DFID RESEARCH STRATEGY 2008-2013

Working Paper Series: Climate Change

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THIS WORKING PAPER ON CLIMATE CHANGE IS ONE OF A SERIES OF 10 PAPERS PUBLISHED ALONGSIDE DFID'S RESEARCH STRATEGY 2008-2013. IT PRESENTS THE CASE FOR DFID-FUNDED RESEARCH ON CLIMATE CHANGE – DRAWING ON THE RESPONSES GIVEN DURING A GLOBAL CONSULTATION THAT DFID CONVENED IN 2007 ABOUT ITS FUTURE RESEARCH.

The purpose of the Working Papers is two fold: to record the key issues raised during the consultation; and to spell out DFID's decisions on new directions, as informed by the consultation. As such, they constitute an important part of the feedback process, and provide an opportunity to clearly articulate DFID's strategic response to the consultations and to other global drivers of research. They also provide guidance to those implementing DFID's research strategy in the future.

Each Working Paper reviews the current state of DFID's research on a given theme, highlights the key questions asked during the consultation process, and documents the main feedback received. The Papers then tease out the implications of the consultation findings on DFID's work, and end by spelling out DFID's future directions on each priority theme. Where possible, each Paper makes clear how DFID has drawn upon the consultation responses to shape its plans.

Other titles in the series are: Economic Growth, including Infrastructure; Sustainable Agriculture; Better Health: Education; Political and Social Science Research; Stimulating Demand for Research; Research Communication; Capacity Building; and Mainstreaming Gender in Research. Note that issues which are not directly addressed under this paper may appear in others (for example the impact of agriculture on climate change is largely addressed in the paper on Agriculture).

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SUMMARY

Climate change is one of the greatest threats to development and will remain so for decades to come. Although there are significant gaps in our understanding of regional impacts, it is clear that poor countries will be affected first and worst and poor people will be most exposed and vulnerable.

Both mitigation and adaptation are necessary, and on a global scale. Adaptation research is needed to develop strategies to cope with the climate change that the world is already committed to, based on past emissions and future trajectories. Developing countries need assistance to adapt to worsening droughts, crop failures, water shortages, rising sea levels, more frequent and intense storms, and extinction of species. Mitigation aims to stabilize CO^2 levels below a threshold that reduces the likelihood of abrupt climate change and lowers the need for adaptation. Given the scale of the challenge, this will require a substantial increase in public and private funding for energy technology research, development and demonstration, and accessibility to developing countries.

A new global deal is needed post-2012 to facilitate and accelerate action to tackle climate change, one that all countries will sign up to and implement. Part of this will involve adapting to climate change impacts we are able to predict; the other part is building a low-carbon global economy. Faster, wider, and more coordinated uptake of existing and new strategies is needed, and policies will need to take account of adaptation across different sectors and different population groups to be most effective.

Climate change will continue to be a priority in the new Research Strategy, with a view to DFID stepping up its work with other UK and international partners to leverage world-class expertise and funding for research to support developing countries in tackling climate change and contributing to a low carbon global economy. Rapid expansion is proposed to cover four new priority themes: *Improving accessibility of climate science, scenarios, and impacts and vulnerabilities at regional, sub-regional, and national level, particularly in Africa; Embedding climate change in international, regional and national policy frameworks and overcoming obstacles to collective action; Expanding work on adaptation to strengthen decision making and implementation of adaptation options; and Investigating mitigation options and low carbon growth pathways.*

This paper sets out: DFID's current research programmes on climate change, the results of an extensive, 9-month consultation across DFID and with our partners in the UK and in 7 countries, and for each of the chosen themes, the current state of knowledge, why this issue is a priority, and how DFID proposes to take forward research in this area.

WHERE WE ARE NOW

1. DFID is one of two international research funders to cover climate change research as an explicit priority. Supporting African research capability to adapt to climate change has been our focus to date. We are jointly funding a 5-year programme with IDRC, the Climate Change Adaptation (CCAA) in Africa programme, which has four main objectives:

    i. To strengthen the capacity of African scientists, organisations, decision-makers and others to contribute to adaptation to climate change.

    ii. To support adaptation by rural and urban people, particularly the most vulnerable, through action research.

    iii. To generate a better shared understanding of the findings of scientists and research institutes on climate variability and change.

    iv. To inform policy processes with good quality science-based knowledge.

2. DFID and IDRC are designing two large regional programmes with partners in Asia and Latin America to address research and capacity needs to help countries tackle the impacts of climate change on the poor. We expect to have these programmes in place late next year.

3. DFID is also contributing to a World Bank research programme to assist decision makers in developing countries in prioritizing, costing and integrating adaptation to their development plans and budgets. This will involve investigating the economic case and costs and benefits of different adaptation options.

4. DFID and the UK Natural Environment Research Council and the UK Economic and Social Research Council are jointly funding a programme on ecosystem services and poverty alleviation (ESPA). Building on the Millennium Ecosystem Assessment, this is designed to understand how ecosystems contribute to poverty reduction at the local, national and global levels, how changes to ecosystems (including climate change), will impact the poor who depend on ecosystems, and how ecosystems can be better managed to continue to support poor people.

5. Adaptation to existing climatic variability and now climate change (for example through development of new crop varieties better adapted to drought stress) is a key theme in DFID-funded agriculture and renewable natural resources research and has been for a number of years.

6. Central Research Department spending on climate change research (excluding expenditure on agriculture) amounted to £5 million in 2006/7 and this will rise to £7.5 million in 2007/8. DFID will also work with partners to explore options for establishing a climate change centre. This will enable better networking of expertise to meet the immediate needs of developing countries to understand and work with the physical, social and economic impacts of climate change. We will work with partners to identify the best way of developing a collective response, building on existing institutions and in response to demand.

7. Within the UK there is considerable expertise on climate change research. The Government commissions a wide range of scientific research on climate change and funds programmes on climate modelling and work on impacts and adaptation. The Climate Prediction Programme at the Met Office's Hadley Centre underpins the Government's climate change policy. An independent review of the Hadley Centre (2006) showed that its climate science is world-leading and unique, and provides excellent policy relevant scientific outputs to UK Government clients.

8. The Stern Review on the Economics of Climate Change was led by Prof. Sir Nicholas Stern (Head of the UK Economic Service). This is the most comprehensive review ever undertaken on the economics of climate change, focusing on the impacts and risks, the costs and opportunities associated with tackling climate change, and the national and international policy challenge of moving to a low-carbon global economy. Climate change research and projections undertaken by the Met Office Hadley Centre provided the core scientific input to the Review.

9. The UK Climate Impacts Programme, set up in April 1997, is funded by the Department for Environment, Food & Rural Affairs (Defra) and based at the University of Oxford. The programme co-ordinates research on climate change impacts within the UK. The UK also supports research which will help developing countries deal with climate change. Current research includes an assessment of how to improve climate modelling and monitoring for Africa, and an investigation into the impacts of climate change on Chinese agriculture.

10. The UK's Natural Environment Research Council (NERC) spends about £40 million each year on climate change research. NERC's world-leading scientists advise the Intergovernmental Panel on Climate Change, recognised worldwide as the definitive source for climate change information.

11. The UK's Tyndall Centre (funded by NERC, the Economic and Social Research Council and the Engineering and Physical Sciences Research Council) brings together scientists, economists, engineers and social scientists, who together are working to develop sustainable responses to climate change through trans-disciplinary research and dialogue on both a national and international level. Focus areas include informing international policy, constructing energy futures, building resilience to climate change, international development, sustainable coasts, engineering cities and integrated modelling.

12. The World Bank has launched a comprehensive research programme into the economic and social dimensions of climate change. DFID and DGIS Netherlands are funding work on the economic case for adaptation and Norway and Finland are funding work on social challenges such as gender and equity, managing risks at the household level, determining the distribution of social costs and benefits across different population groups, and understanding the political economy of climate action. The Bank is also undertaking work on climate change in dryland areas and work on climate change analysis for the urban poor. DFID is also aware that major international foundations are also looking to support research on climate change. Google.org, for example, has expressed interest in partnering with DFID and others to support Climate Change Adaptation in Africa. Opportunities for partnership such as these will continue to be explored.

WHAT THE CONSULTATION ASKED

13. The electronic consultation asked how DFID should build on our climate change research. We noted that water resources are particularly threatened by climate change and asked whether to broaden our research focus to include environmental change more broadly, given the increasing pressure on natural resources such as land, food and water. We highlighted the importance of research helping developing countries to understand their options for reducing the risks of climate change to poverty reduction and growth, as well as seizing any opportunities that arise, for instance through international systems for carbon trading.

14. We held in-country consultations in India, Bangladesh, Ethiopia, Nigeria, Uganda, and China; the China event included specific climate change sessions.

WHAT WE HEARD

15. The consultation emphasised the far-reaching impact of climate change on poverty reduction and the need for DFID research to address this challenge as a research priority in its own right, as well as across its other research themes. Developing country respondents expressed real uncertainty about the way climate change would affect the pattern of development in health, migration, agriculture, land use and food security, and drew attention to the dearth of reliable research to inform not only decision-making but national debate. There was a significant gap in connecting global scenarios to country and regional impact assessment and planning. Where scientific modelling existed, it needed to be linked with social and economic development plans. Above all, there was a need to embed the results of research in policy and to know more about how to change knowledge and attitudes towards climate change. Research on disaster management and risk reduction were also seen as priorities for further research and strengthening scientific capability. In China, mitigation of climate change was noted as a global public good, and the need for better understanding of options for achieving this were seen as priorities for research.

> "The coastal fishermen are the first victims of climate change. Small farmers are also affected. We are not vulnerable in that the water level has reached higher here compared to the rest of World but the poor, lacking any coping mechanisms or capacity, cannot recover from the changes in the climate. So we have to assess what is going to happen in next 50 years. Additionally, the development of a reliable flood warning system will save a lot of lives"
> E-consultation respondent from Bangladesh.

16. The public e-consultation on this question alone yielded 150 responses. Many respondents saw a central role for DFID research in furthering adaptation research, and providing cost/benefit analyses of various adaptation and mitigation strategies to understand the development trade-offs and time-scales. Others felt that specific methods and tools were needed to allow links between the very large scale processes of climate change with the meso-and micro-scale processes of development to be made. Some contributors stated that the priority should be facilitating better understanding of climate-related impacts at national and sub-national level.

17. Many respondents noted the need for linking adaptation with mitigation, predicting the impacts of climate change on growth, and investigating options for low carbon growth pathways, particularly in rapidly developing economies, and the impacts this would have within these countries and on other countries.

> "Our future world will be one in which carbon has a price which continues to rise".
> Speaker at 2007 DFID meeting with research leaders.

18. Clean fuel priorities and new patterns of energy use (e.g. solar, hydro) were a major theme, including the challenges of technology transfer. One respondent noted the power of example and believed that research in developed countries should show developing countries how to move to a low carbon economy. Research into how bio-fuel production can contribute to climate change mitigation whilst also supporting social and economic development and environmental sustainability was highlighted as a critical need for developing countries. Related questions were how energy policy would affect world food supply and prices, and how bio-energy investment and policies would affect both rural and urban poor.

19. A range of suggestions were made for new researchable questions that build on DFID's current climate change research. These included:

    - The impacts of climate change on already stressed environments;
    - The impact of climate change and ecosystems, particularly biodiversity loss, and impacts on food security and agriculture; and
    - The social dimensions of climate change, including its connections with gender equality.

20. Several respondents also highlighted the importance of researching environmental change more widely, including the institutional arrangements for managing land and water.

21. Important synergies and linkages between climate change research and other themes were also noted, particularly sustainable agriculture but also the management of land, forests, reefs, fresh water more broadly. Very many respondents noted that new approaches to agriculture should be a priority for new research, particularly including water conservation and better systems for irrigation.

"Yesterday's irrigation must adapt to respond to tomorrow's needs" E-consultation respondent.

22. The development of new and more **drought-resistant crops** was frequently raised, with some respondents urging the need for field (rather than laboratory) research in this area. Research was needed to develop, maintain and improve the best crops suited to survive new conditions, whether staples for subsistence, traditional commodity crops or new crops. Research was also needed into the linkages between climate change and the **spread of agricultural pests and diseases and human diseases** (Note: responses related to sustainable agriculture are detailed in the working paper on Sustainable Agriculture).

Science and innovation: What technological research and investments are needed to stabilise crop yields across variable weather conditions? Examples could include: new varietals that are better adapted to erratic rainfall, rather than maximising yields under optimal weather conditions; innovative approaches to soil and water conservation, irrigation, rainwater harvesting and groundwater management. This is an old agenda, but one for which new solutions and new innovation pathways must be urgently found. This requires both good science and effective governance of innovation systems to ensure that science and technology efforts meet the needs of the poor living in complex, diverse and risk-prone settings."

23. A number of potential new themes were suggested:

i) Governance and planning frameworks

- Understanding climate change and **governance and institutional capacities and frameworks, particularly in fragile states,** and where climate change may cause or enhance conflict or migration between states;

- Improving **planning tools and governance systems** that facilitate sustainable use of natural resources across different ecosystem types (particularly agricultural and non-agricultural).

ii) Social dimensions of climate change

- Understanding the geography of population growth over the next 30 to 50 years, noting that the vulnerability of the **urban poor** was less well researched than the vulnerability of the rural poor, and including the **connection between climate change and water resources, sanitation, and growth;**

- Researching **local responses and knowledge** to better understand how poor people are currently adapting to adverse weather events and synthesising that knowledge to scale up potential responses;

- Investigating the **causes and consequences of migration,** and how this can be built into and climate change response planning;

- Understanding the linkages between adaptation measures and other socio-economic factors such as overexploitation of natural resources, population growth and pollution, and how approaches such as rights-based approaches may help tackle some of these linkages;

- Assessing the linkages between climate change, **conflict and disaster risk reduction,** taking into account resource scarcity and conservation as a potential DRR and conflict reduction measures;

- Early identification of **health risks** associated with changing climate and newly emerging diseases;

- Understanding the **determinants of climate-relevant behaviour change, including understanding the barriers to uptake of knowledge and technologies.**

ii) Growth and consumption patterns

- Reconciling finite resources with growing patterns of global consumption;

- Balancing low carbon growth, energy access, demand and efficiency, and air quality with poverty reduction;

- Balancing low-carbon growth with poverty reduction;

- Understanding the technology challenges posed by climate change;

- The impacts of future energy markets on poverty reduction goals;

iii) Aid effectiveness

- The implications of climate change for development organisations and developing tools to mainstream climate change adaptation and disaster risk reduction.

24. Important researchable problems about the deteriorating state of the environment in developing countries were raised. Some of these – such as links between eco-systems and poverty reduction – sit firmly within DFID's poverty reduction mandate and could be addressed through the Ecosystems Services and Poverty Alleviation programme (ESPA). However others sit outside, including air quality, increasingly acidic seas and dangerous algae blooms.

IMPLICATIONS AND FUTURE DIRECTIONS

25. Climate change is one of the greatest threats to development and will remain so for decades to come. **DFID will retain climate change as one of our priority research themes.** We will build on the foundation of our research on the impact of climate change on poverty. But addressing adaptation is not enough. The choices surrounding climate change are developmentally complex and profoundly political. Our research will recognise this. We will pay more attention to responding to the requests of partner governments; embedding the results of research in policy; using research intermediaries and targeted communication channels to ensure the results of research reach opinion-formers as well as communities; and ensure that we make connections between our knowledge generated at international, regional and national levels and how this is used for change. Our capacity building efforts in climate change will be in the social sciences as well as natural sciences to identify and scale up appropriate options for adaptation and mitigation in developing countries.

26. Our programmes on ecosystems management (including water resources) will address issues of broader environmental change and impacts on poverty reduction. These will be clearly linked to our existing and new programmes on climate change. Some researchable problems raised in the consultation related to climate change and agriculture can be better addressed through our ongoing support to agricultural research, including through DFID's contribution to the CGIAR system (for example development and testing of drought resistant crop varieties). These are detailed in the Working Paper on Sustainable Agriculture. How we will tackle issues related to energy and water resources is set out in the working paper on infrastructure.

    In all four areas where we scale up our climate change research, communication and capacity building will be central elements. We will place equal importance on placing new policy-relevant knowledge and on facilitating the uptake, implementation and scaling-up of existing knowledge tools, and approaches. Details of how we will do this are set out in the working paper on Agriculture.

27. We will expand rapidly our climate change research to cover four new priorities. These will help to deepen global, regional and national understanding about the impacts of climate change on poor and vulnerable groups; respond to the immediate challenges of adaptation and future challenges of mitigation; and help to make clear the choices facing our partner governments in adapting to and mitigating the effects of climate change as part of their development plans. **The new priority areas have been selected on the basis of:**

    - **Relevance and application to poverty reduction;**
    - **DFID's comparative advantage;**
    - **Support for national and international policy priorities;**
    - **Opportunities to leverage funding and partnerships;**

- Focus on vulnerable groups;
- Impact on/linkages with other development activities;

28. The consultation process largely confirms these new areas as priorities, although there will be some variation between countries (mitigation and poverty reduction is seen as a more pressing research need for example in rapidly developing countries like China, whereas African countries see economic and social impacts of climate change as the most immediate needs). These themes will be:

- Improving accessibility of climate science, scenarios, and impacts and vulnerabilities at regional, sub-regional, and national level, particularly in Africa;
- Embedding climate change in international, regional and national policy frameworks, including support for a new global deal on climate change;
- Expanding work on adaptation to strengthen decision making around adaptation options; and
- Investigating mitigation options and low carbon growth pathways.

29. The following sections outline the current state of knowledge and knowledge gaps, why the issue is a priority, and what DFID can offer in each area.

CLIMATE SCIENCE, ESPECIALLY IN AFRICA

30. The Intergovernmental Panel on Climate Change (IPCC)'s Fourth Assessment Report (2007) concludes that *"Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level"*. It also concludes that the increases in carbon dioxide concentrations are largely due to fossil fuel use and land use change, and increases in methane and nitrous oxide are the result of agriculture. **The report also states that data coverage remains limited in some regions.**

31. A review of decadal forecasting techniques commissioned by DFID shows that different Global Climate Models (GCMs) show remarkable convergence on projected global mean temperatures for the next two or three decades. However, the report cautions that **global averages conceal significant regional variations in temperature and thus the products will remain of limited value to policy-makers and planners** (Wilby, 2007a).

32. In 2005, DFID and Defra jointly commissioned a review of Africa's science needs, which showed that we know remarkably little about Africa's climate. Furthermore, the African climate observing system is the least developed of any continent and deteriorating. **Scientific understanding of the African climate system is, as a whole, low. The level of technical expertise available to support climate science in Africa, is very low** (Wilby, 2007b). A recent paper by DFID's Chief Scientific Adviser explains the knowledge and science gaps in more detail. It highlights the lack of understanding of linkages between the Intertropical Convergence Zone, the El Niño-Southern Oscillation and the annual alternation of the Monsoons. It concludes that far too little is known about the African climate, its drivers and their links to global warming. There is also a paucity of regular, detailed information on the African weather. **This lack of knowledge makes it very difficult to predict with any degree of accuracy what will happen as a result of climate change at a country, or even sub-regional level in Africa.**

33. Since 2005, there has been growing appreciation that climate change must be factored into all development activities. There is also broad recognition by scientific community that a more coordinated approach is needed to address the uncertainties about climate change impacts as well as the links between natural resource management and human well-being (Wilby 2007b). Without accurate data, analyses and information at appropriate levels, decision-makers will not be able to adequately determine impacts and vulnerabilities, identify affected sectors or population groups, or make prudent decisions on interventions. In developing countries, data and capacity to use information are severe constraints to effective adaptation and mitigation. Developing countries need to strengthen these resources internally rather than rely on external information and advice, if they are to be empowered to tackle climate change.

34. As detailed above, the UK is not only funding world-class research on global climate change, but also houses significant expertise in climate science, impact modelling, and integration of climate science into policy making at the national and international level. **There are opportunities for DFID to partner with key institutions such as the Hadley centre and the Tyndall centre, as well as international institutions like WMO, to leverage funding and further expertise.** Filling science and data gaps will contribute to improved global climate modelling as well as prediction of impacts and vulnerabilities at regional, sub-regional and national level, particularly for poor countries where data, tools and capacities are weak. Africa should be a focus for this work.

35. DFID funded research could support the following questions:

- How appropriate are global climate models for predicting impacts and vulnerabilities at regional, sub-regional and national level? What data and capacities are needed for these to be "downscaled"?

- What indicators of climate change are appropriate for developing countries and how can these be used to measure progression towards vulnerability thresholds or environmental tipping points?

- What data, tools and capacities are needed to map impacts and vulnerabilities at regional, sub-regional and national level, for different sectors and population groups?

- How can the above be used together with socio-economic data to predict trends and events (e.g. migration, and conflict)?

- How will climate change impact on urban populations, infrastructure and ecology of urban areas, and how can forecasting and planning be improved, especially for extreme events?

- What confidence limits and understanding of variability and extreme events is needed for effective adaptation, planning and development of early warning and response systems?

- How can climate change information be better communicated to policy makers for integration into strategies and development programmes?

Communication and capacity building will be key to the success of research programmes in this area, to ensure that science findings are easily understood by policy makers and that policy makers have the skills and knowledge to integrate new findings in decision making.

EMBEDDING CLIMATE CHANGE IN NATIONAL AND INTERNATIONAL POLICY FRAMEWORKS

36. Options already exist to mitigate emissions and to adapt to climate change. Pastoral communities in Africa, for example, have been adapting their livelihood strategies to accommodate rainfall variability and disease outbreaks for centuries. Emissions trading and carbon off-setting schemes have been established or have emerged to meet market demands. These autonomous solutions will continue to emerge and some will be successful. But many operate on perverse incentives, and not only do little to tackle climate change, but can contribute to making the problem worse. In Indonesia, for example, peat bogs are being drained to grow palm oil for European markets, yet the emissions from deforestation and draining of the bogs are 30 times higher than the saving in Europe from using cleaner fuels. Rainwater harvesting as an adaptation to increasingly erratic surface water availability results in large pools of standing water, which are ideal breeding habitats for disease vectors like mosquitoes.

    To tackle climate change effectively on a global scale requires a coordinated response. This means taking action proactively, across all sectors, and embedding both adaptation and mitigation in policies and budgets at national and international level. To support a new global deal on climate change, countries need accurate analyses and information on choices, costs and benefits of different choices, and the incentives to comply or not comply with the rules set up.

37. **Urgent action is needed if greenhouse gas concentrations are to be stabilised at a level that would prevent dangerous interference with the climate system. The World Energy Outlook (IEA/OECD 2007) predicts that if all the policy options currently available were implemented,** global emissions would stabilise in the mid-2020s at about 550 parts per million (ppm) (which would correspond to an increase in average temperature of around 3°C above pre-industrial levels).

38. According to Wilby (2007) there is an over-arching need to translate available scientific evidence on climate impacts and risks into guidance for proactive, coordinated planning of adaptation and mitigation options and measures to reduce the risk to investments and development programmes. Technical guidance is urgently needed on:

    - appropriate infrastructure design and climate sensitive planning;
    - avoidance of high-risk areas through land use regulations;
    - incorporation of climate change allowances in the engineering standards applied to flood defences and water supply systems;
    - the management of natural resources; and
    - climate change impacts on and adaptation options for economic growth strategies.

39. He also argues for development of frameworks for upscaling knowledge of local impacts and adaptation approaches to assist country-level adaptation, development and application of composite climate change indices alongside measures of human development and vulnerability, to help target resources for adaptation, and monitor progress.

40. The problem, according to the World Energy Outlook, is that policy options for adaptation and mitigation are not being adopted fast enough, consistently enough, or by enough countries to meet current and future challenges. Research is required therefore, to understand the blockages to uptake of existing options, and to find ways of increasing uptake of existing and new options. **DFID's future research will support identification and development of: institutions, capacities, incentives, and regulatory mechanisms, including trade policies, to support the integration of risk management, mitigation and adaptation into policy frameworks, investments, and programmes at national, regional and international level. Embedding climate change in policies and budgets in more coherent proactive ways will enable developing countries to manage climate risks in more coherent and cost-effective ways, and to fully participate delivering a new global deal on climate change, including through carbon trading schemes.**

41. For example DFID will support research on developing policy frameworks that allow identification and evaluation of climate risks across all sectors, and cost-benefit analysis of different response options. We will support research on identifying techniques to integrate climate risk into budgeting processes, capacity building for decision making when tough choices have to be made about impacts that are disaggregated across space and time and population groups.

42. DFID will support research to identify appropriate institutions and capacities, policy instruments and indicators of success that will support implementation of regional and international agreements on climate change. This may include development of incentives structures, regulations, monitoring

processes, systems for arbitration and dispute resolution, as well as development and regulation of institutions that can provide technical support and advice to developing countries on implementing agreements and obligations. DFID will also support research to identify and overcome blockages to implementing existing agreements and mitigation and adaptation approaches. We will investigate perverse incentives (such as in the case of some countries receiving grants that effectively subsidise old dirty technologies, rather than meet the additional costs of cleaner technologies), and investigate regulatory mechanisms that avoid such loopholes. We will look for innovative frameworks that can accommodate diverse interests –energy consumption and economic growth, affordable and clean energy and fuels, emissions from the energy sector and land use – as well as diverse levels of development.

43. **Other research priorities include investigation of policy and regulatory frameworks to administer an international carbon market**. We will consider, for example what instruments can be used domestically and internationally to ensure developing countries participate fully in a global carbon market, and to ensure that poor people benefit from international trade in carbon. We will examine how land use options can be integrated into an effective global carbon market, and what regulatory frameworks, subsidies and trade regimes will be most supportive of development objectives.

44. Governance arrangements and institutional capacities to cope with climate change are important at national and international level. We will help partner countries find out what works and what can be learned from other cross-cutting issues. This could include a specific component on negotiation capacity, reflecting on the experiences in international trade.

45. DFID research will seek to understand the poverty dimensions of adaptation and the optimal governance arrangements to support effective climate change adaptation at local, national and regional levels. This may include investigating the politics of policy reform and implementation in developing countries and the need for new governance structures to deal with challenges of climate change. We may also commission research on whether rights frameworks facilitate adaptation by poor people to improve their resilience (including - but not exclusively - through redistributive mechanisms such as social protection, and global agreements to facilitate international migration). Climate change is a driver for inclusion of China and India in the G8 and other global governance frameworks, but what are the social and political implications of this in the South?

ADAPTATION STRATEGIES

46. In the Fourth Assessment Report, the IPCC Working Group II on Impacts, Adaptation and Vulnerability presents the evidence that climate change is already having myriad impacts around the world. It reports: enlargement and increased numbers of glacial lakes; increasing ground instability in permafrost regions: changes in some Arctic and Antarctic ecosystems; increased runoff and earlier spring peak discharge in many glacier - and snow-fed rivers; warming of lakes and rivers in many regions, with effects on thermal structure and water quality; ecosystem changes including earlier timing of spring events, such as leaf-unfolding, bird migration and egg-laying; poleward and upward shifts in ranges in plant and animal species; changes in marine and freshwater biological systems associated with rising water temperatures, salinity, oxygen levels and circulation, including shifts in ranges and changes in algal, plankton and fish abundance in high-latitude oceans; and range changes and earlier migrations of fish in rivers.

47. The report concludes that there is much more evidence of impacts of climate change on physical systems than previously recorded, leaving no doubt that we are locked into some degree of climate change. The report also documents secondary impacts on agriculture, forestry and ecosystems; human health; water; and industry and social systems. The need for adaptation, particularly by poor vulnerable groups, is apparent. **The report also states: "A wide array of adaptation options is available, but more extensive adaptation than is currently occurring is required to reduce vulnerability to future climate change. There are barriers, limits and costs, but these are not fully understood.**"

48. It goes on to say "sustainable development can reduce vulnerability to climate change by enhancing adaptive capacity and increasing resilience. At present, however, few plans for promoting sustainability have explicitly included either adapting to climate change impacts, or promoting adaptive capacity." This would seem to advocate for a more coordinated approach to integration of adaptation options into national and regional planning processes, rather than simply implementing responses in particular sectors or communities.

49. The review of climate risk assessment by Wilby (2007) highlights that development activities will be most exposed to climate change risks where human and environmental systems are already marginal (such as semi-arid regions, or coastal zones subject to frequent flooding). In these cases, even modest changes in the mean climate or to extremes could have significant impacts on lives, livelihoods and investments. The author argues for **development of the scientific and economic capacity to identify critical thresholds and to better understand and cope with climate variability, as well as development of climate forecast tools and data sets that capture incremental changes in risk over the scales needed for adaptation planning.**

50. Over the next five years DFID will continue to prioritise research strategies and capacity for adaptation by extending and expanding current work with African partners, which is jointly supported with IDRC. Our new regional programmes in Asia and Latin America are likely to:

- Develop and test of adaptation options across sectors;
- Investigate the dynamics of vulnerability and long-term climate changes; and
- Research linkages between adaptation, mitigation, and poverty.

51. We will expand our research on adaptation to support three main adaptation objectives:

KNOWLEDGE AND TOOLS:

52. We will seek to improve understanding and access to information on the physical impacts of climate change at regional, sub-regional and national level, and how these impact on development. We will explore inter-linkages, synergies, and tipping points, for example between water scarcity, migration and conflict, or between water, food security and human health. We will support developing countries to determine risks, vulnerabilities, and development impacts.

53. Climate-related disasters already significantly threaten development (through loss of lives, livelihoods, homes, infrastructure, natural resources, diverting financial resources from long-term development to immediate response and recovery) and security (including displacement of populations, competition for scarce resources, temporary settlements). The poor are most at risk due to their location and access to resources and information; and climate-related disasters are set to increase in frequency, duration and intensity. Future research is likely to include:

- Methodologies for predicting, planning for and responding to both rapid onset and long-term climate change related disasters (including through development of early warning systems), and related capacity development;
- Methods for assessing the multiple dimensions of vulnerability and identifying vulnerable groups over time and space;
- Investigating linkages between climate change, migration and conflict; and
- Incorporating risk management and risk reduction into adaptation planning at all levels whilst incorporating climate change and disaster management into risk management activities.

54. Expanding the range of adaptation options through new knowledge, approaches, reviews of what works, and lesson learned will be a significant component of this area. Understanding which strategies are available, appropriate and successful in which sectors and situations, and which techniques are appropriate for different communities or groups and at different scales will be key components of our research.

55. This will require further understanding of the physical impacts as well as the secondary impacts on development objectives – on food security, health, migration, and conflict. Studies by the World Bank have shown that the impacts of climate change are likely to have a disproportionate effect on already vulnerable groups such as women, pastoralists, and disabled people, and options for helping these groups are under-researched. We need to understand:

    - Who will benefit and who will lose from shocks caused by climate change (including gender and ethnicity factors)?

    - What are the disaggregated implications of climate change impacts for people's access to assets and livelihoods, migration, urban growth, citizenship rights, inequalities, social cohesion and conflict?

56. For example, climate change contributes to the global burden of disease through facilitating the spread of vector- and water-borne diseases, threatening food security and nutrition, and increasing migration within and between countries. Knock-on effects will include increased pressure on natural resources, tensions and conflicts between communities, risks to lives and livelihoods (even the act of migrating itself may be too tough for the elderly or disabled). DFID will develop research to address these themes.

57. Climate change impacts on the **urban poor** deserve additional research due to predicted growth rates in urban areas over the next 10-20 years. DFID research programmes will seek to inform spatial development planning processes, and service delivery programmes, to be better able to cope with impacts of climate change in urban areas and **large scale migration.** We will also investigate the **costs and benefits and effectiveness of preventive measures** such as watershed protection to reduce the risk of flooding and related health problems, and identify how proactive, cooperative land and resources management can reduce the potential for conflict and migration.

CAPACITIES AND INCENTIVES:

58. The IPCC Fourth Assessment Report says there is a wide range of adaptation strategies but the uptake has been variable. Why are some adaptation options taken up whilst others not? DFID-funded research in this area will seek to understand the constraints to uptake of information and adaptation strategies, and the political economy (who wins and who loses) of adaptation, such as:

    - How the availability of accurate, localised climate impact information and risk assessment influences decision making;

    - The skills required in order to analyse information and adaptation options, how to incorporate them into policy-making and transform them into practical action;

    - Which organisations are best placed to provide capacity-building support to a range of actors in adaptation, at regional, national, sub-national and community level;

- The social, political and economic incentives necessary at different scales and for different groups;
- How countries can achieve greater coordination and coherence of adaptation options at different scales and in different sectors and avoid "mal-adaptation" – different adaptation strategies undermining one another; and
- Which institutional arrangements can be effective in order to integrate climate change adaptation into development plans.

FINANCE:

59. Estimates of the costs of climate change range from US $10-50 billion, but these are based on unreliable and patchy data. Climate change will set back investments in development, and the longer we wait the more it will cost. There is an urgent need therefore to quantify various adaptation options, to understand the distribution of costs and benefits to poor people, and to support developing countries in integrating these assessments into development planning and budgeting. The UK has a strong track record of economic assessments including the Stern Review of Climate Change, and this is a particular area where our research can add value.

60. Future research is likely to help developing countries answer such questions as:

- How much will different adaptation options cost, and what tough choices and trade-offs need to be made?
- How can social and environmental costs and benefits be reflected in economic evaluations of different options at different scales?
- How can economic resilience be increased and reliance on vulnerable economic sectors decreased?
- What will be the impacts of carbon markets on production, trade, transport, energy, and agriculture at national level, and the distribution of these impacts on poor and vulnerable groups?
- How will climate change impact on growth strategies and development pathways, what alternative options are available, and how to factor risk into financial decision making, particularly on insurance and capital markets?
- How can the public and private sector work together to facilitate mitigation and adaptation?

61. Communicating climate change research to policy makers and its integration into strategies and development programmes will be of special importance, as will sharing of knowledge and experiences with adaptation options at all levels. Investing in getting climate change research into use will support DFID's overall goals of securing an acceptable, ambitious and fair global deal, building international centres of excellence on climate change, and empowering poor and vulnerable communities to take proactive measures to protect their livelihoods, health, and their options. Because of the scale and urgency of the challenge DFID will encourage other international research funders to join or complement our research effort.

MITIGATION AND LOW CARBON GROWTH

62. The 2007 World Energy Outlook puts forward convincing arguments for urgent mitigation, on the basis of energy supply, security and avoiding further climate change (IEA/OECD 2007). The report shows that global energy demand will increase by 50% by 2030, with the majority of the new energy coming from fossil fuels. It states "**Rising CO^2 and other greenhouse-gas concentrations in the atmosphere, resulting largely from fossil-energy combustion, are contributing to higher global temperatures and to changes in climate. Growing fossil-fuel use will continue to drive up global energy-related CO^2 emissions over the projection period.**"

63. The IPCC Fourth Assessment concludes that global carbon dioxide concentrations in the atmosphere need to be stabilised around 450ppm to avoid temperature increases above 2.4oC. This would require energy-related CO^2 emissions to fall to 23Gt in 2030. The report's "best-case scenario" whereby all mitigation options currently available are immediately implemented would result in energy-related emissions still being 34Gt by 2030. **Thus research is urgently required to find ways of scaling up implementation of existing mitigation options, development and uptake of new mitigation technologies and land use practices, and to realise the co-benefits of cleaner, more efficient production.**

64. The World Energy Outlook also concludes that mitigation of greenhouse gas emissions in China and India are urgent and immediate priorities. **Mitigation in ways that preserves economic growth in these countries for the local and the global good is the most important challenge, and a priority for research.**

65. The Stern Review of climate change shows that mitigation is costly, but will only get more costly the longer we put off taking effective action. There are also opportunities for developing countries through adoption of mitigation technologies. For example, cleaner technologies reduce air pollution and health-related hazards, of which the poor typically bear the highest social costs.

66. DFID-funded research on mitigation and low carbon growth will contribute to greater knowledge and understanding of mitigation options and development costs and benefits. Future research will support three main areas: policy frameworks, technologies and land use practices, and realising co-benefits.

POLICY FRAMEWORKS:

67. Developing countries need strong energy planning frameworks and the analytical and regulatory capacity to implement them. The current lack of adequate energy planning frameworks is considered to lead to sub-optimum, ad-hoc, short-term decision making in the energy sector. DFID research will help developing countries put in place coherent medium/long-term plans for the energy sector.

68. The importance and inter-connectedness of the three drivers in energy planning (equitable energy access, energy security of supply and climate change) need to be better understood, including how the relative importance of each driver changes over time and space. Frameworks need to be made more flexible to incorporate long-term and short-term objectives, and take into account institutional changes. Research needs to include support for the development of appropriate regulatory and policy structures, for example to take account of the cross-sectoral nature of the biomass supply chain.

69. DFID research will include a review of previous research on power sector reform (such as DFID-supported work in India and Bangladesh that examined how power sector reform could deliver pro-poor development benefits) and examine how energy sector reform could be adapted to deliver climate change mitigation objectives as well. In the fuels sector, alternatives to subsidies need to be developed that still protect the poor from price fluctuations but also reduce air pollution and greenhouse gas emissions. The World Bank's ESMAP programme has also done work in this area, and the Bank would be an appropriate partner in an independent research programme which would provide the evidence base, tools and approaches needed to inform programming and lending choices through the ETF. Energy policy trade-offs work would include an examination of the political economy of planning, how decisions are made, what information needs and models are useful, how to help countries make macro-economic choices about energy investments that will help countries arm themselves with better negotiating positions in the international forums as well as better domestic choices for development and climate change.

70. In rapidly developing countries like China and India, research priorities include supply-side aspects such as the energy mix and diversification, technology, energy efficiency and transmission. Energy efficiency and low carbon infrastructure are cost-effective mitigation options, but additional research is needed on the implications of the production and international consumption on energy demand in rapidly developing countries.

71. Other research priorities include investigation of policy frameworks to support an international carbon market. For example what instruments can be used domestically and internationally to ensure developing countries participate fully in a global carbon market? What regulatory frameworks, subsidies and trade regimes will be most supportive of development objectives? How can developing countries benefit from a carbon market and how can the benefits reach the poor?

TECHNOLOGY AND LAND USE OPTIONS:

72. Energy efficiency and cleaner technologies offer some of the most cost-effective and immediate options open to countries for mitigation. But uptake has been slow. Research is required to understand the blockages to technology development, transfer and implementation, and to investigate how the poor can gain from improving energy production and efficiency. This will include research into trade-related barriers to technology transfer and uptake, for example, what impact could imposing trade tariffs for energy efficiency have on developing countries, and how do these impacts compare to other incentives? What skills and capacities are needed to encourage technology transfer of cleaner options that also support the MDGs? What regulatory frameworks are needed to enhance technology innovation and uptake? What are the cost curves for greenhouse gas abatement in different countries?

73. In future DFID research will help to identify the options available for mitigation in developing countries at national and sectoral level and cost-benefit analyses which cover the distribution of costs and benefits across population groups. We will contribute the development, demonstration and uptake of low carbon energy technologies, including supporting our partner countries to develop locally new clean energy technologies. We will support partner countries in evaluating the feasibility and practicality of low-carbon electricity generation that can be decentralised, is affordable, manageable and maintainable. We will also facilitate South-South technology transfer.

74. We would expect to evaluate the social and environmental opportunities and constraints of land use options such as bio-fuel production in developing countries on the poor, and to assess the political economy of global bio-fuel systems and establish international policies for bio-fuel production and trade that can contribute to sustainable development. This could also include an examination of changes to trade policies for biofuels and how this will impact on the livelihoods of the poor as well as contributing to tackling climate change. We will also support research into other mitigatory land use options (such as avoided deforestation) and seek to understand better the scales at which the adaptation and mitigation benefits can be maximised for different user groups, as well as the policies, regimes and incentives that are likely to support mitigation through land use planning.

REALISING CO-BENEFITS:

75. Environmental and social benefits of mitigation include improved health, access to reliable affordable energy, improved energy security, and improvements in the local environment. On a global scale co-benefits could include reduced biodiversity loss through reduced deforestation, or reduced risk of disaster from improved land and water management. Research can support developing countries to realise these co-benefits through integrating social and environmental costs and benefits into evaluation of mitigation options. For example, how are developing countries likely to be affected by action taken in developed (or rapidly developing) countries to mitigate climate change?

How can global goods like biodiversity and disaster risk reduction be factored into decision making – how do we quantify the social and environmental benefits of these global goods and how can the benefits be realised for the poor who are most dependent on them? What are the likely effects of carbon trading upon the livelihoods of the poor and how can the carbon market be managed to ensure a contribution to poverty reduction and sustainable development? We will also probe the synergies between mitigation and adaptation options within the energy and land use sectors, in particular by developing and evaluating analytical frameworks for linking adaptation and mitigation.

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