintain, or achieve a desired state.
Private Adaptation- Adaptation that is initiated and implemented by individuals, households or private companies. Private adaptation is usually in the actor's rational self-interest.
Public Adaptation- Adaptation that is initiated and implemented by governments at all levels. Public adaptation is usually directed at collective needs.
Reactive Adaptation- Adaptation that takes place after impacts of climate change have been observed.

Adaptation in international climate agreements- the newly released EC White Paper on Adaptation

The United Nations Framework Convention on Climate Change (UNFCCC, 1992) refers to adaptation as 'vital'. However, in the past decade the focus on adaptation was limited, at least in the developed world. Only recently, in 2008, the Bali action plan[3] identified the need for enhanced action on adaptation by the Parties to the Convention, launching the Adaptation Fund.

In 2007 the EEA report on the costs of climate policies[4] stressed the need for a EU position on adaptation, and on the 1st of April this year eventually the EC officially published its long waited White Paper on Adaptation.

With its declared efforts towards an action plan on adaptation, Europe is moving forward trying to fill the existing knowledge gaps, create some consensus and set the ground for a comprehensive and more effective future climate agreement.

The White Paper in fact sets up an action framework for a more consistent and strategic approach to adaptation in Europe, in order to reduce Europe's vulnerability to climate change. This framework intends to complement adaptation actions by individual Member States while supporting international efforts towards a comprehensive post-Kyoto climate agreement. In this direction the White Paper urges all Member States to further develop National or Regional Adaptation Strategies, considering also the possibility that these strategies become mandatory after 2012. By 2011 the EC White Paper also foresees the creation of a Clearing House to facilitate the exchange of information on climate change risk assessment, impacts and best practices between Governments, international agencies and other types of organisations working on adaptation policies.

[3] Designed at the 13th Conference of the Parties to the Convention (COP) in Bali, 2008

[4] Climate change: the cost of inaction and the cost of adaptation, EEA Tech. Report n13/2007

A map of impacts, vulnerability and adaptation needs worldwide. Timing and scaling of adaptation

The design of adaptation strategies in international policies relies upon the scientific evidence currently available on impacts and vulnerability. This is continuously growing but still facing two major difficulties: the incomplete understanding of climate change itself and the "downscaling" of impacts at the local level. Current climate change scenarios and current climate change impact studies are still too crude to capture a number of essential details that determine the impacts and spontaneous adaptation[5].

At the global and regional level the IPCC with its latest report[6] probably provides the most comprehensive map of impacts and vulnerabilities world-wide. We hereby extract a few selected impressive figures.

By 2050, water availability is projected to increase by 10-40% at high latitudes and in some wet tropical areas, but to decrease by 10-30% over some dry regions. By 2020 in Africa between 75 million and 250 million people are estimated to be exposed to increased water stress. Furthermore, in the course of the century water supplies stored in glaciers and snow cover are expected to decline, reducing water availability for approximately one-sixth of the world population.

Approximately 20-30% of the plant and animal species assessed so far are likely to be at increased risk of extinction if increases in global average temperature exceed 1.5-2.5°C.

Above 3°C impacts on food production are expected to be generally negative with some particularly vulnerable African countries, , experiencing a yields reduction from rain-fed agriculture by up to 50% by 2020.

Estimates suggest that by the 2080s many millions more people will be flooded every year due to sea-level rise.

The health sector will widely suffer for an increasing burden from malnutrition, diarrhoeal, cardio-respiratory, and infectious diseases, as well as an increased morbidity and mortality from heat waves, floods, and droughts. The

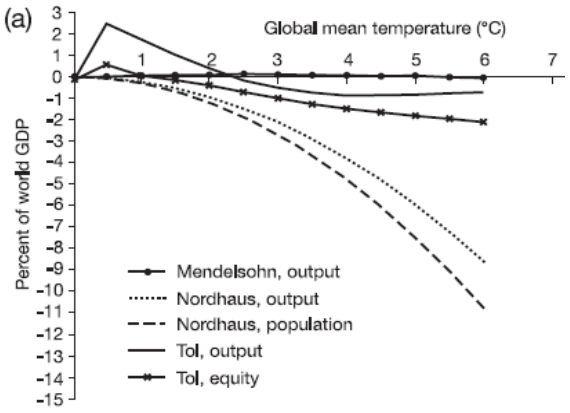
[5] Kuik et al, Methodological aspects of recent climate change damage cost studies, Integrated Assessment Journal Special Issue, Vol 8, n.2, 2008

[6] IPCC 4AR, 2007

balance of positive and negative health impacts will vary from one location to another, and over time.

The following graph[7] compares recent key results in the literature, showing percent changes in world GDP in relation to different global mean temperature increases, with respect to the preindustrial levels.

Graph 1. The costs of climate change: a recent comparison of results in the literature



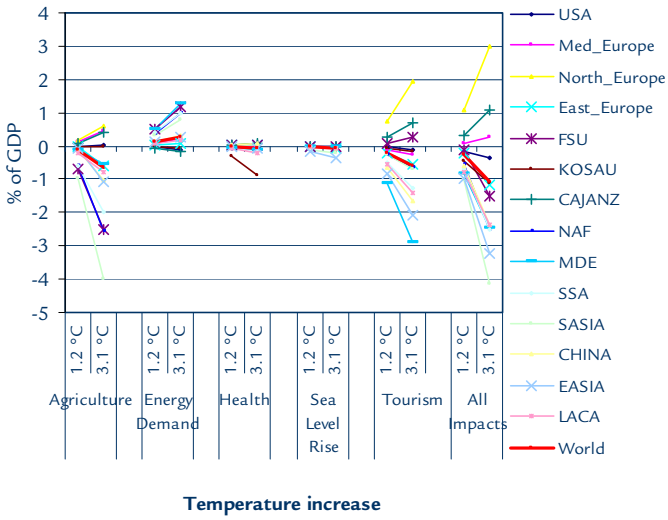
SOURCE: IPCC, 2007 FAR

A new study by FEEM[8], which is part of the research effort FEEM is undertaking within the framework of the Euromediterranean Centre for Climate Change, provides estimates on the country and sectoral break-down of future impacts, assessing the role of autonomous adaptation.

The study was presented at the International Workshop on the Economics of Adaptation to Climate Change, organised in Venice at the beginning of April 2009 by the International Center for Climate Governance, a joint initiative of FEEM and Fondazione Giorgio Cini, in cooperation with the OECD. The workshop brought together key scientists in the field, to discuss costs and benefits of adaptation.

A quick look at graph 2, extracted from the FEEM study, shows that distributional effects are extremely relevant: impacts clearly vary by sector and region.

Graph 2. A summary of climate change impacts



SOURCE: Bosello et al., 2009

Although autonomous adaptation results to be crucial, generally smoothing rather than

amplifying direct costs, these are still relevant.

Moreover the study suggests that developing countries are more severely damaged than developed countries. In developing countries the biggest concern is the negative impact of climate change on agriculture, due to food prices' increase. In developed countries indeed the most relevant impacts occur in the tourism sector.

Some evidence on Europe

A recent EEA report[9] analysed vulnerability at the European level. The most vulnerable European regions are Southern Europe, the Mediterranean Basin, Outermost regions and the Arctic. Furthermore, mountain areas, particularly the Alps, islands, coastal and urban areas and densely populated floodplains result to be most vulnerable. The key sectors affected by climate change in Europe will be agriculture, forestry, fisheries and aquaculture, coastal and marine ecosystems, energy, infrastructures, human health, animal and plant health and tourism. For instance tourism in the Alps and in the Mediterranean regions is shown to be strongly

[7] IPCC 4AR, 2007
[8] Bosello et al, 2009

[9] EEA-JRC-WHO, Impacts of Europe's Changing Climate, 2008 Indicator-based assessment Report, 4/2008.

and negatively affected by the expected temperature increase.

The paper reports some numbers: the projected impact of climate change on precipitation and glacier melt indicate that hydropower production could increase by 5% or more in northern Europe and decrease by 25% or more in southern Europe in the second half of the century. Also, climate change will have severe impacts on the quality and availability of water resources, affecting many sectors including food production, since more than 80% of agricultural land is rain-fed. Europe's high water stress areas are expected to increase from today's 19% to 35% by 2070. This is likely to increase migration pressures and higher flows of environmental refugees, particularly in the Mediterranean region.

Some evidence on Italy

Focusing on Italy, a recent book[10] -outcome of FEEM research- illustrates some evidence on impacts and adaptation to climate change in Italy. The book, which collects the FEEM studies presented at the National Climate Conference held in Rome in September 2007, represents the first attempt to assess climate change impacts in Italy, by sector and region. The book in fact addresses vulnerability in selected key areas: those exposed to erosion risk (coasts), those exposed to hydro-geological risks, those exposed to desertification and biodiversity loss risk (agriculture and forestry), and those exposed to the de-glaciation risk (the Alps).

The expected impacts in 2050 vary by sector and geographical area. We hereby illustrate a few interesting examples extracted from this research.

Estimates suggest that climate change could determine a net 13% decrease in tourists' arrival in the Alpine region by 2030. Due to milder winters and lack of snow, Trentino Alto-Adige is the region that would suffer most in the Alps for the expected decrease in winter tourism demand.

Moving to the South of Italy, 16.500 sq. km are considered vulnerable to desertification. In the absence of adaptation strategies, this may imply an economic loss calculated between 11,5 (for cattle grazing land) and 412,5 (for irrigated land) US million $ per year.

Another example related to the health sector: if anticipatory measures had been taken, 134 million Euros could have been saved from the loss generated by the 2003 heat wave.

Cost assessment of adaptation at the global, regional and sectoral level. The distribution of costs between the North and the South

We've illustrated a few piecemeal numbers on adaptation costs in Italy.

But how much will adaptation cost globally, by region and by sector? And who will bear these costs?

First, it is important to note that given the nature of adaptation, adaptation cost assessment encounters several difficulties.

The concept of adaptation is complex and hard to capture adequately in an impact assessment. Given this complexity, adaptation is not always handled in the same way across studies, which assume different adaptation goals[11]. For example, in some studies the implicit goal of adaptation in agriculture is to maintain current cropping patterns, others indeed aim to maintain current farmers' income, or make existing practices more efficient. Different adaptation goals lead to different adaptation costs and to different residual impacts i.e. those remaining beside any policy action taken to contrast climate change. Various approaches are used to model adaptation (e.g., spatial analogs, micro-economic optimisation), but they all either underestimate or overestimate its effectiveness and costs[12].

Most impact studies take only autonomous adaptation into account, thus omitting to consider those policies undertaken by governments which may well smooth the effects of climate change; furthermore most impact studies lump together adaptation costs and residual impacts. In general, adaptation is treated very differently across sectors. For instance, while adaptation is usually taken into

[10] Cambiamenti climatici e strategie di adattamento in Italia. Una valutazione economica, ed. Carlo Carraro, published by il Mulino, 2008.

[11] Kuik et al, 2008

[12] Tol, 2005

account in energy demand, it is never considered in the case of unmanaged ecosystems.

Adaptation strongly relates to socioeconomic trends determining adaptive capacity.

In general, this increases with development and market flexibility.

Hence, the effectiveness and type of adaptation implemented, heavily depends on the socio-economic scenarios assumed. For instance, the availability of more efficient water irrigation systems or new crop varieties may reduce the negative impacts of climate change on agriculture. Or the capacity to implement early warning systems in flood control may limit the damage of extreme climatic events.

Focusing on the numbers, in the literature adaptation costs are estimated to be in a range between 5 and 25% of the total economic costs of climate change[13].

The UNFCCC in 2007 estimated the total annual costs for adaptation by 2030 for agriculture, forestry and fisheries, water supply, human health and coastal zones infrastructures in a range of 49-171 billions US$ globally, corresponding to 0,06-0,21% of projected GDP in 2030. The break-down of those estimates for developing countries is in a range of 28-67 billion $. FEEM modelling exercise on adaptation presented in Venice, based on latest available literature, estimated an adaptation cost in 2060 of 370 billion $.

Trade-offs and synergies between mitigation and adaptation

One of the key questions on adaptation policies is on the potential trade-offs and/or synergies with mitigation strategies.

Adaptation and mitigation are certainly intertwined, but it is not clear whether they could be substitutes or complements: could strong mitigation avoid adaptation, or should they necessarily go together?

If complements, the optimal balance between the two is not evident.

The table below summarises the main characteristics which distinguish adaptation from mitigation[14].

[13] Tol et al. , 1998
[14] Bosello, 2009

Table 2. Main Characteristics of Mitigation and Adaptation

	Mitigation	Adaptation
Benefited systems	All systems	Selected systems
Scale of effects	Global	Local to regional
Life time	Centuries	Years to centuries
Lead time	Decades	Immediate to decades
Effectiveness	Certain, in term of emission reduction, less certain in term of damage reduction.	Generally less certain
Ancillary benefits	Sometimes	Mostly
Polluter pays	Typically yes	Not necessarily
Payer benefits	Only little	Almost fully
Administrative scale/ implementing bodies	(Mainly) National governments, International negotiations	(Mainly) Local managers/authorities, households
Sectors involved	Primarily energy and transportation in developed countries, energy and forestry sectors in developing countries	Potentially all
Monitoring	Relatively easy	More difficult

SOURCE: Bosello et al., 2009

Mitigation and adaptation work at completely different spatial and time scales. Mitigation is "global" and "long term" (once abated, one ton of say CO2, cannot produce damage anymore) while adaptation is "local" and "shorter term" (It may require adjustments should the damage change or be substantially different from what was originally expected).

Secondly, the effects of mitigation and adaptation occur at different times. Emission reductions today will translate into a lower temperature increase and ultimately lower damage only in the (far) future, whereas adaptation measures, once implemented, are immediately effective in reducing the damage. This differentiation is particularly relevant under

the policy-making perspective: one of the stronger reason for the scarce appeal of mitigation policies is their "certain" and "present" cost facing a future and thus uncertain benefit. This can be less of an issue for adaptation.

Thirdly, mitigation provides a "global", whereas adaptation provides a "local" response to anthropogenic climate change. The benefits induced by a ton of carbon abated are experienced irrespectively of where this ton has been abated. Differently, adaptation entails measures implemented locally whose benefits advantage primarily, but not exclusively, the local communities.

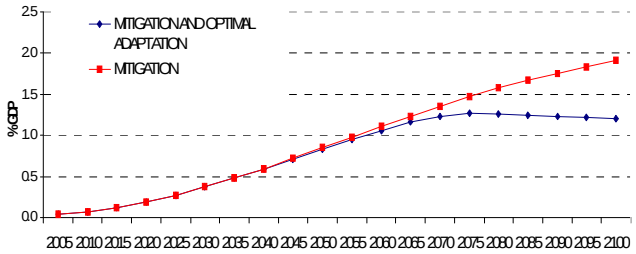
Finally there is an equity dimension. Abatement intrinsically endorses the "polluter-pays" principle. Each one abates her own emissions (directly or indirectly if "where" flexibility is allowed). This is not necessarily the case with adaptation: it can well alleviate damages which are not directly provoked by the affected community.

Hence, adaptation and mitigation show some clear strategic complementarities. One interesting question is whether a climate negotiation linking the two strategies could be more successful both in enlarging participation to developing countries, and in enhancing global environmental effectiveness, than one focussed on mitigation only. However, this field of research is practically unexplored.

More scientific effort has been placed on analysing the trade-offs between adaptation and mitigation. The literature shows that a trade-off exists: the possibility to adapt(mitigate) reduces effectively the need to mitigate(adapt), confirming economic substitutability. However an optimal climate change policy is always composed by a mix of the two strategies, which highlights their strategic complementarity. The latter is supported also by sensitivity analyses showing unambiguously that a higher climate change damage determines an increase of both mitigation and adaptation.

A new research by FEEM - first outcome of a recent research cooperation agreement with the OECD on adaptation - presented at the Venice April Workshop, confirms that the introduction of adaptation policies decreases the need to mitigate and vice versa, reducing global residual damage, as shown in the graph below.

Graph 3. Global Residual Damages as a Percentage of GDP



SOURCE: Carraro et al., 2009

The two policy options are strategic complements though, as they both concur to reduce vulnerability to climate change. Accordingly, they should both be part of an optimal portfolio of policies. This is particularly important for developing countries: being characterized by higher damages, they are the ones that can benefit most from an optimal combination of the two strategies.

It also suggests an optimal mix of adaptation strategies: this should consist in reactive and anticipatory measures accompanied by investments in dedicated knowledge. Proactive adaptation should come first (it is the main adaptation form until 2080), with reactive measures accommodating what cannot be anticipated (they prevail afterwards, when the damage is higher). Regional vulnerability and resources determine regional patterns of adaptation: in NON-OECD regions, reactive adaptation is more widely adopted while R&D which would be most needed, is not undertaken. Richer OECD countries rely on anticipatory adaptation and R&D.

This evidence calls for the design of a future climate agreement based on a North-South cooperation as well as coordinated mitigation and adaptation efforts. Further research in this field however is much needed to support future policies.

Overlaps and trade-offs between development and adaptation funds. The international carbon market and other sources of funding to finance adaptation

Our analysis has shown that adaptation cannot be disentangled from development.

Funds for adaptation, however, should be additional to the resources already committed to development, and not compete with financing development. Rather, they should boost development reducing vulnerabilities and damages induced by climate change.

Three main sources of funds for adaptation currently exist: north-south flows channeled through dedicated multilateral adaptation funds and ODA; domestic flows and south-south flows.

Official Development Assistance (ODA) funds currently amount to approximately 100 billion US$ per annum, far below the global target of 0.7% of GNP.

Tables 3 and 4 illustrate estimates of adaptation costs in developing countries and the current level of multilateral adaptation funds sponsored by the UNFCCC, respectively.

Adaptation costs represent a considerable amount if compared to the current ODA levels, and the multilateral funds currently operational show an order of magnitude well below even the most conservative estimates of adaptation costs. The total resources pledged for these adaptation funds in fact is 320 million $, while the amount disbursed is 154 million $.

Table 3. Estimates of annual adaptation costs in developing countries

Assessment	Annual cost	Year
UNDP 2007	$86 billion	2015
UNFCCC 2007	$28-67 billion	2030
World Bank 2006	$9-41 billion	Present
Oxfam 2007	$50 billion	Present
Stern Review 2006	$4-37 billion	Present

SOURCE: UNDP, 2007; Agrawala, Fankhauser, 2008

Table 4. UNFCCC Adaptation funds in operation (US$ Million)

Fund	Description	Total pledged	Total received	Project approvals
Least Developed Countries Fund	Supports preparation and implementation of National Adaptation plans of Action	180	91,8	36,79
Special Climate Change Fund	Focuses on development; activities should be country-driven, cost-effective and integrated into national poverty reduction strategies	90	59,9	67,6
GEF Trust Fund Special Priority on Adaptation	Finances adaptation activities that also generate global environmental benefits	50	50	50
Total		320	201,7	154,39

Note: Figures as of June, 2008. Project approvals include those officially approved and those in process of being approved

SOURCE: GEF, 2008

These figures indicate the urgent need to generate new additional funding for adaptation in developing countries.

Mainstreaming adaptation into ODA is essential; however ODA is unlikely to provide the new and additional resources required to finance adaptation in the developing world.

Equity considerations suggest that donors, bearing much larger responsibilities for their historical and current levels of greenhouse emissions, should find a way to generate additional resources.

Among the potential options[15], there are proposals to create adaptation funds that would be capitalised by revenues from auctioning emissions' rights to polluters under cap and trade programmes.

Recent World Resource Institute (WRI) estimates suggest that the US Boxer-Lieberman-Warner climate bill would generate approximately $3 billion annually for international adaptation in the first three years

[15] For a detailed analysis see M. Bapna, H. McGray, 2009

of the programme, increasing to as much as $25 billion per year over time.

Early estimates for the EU ETS indeed suggest that this could generate up to €1.5 billion ($2.3 billion) annually in adaptation

related revenues in 2020.

Also global market-based levies, such as those generated through the Clean Development Mechanism (CDM)[16] and devoted to the Global Adaptation Fund, have a highly promising potential, depending on prices and traded volumes.

In order to have a clearer picture of all adaptation funding initiatives and programmes, including national and south-south initiatives, Resources For the Future (RFF)[17] has recently launched an interesting programme, aimed to map funds for adaptation under a Global Adaptation Atlas.

The RFF Atlas identifies mapping as the 'missing link' in adaptation. Mapping refers not only to adaptation funds, but also to data on climate impacts and 'on-the-ground' adaptation activities.

Future Challenges

Adaptation is crucial to future climate policies.

Even if adaptation options have a predominant local dimension, its strategic complementarities with mitigation policies and with development strategies make it a global policy priority.

Several crucial issues, however, remain to be addressed by climate science and policy.

In research, downscaling of climate and socio-economic scenarios is needed, together with a better harmonisation and comparison of integrated assessment exercises.

Generally, the broad field of adaptation cost assessment and its interaction with alternative climate policies must be further investigated. It would be particularly relevant to identify the most effective adaptation options in response to different vulnerabilities, by sector, spatial and temporal scales. Equally important would be to assess the strategic complementarities with mitigation, no regret and development strategies, identifying at the same time the most adequate mechanisms to generate new and additional funds for adaptation.

Better coordination between science, policy and activity 'on the ground' is needed to make adaptation more effective globally.

[16] CDM is one of the project-based mechanisms for greenhouse gases emissions reduction foreseen by the Kyoto Protocol, which contemplates investments in emission reduction implemented by one Annex 1-developed- country in one non-Annex 1-developing-country.

[17] Shalini Vajjhala, 2009

This Policy Brief builds upon the research papers presented at the International Workshop on the Economics of Adaptation to Climate Change, organised in Venice on 2-3 April 2009 by the International Center for Climate Governance, a joint initiative of FEEM and Fondazione Giorgio Cini, in cooperation with the OECD, and the main findings of the book 'Cambiamenti climatici e strategie di adattamento in Italia. Una valutazione economica', ed. Carlo Carraro, published by il Mulino, 2008

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